



Introduction to Living with Environmental Change Pilot Review Reports

When establishing a major research programme such as 'Living with Environmental Change' (LWEC) with such clear relevance to the science-policy interface there is a need for identification of priority policy areas, reflection on the current baseline of evidence, exposure of knowledge gaps and hence the design of programmes of research. This need is now addressed, across many sectors, using a formal evidence-based approach. This approach is perhaps most familiar in the health services, social services and education but is now being actively used in environmental management.

The core methodology in evidence-based practice is the systematic review, involving a rigorous and objective assessment of the best available evidence on a question of concern to policy or practice. However, a systematic review is a significant investment of time and resources and, with the limited resources available it is probably not efficient to launch straight into a programme of systematic reviews without some prior estimation of their value. Consequently a funding scheme for pilot reviews was established.

The Pilot Reviews offer the opportunity to scope academic literature and public reports published on specific questions. It was intended that the reports of the reviews would: outline the existing data and highlight the trends and gaps in knowledge, contain details of the search strategy employed, provide critical appraisal of the quality of the sample of the studies and may produce a draft protocol for a full systematic review. It is hoped that the reports will provide a resource for stakeholders and follow the guidelines given for scoping studies on systematic reviews, which can be accessed at:
<http://www.environmentalevidence.org/Authors.htm>

The LWEC partners agreed six strategic objectives that will inform progress towards the design of the programmes of work that will make up LWEC. The first scheme funded the following reports and was in support of **LWEC Objective B - To manage ecosystem services for human well-being and to protect the natural environment in a changing world**. The LWEC partners were keen to support activities that cover both aspects of Objective B. These include the assessment of links and feedbacks between the natural environment, ecosystem services and human well-being; how these might continue to develop within environmental limits in the face of major environmental change; and how decision-making and local and national planning can take account of these links and feedbacks to help in the development of new social, environmental and economic opportunities. Each of the six reports that form the output of this first scheme provides an initial characterisation of the evidence base on their chosen subjects. This provides a

resource with which to judge the potential value of full systematic reviews and the likely need for primary research.

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Examining the Contribution of Marine Protected Areas to Human Well-Being

FINAL REPORT TO NERC and DEFRA

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Summary

This report presents findings of the pilot systematic review undertaken to explore the contribution of marine protected areas (MPAs) in temperate zones on human well-being. The aim of the review was to scope the literature and relevant public reports, to provide an initial examination of the current state of knowledge and identify potential knowledge gaps.

A variety of electronic sources of literature including bibliographic databases, Internet search engines and specialist sources were searched using a range of keywords. Since the literature on marine protected areas uses a variety of terms to label areas in which certain activities, especially extractive activities are restricted search terms included no-take zones, marine reserves, marine parks, marine sanctuaries and marine protected areas. An Endnote database was used to store all the relevant literature for analysis.

Results indicated that there were three main themes on the human aspects of MPAs: 1) bio-economic models that examine changes in catch rate and potential income; 2) governance and management of MPAs; and, 3) general socio-economic issues (e.g. impacts on multiple stakeholders, perceptions of change). As the governance papers were fewer in number, the review focused primarily on the bio-economic and general socio-economic references. None of the papers examined had specifically set out to identify the impacts of MPAs on human well-being. Most papers had assessed the impact of MPAs on a factor or combination of factors that contributes to human well-being. While links between MPAs and these factors were made, no reference was given to the impact of changes in these factors on well-being itself.

The combination of bio-economic modelling studies and studies reporting empirical data on the socio-economic impacts of MPAs provide a synopsis of the status of the literature of impacts of MPAs on human well-being. They also indicate a high level of heterogeneity among studies making comparison across them difficult. Any future systematic review would benefit from a widening of the geographical search terms and the direct collection of data from MPA managers. A protocol on how such a review could be conducted is suggested. An alternative to a full systematic review could be to develop a standardised approach to the collection of socio-economic data on the impacts of MPAs on well-being.

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1 Introduction

Through the Living With Environmental Change programme (LWEC), Plymouth Marine Laboratory was commissioned by NERC and DEFRA to conduct a pilot systematic review to identify the contribution of marine protected areas to human well-being. This report presents findings from this scoping study.

Marine protected areas (MPAs) are a widely recognised tool for protecting and ensuring the maintenance of functional marine ecosystems. Many authors have shown MPAs to be successful in protecting marine life from threats such as over-fishing (e.g. Gell & Roberts 2004, McClanahan & Mangi 2000), and have advocated for the creation of an extensive network of MPAs (e.g. Roberts & Mason 2008). Fundamentally, MPAs are created and function in the context of societal objectives which inherently reflect human aspirations and values (Charles & Wilson 2009). Understanding how MPAs contribute to human well-being is therefore necessary if MPAs are to function effectively.

A huge literature exists in terms of MPAs, mostly written from a biological perspective (e.g. review by National Research Council 2001, Gell & Roberts 2003). Most of these studies have explored how many, and under what conditions, fish migrate or spillover from MPAs to adjacent fished areas, and how this may maximise the direct benefits of MPAs. Spillover occurs whenever fish are afforded a measure of protection in an MPA, as the MPA provides a source of recruitment for exploited areas outside (McClanahan & Mangi 2000). Social science studies, and, more specifically those linking MPAs and human well-being, however, are less prevalent. Research has focused largely on the impacts of MPAs on discrete activities, such as fisheries, tourism and recreation (e.g. Badalamenti *et al.* 2000, Sumaila *et al.* 2000, Alder & Sumaila 2002, Lynch *et al.* 2004, Lloret *et al.* 2008). This is in part, due to difficulties in measuring human well-being (MEA 2005).

Human well-being is multi-faceted and is often context specific. It is an ambiguous concept and has no universally accepted definition. McGillivray and Clarke (2006) state that a number of terms are used interchangeably with well-being including quality of life, welfare, well-living, living standards, utility, life satisfaction, prosperity, needs fulfilment, development, empowerment, capability expansion, human development, poverty, human poverty, land and happiness. In the past it has also been considered analogous with income and consumption, but more recently its multidimensional nature has been recognised, suggesting that it is wider than welfare (and these other terms) but is inclusive of them (Dasgupta 2001, McGillivray & Clarke 2006). Nevertheless, income is still a commonly used indicator of well-being. Increased income is assumed to increase consumption and therefore utility, but the link between consumption and human well-being is not clear (Jackson & Marks 1999). For the purposes of this study, human well-being is examined through the use of proxies that can be considered as contributors to well-being. These include any socio-economic benefits and detriments, and include tangible factors such as changes in income, education and occurrence of conflict, and intangible factors such as perceptions of change and empowerment.

The impact of MPAs is currently of particular interest within the UK. The forthcoming Marine and Coastal Access Bill will commit the UK Government to deliver an ecologically coherent network of MPAs in English territorial waters and UK offshore waters (adjacent to England and Wales) by 2012. The UK Government must also designate protected areas in the marine environment to fulfil legal obligations under the European Habitats Framework Directive, European Birds Framework Directive and the European Marine Strategy Directive. To date, there are only three statutorily designated marine protected areas within the area of influence of the Marine and Coastal Access Bill: Skomer Island, Lundy Island and part of Lyme Bay. To ensure the success of any proposed network, it is important to understand not only the ecological effects of MPA designation, but also the social and economic impacts and the changes these may bring about in human well-being.

This will be particularly important if the designation of the MPA network impinges on the livelihoods and activities of the local users of the marine space.

Across the world, different terms are applied for the measures used to protect marine space including marine reserves, marine sanctuaries, marine parks, no-take zones and marine protected areas. For the purpose of this report the term ‘marine protected area’ is used to cover all of these terms, but only where the original term refers to an area of marine space that has statutory protection and where extractive activities are restricted or prevented in some, or all, of the designated area.

2 Aims and objectives

The aims of this pilot systematic review were to:

- undertake an initial exploration of the literature and relevant public reports relating to the impact of MPAs in temperate areas on human well-being;
- report on the extent of the evidence and any gaps in the existing knowledge;
- provide a critical appraisal of the data and knowledge where possible;
- develop a protocol for a full systematic review; and
- construct an Endnote database of relevant articles.

3 Methods

The systematic review consisted of a number of carefully crafted stages that led to the identification, selection and critical appraisal of the relevant literature on the contribution of MPAs to human well-being. This pilot stage involved the formulation of appropriate questions for the review; the construction of a search strategy; an initial assessment of the volume of literature available of relevance to the review questions; and a trial appraisal of study content and quality.

3.1 Question formulation

A list of potentially relevant individuals and decision-making organisations was compiled and the questions developed for the initial proposal were sent to them by e-mail (Appendix). This was to ensure that the questions posed by the review are of relevance to policy-makers and practitioners involved in the designation of marine protected areas. Six out of the ten people contacted replied positively agreeing that the questions should be kept as initially proposed. Most suggested that the question should be broad but that the review should be specific to temperate areas and focus on studies with quantitative results where available. As the initial search for literature progressed, it was clear that for an effective systematic review, the questions would need to be subdivided further. The primary question for review therefore became:

- What contributions do marine protected areas make to human well-being in temperate areas?

Table 1: Definition of components of the primary systematic review question.

Subject	Intervention	Comparators	Outcomes
Well-being of stakeholder groups affected by the designation of marine protected areas	Marine protected areas in temperate latitudes (including no-take zones, marine reserves, marine parks and marine sanctuaries)	Comparable marine/coastal areas with no restrictions on human activities Before and after scenarios for individual MPAs	Impacts on the well-being of all stakeholder groups associated with MPAs. Impacts to include tangible factors (e.g. changes in income, education levels, participation) and intangible factors (e.g. changes in perceptions)

The secondary question for review is:

- What advantages do different methods (bio-economic modelling and empirical approaches) have for identifying the impacts of MPAs on human well-being?

3.2 Search strategy

The development of the search strategy was an iterative process. It started with initial searches that used Boolean logic to combine terms relating to marine protected areas and the outcomes of interest, such as “marine protected area” AND livelihood, “marine protected area” AND income. As mentioned above, the literature on marine protected areas uses a variety of terms to label areas in which certain activities, especially extractive activities, are restricted including no-take zones, reserves, parks and sanctuaries. While marine protected area is a commonly used catch-all term, it is not sufficient to capture all the necessary literature. The use of outcome terms was also considered restrictive and led to concerns that relevant literature could be missed. Consequently, the search strategy employed the use of the following exact phrases (denoted by the “ ” around the expression):

“marine no-take zone”
“marine protected area”
“marine reserve”
“marine park”
“marine sanctuary”

To ensure that only literature relevant to temperate areas was identified, a series of exclusion terms, (predominantly country or regional names relating tropical MPAs) were employed. During the early stages of the search it was noted that paleo-ecological studies were also appearing in the search results, together with studies relating to oil and gas production. Paleo* and oil were therefore also used as exclusion terms.

The search terms and exclusion criteria were then used to search a number of databases, Internet search engines and specialist websites. An Endnote database was constructed for each database and search engine used, and one combined Endnote database from the specialist sources. All hits were downloaded for sorting. Often it was not possible to use all of the exclusion criteria in the actual search due to their number. The first level of sorting of the databases therefore involved a search for each of the exclusion criteria and the removal of any reference containing one or more of these terms.

The databases searched included:

- Web of Science
- Science Direct
- CSA Illumina
- Wiley InterScience
- FAO's Waicent Virtual Library and on-line catalogue

Internet search engines used:

- Google (www.google.com)
- All the net (www.alltheweb.com)
- Google Scholar (scholar.google.com)

Specialist sources included:

- Marine Protected Areas of the United States (<http://mpa.gov/>)

- UKMPA Centre (<http://www.ukmpas.org>)
- EMPAFISH Project (<http://www.um.es/empafish/>)
- CoastNET (<http://www.coastnet.org.uk/>)
- EUNIS Database - European Nature Information System (<http://eunis.eea.europa.eu/introduction.jsp>)
- The Network of Managers of Marine protected areas in the Mediterranean (<http://www.medpan.org/>)
- Protect Planet Ocean (<http://www.protectplanetoccean.org/>)
- IUCN World Commission on Protected Areas (<http://www.iucn.org/about/union/commissions/wcpa/>)
- UNEP World Conservation Monitoring Programme (<http://www.unep-wcmc.org/habitats/marine.htm>)
- Environmental Defence Organisation (www.edf.org)
- The Nature Conservancy (<http://www.nature.org/>)
- WWF (<http://www.panda.org/>)
- World Bank publications (<http://www.worldbank.org/reference/>)
- NOAA – National Oceanic and Atmospheric Administration (<http://www.noaa.gov/>)

All of the Endnote databases were then combined into one and any duplicate articles were removed. This resulted in a database containing 1377 references.

3.3 Initial assessment of the volume of the literature

The database of 1377 references was then searched by two researchers independently. It was first searched by key word:

- Catch
- Income
- Livelihood
- Education
- Socio-economic
- Benefit
- Cost
- Stakeholder

This was followed by an assessment of titles for factors relating to impacts of MPAs on people and their well-being to ensure that the key word search had not missed relevant articles. Both researchers narrowed the database down to approximately 475 references. Each reference was then examined by title and abstract for factors relating to well-being, and each researcher reduced the database to 147 and 181 references respectively. On combining these two databases it was discovered that 59 references overlapped, resulting in a total of 269 references. It was concluded that the reasons for the differences in references selected resulted from one reviewer being more familiar with the literature and placing more emphasis on papers that quantified the presence or absence of spillover from MPAs into adjacent fished areas. Given more time, this stage would have been repeated with more clearly defined instructions for including or excluding references. However, given time constraints and the pilot nature of this study, it was decided not to repeat this step, but to examine the full-text of each reference in this final database for relevance for a full systematic review.

While examining the full-text of each reference it quickly became clear that three distinct themes were emerging from the literature on the human aspects of MPAs: bio-economic models that examine changes in catch rate and potential income; empirical studies that examine governance and the management of MPAs; and, empirical studies that examine general socio-economic issues (e.g. impacts on multiple stakeholders, perceptions of change). The majority of the papers fell into the bio-economic or general socio-economic categories, but this finding suggests the potential for

three independent systematic reviews. Given that the governance papers were fewer in number (33), the pilot study focused on the bio-economic and general socio-economic references. This division of papers also reflects the difficulty a full review would have in comparing such methodologically distinct approaches and the fact that the different approaches draw on distinct data sources. Bioeconomic models use both ecological and economic data, while the socio-economic studies draw on social, economic and psychological data.

3.4 Trial appraisal of study content

3.4.1 Empirical studies on general socio-economic issues

Of the 269 references identified, 140 were considered as empirical studies of general socio-economic issues, with 15 also covering aspects of governance and MPA management. To retain a reference for this trial appraisal only two predetermined selection criteria needed to be met: that the reference contained a case study of one or more MPAs, and that it included primary or secondary data relating to the MPA(s) studied. Of the 140 references identified, 33 could not be accessed within the time-frame of the study (due to the absence of electronic copies of particular journal volumes, lack of subscriptions to certain journals, and inability to access a number of books or reports). This imposes some bias in the literature reviewed, but any full systematic review based on these findings would endeavour to locate these additional sources.

14 of the 107 references were considered to focus specifically on a case study or case studies. The remainder were either not case study specific, were hypothetical in nature (suggesting how an MPA might impact on the socio-economic situation of stakeholders), provided guidelines or best practice about how an MPA could be evaluated, or were descriptive in nature and not based on primary or secondary data collection. The 14 papers were then examined to identify the aims of the MPA, the restrictions imposed by the MPA, the socio-economic focus of each study and the method applied. The quality of each paper was then assessed through an examination of the four types of bias recommended for exploration in systematic reviews, namely selection bias, performance bias, measurement bias and attrition bias (Table 2, Pullin & Stewart 2006). Selection and performance bias were explored in terms of study design including factors such as the inclusion of a comparison with a 'control' (i.e. a non designated area) and/or the baseline situation, and the use of time series. Due to the variation in 'treatments' applied (MPA designs and objectives), however, further measurement of performance bias was not considered possible. Measurement bias was assessed by exploring the sampling methods used including the representativeness of any survey applied and the use of appropriate statistical analysis, while attrition bias was explored in studies using time series data where repeated sampling of the same individuals occurred (i.e. panel data collection).

3.4.2 Bio-economic modelling studies

129 out of the 269 references identified had employed bio-economic models to study aspects of human well-being with MPAs. The same *a priori* selection criteria as employed above were used including, the reference had to contain a case study MPA or used data from an actual fishery. Each reference was then examined according to the following criteria:

- The socio-economic focus of the study
- The type of model used (deterministic or stochastic, using single or multi patches)
- Whether sensitivity analysis has been performed
- Key findings
- Other relevant issues

23 of the 129 references could not be accessed within the time frame of the review while 96 did not fulfil the above criteria with an appropriate case study MPA or had not used actual data from a

case study fishery. This meant that 10 references that had used bio-economic modelling were analysed.

Table 2: Sources of bias within the literature identified.

Bias and generic data quality features	Specific data quality features	Quality element
Selection and performance bias	Study design	Randomised controlled trial Quasi-randomised controlled trial Controlled trial Historical controlled trial Site comparison Time series Interrupted time series Expert opinion/questionnaire / data without comparator
Measurement bias	Representative survey	Considered representative Non-representative
	Statistical analysis	Statistical modelling Descriptive analysis No statistical analysis
Attrition bias	Loss of respondents in panel survey	No losses Loss of respondents

4 Findings

4.1 Empirical studies on general socio-economic issues

Ten of the 14 papers pertinent to the review referred to studies that have collected primary data, the remainder use secondary sources. These secondary sources were not locatable within the timeframe of this pilot review, but they should be useful resources for a future full systematic review. The identified papers focus primarily on the Mediterranean, but also include examples from Canada, the USA, Australia, New Zealand and South Africa (Table 3). These references showed that MPAs are applied in different ways in different locations and have differing objectives. Most Mediterranean MPAs are aimed at conservation, but also the protection of artisanal fisheries or traditional livelihoods (Badalamenti *et al.* 2000, Gomez *et al.* 2006). In contrast, MPAs from New Zealand and Australia have focused on conservation and preservation of the natural state of the habitat (Walls 1998, Lynch *et al.* 2004), while those in New Zealand are also designated for research purposes (Taylor & Buckenham 2003). Gell and Roberts (2004) indicate that MPAs in the USA and Canada have fisheries management as their main objectives, while the South African MPA examined had changed its focus over time from conservation to community development (Faasen & Watts 2007). All the MPAs reviewed, have some degree of zonation, whereby part of the MPA is a complete no-take zone. The South African example is the only exemption to this observation, as the whole of the MPA is a no-take zone (Faasen & Watts 2007).

The differing MPA objectives are not the only factors introducing heterogeneity into the papers examined. Each paper also focuses on a different dimension of the impact of MPAs on human well-being. For example Cadiou *et al.* (2009) focus specifically on the impacts of the Port-Cros MPA (France) on artisanal fishers in terms of fishing effort and yield, and the effects of fishing

restrictions. Faasen and Watts (2007) explore the perceptions of the local communities to the no-take fishing policy in Tsitsikamma National Park, South Africa; and Lynch *et al.* (2004) explore conflicts between divers and anglers from Jervis Bay Marine Park, Australia.

The distinctiveness of the papers selected was further apparent as their methodological quality was assessed (Table 4). 10 of the 14 papers draw on findings from a mixture of semi-structured interviews and questionnaire surveys, the remainder utilise secondary sources. None of the study designs fall into the categories considered of high quality in medical studies (i.e. randomised and quasi-randomised control trials). Two of the empirical studies compare an MPA with a control site (Boudouresque *et al.* 2005, Roncin *et al.* 2008), while only a further two compare current MPA data with the baseline situation (Lynch *et al.* 2004, Salmona & Verardi 2001). Generally the studies use a mixture of methods and, in the absence of the survey instruments used, transcripts from the interviews and knowing who exactly was chosen for interview and why, assessing the methodological quality and bias is particularly difficult. This finding, however, is not particularly surprising in a social science setting as standardised study designs and techniques are not commonly applied and survey instruments are not routinely published.

The representative nature of the surveys undertaken is also unclear. In some cases surveys appear comprehensive (e.g. Lloret *et al.* 2008, Himes 2003), but no paper reports the size of the populations of interest. Where studies have been more qualitative in nature, representativeness of the sample is not an objective, so each of these papers must be judged according to its particular focus. It is therefore difficult to assess the measurement bias within these papers. Where data collection has occurred over several years, often this is not time series data as different data have been collected in subsequent years. For example, Faasen and Watts (2007) started with a survey of key informants in 2003, held a workshop in 2004 and completed a full survey during 2004 and 2005. Only Lynch *et al.* (2004) repeat the sampling of the same population, but attrition occurs in their sample, resulting in an unbalanced panel dataset.

Using this categorisation suggests that the quality of the papers reviewed was not particularly high. The surveys used were typically small-scale and could not be considered representative of the populations being studied. The absence of formal statistical analyses meant that most survey results were presented in a descriptive manner. However, the studies by Cadiou *et al.* (2009) and Lynch *et al.* (2004) have performed statistical analyses. Most of the studies also lack a comparator (i.e. a similar area outside the MPA or a before-and-after scenario) and data were collected as a snap-shot or just over one year. This, and the qualitative nature of most of the papers, limits the ability to generalise from the findings and make it difficult to assess whether the impacts examined are truly the consequence of the MPA or not.

Table 3: The MPAs examined and socio-economic focus of each of the 14 papers identified in the category of ‘general socio-economic’.

Author(s)	MPA	Socio-economic focus	Method(s) applied
Primary studies:			
Boudouresque et al. (2005)	Port-Cros National Park (France)	Extent to which MPA constraints hinder artisanal fishing. Focus on artisanal fishing effort, catch per unit effort, catch per area. Park turnover	Monitoring of fishing activities: length of nets, number of 100m net sections per day and per ha (secondary data)
Cadiou et al. (2009)	Port-Cros National Park (France)	Investigates the success of fishing management in the park in terms of environmental conservation, economic and social impact.	Monitoring of artisanal fishery – logbooks, fishing effort charts and on-board data collection of gear type, soak time and depth, corresponding catch and discard. CPUE calculated
Faasen and Watts (2007)	Tsitsikamma National Park (South Africa)	Perception of local communities to national park (to mandate of park, no-take policy, who should be allowed to fish, rationale for fishing inside the park and to illegal fishing)	semi-structured questionnaires, informal interactions, personal observation and workshop for key informants
Gomez et al. (2006)	Cap de Creus (Spain)	Landing and income by artisanal fishers, socio-cultural characteristics of the fishermen, perceptions, conflicts with tourism and recreational activities	Semi-structured interviews, collection of economic and biological data, statistical analysis
Himes (2003)	Egadi Island Marine Reserve and Gulf of Castellammare Fishery Reserve (Italy)	Demographics, fishing activities, reserve knowledge, legal framework, and concerns/perceptions	Brief quantitative survey accompanied by semi-structured interviews and collection of secondary data
Lloret et al. (2008)	Cap de Creus (Spain)	Recreational fishers using boats (~60% of all recreational fishers), visitors and residents	Survey of fishing activities, CPUE and socioeconomic data
Lynch et al. (2004)	Jervis Bay Marine Park (New South Wales, Australia)	Conflict (actual and philosophical) between divers and anglers	Used 2 dive operator logbooks from Jan 1996 – Feb 1999 and the logbooks from 2 ‘live-aboard’ dive operators – compared with data from logbooks from Jan 1988 – Feb 1990 of the same 2 dive operators. Survey of anglers using random stratified sampling design – essentially counted the number of anglers present on chosen days and the angling techniques employed, location (on/off shore)
Roncin et al. (2008)	12 MPAs in Southern Europe	Ecosystem uses including fishing and scuba diving, identity of users, MPA related activity and attitude towards the MPA; including added value and jobs	Survey
Salmona and Verardi (2001)	Monte Portofino (Italy)	Conflict between economic interests (e.g. tourism) and ecosystem protection	Construction of use-ecosystem matrix to identify conflicts in space. Stakeholder interviews: 19 people interviewed

Taylor and Buckenham (2003)	Cape Rodney-Okakari Point (a.k.a. Leigh) Marine Reserve; Tonga Island Marine Reserve and Pohatu (a.k.a. Flea Bay) Marine Reserve (New Zealand)	Socio-economic impact, examination of attitudes and changes in attitudes to marine reserves among local and wider communities and provide insights from a social perspective into the process for establishment of further marine reserves.	Stage 1: Desk study providing basis for case studies. Stage 2: Case studies of three reserves, investigation of attitudes, communication and discussion of research findings in a range of settings. Interviews with residents, business operators and commercial fishers; key informant interviews with local DOC field officers, technical support officers and DOC staff within the main centres associated with the reserves, Maori people and people representing conservation interests
Relevant secondary studies:			
Badalamenti et al. (2000)	MPAs in Spain (11), France (5), Italy (16) and Greece (1)	Impacts on residents (young people and fishers) and tourists	Literature review
Charles and Wilson (2009)	Eastport, Newfoundland (coastal) and the Gully, Nova Scotia (offshore) (Canada)	Ten people oriented aspects of MPA creation and implementation: (i) objectives and attitudes, (ii) people-orientated "entry points", (iii) attachment to place, (iv) make participation meaningful, (v) knowledge has a "people side" (vi) effective governance is critical, (vii) get the rights right, (viii) costs, benefits, and distribution, (ix) deal with displacement, and (x) see MPAs in the bigger picture.	Descriptive (does not mention collection of primary data)
Gell and Roberts (2004)	Leigh Reserve and Long Island (New Zealand); Eastport (Canada); Georges Bank (USA); Gulf of Castellammare (Italy); Tabarca (Spain)	Catch per unit effort and fisheries impacts	Case study description using secondary data/literature review
Walls (1998)	Leigh Reserve (New Zealand)	Description of development of the reserve	Descriptive (does not mention collection of primary data)

Table 4: Critical assessment of study methods in each of the 14 papers identified in the category of ‘general socio-economics’.

Author(s)	Aims of MPA	MPA restrictions	Non-MPA comparator	Comparison with baseline	Time series and attrition	Representativeness of survey	Statistical analysis
Boudouresque et al. (2005)	Nature conservation	Artisanal fishing in 7% area, spear fishing in all MPA, angling from coast to off-shore limit of MPA (E and S) and from coast to 50m (N and W). Fishing constraints: larger mesh size, no trawling etc.	Adjoining non-protected area	No	No. One year (2000/01)	N/A	Descriptive
Cadiou et al. (2009)	Preserving natural heritage, promoting scientific research, educating the public, serving as an example and reference site	Trawling and spear fishing banned since 1963, artisanal fishing is allowed if the fisher has signed the charter and abides by its rules. Charter is updated annually. Recreational fishing increasingly restricted between 1990 and 2004. Only trolling in certain areas allowed.	No	No	6 years of artisanal fishery data	N/A	Kolmogorov-Smirnov test, Wilcoxon and Kruskal Wallis test for comparisons of CPUE, number of fishing vessels per day and differences between years
Faasen and Watts (2007)	Initially conservation, latterly a move towards community development	Marine and terrestrial park. Marine section: no-take policy for fishing	No	No	No. Data collected over 2003-2005, but not time series	100 household heads randomly selected from four communities. 5% of all households. Not clear if representative	N/A
Gomez et al. (2006)	Protect the environment and traditional activities and rebuild depleted stocks	Recreational and artisanal fishing allowed and red coral harvesting. No spear fishing in the partial reserves. Recreational fishing is regulated in terms of hook size, max daily catch and min landing size. Only fish, cephalopod sp and sea urchins can be landed. A	No	No	Price, landing and income data from 1991-2003 (not panel data)	N/A	Descriptive

		fishing license is required that limits a fisher to the use of only 2 types of gear simultaneously. All nets, traps and long lines are prohibited.					
Himes (2003)	Egadi – fisheries management; Gulf of Castellammare (GoC) – fishery reserve to rebuild depleted stocks and eliminate conflict between commercial and artisanal fishers	Egadi – 4 zones of increasing restriction, zone A= no-take; GoC – only artisanal and recreational fishing allowed	No	No	No. Data collected from Feb-Aug 2001	Includes census of MPA managers and researchers. 59% of artisanal fishers in Gulf of Castellammare and 79% of artisanal fishers in Egadi. Findings can be assumed representative of the populations sampled.	Descriptive
Lloret et al. (2008)	Protect the environment and traditional activities and rebuild depleted stocks	Recreational and artisanal fishing allowed and red coral harvesting. No spear fishing in the partial reserves. Recreational fishing is regulated in terms of hook size, max daily catch and min landing size. Only fish, cephalopod sp and sea urchins can be landed. A fishing license is required that limits a fisher to the use of only 2 types of gear simultaneously. All nets, traps and long lines are prohibited.	No	No	No. One year – 2006	409 recreational fishers interviewed on 192 boats. Entire MPA surveyed repetitively and the season surveyed included most boat fishing activity so it is assumed that the number of fishers interviewed includes most of the fishers fishing in the study year. Only 2% refused to be interviewed.	Descriptive
Lynch et al. (2004)	Conserving biodiversity, representative samples of marine ecosystems and	Jervis Bay Marine Park is a multiple use MPA with no-take sanctuary zones. The no-take zones are open to the public but extractive activities are not	No	Compares newly collected data with that of a previous	25 months and 37 months. Unbalanced panel	Not stated	ANOVA, F-tests and contingency tables, Tukey post hoc test

	habitats, rare or threatened species and other areas of high conservation value	allowed		study by Williams et al. Use same collection approach			
Roncin et al. (2008)	Largely conservation	Variable – from zoned to restricted use	Only for fishing does there appear to be an inside outside comparison	No	No. One year, 2005-06	1836 questionnaires completed for diving, 60 for dive operators, 699 for recreational fishing, 170 for professional fishing across the 12 case studies. Small sample size in some cases.	Descriptive
Salmona and Verardi (2001)	Ecosystem protection	Zoning (strict – scientific research, surveillance and rescue only; general – as for strict plus small sailing boats, fishing by local residents, bathing, diving, sport fishing from shore (non-residents) and sport fishing from boats (residents), collection of organisms for research; and partial – as for general, but relaxation of recreational fishing regulations.) and temporary restrictions in the area.	No	Yes, but not clear in which years the interviews were undertaken	No	N/A	No
Taylor and Buckenham (2003)	Marine reserve	Not stated, but could possibly be obtained from elsewhere	No	No	Leigh MPA has a tourism time-series dating back to 1974, documenting visitor and vehicle numbers	N/A	Only of the content analysis

Relevant secondary studies:

Badalamenti et al 2000	Variable, from protecting fisheries and traditional livelihoods to conservation	Variable - from zoned to restricted use	Separates MPAs near urban areas from remote areas	No	Not clear, but possibly just snap shots	N/A	N/A
Charles and Wilson (2009)	Gully - biodiversity conservation; Eastport - community based MPA for fisheries management	Not stated (could be obtained from elsewhere?)	No	No	Not clear, some initial baseline data available, but subsequent data collection not obvious	N/A	N/A
Gell and Roberts 2004	NZ - primarily for conservation; Canada - fisheries, USA - fisheries, Italy - fisheries and conflict resolution; Spain - ??	Variable - from zoned to restricted use	NZ studies yes	No	varies with study, in NZ some 9 year time series available	N/A	Chi squared tests
Walls (1998)	Assist research on marine life un-impacted by harvesting. Environmental protection	No-take	No	No	N/A - although tourism surveys appear to be available dating back to 1984	N/A	N/A

4.2 Bio-economic modelling studies

Bio-economic modelling is a major analytical tool that has been widely used in economic studies concerning the impacts of MPAs in fisheries management (e.g. Holland & Brazee 1996, Sanchirico & Wilen 1999, Sanchirico 2004, Schnier 2005). Bio-economic models of MPAs may be deterministic, where the modeller assumes they know levels of certain parameters, or stochastic, where environmental variability is incorporated into the model. The papers reviewed include five that have used deterministic models, three that have incorporated stochasticity into their models and two references that presented approaches rather than models.

Five of the ten papers reviewed had employed spatially explicit models to represent a discrete number of fish populations distributed in separate zones (referred to as patches), but that were interconnected by dynamic economic and biological systems (Greenville & MacAulay 2006, Merino *et al.* 2009). Two papers analysed the impacts of economic and biological changes using a single patch model while the remainder analysed issues relating to fishing effort reduction or single species fisheries that are harvested by multiple fleets (e.g. Sumaila & Armstrong 2006, Steinback *et al.* 2008).

In terms of the socio-economic focus of the references, five of the references focus on the benefits to fishers fishing adjacent to MPAs (e.g. Greenville & MacAulay 2006, Sumaila & Armstrong 2006), with benefits quantified as net profits or gross revenues from fishing (Table 5). Two references (Wielgus *et al.* 2008, Merino *et al.* 2009) focus on revenues from tourism and recreational activities due to MPAs, while two other references (Alder *et al.* 2002, Hu & Wroblewski 2009) carry out general evaluation of MPAs in terms of biological and economic criteria. The remaining reference (Steinback *et al.* 2008) quantifies the effects of a reduction in fishing effort on the sales, income and employment of other businesses in the wider regional economy.

A variety of bio-economic simulation models have been used in the references including some that combine ecological with economic data. Wielgus *et al.* (2008) used the quantity of fish landings, price for fish charged by fishers and amount of fuel per fishing trip to calculate the cost of fishing per kilogramme of grouper. The model incorporated the amount divers were willing to pay to observe additional groupers and simulated the impact of establishing an MPA. Steinback *et al.* (2008) present a bio-economic model that incorporates linkages between the population dynamics of lobsters and fishers. This was coupled with a regional input-output model that examines how the fleet wide economic results from the first model will impact sales, income and employment of other businesses in the regional economy. Alder *et al.* (2002) present an evaluation method for MPAs using a range of evaluation fields including living resources, non-living resources, economic, social, management and ecosystem functions. Alder *et al.* (2002) use these evaluation criteria to evaluate a number of tropical, subtropical and temperate MPAs and present scores on how well they are managed.

The key findings from these references have shown that economic benefits for fishers decrease with increasing size of a no-take area, while benefits for divers increase with increasing size of no-take area. The welfare gains of divers could compensate for losses incurred by fishers if parts of their fishing grounds are closed (Wielgus *et al.* 2008). Steinback *et al.* (2008) showed that gains in harvesting efficiency from the implementation of an effective effort control program could create higher incomes for participating vessels owners and crew, and stimulate additional economic growth in sales and income for other businesses in the regional economy. Steinback *et al.* (2008) also indicate that while fewer fishing jobs will result from gains in harvesting efficiency, these losses may be largely offset by gains in employment in other sectors of the regional economy. Analysis of effort reduction scenarios have shown that they all lead to an improvement in the state of the resource, generate higher levels of landings, and increase fishers income over time (Steinback *et al.* 2008). Key findings from Merino *et al.* (2009) show that the Mendes Island MPA is a tourism-income generator; it directly generates 0.21 million Euros to the local economy. Grafton *et al.* (2005) reported that even with the repeated occurrence of negative shocks (such as environmental

disturbances) it still paid to have a marine reserve. A reserve generates an economic payoff to fishers by increasing resource rents.

The bio-economic modelling papers were assessed for their quality based on whether the authors had performed a sensitivity analysis. Sensitivity analysis is a way to determine how the variation in the results of the model can be apportioned qualitatively or quantitatively to different sources of variation in the input of the model. Only three of the ten papers examined had performed sensitivity analyses and it was therefore concluded that the quality of the studies was low.

Table 5: Summary of the features of the bio-economic models used in the references reviewed.

Author(s)	MPA	SE focus	Deterministic / stochastic model	Single / multi-patch	Sensitivity analysis	Other features
Wielgus et al. (2008)	Loreto Bay National park, Gulf of California, Mexico	Consumption and non-consumption economic benefits provided by leopard grouper population	Deterministic	Multi-agent	No	Bio-economic model with ecological and economic data.
Hu and Wroblewski (2009)	Gilbert Bay, Labrador, Canada	To find a balance between conservation and subsistence/recreational fishing	Deterministic	Multi-agent	Yes	Simulation for population dynamics of cod to determine whether allowing recreational fishing for cod in MPA can still maintain cod population.
Greenville and MacAulay (2006)	Manning Shelf Bioregion Marine Park, Australia	Changes in net social values under three controlled management structures	Stochastic	Multi-agent	No	Model to study changes in net social values under three controlled management structures
Steinback et al. (2008)	Lobster Conservation Management Area 2 (Southern New England Inshore waters)	Effect of reduction in fishing effort	Deterministic	Effort reduction scenarios	No	Two models: 1) a bio-economic simulation model that incorporates linkages between the population dynamics of lobster resource and a harvest sector, and 2) a regional input-output model that examines how the fleet wide economic results from the first model will impact sales, income and employment of other businesses in the regional economy.
Sumaila and Armstrong (2006)	Implementing a MPA in the Northeast Atlantic cod fishery in Barents Sea.	Profit from fishing for two main vessel types: trawlers and coastal vessels	Stochastic	Single species fishery with multiple harvesters	Yes	Model combines biological and economic aspects of cooperative or non-cooperative behaviour of fishing fleets
Alder et al. 2002	Used 20 MPAs from around the world	Evaluation of MPA using a set criteria including living, non-living, economic, social,	More of an approach than a model		No	The authors are evaluating MPAs using criteria including living resources, economic, non-living resources, social, management, and ecosystem functions.

		ecosystem functions, and management				
Sanchirico et al. (2008)	Chesapeake Bay, USA	Fishing revenues, ways to reduce MPA management costs	An adapted financial portfolio theory		No	Uses an ecosystem based fisheries management approach to examine fishing revenues and ways to reduce MPA management costs
Merino et al. (2009)	Mendes islands, Spain	Revenues from fishing and tourism	Deterministic	Multi-agent	No	Effects of different MPA zones to fisheries and tourism
Sumaila (1998)	Barents sea cod fishery	Level of fish catches	Stochastic	Single	Yes	Model examining level of fish catches
Grafton et al. 2005	Used annual data using real prices from 1929-1986 from the Pacific halibut fishery	Benefits of MPAs to fishers	Stochastic		No	Model quantifying the benefits of MPAs to fishers

4.3 Critical assessment of the evidence

The evidence presented in this report suggests that there is insufficient data available to answer the question set by this review. This assessment is made through the analysis of the strength of the evidence based on the following categories:

a. Study quality

Using the criteria for assessing study quality suggested for systematic reviews, most of the papers reviewed are not of sufficiently high quality for further analysis. It is therefore difficult to distinguish what impacts are the consequence of MPAs as opposed to wider socio-economic change. To a certain extent this reflects the restrictive nature of the systematic review process, but also the differing approaches used by different scientific disciplines. A qualitative study of a small number of key informants may be of equal quality to a quantitative, representative survey across a number of stakeholder groups, but these two approaches are not considered equal by the review process. To overcome this problem, methods for systematic reviews of social science studies require further development. Studies are also needed that focus equally on all stakeholders associated with MPAs and preferably with a consistent methodological approach.

b. Consistency of effects across MPAs

The heterogeneity of the MPAs in terms of location, physical characteristics, objectives and stakeholder involvement is considerable. Comparing the impacts of MPAs across sites is therefore challenging and it has not been possible to explore, in this pilot setting, the degree to which this heterogeneity influences the impacts identified.

c. Confounding effects

Given the absence of control sites and a comparison of findings with a baseline setting, it is difficult to identify what impacts are consequences of the designation of an MPA. Furthermore, only one of the studies presented here place its findings in the context of wider social and economic change. Isolating social and economic impacts of an intervention is a key challenge in ex-post socio-economic impact analysis. Given the substantial variation in the study sites in terms of socio-economic and political context, it is therefore unclear to what extent the impacts identified are a consequence of the designation of an MPA.

5 Discussion

5.1 Evidence of the contribution of MPAs to human well-being

The primary objective of this review was to identify the contribution of MPAs to human well-being within temperate areas. Most of the papers examined do not specifically set out to identify the impacts of MPAs on human well-being. Typically they assess the impact of MPAs on one or more factors that contribute to well-being without referring to how it will actually impact on human well-being. For example, increases in income are reported, but not the impacts on well-being of that increased income. The evidence found is therefore insufficient to give a comprehensive response to the original question and does not appear suitable for further statistical analysis. The following summarises the general findings:

a. Impacts on fishers

Some authors have argued that the economic performance of fisheries depends on economic profit and not fish yield (White *et al.* 2008). Two of the papers reviewed used bio-economic models to analyse the profit from fishing for different vessel types fishing adjacent to an MPA (Sumaila & Armstrong 2006, BenDor *et al.* 2009). Both studies explore the level of profits based on

cooperation or the lack of cooperation with MPA restrictions for the different competing vessels. Using game theoretic models, they have shown that individual fishers maximise profit from a fixed amount of fishing effort but compete with one another. When the competing fishers cooperate with MPA restrictions then fish stocks and profits tend to stabilise leading to a continuous accumulation of capital for all fishers. When they do not cooperate, then it is only particular groups that gain from the MPA.

Steinback *et al.* (2008) used different effort reduction scenarios to show that an improvement in the state of the resource (e.g. through establishing an MPA) generates higher levels of landings and increase fishers' income over time. They suggest that while fewer fishing jobs will result from gains in harvesting efficiency, losses may be largely offset by gains in employment in other sectors of the regional economy. A reduction in fishing effort has the potential to improve the sustainability characteristics of the resources being protected and actually stimulate economic growth in the coastal economy.

The findings from the socio-economic studies reporting empirical data are more variable. Boudouresque *et al.* (2005) indicate the existence of benefits to fishers from MPAs, while Cadiou *et al.* (2009) state that there is no obvious impact. Gomez *et al.* (2006) suggests a decline in the number of fishers observed in Cap de Creus MPA, but suggest that it is not solely attributable to the MPA. Other factors, such as the general state of the economy and employment in the area, are equally if not more important. However, relevant data to support this statement are not provided.

b. Impacts on recreational activities and the wider community

A number of references reported an increase in income from diving activities in many MPAs (e.g. Badalamenti *et al.* 2000, Lloret *et al.* 2008, Walls 1998). These authors also suggest that increased visitor numbers have led to increased infrastructure. Walls (1998) argue that communities feel better off with the MPA, while Taylor and Buckenham (2003) and Lloret *et al.* (2008) suggest that there were positive impacts on the associated local communities due to MPAs. MPAs have a considerable impact to the local and regional economy as a result of expenditure derived from tourism, and especially from diving related activities. This in turn may generate multiplier effects such that the initial expenditure in the tourism industry creates further rounds of spending that raise incomes in other sectors. Merino *et al.* (2009) reported that the Mendes Islands MPA is a tourism-income generator that directly generates 0.21 million Euros to the local economy. Excessive diving however, has led to environmental damage in some locations (e.g. Lynch *et al.* 2004), resulting in conflict with the conservation objectives of MPAs.

d. Conflict and stakeholder engagement

The impacts of MPAs on various groups of stakeholders may differ. They may be uneven, resulting in conflicts and making local communities reluctant to support MPAs. Lynch *et al.* (2004) suggest that conflict may not only be physical, in terms of multiple users wanting the same resource or resource space, but that it may also be philosophical, with stakeholders disagreeing over the objectives and appropriate use of resources within an MPA. The role of conflict, and community engagement in overcoming (or avoiding) conflict, is a theme within these papers. Both factors can be assumed of importance to human well-being, although can be expected to have opposite effects. Charles and Wilson (2009), Himes (2003) and Faasen and Watts (2007) indicate the importance of engaging the local community and various stakeholder groups to the relative success of the MPA. Charles and Wilson (2009) also suggest that successful engagement can improve communication between stakeholder groups. Successful engagement from the start of the MPA designation process pre-empts potential conflict and appears to give the perception of positive impacts from the MPA (Charles & Wilson 2009). Where this has not occurred, there is often a negative perception of benefits from the MPA (e.g. Himes 2003). Stakeholder engagement therefore appears essential for reducing the negative effects on well-being.

e. Uncertainty

The studies reviewed show that MPAs also have value because either they can mitigate the effects of environmental surprises and help ensure the persistence of fish populations given management error (inability to control harvest) or management uncertainty (imprecise information on current population), or because they reduce the variance of fish populations and harvests. Sanchirico *et al.* (2008) used an ecosystem-based fisheries management approach to argue that managing ecosystems to improve stability or reduce variance can be ecologically and economically beneficial. Sumaila (1998) also shows that reserves mitigate biological losses that may arise due to recruitment failure. Grafton *et al.* (2005) used their model to show that MPAs act as a hedge in the presence of negative shocks such as environmental disturbances. MPAs therefore have positive economic value under uncertainty, even if harvesting is optimal in the sense that the discounted resource rents are maximised.

f. Other factors

Most MPAs relate to ecosystem-based management, which considers the linkages between human and natural systems and recognizes the need for management strategies that address these relationships while incorporating human use and values of the ecosystems. It is therefore important to see MPAs in the overall picture of marine conservation, coastal livelihoods and the broader socio-economic uses of the oceans such as fisheries. Among the papers reviewed, Roncin *et al.* (2008) used surveys to quantify the ecosystem services (fishing and diving) provided by marine ecosystems in MPAs in southern Europe. The use of MPAs for educational purposes and how education can increase understanding of MPAs are key points discussed by Charles and Wilson (2009), Badalamenti *et al.* (2000), and Taylor and Buckenham (2003). Most of these papers reinforce the importance of human dimensions in MPA planning, implementation and management. Other factors that may influence human well-being such as human health and empowerment however, were not addressed in the papers selected for review.

Finally, the different approaches used to explore the impacts of MPAs compliment each other. The bio-economic models emphasise impacts on fishers and fisheries, and when coupled to local or regional economic models (e.g. input-output models), they can be used to explore the economic impacts of MPAs on the wider economy. The findings from these studies also tend to be quantitative and amenable to formal statistical analysis. The references on empirical studies tend to explore wider impacts and can be used to explore factors that do not lend themselves to quantification (e.g. conflict and in-depth exploration of attitudes and perceptions). Each method has its benefits and can be used to explore specific questions, but used together they create a powerful understanding of the impact of MPAs on human well-being when applied specifically to this problem.

5.2 Potential for a full systematic review

The discussion above highlights a number of issues that need exploring before a full systematic review can be undertaken:

a. Volume of literature

The volume of pertinent literature found by this pilot review has been limited as a number of sources identified were inaccessible within the study timeframe. Any future systematic review should aim to assess these additional sources. The search strategy presented was effective at identifying peer-reviewed literature and reports from key organisations, but it was not so successful at locating the wider grey literature. This could be dealt with in future by making contact with key individuals, such as other academics, MPA managers and planners. It was also apparent from the

bibliographies of some of the references found, that any future search would have to include foreign language searches, especially French, Spanish and Italian.

b. Heterogeneity within the references

One factor that emerged clearly from the references reviewed is that MPAs are applied in different ways in different locations and with different objectives. This introduces a degree of heterogeneity into the references and makes it difficult to compare like with like. Most MPAs, however, share certain features in common, such as having a closed or no-take area.

c. Quantifying findings

Many of the findings from the bio-economic models could easily be quantified and therefore make them more easily comparable. Papers on empirical studies, however, presented more qualitative findings that were difficult to compare. Any future study could prioritise quantifiable results, but could also explore methods for quantifying qualitative findings, such as content analysis and coding of findings. Combining both quantitative and qualitative findings could present very strong evidence of MPA impacts.

d. Meaningfulness of temperate/tropical split

Following advice received early in this pilot review, this study has focused specifically on MPAs in temperate areas. While in biological terms, this split may be meaningful, in socio-economic terms it is less so. When considering socio-economic factors, MPAs may be more appropriately divided in terms of the economic status (i.e. developed and developing) of the country. This would mean that a number of well studied tropical MPAs that are found in developed countries (e.g. the Great Barrier Reef in Australia, Tortugas National Marine Park in Florida, USA) could be included into the analysis. Lessons can also be learnt from MPAs in developing countries and it is therefore suggested that any future full systematic review should draw from findings across the world.

e. Focus on human well-being

The particular focus on human well-being has also been a challenge to this pilot review. As stated earlier, none of the papers reviewed specifically set out to explore the impacts of MPAs on human well-being. In taking this subject forward, it may therefore be more pertinent to widen the focus to socio-economic impacts. This would also remove some of the ambiguity around the meaning of human well-being and our ability to measure it.

f. Methodological quality

Many of the papers reviewed in this pilot study did not meet the criteria for high quality papers. This is a factor that may be difficult to improve upon given the nature of the subject, the methods generally applied and the volume of literature available. For any future review, when doubt over methodological quality arises, the reviewers should endeavour to contact the authors of the paper under review and request further details of the methods employed. This should improve the assessment of quality and the identification of bias.

To conclude, there is a potential for a full systematic review if the factors mentioned above can be incorporated.

5.3 Alternatives to a full systematic review

The literature reviewed highlights a considerable gap in our knowledge about the impacts of MPAs on human well-being and presents a challenge to policy-makers who are involved in the process of MPA designation. To overcome this, an alternative to a full systematic review could be the development of a framework for assessing the impact of MPAs on human well-being.

At present it is important to introduce novelty into research design, to demonstrate how knowledge is being progressed and research techniques are being evolved. For the purposes of effective evaluation of the impacts of MPAs, and to allow findings to be compared across MPAs, an impact framework should be developed in such a way that it can be applied easily and consistently across MPAs. This would imply a common research design across all MPAs. Such a framework would need to include the collection of baseline socio-economic data, collection of data at regular intervals once the MPA has been designated, and an exploration of wider issues such as the impacts of the MPA management and structure on the functioning of the MPA. The findings from such an impact framework should facilitate an adaptive management approach and allow the MPA to evolve as its impacts are identified. The framework should also take into account the wider benefits received from MPAs by examining the impact of MPA designation on all the ecosystem goods and services provided by the area of interest.

6 Full systematic review protocol

This section explores how a full systematic view could be conducted.

6.1 Review objectives

The primary review question will be:

- What are the social and economic impacts of marine protected areas around the world?

The essential elements of the review question would be defined as:

Subject	Intervention	Comparators	Outcomes
Stakeholder groups affected by the designation of marine protected areas	Marine protected areas (including no-take zones, marine reserves, marine parks and marine sanctuaries)	Comparable marine/coastal areas with no restrictions on human activities Before and after scenarios for individual MPAs	Social and economic impacts on all stakeholder groups associated with MPAs. Impacts will include tangible factors (e.g. changes in income, education levels, participation) and intangible factors (e.g. changes in perceptions)

The secondary questions will include:

- Which MPA structures (in terms of zonation and management approach) generate the most positive and most negative social and economic impacts?
- How do the socio-economic impacts of MPAs vary in relation to the economic status of the country?

A stakeholder workshop will be organised to ensure the questions proposed are of relevance to policy-makers and those involved in the designation of MPAs. This workshop will draw on the findings from this pilot review and will involve presentations and facilitated discussion sessions.

6.2 Methods

6.2.1 Search strategy

The search strategy proposed will replicate the strategy used in the pilot review, but will also include sources that draw from MPAs all around the globe, irrespective of location. It will use the same databases, Internet search engines and specialist sources, and use the same search terms as those presented in section 3.2. Searches will be undertaken in languages including English, Spanish, Italian and French.

All hits from the databases named will be downloaded, but only the first 100 hits from the general Internet search engines and the specialist websites will be reviewed. Where access to an identified document is not immediately available, this will be sought through appropriate library channels or through direct contact with the corresponding author. Where MPAs have been identified, but no literature appears to be available for them, the MPA manager will be contacted to request any unpublished documents of relevance.

6.2.2 Study inclusion criteria

Relevant subjects: the subject of this review will be marine protected areas throughout the world.

Types of intervention: interventions will include marine protected areas, marine reserves, marine parks, marine sanctuaries and marine no-take zones where human activities are either partially or completely restricted.

Types of comparator: comparators will include comparative marine or coastal areas where human activities are unrestricted.

Types of outcome: any metric of human well-being including both tangible (e.g. income and education) and intangible (e.g. perceptions and attitudes) factors.

Types of study: scientific articles, reports, institutional and non-institutional reports (including unpublished reports where possible), book chapters, conference papers. The studies will need to focus on a specific MPA (or MPAs) and contain primary data, and both quantitative and qualitative studies will be included. Theoretical studies will not be included.

All studies collected will pass through a three stage filtering process:

Stage 1: Titles will be assessed for relevance to questions posed by the review; those considered relevant will be retained for stage 2.

Stage 2: Abstracts will be examined to ensure the source refers to a specific case study and conforms to the inclusion criteria mentioned above.

Stage 3: The full text of all studies passing through stage 2 will be examined to identify those from which data can be usefully extracted for analysis.

Each stage will initially be undertaken by one reviewer, but a second reviewer will re-examine 25 percent of the selected references to ensure that the selection criteria are being met. After each stage the degree of convergence between the two reviewers will be examined using the Kappa test. Where a Kappa score of 0.7 or greater is obtained, the next stage of filtering will be undertaken, but where a score of less than 0.7 is obtained, the inclusion criteria will be reviewed and modified and the stage will be repeated.

6.2.3 Potential reasons for heterogeneity

Heterogeneity is most likely due to a number of sources including:

- MPA design, objectives and management regimes:

- Structure of protected area (zoned or unzoned)
- Size of protected area
- Length of time since protection
- Management structure, policy and objectives
- Funding available for MPA management
- Use of different methods to monitor the impacts of the MPA(s)
- Human factors
 - Cultural value of marine ecosystems
 - Proximity of MPA to land and the built environment
 - The extent to which stakeholder groups are involved in MPA management
 - Understanding of the importance of MPAs
 - Support for the MPA by stakeholder groups
- Ecological factors
 - Ecosystem characteristics
 - Threats to MPA from human activity

6.2.4 Study quality assessment

Methodological quality of the sources identified will be assessed following Pullin and Stewart (2006). Studies from the social sciences, however, do not tend to follow strict rules of experimental design applied in the natural sciences. Assessment of quality will therefore require review specific criteria which can be explored and refined during the stakeholder workshop. Criteria for studies using structured surveys may include an assessment of the representativeness of the surveys undertaken, the use of appropriate statistics for analysis, the use of a comparator, the collection or use of time-series data and any limitations recognisable from the information presented in the paper. For purely qualitative studies, quality could be assessed by identifying the use of a comparator, whether the interviews were repeated on more than one occasion and any obvious limitations of the approach.

This assessment will be undertaken independently by two reviewers and the degree of congruence between them will be assessed using a Kappa analysis. Where a Kappa score of 0.7 or over is achieved, the quality assessment criteria will be considered adequate. If a Kappa score of less than 0.7 is obtained, the quality assessment criteria will be reassessed and this stage will be repeated.

6.2.5 Data extraction strategy

Both quantitative and qualitative data will be extracted from the sources that fulfil the inclusion and quality criteria. Data will be summarised and tabulated in a predesigned table which will be adjusted and updated accordingly as the extraction process continues. It is expected that the majority of the data extracted will be qualitative in nature, but if sufficient quantitative data can be extracted from the sources (or can be obtained from the authors or MPA managers) the potential for a formal meta-analysis will be examined and undertaken if appropriate.

Data extraction will be undertaken by one reviewer, but will be evaluated by a second reviewer to ensure that the tables are adequate and all necessary data are captured.

6.2.6 Data synthesis and presentation

Given the findings from the pilot review it is expected that data synthesis will largely be qualitative. All findings will be tabulated and summarised, and major findings will be highlighted. If sufficient quantitative data can be obtained, data synthesis will also include formal statistical analysis. Each source, including relevant bibliographic details, will be recorded in an Endnote database.

Given the policy relevance of this topic, in addition to a final report from the systematic review, a policy brief will be compiled. This will highlight the key findings and the social and economic issues of relevance to the designation of a network of MPAs in UK territorial waters.

7 Potential conflicts of interest and sources of support

None expected.

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10 Appendix

List of people consulted during the question formulation phase

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5. Nick Polunin, University of Newcastle
6. Geoff Boxshall, Natural History Museum
7. Dan Laffoley, IUCN and Natural England
8. Manuel Barange, Plymouth Marine Laboratory
9. Jon Lovett, Natural England
10. Melanie Austen, Plymouth Marine Laboratory