

This is a repository copy of *Your evidence or mine? : Systematic evaluation of reviews of marine protected area effectiveness*.

White Rose Research Online URL for this paper:  
<https://eprints.whiterose.ac.uk/109084/>

Version: Accepted Version

---

**Article:**

Woodcock, Paul, O'Leary, Bethan Christine [orcid.org/0000-0001-6595-6634](https://orcid.org/0000-0001-6595-6634), Kaiser, Michel et al. (1 more author) (2017) *Your evidence or mine? : Systematic evaluation of reviews of marine protected area effectiveness*. *Fish and fisheries*. pp. 668-681. ISSN 1467-2960

<https://doi.org/10.1111/faf.12196>

---

**Reuse**

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

**Takedown**

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing [eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk) including the URL of the record and the reason for the withdrawal request.



**Your evidence or mine? Systematic evaluation of reviews of marine protected area effectiveness**

Journal:	<i>Fish and Fisheries</i>
Manuscript ID	FaF-16-May-OA-095.R1
Wiley - Manuscript type:	Original Article
Date Submitted by the Author:	n/a
Complete List of Authors:	Woodcock, Paul; Bangor University, Centre for Evidence-Based Conservation, School of the Environment, Natural Resources and Geography O'Leary, Bethan C; Bangor University, Centre for Evidence-Based Conservation, School of the Environment, Natural Resources and Geography; Kaiser, Michel; Bangor University, School of Ocean Sciences Pullin, Andrew; Bangor University, Centre for Evidence-Based Conservation, School of the Environment, Natural Resources and Geography
Key terms:	biodiversity conservation, CEESAT, evidence review, evidence synthesis, evidence-base, review evaluation
Abstract:	Marine Protected Areas (MPAs) are a key strategy for mitigating the impacts of fisheries, but their designation can be controversial, and there is uncertainty surrounding when and where MPAs are most effective. Evidence synthesis that collates primary research on MPA effectiveness can provide a crucial bridge between research, policy, and practice. However, reviews vary in scope and rigour, meaning decision-makers face the challenge of identifying appropriate reviews. Documenting differences amongst reviews can therefore support non-specialists in locating the most relevant and rigorous reviews, and can also assist researchers in targeting evidence gaps. We addressed these priorities by systematically searching for reviews examining effectiveness of MPAs for biodiversity, critically appraising methods used, and categorising review scope. The 27 reviews assessed overlapped in scope (suggesting some redundancy) and differed substantially in reliability. Key strengths related to the effects of MPAs on fish abundance and the influence of MPA size and age on effectiveness. However, several gaps were noted, with some questions not addressed and others lacking highly reliable syntheses – importantly, the latter may create the perception that particular questions have been adequately addressed, potentially deterring new syntheses. Our findings indicate key aspects of review conduct that could be improved (e.g. documenting critical appraisal of primary research, evaluating potential publication bias), and can facilitate evidence-based policy by guiding non-specialists to the most reliable and relevant reviews. Lastly, we suggest that future reviews with broader taxonomic coverage and considering the influence of a wider

	range of MPA characteristics on effectiveness would be beneficial.

SCHOLARONE™  
Manuscripts

For Review Only

1 **Title** (option 1): Your evidence or mine? Systematic evaluation of reviews of marine protected area  
2 effectiveness

3 **Title** (option 2): Your evidence or mine? Systematic evaluation of the scope and reliability of reviews of  
4 marine protected area effectiveness

5 **Running Title**: Evaluating marine protected area reviews

6 Paul Woodcock<sup>1</sup>, Bethan C. O’Leary<sup>1</sup>, Michel J. Kaiser<sup>2</sup>, Andrew S. Pullin<sup>1\*</sup>,

7

8 <sup>1</sup> Centre for Evidence-Based Conservation, School of Environment, Natural Resources and Geography,  
9 Bangor University, Gwynedd LL57 2UW, UK

10 <sup>2</sup> School of Ocean Sciences, Bangor University, Menai Bridge, Anglesey, UK, LL59 5AB

11

12 \* Corresponding author email: [a.s.pullin@bangor.ac.uk](mailto:a.s.pullin@bangor.ac.uk), fax: 01248 354997, tel: 01248 382444

13 **Abstract**

14 Marine Protected Areas (MPAs) are a key strategy for mitigating the impacts of fisheries, but their  
15 designation can be controversial, and there is uncertainty surrounding when and where MPAs are most  
16 effective. Evidence synthesis that collates primary research on MPA effectiveness can provide a crucial  
17 bridge between research, policy, and practice. However, reviews vary in scope and rigour, meaning  
18 decision-makers face the challenge of identifying appropriate reviews. Documenting differences amongst  
19 reviews can therefore support non-specialists in locating the most relevant and rigorous reviews, and can  
20 also assist researchers in targeting evidence gaps. We addressed these priorities by systematically  
21 searching for reviews examining effectiveness of MPAs for biodiversity, critically appraising methods  
22 used, and categorising review scope. The 27 reviews assessed overlapped in scope (suggesting some  
23 redundancy) and differed substantially in reliability. Key strengths related to the effects of MPAs on fish  
24 abundance and the influence of MPA size and age on effectiveness. However, several gaps were noted,  
25 with some questions not addressed and others lacking highly reliable syntheses – importantly, the latter  
26 may create the perception that particular questions have been adequately addressed, potentially deterring  
27 new syntheses. Our findings indicate key aspects of review conduct that could be improved (e.g.  
28 documenting critical appraisal of primary research, evaluating potential publication bias), and can facilitate  
29 evidence-based policy by guiding non-specialists to the most reliable and relevant reviews. Lastly, we  
30 suggest that future reviews with broader taxonomic coverage and considering the influence of a wider  
31 range of MPA characteristics on effectiveness would be beneficial.

32 **Keywords:** biodiversity conservation, CEESAT, evidence review, evidence synthesis, evidence-base,  
33 review evaluation.

34	<b>Table of contents:</b>
35	Introduction
36	Materials and Methods
37	<i>Review searching and screening</i>
38	<i>Assessing review scope</i>
39	<i>Critical appraisal of review reliability</i>
40	<i>Representing the review landscape</i>
41	Results
42	<i>Searching and screening</i>
43	<i>Review scores</i>
44	<i>Repeatability of scoring</i>
45	<i>Scope of meta-analytical reviews</i>
46	<i>Scope of narrative syntheses</i>
47	Discussion
48	<i>General strengths and weaknesses in the conduct of reviews: implications for policy and research</i>
49	<i>Redundancy in the review literature</i>
50	<i>Gaps in the review literature</i>
51	Conclusions
52	Acknowledgements
53	References
54	Supporting Information

## 55 **Introduction**

56 Fisheries exert one the most widespread anthropogenic impacts on marine ecosystems, and can threaten the  
57 populations and processes that underpin vital ecosystem services (Butchart et al., 2010, Ramirez-Llodra et  
58 al., 2011, Halpern et al., 2012). Establishing marine protected areas (MPAs), in which fishing is restricted  
59 to varying degrees, is one of the principal tools for mitigating these impacts (Gaines et al., 2010, Halpern  
60 et al., 2010, OSPAR, 2010, Lascelles et al., 2012). Accordingly, the extent of the marine environment with  
61 some level of protection from fisheries (and other human activities) has increased steadily from around  
62 0.9% in 2000 to an estimated 3.5% in 2015 (Thomas et al. 2014; Lubchenco & Grorud-Colvert 2015), and  
63 is set to rise further in line with the Convention on Biological Diversity target of 10% coverage by 2020  
64 (CBD, 2010).

65 There are a range of options for expanding the MPA network in terms of design, placement, and  
66 management. Different taxa may also benefit from protection to varying degrees, and across different  
67 timescales (Fox et al., 2012, Hays and Scott, 2013). Given the importance that strategies to mitigate  
68 fisheries impacts place on MPAs, the increasing promotion of MPAs as a fisheries management tool, and  
69 the potential socio-economic and political challenges associated with establishing new reserves, it is  
70 essential that scientific evidence is used to identify and communicate the factors that influence  
71 effectiveness – thereby allowing new MPAs to be optimally designed and the predicted benefits to be  
72 understood. While primary research forms the basis of this evidence, increasing publication rates  
73 (Pautasso, 2012, Larsen and von Ins, 2010, Li and Zhao, 2015) and the variable quality of primary studies  
74 (Willis et al., 2003, Caveen et al., 2012) creates problems for decision-makers in: (1) keeping up-to-date  
75 with emerging research; (2) evaluating the appropriateness of methods, data analysis and interpretation in  
76 each study; and (3) obtaining an accurate representation of the overall evidence base on MPA  
77 effectiveness.

78 Evidence syntheses can assist decision-makers by summarising primary literature on MPAs, with reviews  
79 providing a crucial bridge linking primary research with policy and practice. The number of reviews  
80 examining MPAs is increasing rapidly (Caveen et al., 2012). However, reviews that do not follow rigorous  
81 methods to maximise objectivity and comprehensiveness in searching for, appraising, and synthesising  
82 primary research may unintentionally misinform or misrepresent the evidence base. For example,

83 Huntington (2011) argued that the majority of meta-analyses that examined the effectiveness of MPAs did  
84 not address possible publication bias (the tendency to publish positive or hypothesis-affirming results  
85 rather than null or controversial findings; Møller and Jennions, 2001) and so may have provided an  
86 incomplete picture of the available primary research. Decision-makers and other non-specialists may lack  
87 the resources or expertise to systematically collate and appraise all reviews prior to use, and are therefore  
88 faced with a similar challenge as for primary literature: identifying the most relevant and rigorous reviews  
89 and appreciating the strengths and limitations of the reviews used. Furthermore, where reviews overlap in  
90 scope, apparently conflicting interpretations of evidence can reflect variation in review reliability or subtle  
91 differences in emphasis amongst reviews. This leads to a perception amongst policymakers that the science  
92 is inconclusive, resulting in no decisions being made, unnecessary delays, or selective use of evidence. The  
93 existence of a review on a particular topic could also give the impression that the topic has already been  
94 investigated and so does not require further exploration, even if the review is potentially less reliable.  
95 Future high quality syntheses might thus be deterred, resulting in what could be termed ‘cryptic’ evidence  
96 gaps.

97 To address the above issues, we evaluated the scope and the methods used by reviews that examine the  
98 effectiveness of MPAs as a tool for mitigating the impacts of fisheries on biodiversity. We carried out a  
99 systematic search for relevant reviews and categorised the scope of each review according to: (i) the  
100 geographic region(s) explored (global, temperate, tropical, polar), (ii) the taxa considered (fish,  
101 invertebrates, algae, birds, mammals, reptiles), (iii) the characteristics of MPAs investigated (size, age,  
102 level of protection, size of buffer zone, connectivity), and (iv) the measures used to evaluate MPA  
103 effectiveness (abundance, biomass, species richness, size distribution of individuals within or amongst  
104 species). We then assessed the reliability (objectivity, transparency and comprehensiveness) of each  
105 review using a standardised, published protocol (Woodcock et al., 2014), and identified general strengths  
106 and weaknesses in the review literature. Finally, we combined the categorisation of review scope with the  
107 assessment of review rigour to describe the review landscape on MPA effectiveness.

108 The principal objectives of our study are therefore to:

- 109 1) Assist decision-makers in quickly identifying the most relevant and rigorous reviews on topics of  
110 interest, and any limitations in the evidence used.



- 111 2) Assist decision-makers and researchers in targeting gaps in the review literature and avoiding  
112 duplication of previous reviews.
- 113 3) Identify strengths and weaknesses in the methods used by reviews, to assist researchers in  
114 maintaining and improving the rigour of future evidence syntheses.

115 We focused on reviews that synthesised empirical research on MPA effectiveness. Empirical data  
116 represent a large and growing volume of evidence, and reviews of this research have clear potential to  
117 support decision-making if results are provided on the outcomes of implementing MPAs, or on the  
118 characteristics that influence MPA effectiveness (e.g. Lester et al. 2009; Sciberras et al. 2013). We stress  
119 however, that the findings from such reviews should be considered in conjunction with insights from the  
120 extensive body of theoretical work on MPA effectiveness (e.g. Gaines et al. 2003; White et al. 2011), as  
121 well as site-specific considerations relating to stakeholder priorities and the objectives of individual MPAs.

## 122 **Materials and methods**

### 123 *Review searching and screening*

124 We compiled a database of review articles that examined MPA effectiveness through searches of peer-  
125 reviewed and grey literature using multiple databases (Web of Science, Scopus, Aquatic Sciences and  
126 Fisheries Abstracts, ScienceDirect, Centre for Agriculture and Bioscience International, Directory of Open  
127 Access Journals, and Index to Theses online), www.google scholar.com, and websites of a range of  
128 organisations (Table A1). We used search terms adapted from a recent systematic review that evaluated the  
129 effectiveness of fully and partially protected MPAs (Sciberras et al., 2013, Sciberras et al., 2015). Search  
130 strings were modified according to the database used, but included the terms ‘marine protected area’,  
131 ‘marine reserve’, ‘marine sanctuary’, ‘no-take area’, ‘partially protected area’, ‘fishery reserve’, ‘marine  
132 area closure’, ‘gear restriction zone’ and ‘buffer zone’ to identify research related to MPAs. To narrow the  
133 focus to review articles we combined these terms with ‘review’, ‘meta-analysis’ and ‘synthesis’. For  
134 example, the search string used for locating studies in Web of Science, AFSA, CABI, ScienceDirect and  
135 Scopus was:

136 (“marine reserve\*” OR “marine sanctuary” OR (marine AND “no-take zone”) OR (marine AND harvest  
137 refug\*) OR (marine AND “buffer zone”) OR (marine AND partial\* AND protect\*) OR (marine AND

138 "closed area") OR (marine AND "area closure") OR (fisher\* AND (reserve OR closure)) OR ("fishing  
139 gear restriction\*") OR ("recreational fishing" AND protection) OR "marine protected area\*")

140 AND

141 (review OR "meta-analy\*" OR synthes\*)

142 We only considered reviews published in the year 2000 or later to restrict our assessment to recent  
143 literature. Searches took place from 14-21 May 2014 and so our study encompasses the period from 2000  
144 up to this point. Full details of the search strategy including search strings with Boolean operators and  
145 search dates are given in Table A1.

146 All studies found by the search were assessed for relevance and retained if the following inclusion criteria  
147 were met: Type of Article: Relevant reviews should be focused on synthesising primary research that  
148 collects field data to compare MPAs (fully or partially protected) with unprotected areas. This excludes  
149 articles clearly marked as opinions, perspectives, technical reports/management documents that are not  
150 explicitly presented as syntheses, modelling studies in which parameters are estimated through literature  
151 review, and studies that analyse long-term survey data (including articles that apply meta-analytical  
152 techniques – e.g. Ojeda-Martinez et al., 2007). Reviews primarily focused on synthesising the results from  
153 models, or on methodological aspects of MPA monitoring and evaluation were also excluded, as were  
154 reviews that focused on the ecological principles of MPA design (rather than synthesising empirical  
155 research on MPA effectiveness). Whilst each of these pieces of evidence are potentially valuable, it would  
156 not be appropriate to evaluate such studies using a tool designed for assessing reviews of primary research.  
157 For example, analyses of long-term survey data would not necessarily be expected to follow all of the  
158 methods required to produce a rigorous review of primary research (e.g. comprehensive and transparent  
159 search for relevant literature, assessment of publication bias etc.). Population: Reviews can consider any  
160 taxa, in any region. Intervention: Reviews must primarily examine the effects of fully and/or partially  
161 protected MPAs. Outcome: Reviews must clearly examine the effectiveness of MPAs with respect to at  
162 least one of: abundance, species richness, biomass, organism size. Because our emphasis was primarily on  
163 the direct implications of MPAs for biodiversity conservation and mitigating the impacts of fisheries,  
164 reviews that focused principally on ecosystem properties (e.g. nutrient cycling) or ecological processes

165 (e.g. competition, trophic interactions) were not considered. Questions relating only to socio-economic  
166 effects also fall outside the scope of our study.

167 We screened all articles returned by the search for relevance, first based on the title with retained articles  
168 then assessed based on the abstract. Decisions on article inclusion can be subjective and so 10% of articles  
169 screened at the abstract stage were also independently evaluated for relevance by a second person.  
170 Following conventional practice for systematic reviews (CEE 2013), kappa values were used to evaluate  
171 agreement on article relevance (Cohen 1960, Landis & Koch 1977). Kappa values account for the  
172 agreement expected by chance, and are calculated as:

$$173 \kappa = (\text{observed agreement} - \text{expected agreement}) / (1 - \text{expected agreement})$$

174 'Observed agreement' is the proportion of decisions in which there is agreement (i.e. both assessors regard  
175 an article as relevant, or both assessors regard an article as non-relevant). 'Expected agreement' is  
176 calculated as: [(proportion of articles accepted as relevant by A1 \* proportion of articles accepted by A2) +  
177 (proportion of articles rejected by A1 \* proportion of articles rejected by A2)], where A1 and A2 are the  
178 two assessors. Kappa scores of 0.6-0.8 tend to be regarded as indicating good agreement: we obtained a  
179 kappa score of 0.75, indicating that decisions over article relevance were sufficiently repeatable (CEE,  
180 2013). Where there was disagreement on relevance during Abstract screening, articles were retained. All  
181 articles retained after the abstract screening stage were then read in full and assessed for relevance. Articles  
182 in which the relevance was uncertain at a particular stage were retained for the subsequent stage. Lastly,  
183 bibliographies of all reviews retained after full-text screening were searched for additional references – this  
184 approach increases the comprehensiveness of our search by capturing relevant reviews that may have  
185 omitted our search terms from the Abstract. Any potentially relevant studies located in this way were  
186 screened using the same title>abstract>full-text process.

### 187 *Assessing review scope*

188 We compiled 153 questions related to the effectiveness of MPA for biodiversity conservation and  
189 mitigating the impacts of fisheries. The parameters of these questions are provided in Table 1 and consider  
190 region (e.g. global, tropical etc.), taxa (fish, invertebrates etc.), MPA characteristics (e.g. size, age etc.) and  
191 outcome measures (e.g. effects on abundance, biomass etc.). Questions therefore take the broad form:

192 ‘What are the effects of MPAs on [*fish*]?’ ‘How does MPA [*size*] influence effectiveness?’ etc. At this  
193 level, there are 19 distinct questions, representing each element in Table 1. We then considered each  
194 possible two-way combination of Taxa, Region, MPA Characteristic, and Outcome Measure to assess  
195 specific questions, e.g. ‘What are the effects of MPA [*size*] on [*fish*]?’ ‘What are the effects of [*tropical*]  
196 MPAs on [*species richness*]?’ At this level, there are 134 distinct questions. Note that constructing  
197 questions by systematically combining terms in this way results in some questions that are likely to be  
198 more relevant than others. However, our intention is for the evaluation of review scope and rigour to be  
199 valuable to policymakers and researchers with a diverse range of priorities. In the case of the MPA  
200 literature, much of the research focus has been on harvested species, whereas policy questions are  
201 increasingly broad, addressing a wide range of taxa (e.g. EU Birds Directive, EU Habitats Directive). For  
202 this type of exercise, we therefore view a systematic approach as preferable to identifying questions in a  
203 more *ad hoc* manner based on perceived importance.

204 Reviews were categorised according to the question(s) addressed and the type of synthesis undertaken  
205 (narrative synthesis [reviews that use prose to summarise and draw conclusions from primary research] or  
206 meta-analysis). For the purposes of this study, we did not focus on any specific element of MPA  
207 connectivity – reviews examining how any aspect of MPA connectivity influences effectiveness were  
208 therefore considered to address this question. Defining the questions addressed by narrative syntheses  
209 proved challenging because such syntheses are often broad-ranging with no clear boundaries to objectively  
210 decide whether or not a particular question has been addressed in sufficient detail. As such, narrative  
211 syntheses were categorised according to the broad focus (biodiversity conservation or fisheries) and the  
212 region, type of protection (highly protection MPA [no-take] or all forms of protection [MPA]) and MPA  
213 characteristic(s) explored. Each meta-analysis was categorised according to all 153 questions outlined in  
214 the preceding paragraph. We categorised a meta-analytical review as addressing a particular question if  
215 effect sizes were quoted directly (e.g. response ratio comparing fish density inside vs outside MPA),  
216 presented graphically or used in statistical tests of relationships (e.g. relationship between effect size and  
217 MPA size).

218 In calculating effect sizes for one property (e.g. the influence of MPA size), meta-analyses could include  
219 other properties as potential confounding variables (e.g. MPA age), without directly calculating effect sizes

220 for these confounding variables. From a policy perspective, it would therefore not be possible to use such  
221 an analysis to fully understand the relationship between MPA age and effectiveness. Reviews that included  
222 relevant terms (from Table 1) as potentially confounding variables without directly reporting effect sizes  
223 for these terms were therefore noted (Supplementary Information) but not considered to directly address  
224 questions relating to the confounding variables. Finally, there may be instances in which meta-analyses are  
225 based on a small number of primary studies and so the generality of findings would be less certain. To be  
226 included as addressing a particular question, we set an arbitrary minimum threshold that meta-analyses  
227 should contain at least 10 primary research studies addressing that question. Where meta-analyses  
228 addressed a particular question but contained less than 10 studies, we noted this intended focus, as well as  
229 instances in which reviews indicated an intention to investigate a question but expressly stated that  
230 insufficient studies were available. If recent, such reviews might suggest the need for further primary  
231 research rather than additional reviews.

### 232 *Critical appraisal of review reliability*

233 We used a standardised protocol designed to assess the reliability of environmental evidence reviews (the  
234 Collaboration for Environmental Evidence Synthesis Assessment Tool [CEESAT], Woodcock et al., 2014)  
235 to critically appraise the methods of each relevant review. CEESAT assesses reviews based on 13 criteria  
236 (Table 2) for which a review can receive 3 points, 1 point or 0 points (maximum 39). The higher the score,  
237 the greater the confidence that the review is robust. Whilst CEESAT does have important limitations (e.g.  
238 does not account for methodological or interpretation errors or fraud, or include a detailed evaluation of the  
239 appropriateness of any statistical techniques used) it considers each key step of the review process and so  
240 provides a good overall picture of the likelihood that the review uses transparent methods to produce an  
241 objective, rigorous, and comprehensive synthesis of all available primary research.

242 All reviews were independently appraised by two assessors using CEESAT. Disagreements in scoring  
243 were then discussed and scores were amended if relevant information was overlooked by an assessor.  
244 When disagreements reflected uncertainty between assessors over whether or not a criterion was met, the  
245 midpoint score of the two assessors was used. We evaluated agreement in scoring by using a Spearman's  
246 rank test to compare the overall scores for each review between assessors, and by examining repeatability  
247 in scoring for individual criteria using (i) % agreement and (ii) kappa test as described above, but extended

248 to the three scoring categories of 0, 1, or 3. However, larger disagreements in the scores awarded for a  
249 criteria are more important than smaller disagreements (e.g. if one scorer awards a 0 for a given criterion, it  
250 would be more concerning if the second scorer awarded a 3 than a 1). As such, we also assessed agreement  
251 in scoring for each criterion using weighted kappa (Cohen 1968; Landis & Koch 1977; Viera & Garrett  
252 2005; Shea et al. 2007). Matrices of the observed scores awarded by the two assessors were produced for  
253 each individual criterion, giving 13 separate matrices, each containing nine cells indicating the number of  
254 reviews awarded 0, 1, or 3 points by each assessor. Similar matrices of expected scores for each criterion  
255 were calculated as for a chi-squared test. A matrix containing nine cells representing the magnitude of  
256 disagreement between assessors was then constructed, e.g. a 1-0 disagreement is ranked as magnitude 1,  
257 whereas a 3-0 disagreement is ranked as magnitude 3 (Viera and Garrett, 2005, Shea et al., 2007). For an  
258 individual criterion, each cell in the observed matrix is then multiplied by the corresponding weight (e.g.  
259 cells where there is a 3-1 disagreement or a 1-3 disagreement are multiplied by 2). The observed weighted  
260 disagreement for that criterion is the sum of these values, with the expected weighted disagreement  
261 calculated in the same manner. The weighted kappa score for a criterion (which reflects *agreement*, and is  
262 interpreted in the same way as the unweighted kappa) is then:

$$263 \kappa = 1 - (\text{observed weighted disagreement} / \text{expected weighted disagreement})$$

264 Lastly, we divided the total CEESAT scores into three categories: 0-13, 13.5-26 and 26.5+ (reflecting an  
265 average score across the 13 criteria of 0-1, 1-2 and 2-3) to represent low, intermediate/moderate and high  
266 reliability (although see Woodcock et al., 2014 for further discussion regarding the interpretation of  
267 scores). Each review was assigned to one of these reliability categories based on the overall CEESAT  
268 score.

### 269 *Evaluating the review landscape*

270 Using our critical appraisal and assessment of review scope we then visually represented reviews  
271 examining the effectiveness of MPAs for biodiversity conservation and mitigating the impacts of fisheries  
272 in two matrices, one covering meta-analytical reviews and one summarising narrative syntheses. These  
273 matrices were designed to guide decision-makers to the most relevant and reliable reviews, and to enable  
274 easy visualisation of gaps and redundancy (multiple reviews on closely related topics) to target future

275 reviews. Detailed information indicating which reviews address each specific question is given in a series  
276 of supporting tables. Strengths of MPA reviews and aspects of review methods that could be improved  
277 were explored and evidence gaps and redundancy were identified.

## 278 **Results**

### 279 *Searching and screening*

280 Searches (Table A1) returned 2,485 results; these were refined to 287 after screening at title stage, 98 after  
281 abstract screening, and finally reduced to 24 relevant reviews following full-text examination. The  
282 bibliographies of relevant reviews were then hand-searched for additional references, giving a final total of  
283 27 included reviews. To maintain transparency, a complete list of all included and excluded articles (at full  
284 text) together with reasons for exclusion is provided in Table A2-A3.

### 285 *Review scores*

286 Review scores ranged from 0-34 (mean =  $12.3 \pm 1.8$  standard error [SE]), median = 13.5, Fig. 1a): note  
287 that because scores are the average across the two assessors, non-integer values are possible. Although no  
288 review achieved the maximum score of 39, the maximum possible points (3) were awarded for each  
289 criterion at least once. The majority of reviews (93%) achieved low ( $\leq 13$ , N=13) or intermediate (13-26,  
290 N=12) scores. Criteria 3.1, 5.1 and 6.1 represented particular strengths (see Table 2 for explanation of  
291 criteria), whilst criteria 1, 3.2, 3.3 and 6.3 were consistent weaknesses in review conduct (Fig. 1b). Of the  
292 27 reviews assessed, 18 contained meta-analysis and nine conducted a narrative synthesis. As would be  
293 expected, the mean score for meta-analyses was higher than for all reviews combined (mean =  $17.3 \pm 1.6$   
294 SE, median = 16), although a substantial range of scores was still evident (9.5-34).

### 295 *Repeatability of scoring*

296 The total scores awarded to each review were highly correlated between assessors (Spearman's  $\rho=0.96$ ,  
297  $p<0.001$ ) and the mean absolute difference in scores was small ( $1.7 \pm 0.3$ ). Scoring for individual criteria  
298 was also generally consistent: for 11 of 13 criteria, agreement was greater than 70% and weighted kappa  
299 scores were around 0.7 or higher (Table 3; substantial agreement, Landis and Koch, 1977). The latter  
300 indicates that most disagreements were relatively minor (e.g. 0 vs 1, rather than 0 vs 3).

301 *Scope of meta-analytical reviews*

302 Most of the broad question elements in Table 1 were examined to some degree by meta-analyses but a  
303 clear focus was apparent with respect to the taxa (fish), MPA characteristics (size and age), and outcome  
304 measures (abundance) considered (Fig. 2, Table A4). For example, the vast majority of meta-analyses  
305 examined if/how MPA size influences the effectiveness of the protected area, with fewer investigations  
306 into the importance of other characteristics such as the level of protection (N=3), buffer zone size (N=2) or  
307 connectivity (N=1). No meta-analyses were detected that examined the effectiveness of MPAs in polar  
308 regions, or the effects of MPAs on birds, mammals or reptiles. At least one high-scoring review ( $\geq 26$   
309 points) was available for 11 of the broad questions, although these questions were also the subject of low-  
310 moderate scoring reviews. Two broad questions ('effects of MPAs on algae' and 'influence of connectivity  
311 on MPA effectiveness') were each only addressed by one moderate scoring review, representing cryptic  
312 evidence gaps that might not be readily apparent.

313 Gaps across review questions became more pronounced when specific questions were considered (Fig. 2,  
314 Tables A5-A10). Several more specific questions were the subject of multiple reviews with at least one  
315 high scoring review (e.g. 'fish' and 'abundance') demonstrating that there is some duplication in the  
316 review literature. However there are also examples of cryptic evidence gaps in which reviews were present  
317 but none were high-scoring (e.g. 'tropics' and 'species richness'). Furthermore, in addition to an absence  
318 of reviews considering polar regions, birds, mammals and reptiles, no reviews were identified for a further  
319 15 specific questions, and an additional seven questions were either not addressed due to the low number  
320 of primary studies available, or were only addressed through a synthesis of  $< 10$  studies.

321 *Scope of narrative syntheses*

322 Narrative syntheses were generally of broader scope than meta-analyses (Fig. 3, Tables A11-A17). The  
323 majority (7 out of 9 narrative reviews) discussed the effects of MPAs globally rather than focusing on  
324 specific regions. The focus was split evenly between MPA effects on biodiversity and fisheries and most  
325 reviews considered MPAs as a whole rather than just highly protected (no-take) MPAs. No moderate- or  
326 high-scoring narrative reviews were identified (range in narrative review scores 0-12). Gaps and/or  
327 redundancy were noted in the majority of questions.



328 **Discussion**

329 The increasing importance of MPAs in global conservation strategies has stimulated extensive primary  
330 research examining the effectiveness of MPAs for mitigating the impacts of fisheries (Lester et al., 2009,  
331 Caveen et al., 2012). Reliably incorporating this research into policy requires syntheses that use  
332 systematic, with objective methodologies to address key questions. However, our findings highlight  
333 substantial variation in scope and rigour amongst reviews that examine the effectiveness of MPAs for  
334 biodiversity conservation (Figure 1). This variation illustrates the need to ensure non-specialists can locate  
335 the most rigorous reviews on questions of interest, and parallels that found in other fields of ecology and  
336 environmental management (Philibert et al. 2012; Koricheva et al. 2014; O'Leary et al. 2016).  
337 Furthermore, we found that reviews strongly favoured particular questions – e.g. exploring if the size and  
338 age of an MPA influenced the effects on fish. Whilst these questions are vital for both biodiversity  
339 conservation and fisheries management, there is a danger that findings from such syntheses could be  
340 extrapolated to other taxonomic groups (e.g. birds, mammals) and that rigorous syntheses exploring the  
341 importance of other MPA design characteristics (e.g. connectivity) will not be undertaken. The summary  
342 of review scope and rigour provided here can assist future reviews in ensuring that the intended questions  
343 complement rather than duplicate the existing review literature. Note that our study encompasses the time  
344 period from 2000-2014. As with reviews of primary literature, the value of this information as a means to  
345 explore review rigour and scope will thus be maximised if updates are conducted after a suitable time  
346 period: by providing detailed methods and transparent descriptions we hope to facilitate such updates.

347 *General strengths and weaknesses in the conduct of reviews: implications for policy and research*

348 We found reviews to be of variable reliability with often overlapping scope (Figs. 2 and 3, Tables A4-  
349 A17). Reviews regularly applied several approaches (e.g. meta-analytical techniques and transparent  
350 reporting of inclusion criteria) that are important for rigorous synthesis (Fig. 1a and b). However, certain  
351 aspects of MPA review conduct could be improved, such as ensuring that decisions over which articles are  
352 relevant to include in the review are repeatable and transparent (by conducting kappa tests and listing all  
353 articles read at full-text but excluded from the synthesis) and that critical appraisal of the methods of  
354 included studies is undertaken and clearly reported (Fig. 1b). Narrative reviews were all assessed as being  
355 of low reliability (N=9), partly reflecting the lack of quantitative synthesis. Nonetheless, there is no

356 inherent reason that narrative reviews cannot, for example, provide clear information on search strategies  
357 and scope, and document the extracted data. Given that narrative reviews can still contain valuable insights  
358 (and do influence policy) we argue that such reviews could benefit considerably from adopting such  
359 practices – indeed, one narrative review (Peppin et al. 2011) assessed during the initial evaluation of  
360 CEESAT achieved a score of 20 (Woodcock et al. 2014), which is similar to many of the meta-analyses  
361 considered here.

362 Scoring cannot distinguish between reviews undertaken using less rigorous methods and those that do not  
363 document rigorous methods where used. Just as with primary research, transparent reporting of review  
364 methods is vital, because it allows the review to be verified and updated. We therefore highlight the  
365 importance of effective reporting, and suggest that this represents a relatively straightforward means by  
366 which many reviews (narrative and meta-analyses) could be improved. More generally, we stress that in  
367 our view, limitations in reviews in environmental science reflect a lack of awareness of relevant systematic  
368 review methods, rather than a deliberate intention to mislead.

369 From a policy perspective, the large number of reviews with low-intermediate scores represents a potential  
370 problem. In low-intermediate scoring reviews, steps that are important for producing a comprehensive,  
371 objective, and transparent evidence synthesis are either absent or incomplete. Such limitations reduce the  
372 likelihood that the review provides an accurate picture of all available primary research. Although the  
373 effects of omitting certain steps on review reliability and findings are context-specific, in the absence of  
374 clear mechanisms to communicate the rigour of review methods to non-specialists, there is a risk that  
375 decision-makers will not take into account potential limitations in the conduct of the review(s) consulted.

#### 376 *Redundancy in the review literature*

377 We identified substantial redundancy in the review literature (multiple reviews asking the same question)  
378 which could create difficulties for decision-makers looking to base decisions on the most robust synthesis  
379 available. In some instances, redundancy is a consequence of reviews providing effect sizes for broader  
380 questions and then exploring a range of more specific questions, or updating a particular question.  
381 Although such analyses are valuable for completeness and comparisons, decision-makers often lack the  
382 resources to locate and evaluate all relevant reviews. These situations therefore risk leading to policy and

383 practice that is not based on the most rigorous available evidence. As such, we hope that the results from  
384 studies such as ours can assist decision-makers in rapidly locating the reviews most likely to accurately  
385 synthesise all relevant evidence on the specific questions of interest. These outputs may also inform future  
386 research direction. For example, questions relating to fish abundance and MPA size have been the subject  
387 of reliable meta-analyses and so in the absence of substantial new research, attention might be better  
388 focused on synthesising evidence on other questions. Such investigations might include consideration of a  
389 broader range of taxa and MPA characteristics, as well as more specific factors that influence the effects of  
390 MPAs on fish abundance in order to inform on the degree to which findings are generalisable.

#### 391 *Gaps in the review literature*

392 Gaps in the review literature are to be expected to an extent as a result of differences in public interest,  
393 policy relevance, availability of primary research (potentially influenced by e.g. logistical constraints in  
394 sampling fauna or flora), and question validity. However, some evidence gaps are in areas of high policy  
395 relevance. For example, the protection of seabirds and marine mammals is an important driver of MPA  
396 designation under European Directives, and MPAs are globally important tools in the conservation of a  
397 range of taxa (Hooker & Gerber 2004; Christianen et al. 2014). Furthermore, designation (or non-  
398 designation) can be controversial, and greater confidence in decisions would likely arise if robust evidence  
399 syntheses on the effectiveness of MPAs for multiple taxa were available. Our study also suggests some  
400 differences in the availability of reviews on tropical versus temperate MPAs. Relatively few meta-analyses  
401 quantify the effectiveness of MPAs in the former, particularly for less well-studied taxa and certain aspects  
402 of MPA design (note that global-scale reviews incorporating primary research from the tropics do not  
403 necessarily specifically evaluate the effectiveness of tropical MPAs). Decision-makers in the tropics would  
404 therefore be reliant on moderately reliable syntheses from this region and/or global syntheses that combine  
405 data from temperate and tropical MPAs. This contrasts with temperate regions, for which the effects of  
406 MPA size and age are specifically quantified by several reviews (Figure 2-3 and Supporting Information).  
407 There are also some instances in which reviews have been conducted but a highly rigorous synthesis is  
408 lacking (Figure 2-3). These could represent cryptic evidence gaps, in which the presence of existing  
409 reviews may create the perception that the question has been considered, and potentially deter new  
410 synthesis or primary research for several years.

411 Identification of gaps in the review literature highlights the need for new, more reliable syntheses (or  
412 primary research) to be conducted, providing a more solid basis for policy. Importantly, gaps become more  
413 frequent as questions become more specific, indicating that users should consider how applicable more  
414 general reviews are to particular contexts. It is important to stress that our primary emphasis was on  
415 properties relevant to the effectiveness of MPAs as a conservation tool for mitigating the impacts of  
416 fisheries on biodiversity. Valuable extensions of our study could therefore more specifically consider the  
417 review literature examining the extent to which MPAs provide fisheries benefits, as well as possible gaps  
418 in terms of the effects of MPAs on ecosystem functioning (e.g. productivity, nutrient cycling, food web  
419 structure), more sophisticated outcome metrics relating to conservation effectiveness (e.g. IUCN threat  
420 status), and the socioeconomic consequences of MPAs.

#### 421 **Conclusions**

422 MPAs are a key component of global conservation strategies, but there is considerable uncertainty  
423 surrounding when and where reserves are most effective. Evidence reviews examining the effectiveness of  
424 MPAs are therefore likely to directly influence decision-making and future research. However, the  
425 overlapping scope and variation in reliability we identified amongst reviews presents a potentially  
426 important problem from the perspective of decision-makers seeking to make evidence-informed decisions.  
427 Our evaluation of reviews is intended to support decision-making by guiding non-specialists to the most  
428 reliable and relevant reviews. Findings from such reviews should be considered alongside other key pieces  
429 of evidence, in particular the extensive body of theoretical work on MPA effectiveness (e.g. Gaines et al.  
430 2003; White et al. 2011) and more context-specific information relating to individual MPAs. Our findings  
431 can also assist researchers in identifying and targeting key knowledge gaps for review or new data  
432 collection including (but not limited to) ensuring broader taxonomic coverage, consideration of a wider  
433 range of MPA characteristics and examination of more specific questions for which we have identified  
434 evidence gaps.

#### 435 **Acknowledgements**

436 We thank our potential end-users Ally Dingwall (Sainsbury's), Tom Pickerell (Seafish, Seafood Watch),  
437 Jon Harman (Seafish), Mike Mitchell, David Parker (Young's Seafood), David Jarrad (Shellfish

438 Association of Great Britain) for their contribution to discussions regarding review reliability. This project  
439 was supported by a UK Natural Environmental Research Council Knowledge Exchange Grant  
440 NE/J006386/1.

#### 441 **References**

442 Butchart, S.H.M., Walpole, M., Collen, B., *et al.* (2010) Global Biodiversity: Indicators of Recent  
443 Declines. *Science* **328**, 1164-1168.

444 Caveen, A.J., Sweeting, C.J., Willis, T.J., Polunin, N.V.C. (2012) Are the scientific foundations of  
445 temperate marine reserves too warm and hard? *Environmental Conservation* **39**, 199-203.

446 CBD (2010) COP Decision X/2. Strategic plan for biodiversity 2011–2020. Available at:  
447 <http://www.cbd.int/decision/cop/?id=12268>. Accessed 6 April 2015.

448 CEE (2013) Guidelines for systematic review and evidence synthesis in environmental management.

449 Christianen, M.J.A., Merman, P.M.J., Bouma, T.J., *et al.* (2014) Habitat collapse due to overgrazing  
450 threatens turtle conservation in marine protected areas. *Proceedings of the Royal Society B* **281**  
451 20132890, doi:10.1098/rspb.2013.2890.

452 Cohen, J. (1960) A coefficient of agreement for nominal scales. *Educational and Psychological*  
453 *Measurement* **20**, 37-46

454 Cohen, J. (1968) Nominal scale agreement provision for scaled disagreement or partial credit.  
455 *Psychological Bulletin* **70** 213-220

456 Fox, H.E., Soltanoff, C.S., Mascia, M.B., *et al.* (2012) Explaining global patterns and trends in marine  
457 protected area (MPA) development. *Marine Policy* **36**, 1131-1138.

458 Gaines, S.D., Gaylord, B., Largier, J.L. (2003) Avoiding current oversights in marine reserve design.  
459 *Ecological Applications*, **13**, S32-46.

460 Gaines, S.D., Lester, S.E., Grorud-Colvert, K. *et al.* (2010) Evolving science of marine reserves: New  
461 developments and emerging frontiers. *Proceedings of the National Academy of Sciences* **107**,  
462 18251-18255.

463 Grorud-Colvert, K., Claudet, J., Tissot, B.N., *et al.* (2014) Marine Protected Area networks: assessing  
464 whether the whole is greater than the sum of its parts. *PLoS ONE* **9**, e102298.

- 465 Halpern, B.S., Lester, S.E., McLeod, K.L. (2010) Placing marine protected areas onto the ecosystem-based  
466 management seascape. *Proceedings of the National Academy of Sciences* **107**, 18312-18317.
- 467 Halpern, B.S., Longo, C., Hardy, D., *et al.* (2012) An index to assess the health and benefits of the global  
468 ocean. *Nature* **488**, 615-620.
- 469 Hays, G.C., Scott, R. (2013) Global patterns for upper ceilings on migration distance in sea turtles and  
470 comparisons with fish, birds and mammals. *Functional Ecology* **27**, 748-756.
- 471 Hooker, S.K., Gerber, L.R. (2004) Marine reserves as a tool for ecosystem-based management: the  
472 potential importance of megafauna. *BioScience* **54**, 27-39.
- 473 Huntington, B.E. (2011) Confronting publication bias in marine reserve meta-analyses. *Frontiers in*  
474 *Ecology and Environment* **9**, 375-376.
- 475 Koricheva, J. & Gurevitch (2014) Uses and misuse of meta-analysis in plant ecology. *Journal of Ecology*  
476 **102**, 828-844.
- 477 Landis, J.R., Koch, G.G. (1977) The measurement of observer agreement for categorical data. *Biometrics*  
478 **33**, 159-174.
- 479 Larsen, P.O., von Ins, M. (2010) The rate of growth in scientific publication and the decline in coverage  
480 provided by Science Citation Index. *Scientometrics* **84**, 575-603.
- 481 Lascelles, B.G., Langham, G.M., Ronconi, R.A., Reid, J.B. (2012) From hotspots to site protection:  
482 identifying marine protected areas for seabirds around the globe. *Biological Conservation* **156**, 5-  
483 14.
- 484 Lester, S.E., Halpern, B.S., Grorud-Colvert, K., *et al.* (2009) Biological effects within no-take marine  
485 reserves: a global synthesis. *Marine Ecology Progress Series* **384**, 33-46.
- 486 Lubchenco, J., Grorud-Colvert, K. (2015) Making waves: The science and politics of ocean protection.  
487 *Science* **23**, 382-383.
- 488 Li, W., Zhao, Y. (2015) Bibliometric analysis of global environmental assessment research in a 20-year  
489 period. *Environmental Impact Assessment Review* **50**, 158-166.
- 490 Marine Conservation Institute (2015) MPAtlas. Available from: [www.mpatlas.org](http://www.mpatlas.org). Accessed 27/10/2015.
- 491 Marinesque, S., Kaplan, D.M., Rodwell, L.D. (2012) Global implementation of marine protected areas: is  
492 the developing world being left behind? *Marine Policy* **36**, 727-737.

- 493 Møller, A.P., Jennions, M.D. (2001) Testing and adjusting for publication bias. *Trends in Ecology &*  
494 *Evolution* **16**, 580-586.
- 495 Ojeda-Martinez, C., Bayle-Sempere, J.T., Sanchez-Jerez, P., Forcada, A., Valle, C. (2007) Detecting  
496 conservation benefits in spatially protected fish populations with meta-analysis of long term  
497 monitoring data. *Marine Biology* **151**, 1153-1161.
- 498 O'Leary, B.C., Kvist, K., Bayliss, H.R., Derroire, G., Healey, J.R., Hughes, K., Kleinschroth, F.,  
499 Sciberras, M., Woodcock, P., Pullin AS (2016) The reliability of evidence review methodology in  
500 environmental science and conservation. *Environmental Science and Policy* **64**, 75-82.
- 501 OSPAR (2010) The North-East Atlantic environment strategy of the OSPAR Commission for the  
502 protection of the marine environment of the North-East Atlantic 2010-2020 (OSPAR Agreement  
503 2010-2013).
- 504 Pautasso, M. (2012) Publication growth in biological sub-fields: patterns, predictability and sustainability.  
505 *Sustainability* **4**, 3234-3247.
- 506 Peppin, D., Fule, P., Beyers, J. et al. (2011) Does seeding after severe forest fire in western USA mitigate  
507 impacts on soils and plant communities. CEE review 08-023 (SR60). Collaboration for  
508 Environmental Evidence. [www.environmentalevidence.org/SR60.html](http://www.environmentalevidence.org/SR60.html).
- 509
- 510 Philibert, A., Loyce, C., Makowski, D. (2012) Assessment of the quality of meta-analyses in agronomy.  
511 *Agriculture, Ecosystems & Environment* **148**, 72-82.
- 512 Ramirez-Llodra, E., Tyler, P.A., Baker, M.C., et al. (2011) Man and the last great wilderness: human  
513 impact on the deep sea. *PLoS ONE* **6**, e:22588.
- 514 Sciberras, M., Jenkins, S.R., Kaiser, M.J., Hawkins, S.J., Pullin, A.S. (2013) Evaluating the biological  
515 effectiveness of fully and partially protected marine areas. *Environmental Evidence* **2:4**.
- 516 Sciberras, M., Jenkins, S.R., Mant, R., Kaiser, M.J., Hawkins, S.J., Pullin, A.S. (2015) Evaluating the  
517 relative conservation value of fully and partially protected marine areas. *Fish and Fisheries* **16**,  
518 58-77.
- 519 Shea, B.J., Bouter, L.M., Peterson, J., et al. (2007) External validation of a measurement tool to assess  
520 systematic reviews. *PLoS ONE* **2**, e:1350.

- 521 Thomas, H.L., Macsharry, B., Morgan, L. et al. (2014) Evaluating official marine protected area coverage  
522 for Aichi Target 11: appraising the data and methods that define our progress. *Aquatic*  
523 *Conservation: Marine and Freshwater Ecosystems* **24**, 8-23.
- 524 Viera, A.J., Garrett, J.M. (2005) Understanding interobserver agreement: the kappa statistic. *Family*  
525 *Medicine* **37**, 360-363.
- 526 White, J.W., Botsford, L.W., Baskett, M.L., et al. (2011) Linking models with monitoring data for  
527 assessing performance of no-take marine reserves. *Frontiers in Ecology and the Environment*, **9**,  
528 390-399.
- 529 Willis, T.J., Millar, R.B., Babcock, R.C., Tolimiera, N. (2003) Burdens of evidences and the benefits of  
530 marine reserves: putting Descartes bes des horse? *Environmental Conservation* **30**, 97-103.
- 531 Woodcock, P., Pullin, A.S., Kaiser, M.J. (2014) Evaluating and improving the reliability of evidence  
532 syntheses in conservation and environmental science: a methodology. *Biological Conservation*  
533 **176**, 54-62.

534

### 535 **Supporting Information**

536 Additional Supporting Information may be found in the online version of this article: **Tables A1-A17**.



537 **Table 1:** Key aspects of Marine Protected Areas (MPAs) that may influence effectiveness (geographic  
 538 region, taxon of interest, design characteristic), and outcome measures frequently used to assess MPA  
 539 effectiveness.

<b>Region</b>	<b>Taxa</b>	<b>MPA Characteristic</b>	<b>Outcome Measure</b>
Global	Fish	MPA Size	Abundance
Tropical	Invertebrate	MPA Age	Biomass
Temperate	Algae	MPA Connectivity	Species Richness
Polar	Mammal	MPA Buffer Zone Size	Organism Size
	Bird	MPA Protection Level	
	Reptile		

540

541 **Table 2:** Criteria and brief rationale for the Collaboration for Environmental Evidence Synthesis  
 542 Assessment Tool (CEESAT). See Woodcock et al. (2014) for details.

Criteria	Rationale
1.1 Was an <i>a-priori</i> protocol available for comment before the synthesis was conducted?	Increases robustness of review against <i>post hoc</i> changes in methods and scope.
2.1 Does the search for literature use a comprehensive range of resources?	Increases likelihood that all potentially relevant articles are captured by search.
2.2 Are the search strings clearly defined?	Allows search to be repeated and evaluated. Avoids open-ended searches.
3.1 Does the review apply clearly documented inclusion criteria to all potentially relevant studies found during the search?	Increases transparency. Reduces risk of subjective decisions influencing the studies included in the review.
3.2 Does the review demonstrate that inclusion decisions are repeatable?	Demonstrates repeatability of review, and that subjective decisions have not overly influenced the articles included.
3.3 Are inclusion/exclusion decisions transparent?	Ensures that the process of including and excluding studies can be externally verified.
4.1 Does the review report critical appraisals of the methods of each study?	Makes quality of the evidence-base for the synthesis clear.
4.2 Are studies objectively weighted according to methodological quality?	Gives greater emphasis to more robust studies.
5.1 Is data extraction documented, repeatable and consistent?	Reduces potential for bias in the extraction of metrics from individual studies.
5.2 Are the extracted data reported for each study?	Ensures that the extracted data can be verified and analysed by readers.
6.1 Is a quantitative synthesis conducted?	Reduces potential for subjectivity to influence data synthesis.
6.2 Is heterogeneity in the impact of the intervention investigated statistically?	Indicates the degree to which results are generalisable and the appropriateness of combining studies.
6.3 Does the review consider possible publication bias?	Reduces potential for bias arising from non-publication of non-significant or controversial results.

543

544 **Table 3: Agreement in scoring between reviewers.** Data shown for each criterion are % of reviews for  
 545 which the two reviewers awarded the same score, kappa test, and kappa test weighted by magnitude of  
 546 disagreement. Kappa score of 1 = perfect agreement, kappa score of 0 = agreement no different from that  
 547 expected by chance).

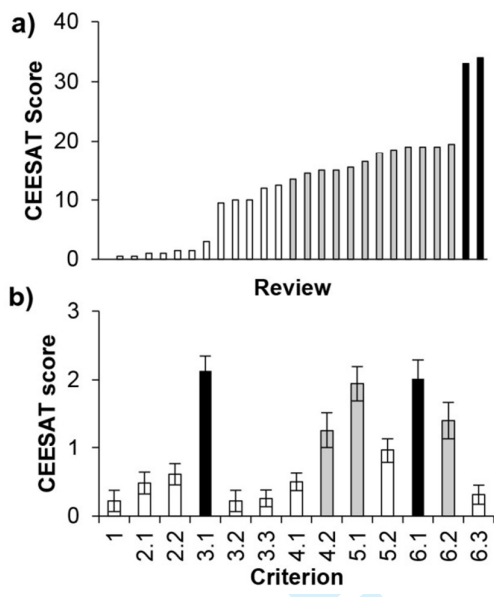
Criteria	Agreement (%)	Kappa	Weighted Kappa
1.1 Protocol	100	1.00	1.00
2.1 Search resources	85	0.70	0.80
2.2 Search string stated	41	0.15	0.36
3.1 Documented inclusion criteria	74	0.51	0.72
3.2 Evidence that inclusion decisions repeatable	100	1.00	1.00
3.3 Documented exclusion decisions	85	0.53	0.67
4.1 Critical appraisal of methods	81	0.65	0.71
4.2 Objective weighting	78	0.62	0.70
5.1 Data extraction documented	78	0.59	0.70
5.2 Extracted data reported	59	0.35	0.49
6.1 Quantitative synthesis	96	0.92	0.97
6.2 Heterogeneity investigated	81	0.65	0.66
6.3 Publication bias considered	93	0.78	0.79

548

549 **Fig. 1. CEESAT scores for reviews examining the effectiveness of MPAs. (a)** total review scores, and  
 550 **(b)** mean score  $\pm$  S.E. for each criterion. Scores are white (mean score per criterion of <1), grey (mean  
 551 score from 1-2), and black (mean score per criterion of >2). Higher scores indicate that the review  
 552 demonstrates greater objectivity, transparency, and comprehensiveness, and is therefore more likely to  
 553 provide an accurate reflection of the primary literature.

554 **Fig. 2: Matrix summarising the reliability and scope of meta-analytical reviews that examine MPA**  
 555 **effectiveness for biodiversity conservation.** Matrix overview of the 19 broad and 134 specific questions  
 556 we considered in our evaluation. Doughnut pie charts indicate the proportion of review achieving low (0-  
 557 13; white), moderate (13-26; grey), or high (>26; black) CEESAT scores. Total number of reviews  
 558 considering each question is in the centre of each chart. The matrix should be read using combinations  
 559 from the top and left headings to form the question of interest; relevant reviews can then be found in  
 560 Tables A4-10. For example, to explore the effect of MPA size on fish, locate MPA size under MPA  
 561 Characteristics in the top set of headings and read down to fish under Taxa on the left; consult Table A6  
 562 for details of reviews. Stars indicate reviews that considered the question but with <10 primary studies, or  
 563 stated that the question could not be investigated due to low number of primary studies. White areas  
 564 indicate questions that are not applicable, e.g. Global/Temperate question combinations. Abbreviations in  
 565 headings refer to: Outcome Measures - Abund=abundance and Sp.Rich=species richness; MPA  
 566 Characteristics - Conn=connectivity, Buff=buffer zone size, Prot=level of protection; and Taxa -  
 567 Invert=invertebrates.

568 **Fig. 3: Matrix summarising the reliability and scope of narrative syntheses that examine MPA**  
 569 **effectiveness for biodiversity conservation.** Matrix should be read using combinations from the top and  
 570 left headings to form the question of interest; full details of reviews can then be found in Tables A11-17.  
 571 For consistency, shading of doughnut pie charts are as for Figure 2. In practice, all narrative reviews we  
 572 assessed scored from 0-13, and so are coloured white. Blank areas indicate questions that are not  
 573 applicable, e.g. Global/Temperate question combinations. Abbreviation 'Conn.' in MPA Characteristics  
 574 refers to connectivity.



For Review Only



		Broad Focus		Type of Protected Area		MPA Characteristic		Region		
		Biodiversity	Fisheries	No-take	MPA	Size	Conn.	Global	Temperate	Tropical
Region	Global	(5)	(6)	(1)	(6)	(3)	0	(7)		
	Temperate	(1)	(1)	0	(1)	0	0		(1)	
	Tropical	(1)	0	(1)	0	(1)	(1)			(1)
MPA Characteristic	Size	(2)	(3)	(1)	(3)	(4)				
	Conn.	(1)	0	(1)	0		(1)			
Type of Protected Area	No-take	(2)	0	(2)						
	MPA	(5)	(7)		(7)					
Broad Focus	Biodiversity	(2)								
	Fisheries		(7)							



**Supporting Information:** Woodcock, P., O’Leary, B.C., Kaiser, M.J. and Pullin, A.S. *Fish & Fisheries*

This document contains:

- Table A1: Search strategy for locating reviews that examine the effectiveness of marine protected areas
- Table A2: Reviews assessed as relevant for inclusion, with review score.
- Table A3: Studies read at full-text but subsequently excluded.
- Table A4: Scope of meta-analyses that examine broad MPA questions: Region, Taxa, MPA Characteristic, Outcome Measure
- Table A5: Scope of meta-analyses that examine the effectiveness of marine protected areas: Region x Taxa
- Table A6: Scope of meta-analyses that examine the effectiveness of marine protected areas: Taxa x MPA Characteristic
- Table A7: Scope of meta-analyses that examine the effectiveness of marine protected areas: Taxa x Outcome Measure
- Table A8: Scope of meta-analyses that examine the effectiveness of marine protected areas: MPA Characteristic x Region
- Table A9: Scope of meta-analyses that examine the effectiveness of marine protected areas: MPA Characteristic x Outcome Measure
- Table A10: Scope of meta-analyses that examine the effectiveness of marine protected areas: Region x Outcome Measure
- Table A11: Scope of narrative syntheses that examine the effectiveness of marine protected areas based on Broad Focus, Region, Type of Protected Area; MPA Characteristic
- Table A12: Scope of narrative syntheses that examine the effectiveness of marine protected areas: Focus x Region
- Table A13: Scope of narrative syntheses that examine the effectiveness of marine protected areas: Type of Protected Area x Region
- Table A14: Scope of narrative syntheses that examine the effectiveness of marine protected areas: MPA Characteristic x Region



Table A15: Scope of narrative syntheses that examine the effectiveness of marine protected areas: MPA Characteristic x Focus

Table A16: Scope of narrative syntheses that examine the effectiveness of marine protected areas: MPA Characteristic x Type of Protected Area

Table A17: Scope of narrative syntheses that examine the effectiveness of marine protected areas: Type of Protected Area x Focus

For Review Only

**Table A1: Search strategy for locating reviews that examine the effectiveness of marine protected areas (MPAs).** Resources and search strings are adapted from those presented in a recent systematic review of MPA effectiveness (Sciberras et al. 2013). All searches were limited to articles published after 2000 and in English.

Resource and Search Fields	Date	Search String
Web of Knowledge (topic)	14/5/2014	<i>("marine reserve*" OR "marine sanctuary" OR (marine AND "no-take zone") OR (marine AND harvest refug*) OR (marine AND "buffer zone") OR (marine AND partial* AND protect*) OR (marine AND "closed area") OR (marine AND "area closure") OR (fisher* AND (reserve OR closure)) OR ("fishing gear restriction*") OR ("recreational fishing" AND protection) OR "marine protected area*")</i>
Aquatic Sciences and Fisheries Abstracts (advanced search, anywhere except full text)	14/5/2014	
CABI (all fields)	14/5/2014	
ScienceDirect (expert search, title-abstract-keywords)	14/5/2014	
Scopus (title, abstract, keywords)	15/5/2014	AND  <i>(review OR "meta-analy*" OR synthes*)</i>
Directory of Open Access Journals (advanced search, search all)	20/5/2014	<i>"marine reserve" "marine reserves" "marine sanctuary" marine AND "no take zone" marine AND "buffer zone" marine AND "harvest refuge" marine AND "harvest refugium" marine AND "closed area" marine AND "area closure" fisheries AND reserve fisheries AND closure "fishing gear restriction" "marine protected area"</i>
Index to Theses Online	20/5/2014	<i>"marine reserve" "marine sanctuary" "marine national park" "marine protected area"</i>
www.google scholar.com (advanced search, with the exact phrase, anywhere in the article. First 50 hits examined in each search)	20/5/2014	<i>"marine reserve" "marine protected area" "marine sanctuary" (marine AND "harvest refuge")</i>  The above search strings were combined individually with: AND (review OR synthes* OR "meta-analy*")

<b>Resource and Search Fields</b>	<b>Date</b>	<b>Search String</b>
JNCC: www.jncc.defra.gov.uk (site search)	21/5/2014	<i>"marine protected area"</i> <i>"marine reserve"</i>
DEFRA: www.gov.uk (Publications > DEFRA, all publication types)	21/5/2014	
CEFAS: http://www.cefass.defra.gov.uk/ (site search)	21/5/2014	
NCCOS: http://ccma.nos.noaa.gov/ (search Publications)	21/5/2014	
Department of Conservation, New Zealand: www.doc.govt.nz/	21/5/2014	
National MPA Center: http://marineprotectedareas.noaa.gov/ Resources > MPA Center Publications	21/5/2014	Hand-searched all Factsheets, and Reports, including Archives
Department of Sustainability, Environment, Water: http://www.environment.gov.au/ Publications > Marine > Marine Reserves (searched all)	21/5/2014	Hand-searched all articles

**Table A2 Reviews assessed as relevant for inclusion, with review ID and CEESAT score.** Meta-analyses are assigned number IDs and narrative syntheses letters.

Review ID	Reference	Score
a	Almany, G.R., S.R. Connolly, D.D. Heath, J.D. Hogan, G.P. Jones, L.J. McCook <i>et al.</i> (2009) Connectivity, biodiversity conservation and the design of marine reserve networks for coral reefs. <i>Coral Reefs</i> , <b>28</b> , 339-351.	0.5
b	Botsford, L.W., F. Micheli, A.M. Parma (2007) Biological and ecological considerations in the design, implementation and success of MPAs. <i>FAO Fisheries Report Background Paper 2</i> , 109-148	1.5
c	Burfeind, D.D., K.A. Pitt, R.M. Connolly & J.E. Byers (2013) Performance of non-native species within marine reserves. <i>Biological Invasions</i> , <b>15</b> , 17-28	12
[1]	Claudet, J. C.W. Osenberg, L. Benedetti-Cecchi, P. Domenici, J.-A. Garcia-Charton, A. Perez-Ruzafa, F. Badalmenti, J. Bayle-Sempere, A. Brito, F. Bulleri <i>et al.</i> (2008) Marine reserves: size and age do matter. <i>Ecology Letters</i> , <b>11</b> , 481-489	16.5
[2]	Claudet, J., C.W. Osenberg, P. Domenici, F. Badalmenti, M. Milazzo, J.M. Falcón, I. Bertocci, L. Benedetti-Cecchi, J.-A. Garcia-Charton, R. Goni <i>et al.</i> (2010) Marine reserves: fish life history and ecological traits matter. <i>Ecological Applications</i> , <b>20</b> , 830-839	18.5
[3]	Côté, I.M., I.M. Mosqueira & J.D.R. Reynolds (2001) Effects of marine reserve characteristics on the protection of fish populations: a meta-analysis. <i>Journal of Fish Biology</i> , <b>59</b> , 178-189.	19.5
[4]	Fenberg, P.B., J.E. Caselle, J. Claudet, M. Clemence, S.D. Gaines, J.A. Garcia-Charton, E.J. Gonçalves, K. Grorud-Colvert, P. Guidetti, S.J. Jenkins <i>et al.</i> (2012) The science of European marine reserves: status, efficacy, and future needs. <i>Marine Policy</i> , <b>36</b> , 1012-1021.	10
d	García-Charton, J.A., A. Pérez-Ruzafa, C. Marcos, J. Claudet, F. Badalmenti, L. Benedetti-Cecchi, J.M. Falcón, M. Milazzo, P.J. Schembri, B. Stobart <i>et al.</i> (2008) Effectiveness of European Atlanto-Mediterranean MPAs: Do they accomplish the expected effects on populations, communities and ecosystems? <i>Journal for Nature Conservation</i> , <b>16</b> , 193-221	1
e	Gell, F.R. & C.M. Roberts (2002) The Fishery Effects of Marine Reserves and Fishery Closures. WWF-US. 1250 24 <sup>th</sup> Street, NW, Washington, DC 20037, USA.	0.5
f	Gubbay, S. (2006) Marine protected areas. A review of their use for delivering marine biodiversity benefits. <i>English Nature Research Reports</i> , <b>688</b> .	0
[5]	Guidetti, P. & E. Sala (2007) Community-wide effects of marine reserves in the Mediterranean Sea. <i>Marine Ecology Progress Series</i> , <b>335</b> , 43-56.	12.5
[6]	Halpern, B.S. (2003) The impact of marine reserves: do reserves work and does reserve size matter. <i>Ecological Applications</i> , <b>13</b> , 117-137	14.5
[7]	Halpern, B.S. & R.R. Warner (2002) Marine reserves have rapid and lasting effects. <i>Ecology Letters</i> , <b>5</b> , 361-366.	13.5

Review ID	Reference	Score
[8]	Lester, S.E., B.S. Halpern, K. Grorud-Colvert, J. Lubchenco, B.I. Ruttenberg, S.D. Gaines <i>et al.</i> (2009) Biological effects within no-take marine reserves: a global synthesis. <i>Marine Ecology Progress Series</i> , <b>384</b> , 33-46.	15.5
[9]	Lester, S.E. & B.S. Halpern (2008) Biological responses in marine no-take reserves versus partially protected areas. <i>Marine Ecology Progress Series</i> , <b>367</b> , 49-56.	10
[10]	Maliao, R.J., A.T. White, A.P. Maypa & R.G. Turingan (2009) Trajectories and magnitude of change in coral reef fish populations in Philippine marine reserves: a meta-analysis. <i>Coral Reefs</i> , <b>28</b> , 809-822.	18
g	Mesnildrev, L., D. Gascuel & O. Le Pape (2013) Integrating marine protected areas in fisheries management systems: some criteria for ecological efficiency. <i>Aquatic Living Resources</i> , <b>26</b> , 159-170	1.5
[11]	Micheli, F., B.S. Halpern, L.W. Botsford & R.R. Warner (2004) Trajectories and correlates of community change in no-take marine reserves. <i>Ecological Applications</i> , <b>14</b> , 1709-1723.	15
[12]	Molloy, P.P., J.D. Reynolds, M.J.G. Gage, I. Mosqueira & I. M. Côté (2008) Links between sex change and fish densities in marine protected areas. <i>Biological Conservation</i> , <b>141</b> , 187-197.	19
[13]	Molloy, P.P., I.B. McLean & I.M. Côté (2009) Effects of marine reserve age on fish populations: a global meta-analysis. <i>Journal of Applied Ecology</i> , <b>46</b> , 743-751.	19
[14]	Mosqueira, I., I.M. Côté, S. Jennings & J.D. Reynolds (2000) Conservation benefits of marine reserves for fish populations. <i>Animal Conservation</i> , <b>4</b> , 321-332	19
h	Palumbi, S.R. (2001) The ecology of marine protected areas. In: <i>Marine Community Ecology</i> (eds: M. Bertness, S. Gaines & M. Hay). Sinauer Press.	1
[15]	Pande, A., A.B. MacDiarmid, P.J. Smith, R.J. Davidson, R.G. Cole, D. Freeman <i>et al.</i> (2008) Marine reserves increase the abundance and size of blue cod and rock lobster. <i>Marine Ecology Progress Series</i> , <b>366</b> , 147-158.	15
[16]	Ruttenberg, B., K. Grorud-Colvert, P. Guarderas, S. Lester & J. Lubchenco (2007) The science of marine reserves: a synthetic analysis of global effects and a new communication tool for Latin America and the Caribbean. <i>Proceedings of the 60<sup>th</sup> Gulf and Caribbean Fisheries Institute</i>	9.5
[17]	Sciberras, M., S.R. Jenkins, M.J. Kaiser, S.J. Hawkins & A.S. Pullin (2013) Evaluating the biological effectiveness of fully and partially protected marine areas. <i>Environmental Evidence</i> , <b>2:4</b> , <a href="http://environmentalevidencejournal.org/content/2/14">http://environmentalevidencejournal.org/content/2/14</a>	34
[18]	Stewart, G.B., I.M. Côté, M.J. Kaiser, B.S. Halpern, S.E. Lester, H.R. Bayliss <i>et al.</i> (2008) Are marine protected areas effective tools for sustainable fisheries management? Biodiversity impact of marine reserves in temperate zones. CEE review 06-002 (SR23). Collaboration for Environmental Evidence: <a href="http://www.environmentalevidence.org/SR23.html">www.environmentalevidence.org/SR23.html</a>	33
i	Ward, T.J., D. Heinemann & N. Evans (2001) The Role of Marine Reserves as Fisheries Management Tools: A Review of Concepts, Evidence and International Experience. Bureau of Rural Sciences, Canberra, Australia	3

**Table A3: Studies read at full-text but subsequently excluded.** Note that some articles would have been excluded for several reasons in addition to those stated in the Table. There was ambiguity over inclusion/exclusion for some reviews – these were excluded but marked as ‘Borderline’.

<b>Review</b>	<b>Reason for Exclusion</b>
Appeldoorn, R.S. & K.C. Lindeman (2003) A Caribbean-wide survey of marine reserves: spatial coverage and attributes of effectiveness. <i>Gulf and Caribbean Research</i> , <b>14</b> , 139-154	<i>Primarily an assessment of reserve characteristics (number, size etc.) rather than reserve effectiveness</i>
Baine, M. & J. Side (2003) Habitat modification and manipulation as a management tool. <i>Reviews in Fish Biology &amp; Fisheries</i> , <b>13</b> , 187-199.	<i>Focus on artificial reefs, not MPAs</i>
Bergen, L.K. & M.H. Carr (2003) Marine reserves: how can science best inform policy? <i>Environment</i> , <b>45</b> , 8-19.	<i>Presented as a broad introductory overview, not synthesis of primary research</i>
Blount, B.G. & A. Pitchon (2007) An anthropological research protocol for marine protected areas. <i>Human Organisation</i> , <b>66</b> , 103-111.	<i>Focus on socioeconomic aspects of MPAs, and implications for anthropological research</i>
Botsford, L.W. (2005) Potential contributions of marine reserves to sustainable fisheries: recent modelling results. <i>Bulletin of Marine Science</i> , <b>76</b> , 245-259.	<i>Reviews the results from models, not field data collection.</i>
Botsford, L.W., F. Micheli & A. Hastings (2003) Principles for the design of marine reserves. <i>Ecological Applications</i> , <b>13</b> , 25-31.	<i>Focus is on reviewing results from models, not field data collection.</i>
Caveen, A.J., C.J. Sweeting, T.J. Willis & N.V.C. Polunin (2012) Are the scientific foundations of temperate marine reserves too warm and hard? <i>Environmental Conservation</i> , <b>39</b> , 199-203.	<i>Summarises scope of MPA research</i>
Christie, P. (2004) Marine protected areas as biological successes and social failures in Southeast Asia. <i>American Fisheries Society Symposium</i> , <b>42</b> , 155-164	<i>Primary research</i>
Dee, L.E., S.S. Horii & D.J. Thornhill (2014) Conservation and management of ornamental coral reef wildlife: successes, shortcomings, and future directions. <i>Biological Conservation</i> , <b>169</b> , 225-237	<i>Synthesis of regulations and management strategies relating to wildlife trade</i>
Diaz-Guisado, D., R.G. Cole, R.J. Davidson, D.J. Freeman, S. Kelly, A. Macdiarmid <i>et al.</i> (2012) Comparison of methodologies to quantify the effects of age and area of marine reserves on the density and size of targeted species. <i>Aquatic Biology</i> , <b>14</b> , 185-200	<b>Borderline relevant.</b> <i>Primary focus is in comparing the results from different meta-analytical approaches</i>

Review	Reason for Exclusion
Edgar, G.J. & N.S. Barrett (2002) Long-term monitoring of Tasmanian coastal MPA's. In: Examining Underwater Visual Census Techniques for the Assessment of Population Structure and Biodiversity in Temperate Coastal marine protected areas. Eds: N Barrett & C Buxton. <i>Tasmanian Aquaculture &amp; Fisheries Institute Technical Report Series</i> , <b>11</b> , 46-55	<i>Workshop report describing approaches and findings from specific MPA monitoring programmes</i>
Fletcher, S., J. Saunders & R.J.H. Herbert (2011) A review of the ecosystem services provided by broad-scale marine habitats in England's MPA network. <i>Journal of Coastal Research</i> , <b>64</b> , 378-383	<b>Borderline relevant.</b> <i>Reviews types of ecosystem services potentially provided by MPAs, and types of evidence available (peer-reviewed, unpublished etc.), but does not synthesise the findings from primary research</i>
Fonteneau, A. (2007) Tuna management and closed areas. <i>International Commission for the Conservation of Atlantic Tunas: Collective Volume of Scientific Papers</i> , <b>60</b> , 190-223	<b>Borderline relevant.</b> <i>Judged to be an overview/report on MPA, with emphasis on underlying concepts and knowledge gaps, rather than synthesising primary research</i>
Francis, J., A. Nilsson & D. Waruinge (2002) Marine protected areas in the Eastern African region: how successful are they? <i>Ambio</i> , <b>31</b> , 503-511	<i>Some information on MPA effectiveness, but main focus judged to be on the history, management, and characteristics of MPAs</i>
Fraschetti, S., A. Terlizzi, F. Micheli, L. Benedetti-Cecchi & F. Boero (2002) Marine protected areas in the Mediterranean Sea: objectives, effectiveness and monitoring. <i>Marine Ecology</i> , <b>23</b> , 190-200	<i>Focus on evaluating and informing the design of research into MPA effectiveness</i>
Gaines, S.D., C. White, M.H. Carr & S.R. Palumbi. (2010) Designing marine reserve networks for both conservation and fisheries management. <i>Proceedings of the National Academy of Sciences</i> , <b>107</b> , 18286-18293	<b>Borderline relevant.</b> <i>Judged to be focused more on synthesising ecological concepts than primary research into MPA effectiveness.</i>
Game, E.T., H.S. Grantham, A.J. Hobday, R.L. Pressey, A.T. Lombard, L.E. Beckley, K. Gjerde, R. Bustamente, H.P. Possingham & A.J. Richardson. (2009) Pelagic protected areas: the missing dimension in ocean conservation. <i>Trends in Ecology &amp; Evolution</i> , <b>24</b> , 360-369	<i>Article is marked as an Opinion piece (i.e. not presented as an objective assessment)</i>
Garcia-Charton, J.A., I.D. Williams, A. Perez Ruzafa, M. Milazzo, R. Chemello, C. Marcos, M.-S. Kitsos, A. Koukouras & S. Riggio. (2000) Evaluating the ecological effects of Mediterranean marine protected areas: habitat, scale and the natural variability of ecosystems. <i>Environmental Conservation</i> , <b>27</b> , 159-178	<b>Borderline relevant.</b> <i>Stated aim to: 'address the methodological implications of marine ecosystem heterogeneity for the design of sampling strategies to evaluate the ecological effects of MPAs, and identify knowledge gaps...' Not principally intended to synthesise findings from primary research into MPA effectiveness.</i>



Review	Reason for Exclusion
Gaston, K.J., S. F. Jackson, L. Cantu-Salazar & G. Cruz-Pinon (2008) The ecological performance of protected areas. <i>Annual Review of Ecology, Evolution and Systematics</i> , <b>39</b> , 93-113	<i>Broad overview of protected area concepts, and considers all types of reserve (not just marine)</i>
Gell, F.R. & Roberts, C.M. (2003) Benefits beyond boundaries: the fishery effects of marine reserves. <i>TRENDS in Ecology and Evolution</i> , <b>18</b> , 448-455	<i>Article is marked as an Opinion piece (i.e. not presented as an objective assessment)</i>
Gianni, F., F. Bartolini, F., L. Airoidi, E. Ballesteros, P. Francour, P. Guidetti, A. Meinesz, T. Thibaut & L. Mangialajo (2013) Conservation and restoration of marine forests in the Mediterranean Sea and the potential role of marine protected areas. <i>Advances in Oceanography and Limnology</i> , <b>4</b> , 83-101	<i>Focus on the conservation of marine forests, with MPAs as a potential tool</i>
Goodsell, P.J. & A.J. Underwood (2009) Protection of biota and the value of marine protected areas. <i>Ecological Studies</i> , <b>206</b> , 345-355	<i>Some consideration of evidence for effectiveness of MPAs, but a broad overview with a stated focus on 'the threats and processes that necessitate protection'</i>
Gotz, A., S.E. Kerwath & C.G. Attwood (2013) A step-by-step framework to assess benefits of established temperate marine protected areas. <i>South African Journal of Science</i> , <b>102</b> , 36-44	<i>Focus on developing a framework for assessing MPA effectiveness, and testing this using a case study</i>
Grafton, R.Q., T. Kompas & V. Schneider (2005) The bioeconomics of marine reserves: a selected review with policy implications. <i>Journal of Bioeconomics</i> , <b>7</b> , 161-178	<i>Includes a synthesis of the effects of marine reserves, but focus is more on bioeconomic modelling of reserve effects</i>
Green, A.L., L. Fernandes, G. Almany, R. Abesamis, E. McLeod, P. M. Alino, A.T. White, R. Salm, J. Tanzer & R.L. Pressey (2014) Designing marine reserves for fisheries, management, biodiversity conservation, and climate change adaptation. <i>Coastal Management</i> , <b>42</b> , 143-159	<b>Borderline relevant.</b> <i>Judged to focus more on providing advice for MPA design rather than evaluating whether or not reserves are effective</i>
Gruss, A., D.M. Kaplan, S. Guenetter, C.M. Roberts & L.W. Botsford (2011) Consequences of adult and juvenile movement for marine protected areas. <i>Biological Conservation</i> , <b>144</b> , 692-702	<i>Using information on fish movement patterns to make recommendations on reserve design – i.e. not synthesising primary research on MPA effectiveness</i>
Guidetti, P., M. Milazzo, S. Bussotti, A. Molinari, M. Murenu, A. Pais, N. Spano, R. Balzano, T. Agardy, F. Boero, G. Carrada, R. Cattaneo-Vietti, A. Cau, R. Chemello, S. Greco, A. Manganaro, G. N. di Sciara, G. F. Russo & L. Tunesi (2008) Italian marine reserve effectiveness: Does enforcement matter? <i>Biological Conservation</i> , <b>141</b> , 699-709.	<i>Uses meta-analysis but appears to be analysing primary data</i>



Review	Reason for Exclusion
Halpern, B.S., S.E. Lester & J.B. Kellner (2010) Spillover from marine reserves and the replenishment of fished stocks. <i>Environmental Conservation</i> , <b>36</b> , 267-276	<i>Uses synthesis to develop model parameters</i>
Hatton-Ellis, T. (2005) Fish communities and fisheries in Wales's National nature Reserves: A review. <i>Freshwater Forum</i> , <b>24</b> , 82-104	<i>Focus on freshwater protected areas</i>
Higgins, R.M., F. Vandeperre, A. Perez-Ruzafa & R.S. Santos (2008) Priorities for fisheries in marine protected area design and management: implications for artisanal-type fisheries as found in southern Europe. <i>Journal for Nature Conservation</i> , <b>16</b> , 222-233.	<i>Judged to be a broad overview of MPA management and design</i>
Hilborn, R., K. Stokes, J.-J. Maguire, T. Smith, L.W. Botsford, M. Mangel, J. Orensanz, A. Parma, J. Rice, J. Bell, K.L. Cochrane, S. Garcia, S.J. Hall, G.P. Kirkwood, K. Sainsbury, G. Stefansson & C. Walters (2004) When can marine reserves improve fisheries management? <i>Ocean &amp; Coastal Management</i> , <b>47</b> , 197-205	<b>Borderline relevant.</b> <i>Excluded because provides a broad overview of advantages and disadvantages of MPAs (including value in understanding long-term trends, potential increased fishing effort elsewhere, social impacts) – i.e. not primarily focused on direct effects of MPAs on biodiversity.</i>
Hooker, S.K. & L.R. Gerber (2004) Marine reserves as a tool for ecosystem-based management: the potential importance of megafauna. <i>BioScience</i> , <b>54</b> , 27-39	<i>MPA design, effectiveness and importance primarily assessed by synthesis and development of concepts</i>
Horigue, V., P.M. Alino & R.L. Pressey (2014) Evaluating management performance of marine protected area networks in the Philippines. <i>Ocean &amp; Coastal Management</i> , <b>95</b> , 11-25	<i>Evaluating MPA management practices</i>
Huntingdon, B.E. (2011) Confronting publication bias in marine reserve meta-analysis. <i>Frontiers in Ecology &amp; the Environment</i> , <b>9</b> , 375-376	<i>Assessing rigour of meta-analyses on MPA effectiveness with respect to treatment of potential publication bias</i>
Kemp, J., G.P. Jenkins, D.C. Smith & E. Fulton (2012) Measuring the performance of spatial management in marine protected areas. <i>Oceanography &amp; Marine Biology</i> , <b>50</b> , 287-314	<i>Excluded because (i) expressly states a focus on selected case study reserves and (ii) emphasis is more on trends within selected MPAs over time</i>
Koldeway, H.J., D. Curnick, S. Harding, L.R. Harrison & M. Gollock (2010) Potential benefits to fisheries and biodiversity of the Chagos Archipelago/British Indian Ocean Territory as a no-take marine reserve. <i>Marine Pollution Bulletin</i> , <b>60</b> , 1906-1915	<i>Evaluates evidence to determine potential impacts and benefits of a proposed MPA</i>

Review	Reason for Exclusion
Magdaong, E.T., Fujii, M., Yamano, H., Licuanan, W.Y., Maypa, A., Campos, W.L., Alcala, A.C., White, A.T., Apistar, D. & Martinez, R. (2014) Long-term change in coral cover and the effectiveness of MPAs in Philippines: A meta-analysis. <i>Hydrobiologia</i> , <b>733</b> , 5-17	<b>Borderline relevant</b> <i>Excluded because it is a synthesis of studies that have been monitoring coral cover, not a synthesis of BA/CI/BACI studies.</i>
Maliao, R.K., R.S. Pomeroy & R.G. Turingan (2009) Performance of community-based coastal resource management (CBCRM) <i>Marine Policy</i> , <b>33</b> , 818-825	<i>Focus on perceptions of MPA management/governance, assessed through questionnaire</i>
Martin, K., M.A. Samoily, A.K. Hurd, I. Meliane & C.G. Landin (2007) Experiences in the use of marine protected areas with fisheries management objectives – a review of case studies. Background Paper 1. In: Report and Documentation of the Expert Workshop on Marine Protected Areas and Fisheries Management: Review of Issues and Considerations. <i>Food &amp; Agriculture Organisation Fisheries Report</i> , <b>825</b> , p21-108	<i>Broad overview, expressly based on selected case studies</i>
McCook, L.J., T. Ayling, M. Cappel, J.H. Choat, R.D. Evans, D.M. De Freitas, M. Heupel, T.P. Hughes, G.P. Jones, B. Mapstone, H. Marsh, M. Mills, F.J. Molloy, C.R. Pitcher, R.L. Pressey, G.R. Russ, S. Sutton, H. Sweatman, R. Tobin, D.R. Wachenfeld & D.H. Williamson (2010) <i>Proceedings of the National Academy of Sciences USA</i> , <b>107</b> , 18278-18285	<i>Focus is on the effects of zoning, rather than the effects of the MPA. Also marked as a Perspective</i>
Mora, C. & P.F. Sale (2011) Ongoing global biodiversity loss and the need to move beyond protected areas: a review of the technical and practical shortcomings of protected areas on land and sea. <i>Marine Ecology Progress Series</i> , <b>434</b> , 251-266	<i>Broad overview of strengths and weaknesses of the protected areas concept in relation to aquatic and terrestrial conservation</i>
Nagelkerken, I., M.G.G. Grol & P.J. Mumby (2012) Effects of marine reserves versus nursery habitat availability on structure of reef fish communities. <i>PLOS ONE</i> , <b>7</b> , e36906. doi:10.1371/journal.pone.0036906	<i>Primary research</i>
Nikolaeva, N.G., V.A. Spiridonov & Y.V. Krasnov (2006) Existing and proposed marine protected areas and their relevance for seabird conservation: a case study in the Barents Sea region. In: <i>Waterbirds around the world</i> . Eds. G.C. Boere, C.A. Galbraith & D.A. Stroud. The Stationery Office, Edinburgh, UK. pp743-749	<i>Outline of bird distributions with reference to proposed and existing MPAs</i>

Review	Reason for Exclusion
Natural England Research Report (2010) Guidance on the size and spacing of marine protected areas in England. NECR037	<i>Recommendations on MPA design based on species ecology and distributions</i>
Ojeda-Martinez, C., J.T. Bayle-Sempere, P. Sanchez-Jerez, A. Forcada & C. Valle (2007) Detecting conservation benefits in spatially protected fish populations with meta-analysis of long term monitoring data. <i>Marine Biology</i> , <b>151</b> , 1153-1161	<i>Synthesis of long-term monitoring data – judged not to be intended as a review of primary research that examines MPA effectiveness using a BA or CI approach</i>
Ojeda-Martinez, C., J.T. Bayle-Sempere, P. Sanchez-Jerez, F. Salas, B. Stobart, R. Goni, J.M. Falcon, M. Graziano, I. Guala, R. Higgins, F. Vandeperre, L. Le Direach, P. Martin-Sosa & S. Vaselli (2011) Review of the effects of protection in marine protected areas: current knowledge and gaps. <i>Animal Biodiversity &amp; Conservation</i> , <b>34</b> , 191-203	<i>Describing and summarising the characteristics of studies conducted on MPAs</i>
Pelc, R.A., R.R. Warner, S.D. Gaines & C.B. Paris (2010) Detecting larval export from marine reserves. <i>Proceedings of the National Academy of Sciences USA</i> , <b>107</b> , 18266-18271	<i>Primarily modelling study that uses a review to check model findings</i>
Perera, N. & A. de Vos (2007) Marine protected areas in Sri Lanka: a review. <i>Environmental Management</i> , <b>40</b> , 727-738	<i>Overview of status (history, design, management, governance etc.) of MPAs</i>
Pinnegar, J.K., N.V.C. Polunin, P. Francour, F. Badalmenti, R. Chemello, M.-L. Harmelin-Vivien <i>et al.</i> (2000) Trophic cascades in benthic marine ecosystems: lessons for fisheries and protected-area management. <i>Environmental Conservation</i> , <b>27</b> , 179-200	<i>Documenting examples of trophic cascades (predicted or actual) inside and outside MPAs, rather than examining the effects of MPAs</i>
Planes, S., R. Galzin, A. Garcia Rubies, R. Goni, J.-G. Harmelin, L. Le Direach, P. Lenfant & A. Quetglas (2000) Effects of marine protected areas on recruitment processes with special reference to Mediterranean littoral ecosystems. <i>Environmental Conservation</i> , <b>27</b> , 126-143	<b>Borderline relevant.</b> <i>Judged to focus largely on the ecological concepts influencing MPA effectiveness, rather than reviewing primary research that directly examines MPA effects.</i>
Rife, A.N., B. Erisman, A. Sanchez & O. Aburto-Oropeza (2013) When good intentions are not enough...Insights on networks of “paper park” marine protected areas. <i>Conservation Letters</i> , <b>6</b> , 200-212	<i>Article marked as Policy Perspective, so not intended as an objective synthesis</i>
Sale, P.F., R.K. Cowen, B.S. Danilowicz, G.P. Jones, J.P. Kritzer, K.C. Lindeman, <i>et al.</i> (2005) Critical science gaps impede use of no-take fishery reserves. <i>Trends in Ecology &amp; Evolution</i> , <b>20</b> , 74-80	<i>Article marked as Opinion, so not intended as an objective synthesis</i>

Review	Reason for Exclusion
Samy, M. J.L. Sanchez Lizaso & A. Forcada (2011) Status of marine protected areas in Egypt. <i>Animal Biodiversity and Conservation</i> , <b>34</b> , 165-177	<i>Some consideration of effects of MPA on biodiversity, but part of a general overview describing location, governance, threats etc.</i>
Sanchez Lizaso, J.L., R. Goni, O. Renones, J.A. Garcia Charton, R. Galzin, J.T. Bayle, P. Sanchez Jerez, A. Perez Ruzafa & A.A. Ramos (2000) Density dependence in marine protected populations: a review. <i>Environmental Conservation</i> , <b>27</b> , 144-158	<i>Some synthesis of primary research on the effects of MPAs, but focus is more on synthesising general ecological concepts and research then applying this to reserves</i>
Sumaila, U.R., S. Guenette, J. Alder & R. Chuenpagdee (2000) Addressing ecosystem effects of fishing using marine protected areas. <i>ICES Journal of Marine Science</i> , <b>57</b> , 752-760	<i>Broad overview of MPAs with extensive treatment of modelling approaches for MPA management and limited synthesis of primary research examining MPA effects</i>
Valentine, J.F. & K.L. Heck Jr (2005) Perspective review of the impacts of overfishing on coral reef food web linkages. <i>Coral Reefs</i> , <b>24</b> , 209-213	<i>Article marked as Perspective</i>
Vandeperre, F., R.M. Higgins, J. Sanchez-Meca, F. Maynou, R. Goni, P. Martin-Sosa, A. Perez-Ruzafa, P. Afonso, I. Bertocci, R. Crec'hiou, G. D'Anna, M. Dimech, C. Dorta, O. Esparza, J.M. Falcon, A. Forcada, I. Guala, L. Le Direach, C. Marcos, C. Ojeda-Martinez, C. Pipitone, P.J. Schembri, V. Stelzenmuller, B. Stobart & R.S. Santos (2011) Effects of no-take area size and age of marine protected areas on fisheries yields: a meta-analytical approach. <i>Fish &amp; Fisheries</i> , <b>12</b> , 412-426	<b>Borderline relevant.</b> <i>Excluded because meta-analysis is used to explore selected datasets and case studies to analyse trends</i>
Wenzel, L., J. Gass, M. D'Iorio & J. Blackburn (2013) A national perspective on the role of marine protected areas in sustaining fisheries. <i>Fisheries Research</i> , <b>144</b> , 23-27	<i>Overview of MPA management and locations</i>
Willis, T.J., R.B. Millar, R.C. Babcock & N. Tolimieri (2003) Burdens of evidence and the benefits of marine reserves: putting Descartes before des horse? <i>Environmental Conservation</i> , <b>30</b> , 97-103	<i>Mostly focused on summarising the types of MPA studies conducted and evaluating the methods used. Article also marked as Comment</i>
Willis, T.J. (2013) Scientific and biodiversity values of marine reserves: a review. <i>DOC Research and Development Series</i> . New Zealand Department of Conservation, Wellington	<b>Borderline relevant.</b> <i>More of a broad overview of the field, with emphasis on summarising the types of research conducted, providing information on study design, describing research conducted within MPAs (whether or not this examines effectiveness)</i>

<b>Review</b>	<b>Reason for Exclusion</b>
Wilson, B. (2005) Marine protected areas for whales, dolphins and porpoises: a world handbook for cetacean habitat. <i>Environmental Conservation</i> , <b>32</b> , 283-284	<i>Book review. *NB: Based on the review, the book appears to focus primarily on describing the history, management, context and distribution of MPAs</i>
Witherell, D. & D. Woodby (2005) Application of marine protected areas for sustainable production and marine biodiversity off Alaska. <i>Marine Fisheries Review</i> , <b>67</b> , 1-27	<i>Overview of management and history of MPAs. Some data synthesis, but based on trends detected in monitoring programmes</i>

For Review Only

**Table A4: Scope of meta-analyses that examined the effectiveness of marine protected areas.** Each number corresponds to a review – see Table A2 for details. Dashes indicate that no meta-analyses addressing particular questions were located.

	<b>SCOPE</b>	<b>REVIEW</b>
<b>REGION</b>	Global	3, 6-9, 11-14, 16, 17
	Tropical <sup>a</sup>	8, 10
	Temperate <sup>a</sup>	1, 2, 4, 5, 8, 15, 18
	Polar <sup>a</sup>	-
<b>TAXA</b>	Fish <sup>b, c, d</sup>	1-3, 5, 6, 8, 10-18
	Invertebrate <sup>b, c, d</sup>	6, 8, 15, 16, 18
	Algae <sup>c</sup>	8
	Bird	-
	Mammal	-
	Reptile	-
<b>MPA CHARACTERISTIC</b>	Size <sup>e, f</sup>	1-3, 5, 6, 8, 10, 11, 15, 17, 18
	Age <sup>c</sup>	1-3, 5, 7, 10-13, 15, 17, 18
	Connectivity	1
	Buffer Zone Size	1, 2
	Protection Level	9, 10, 17
<b>OUTCOME MEASURE</b>	Abundance	1-18
	Biomass <sup>g, h, i</sup>	4-8, 17, 18
	Species Richness <sup>g, i, j</sup>	1, 3, 4, 6-8, 17
	Organism Size <sup>g, i</sup>	4, 6-8, 15, 17

**Notes:** <sup>a</sup> Review [3] found no influence of latitude on MPA effectiveness, and Review [13] included latitude as a potential confounding factor. Neither review directly reports effect sizes for reserves in different regions.

<sup>b</sup> Review [7] found consistent results across fish and invertebrates but did not present taxon-specific data.

<sup>c</sup> Review [9] recognised the potential importance of differences amongst taxa but was unable to explore this due to low number relevant primary studies. Review [17] investigated the effects of MPAs on invertebrates, but with <10 primary studies. Review [18] investigated the effects of MPAs on algae, but with <10 primary studies.

<sup>d</sup> Review [15] investigated MPA effectiveness at the level of two individual species (one fish, one invertebrate) rather than across assemblages.

<sup>e</sup> Review [9] recognised the potential importance of MPA size and MPA age, but was unable to explore this due to low number of relevant primary studies.

<sup>f</sup> Review [13] included MPA size as a potential confounding factor, but did not directly report effect size.

<sup>g</sup> Review [9] examined effect of MPAs on biomass, species richness, and organism size, but with <10 primary studies.

<sup>h</sup> Review [11] unable to consider effects of MPAs on biomass due to low number of relevant primary studies.

<sup>i</sup> Review [16] collected data on other outcome measures, but only directly presents data on abundance.

<sup>j</sup> Review [18] investigated effects of MPAs on species richness, but with <10 primary studies.

**Table A5: Scope of meta-analyses that examine the effectiveness of marine protected areas.** Combinations of Region and Taxa are shown. Each number corresponds to a review – see Table A2 for details.

		REGION		
		Global	Temperate	Tropical
	Fish	3, 6, 8, 11-14, 16, 17	1-2, 5, 8, 15, 18, <sup>b,c</sup>	8, 10, <sup>b,c</sup>
<b>TAXA</b>	Invertebrates	6, 8, 16, <sup>a</sup>	8, 15, 18	8
	Algae	8	8	<sup>e</sup>

Notes: <sup>a</sup> Review [17] investigated the effects of MPAs on invertebrates at a global scale, but with <10 primary studies.

<sup>b</sup> Review [3] found no influence of latitude on MPA effectiveness for fish, but did not directly report effect size for reserves in different regions.

<sup>c</sup> Review [13] examined effectiveness of MPAs for fish and included latitude as a potential confounding factor, but did not directly report effect size for reserves in different regions.

<sup>d</sup> Review [18] investigates effect of MPAs on temperate algae, but based on 9 studies.

<sup>e</sup> Review [8] investigates effect of MPAs on tropical algae, but only 5 studies were available.

**Table A6: Scope of meta-analyses that examine the effectiveness of marine protected areas.** Combinations of Taxa and MPA Characteristics are shown. Each number corresponds to a review – see reference list for details. Dashes indicate that no meta-analyses addressing particular combinations were located.

		MPA CHARACTERISTIC				
		Size	Age	Protection	Buffer Zone Size	Connectivity
	Fish	1-3, 5, 6, 10, 11, 15 <sup>a</sup> , 17, 18, <sup>b,c</sup>	1-3, 5, 10-13, 15 <sup>a</sup> , 17, 18, <sup>e</sup>	10, 17, <sup>f</sup>	1, 2	1
<b>TAXA</b>	Invertebrates	6, 15 <sup>a, b, d</sup>	15 <sup>a, d</sup>	<sup>d, f</sup>	-	-
	Algae	-	-	<sup>f</sup>	-	-

Notes: <sup>a</sup> Review [15] focuses on two species (one invertebrate, one fish).

<sup>b</sup> Review [8] examined effect of MPA size but did not present this relationship for specific taxa.

<sup>c</sup> Review [13] examined effectiveness of MPAs for fish and included MPA size as a potential confounding factor, but did not directly report effect size for relationship between reserve size and effectiveness.

<sup>d</sup> Review [17] unable to investigate effect of MPA characteristics (size, age, level of protection) on invertebrates due to low number of relevant primary studies.

<sup>e</sup> Review [7] states that effect of MPA age is consistent for fish and invertebrates but does not present effect sizes for each taxon separately.

<sup>f</sup> Review [9] unable to investigate effect of MPA protection level on different taxa separately due to low number of relevant primary studies.



**Table A7: Scope of meta-analyses that examine the effectiveness of marine protected areas.** Combinations of taxa and Outcome Measure are shown. Each number corresponds to a review – see Table A2 for details.

		OUTCOME MEASURE			
		Abundance	Biomass	Species Richness	Organism Size
<b>TAXA</b>	Fish	1-3, 5, 6, 8, 10-18, <sup>a, b</sup>	5, 6, 8, 17, <sup>a, b, c, d</sup>	1, 3, 6, 8, 17, <sup>a, b, d</sup>	8, 15, 17, <sup>a, b, f</sup>
	Invertebrates	6, 8, 15, 16, 18, <sup>a, b, e</sup>	8, <sup>a, b, d, e, f</sup>	a, b, d, e, f, g	8, 15, <sup>a, b, e, f</sup>
	Algae	8, <sup>b, d</sup>	b, d, g	b, d, g	b, g

Notes: <sup>a</sup> Review [7] states that effectiveness of MPAs is consistent for fish and invertebrates but does not present effect sizes for each taxon separately.

<sup>b</sup> Review [9] unable to disaggregate results by taxa due to low number of relevant primary studies.

<sup>c</sup> Review [11] unable to investigate effects of MPAs on fish biomass due to low number of relevant primary studies.

<sup>d</sup> Review [18] investigated effects of MPAs but with <10 primary studies for the following combinations: fish biomass and species richness, invertebrate biomass and species richness, algae density, biomass, and species richness.

<sup>e</sup> Review [17] attempted to investigate effects of MPAs on invertebrates, but <10 relevant primary studies were available.

<sup>f</sup> Review [6] investigated the effect of MPAs on fish size, but with <10 primary studies for each of the trophic groups considered, and also investigated the effects of MPAs on invertebrate biomass, species richness, and size, but again <10 relevant primary studies were available in each case.

<sup>g</sup> Review [8] investigated the effect of MPAs on invertebrate species richness, and on biomass, species and organism size for algae, but with <10 primary studies.

**Table A8: Scope of meta-analyses that examine the effectiveness of marine protected areas.** Combinations of Region and MPA Characteristic are shown. Each number corresponds to a review – see Table A2 for details. Dashes indicate that no meta-analyses addressing particular combinations were located.

		MPA CHARACTERISTIC				
		Size	Age	Protection	Buffer Zone Size	Connectivity
<b>REGION</b>	Global	3, 6, 8, 10, 17, <sup>a</sup>	3, 7, 10, 12, 13, 17	9, 17	-	-
	Temperate	1, 2, 5, 8, 15, 18	1, 2, 5, 15, 18	-	1, 2	1
	Tropical	8, 10	10	10	-	-

Notes: <sup>a</sup> Review [13] included MPA size and latitude as potential confounding factors, but did not directly explore these properties.



**Table A9: Scope of meta-analyses that examine the effectiveness of marine protected areas.** Combinations of MPA Characteristic and Outcome Measure are shown. Each number corresponds to a review – see Table A2 for details. Dashes indicate that no meta-analyses addressing particular combinations were located.

		MPA CHARACTERISTIC				
		Size	Age	Protection	Buffer Zone Size	Connectivity
<b>OUTCOME MEASURE</b>	Abundance	1-3, 5, 6, 8, 10, 11, 15, 17, 18, <sup>a,d</sup>	1-3, 5, 7, 10-13, 15, 17, 18	9, 10, 17	1, 2	1
	Biomass	6, 8, 17, 18, <sup>a,c</sup>	7, 17, 18, <sup>a,c</sup>	17, <sup>b</sup>	-	-
	Richness	1, 3, 6, 8, <sup>e,f</sup>	1, 3, 7, <sup>e,f</sup>	17, <sup>b</sup>	1	1
	Organism Size	6, 8, 15, <sup>e</sup>	7, 15, <sup>e</sup>	<sup>b,e</sup>	-	-

Notes: <sup>a</sup> Review [5] used density data to investigate the effect of MPA size and MPA age on community composition, but was unable to investigate effects of MPA size and age on biomass due to low number of relevant primary studies.

<sup>b</sup> Review [9] compared no-take MPAs with partially protected MPAs, but <10 primary studies were available for changes in biomass, species richness, and organism size.

<sup>c</sup> Review [11] did not investigate effects of MPA size and age on biomass due to low number of primary studies.

<sup>d</sup> Review [13] included MPA size as a potential confounding factor, but did not directly investigate the effects of reserve size on abundance.

<sup>e</sup> Review [17] was limited in investigation of effects of MPA size and age on species richness and on organism size due to low number of relevant primary studies.

<sup>f</sup> Review [18] was unable to investigate the effects of MPA size and age on species richness due to the low number of relevant primary studies.

**Table A10: Scope of meta-analyses that examine the effectiveness of marine protected areas.** Combinations of Region and Outcome Measures are shown. Each number corresponds to a review – see Table A2 for details.

		OUTCOME MEASURE			
		Abundance	Biomass	Species Richness	Size
<b>REGION</b>	Global	3, 6-9, 11-14, 16, 17, <sup>b</sup>	6-8, 17, <sup>b,c,d</sup>	3, 6-8, 17, <sup>b,c</sup>	6-8, 17, <sup>b,c</sup>
	Temperate	1, 2, 4, 5, 8, 15, 18, <sup>a,e</sup>	4, 5, 8, 18	1, 4, 8, <sup>f</sup>	4, 8, 15
	Tropical	8, 10 <sup>a,e</sup>	8	8	8

Notes: <sup>a</sup> Review [3] examined effect of latitude on density, but did not report separate effect sizes for temperate and tropical regions.

<sup>b</sup> Review [4] includes data from a previous global-scale synthesis (Lester et al. 2009, see main text for full reference).

<sup>c</sup> Review [9] examined effects of MPAs on biomass, species richness, and organism size, but <10 relevant primary studies were found.

<sup>d</sup> Review [11] did not investigate effects of MPAs on biomass due to low number of relevant primary studies.

<sup>e</sup> Review [13] included latitude as potential confounding factor but did not directly investigate the effect sizes for tropical and temperate regions.

<sup>f</sup> Review [18] investigated effects of MPAs on species richness, but with <10 primary studies.

**Table A11: Scope of narrative syntheses that examine the effectiveness of marine protected areas based on Broad Focus, Region, Type of Protected Area; MPA Characteristic.** Each letter corresponds to a review – see Table A2 for details.

	<b>SCOPE</b>	<b>REVIEW</b>
<b>BROAD FOCUS</b>	Biodiversity	a, b, c, d, f, h, i
	Fisheries	b, d, e, f, g, h, i
<b>REGION</b>	Global	b, c, e, f, g, h, i
	Tropical <sup>a</sup>	a
	Temperate <sup>a</sup>	d
<b>TYPE OF PROTECTED AREA</b>	No-take	a, c
	MPA	b, d, e, f, g, h, i
<b>MPA CHARACTERISTIC</b>	Size <sup>e, f</sup>	a, e, g, i
	Connectivity	a

**Table A12: Scope of narrative syntheses that examine the effectiveness of marine protected areas: Focus x Region.** Each letter corresponds to a review – see Table A2 for details.

	<b>FOCUS</b>		
	Biodiversity	Fisheries	
<b>REGION</b>	Global	b, c, f, h, i	b, e, f, g, h, i
	Temperate	d	d
	Tropical	a	

**Table A13: Scope of narrative syntheses that examine the effectiveness of marine protected areas: Type of Protected Area x Region**

		TYPE OF PROTECTED AREA	
		No-take	MPA
<b>REGION</b>	Global	c	b, e, f, g, h, i
	Temperate		d
	Tropical	a	

**Table A14: Scope of narrative syntheses that examine the effectiveness of marine protected areas: MPA Characteristic x Region**

		MPA CHARACTERISTIC	
		Size	Connectivity
<b>REGION</b>	Global	e, g, i	
	Temperate		
	Tropical	a	a

**Table A15: Scope of narrative syntheses that examine the effectiveness of marine protected areas: MPA Characteristic x Focus**

		MPA CHARACTERISTIC		
		Size	Connectivity	Spacing
<b>FOCUS</b>	Biodiversity	a	a	a
	Fisheries	e, g, i		

**Table A16: Scope of narrative syntheses that examine the effectiveness of marine protected areas: MPA Characteristic x Type of Protected Area**

		<b>MPA CHARACTERISTIC</b>		
		Size	Connectivity	Spacing
	No-take	a	a	a
<b>TYPE OF PROTECTED AREA</b>	MPA	e, g, i		

**Table A17: Scope of narrative syntheses that examine the effectiveness of marine protected areas: Type of Protected Area x Focus**

		<b>FOCUS</b>	
		Biodiversity	Fisheries
	No-take	a, c	
<b>TYPE OF PROTECTED AREA</b>	MPA	b, d, f, h, i	b, d, e, f, g, h, i