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Social and ecological outcomes of conservation interventions in tropical coastal marine ecosystems: a systematic map protocol

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Abstract

Background: Tropical coastal marine ecosystems (TCMEs) are rich in biodiversity and provide many ecosystem services, including carbon storage, shoreline protection, and food. Coastal areas are home to increasing numbers of people and population growth is expected to continue, putting TCMEs under pressure from development as well as broader environmental changes associated with climate change, e.g. sea level rise and ocean acidification. Attention to TCMEs by conservation organizations has increased and although a variety of interventions to promote conservation and sustainable development of TCMEs have been implemented, evidence regarding the outcomes of these—for people or ecosystems—is scattered and unclear. This study takes a systematic mapping approach to identify articles that examine the ecological and social outcomes associated with conservation interventions in TCMEs; specifically in coral reef, mangrove, and seagrass habitats.

Methods: We developed a comprehensive framework of conservation interventions and outcomes, drawing on existing frameworks and related evidence synthesis projects, as well as interviews with marine conservation practitioners. We modified existing frameworks to: (i) include features of TCME that are not fully captured in existing frameworks; and (ii) further specify and/or regroup existing interventions or outcomes. We developed a search string informed by habitat, geography, interventions, and outcomes of interest, to search the peer-reviewed primary literature in four bibliographic databases and the grey literature on relevant institutional websites. All searches will be conducted in English. We will screen returned articles at the title and abstract level. Included articles will be screened at full text level and data coding will follow. Number of articles and reasons for excluding at full text level screening will be recorded. At each phase (title and abstract screening, full text screening, data coding), articles will be assessed independently by two members of the review team. Coded data will be reported in a narrative review and a database accessible through an open access, searchable data portal. We will summarize trends in the evidence base, identify interventions and outcomes where evidence can be further assessed in subsequent systematic reviews and where gaps in the literature exist, and discuss the implications of research gaps and gluts for TCME conservation policy, practice, and future research.

Keywords: Ecosystem functions, Ecosystem services, Human well-being, Governance, Coral, Mangrove, Seagrass

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Background

Coastal areas are home to much of the world's human population, with roughly half living within 100 km of the coast [1] and coastal population growth expected to continue [2]. Coastal marine ecosystems support a significant portion of the global economy, estimated at US$24 trillion [1], and provide critical ecosystem services including carbon storage, shoreline protection, and food [3, 4]. Globally, more than 775 million people are highly dependent on coastal marine ecosystems [5]. On food provision alone, the FAO estimates that fish provide 3.2 billion people with 20% of their protein, and a higher percentage in developing countries. Fish also provide critical micronutrients and are especially important in the diets of residents of small island developing states [6]. Additionally, fisheries and aquaculture provide employment, livelihoods, and cultural identity for 56.9 million people [6].

Coastal marine ecosystems are vulnerable to both increased and intensified development activity and related environmental change, and the impacts of human activities on coastal marine ecosystems are of increasing concern [7]. Habitat coverage and quality have declined across habitat types (e.g. oyster reefs, salt marshes, coral reefs, seagrasses, and mangroves) and climate change and associated sea level rise are predicted to exacerbate already increasing rates of degradation [2, 8, 9]. In tropical regions, coastal marine ecosystems support diverse, productive ecosystems; coral reefs, mangroves, and seagrasses are of particular interest to conservation organizations because of their biodiversity value and the other ecosystem services they provide. All three habitats have experienced declines in habitat quality and spatial extent. For example, 35% of mangroves have been lost [10] and the global rate of mangrove forest loss is estimated as 5 times the average rate of global forest loss [11]. Seagrasses have declined globally by 29% [9]. Although 27% of coral reefs are protected, 75% are considered threatened [12] and over 50% have been lost [1].

Coral reef ecosystems have received considerable attention by scientists, conservationists, and governments. There are numerous organizations and initiatives dedicated to coral reef conservation (e.g. Coral Reef Alliance, International Coral Reef Initiative) and long standing coral reef conservation programs in larger conservation organizations. The Convention on Biological Diversity has among its 20 Aichi Biodiversity Targets for 2020 one specific to coral reefs (Target 10), the only marine habitat singled out for protection. Mangroves and seagrasses have received less and little coordinated attention by conservation organizations, although this is changing for mangroves. In 2014, the UNEP published a *Call to Action* for mangroves [11] and the Global Mangrove Alliance was launched in June 2017. Seagrasses continue to receive less attention, but efforts to organize are apparent (e.g. the World Seagrass Association campaign for a World Seagrass Day).

Increased recognition of the value of mangroves and seagrasses reflects a general increase in interest in and support for ocean conservation over the past several decades [13] as well as calls for a more holistic ecosystem based approaches to ocean conservation [14]. Philanthropic support has also grown and in 2015 philanthropies provided about half of a (conservative) estimate of $800 M USD grant funding for ocean conservation [15]. To date, ocean conservation interventions have been dominated by the establishment of marine protected areas (MPAs) by national governments [16]. Although protected areas generally have long been mired in a 'parks versus people' debate [17], and their impacts on people are debated [18, 19], most contemporary conservation efforts recognize the need to deliver benefits to human communities. This need arises from practical (communities have high stakes in conservation outcomes; community support can be critical to success), philosophical (humans are part of ecosystems), and ethical (local people bear disproportionate costs of conservation) concerns [20], and these concerns are reflected in a number of contemporary conservation approaches, including, 'ecosystem services' [10], 'nature's contributions to people' [21], 'rights based conservation' [22], or 'new conservation' [23]. Interest in delivering benefits to people via conservation means that the social outcomes of MPAs have received increased attention (e.g. [24–26]), and that conservation organizations have diversified both the tools they use to promote conservation (e.g. rights based fisheries, certification schemes, payments for ecosystem services, community-based conservation, etc.) and approaches to implementation (e.g. through bottom up, participatory processes, social media campaigns, education and capacity building, etc.). Achieving positive social outcomes, or at least minimizing negative ones, is now considered critical to ethical conservation [24]. As need, interest, and funding for tropical coastal marine ecosytem (TCME) conservation grows, it is timely to consider the extent of current evidence regarding the outcomes of conservation interventions to date.

Like other fields of conservation, there is a growing but scattered body of literature on the social or ecological outcomes of conservation interventions in TCMEs, which limits clear understanding of the extent and strength of evidence available to inform decisions in marine conservation [27]. While a handful of reviews and

syntheses have investigated specific marine conservation interventions and their subsequent outcomes, they have been limited in scope, typically focusing on one type of marine intervention (e.g. MPAs [28]) and either ecological or social outcomes (e.g. [26]). For example, recent and ongoing evidence syntheses efforts have focused on the efficacy of partially and fully protected MPAs [29], socioeconomic factors that influence how MPAs impact on ecosystems and livelihoods [30], impacts of energy systems on marine ecosystem services [31], knowledge gaps related to cultural ecosystem services provided by coastal marine ecosystems [32], seafood certification [33], and future prospects of coastal marine ecosystem services [34]. Our review aims to scope and identify existing articles that document evidence of social or ecological impacts from a broad suite of conservation interventions within TCMEs.

Stakeholder engagement

Staff on the Ocean Conservation and Science teams at World Wildlife Fund-US (WWF) (Ahmadia, Andradi-Brown, Glew), researchers at Duke University's Nicholas School of Environment (Campbell, Brooks, Gill, Rudd, Silliman), and Dr. Samantha Cheng (American Museum of Natural History) collaborated to formulate the review question and scope of this systematic map. WWF is an international conservation non-profit organization that supports ongoing tropical marine conservation efforts. Although WWF initiated the collaboration, the goal is to produce a map that can inform the work of conservation organizations and other stakeholders supporting conservation in TCMEs.

Our multi-organizational team of practitioners, researchers, and evidence synthesis specialists held several planning meetings to agree on the scope of the map and to develop a conceptual framework for this study, and these were further refined based on insights from informational interviews with marine conservation practitioners who also had experience with systematic mapping. Overall, our interests are in a broadly scoped review of TCMEs, and we worked to balance this interest with project feasibility. Conceptually, we are interested in direct impacts of conservation interventions on people and/or TCMEs, as well as indirect impacts (Fig. 1). In order to include a broad suite of interventions as well as multiple social and ecological outcomes, we narrowed our focus on TCMEs to coral reefs, mangroves, and seagrasses. Even with this narrowing, the scope is broad in comparison with many other reviews. This broad scoping is possible through Duke University's Bass Connections program, which facilitates student participation in research projects as part of the educational experience. We planned our review project knowing a large team of undergraduate and graduate students (n = 10–20) will be available to assist with screening each semester, and that we will be able to run the project in multiple years. The project is funded through Bass Connections core funding as well as funding made available to both Duke and WWF to support collaboration.
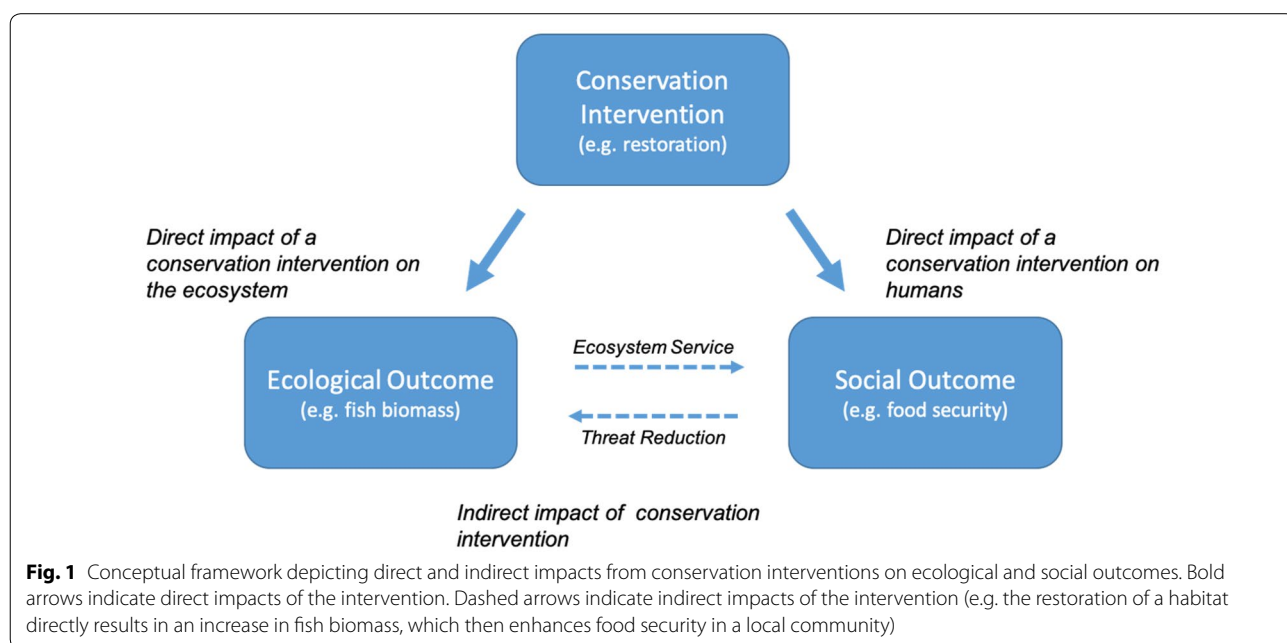

Fig. 1 Conceptual framework depicting direct and indirect impacts from conservation interventions on ecological and social outcomes. Bold arrows indicate direct impacts of the intervention. Dashed arrows indicate indirect impacts of the intervention (e.g. the restoration of a habitat directly results in an increase in fish biomass, which then enhances food security in a local community)

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Framework development

The IUCN-Conservation Measures Partnership's (IUCN-CMP) *Conservation Actions v2.0* was developed to provide a uniform framework for conservation interventions [35]. This framework identifies three distinct conservation interventions or action types: (i) target restoration/stress reduction actions, (ii) behavioral change/threat reduction actions, and (iii) enabling condition actions. Within these three action types are 10 conservation action categories: (1) land/water management, (2) species management, (3) awareness raising, (4) law enforcement and prosecution, (5) livelihood, economic, and moral incentives, (6) conservation designation and planning, (7) legal and policy frameworks, (8) research and monitoring, 9) education and training, and 10) institutional development. Building on this pre-existing framework ensures uniformity in our designation of conservation actions, and allows for reproducible and/or comparable results in future studies. Although some marine issues and examples are included in the framework, most are terrestrial, so we adapted the IUCN-CMP framework (with input and feedback from interviews with marine conservation practitioners) to better represent TCMEs. For example, we added the subcategories of *habitat management* and *fisheries management* to the *species management* category, as both are relevant to managing marine species at different life stages (e.g. habitat management might be relevant at the larval stage). Further, in contrast to many wild terrestrial species targeted for conservation, fish are frequently harvested making fisheries management relevant for conservation. The adaptation of the IUCN-CMP typology itself is a valuable contribution, providing a framework to better understanding the evidence base for marine conservation interventions.

We compiled our conservation outcomes framework from existing systematic reviews and syntheses on conservation topics [36–38], a pre-existing theory-based framework for analyzing conservation impacts [39], and the Millennium Ecosystem Assessment [10]. We identified and synthesized seven outcome categories of interest: (1) animal population/species, (2) ecological community, (3) ecosystem function, (4) ecosystem services, (5) human knowledge and behavior, (6) human well-being, and (7) governance. We modified existing human well-being outcome frameworks (e.g., [36], to recognize governance as a separate outcome category, distinct from human well-being. We define governance as "the formal and informal institutions through which authority and power are conceived and exercised" [40], and recognize that conservation interventions can reshape governance systems, in ways that may be positive, negative or neutral for both social and ecological outcomes. In this way, we classify governance as a potential mediator of social or ecological outcomes, as well as an outcome in its own right. We also further expand on the types of relations and processes that constitute governance in our framework, in order to provide additional clarity.

Our intervention and outcome framework (Additional file 1: Intervention framework & Additional file 2: Outcome framework) were finalized after a workshop in September 2018 during which the majority of the collaborators and review team members were able to meet in person, discuss the frameworks, agree on definitions, and test their application to sample articles.

Objective of the review

The primary objective of this systematic map is to identify and describe the evidence base surrounding the social or ecological outcomes of a broad range of conservation interventions undertaken in TCMEs, and specifically in tropical coral reef, mangrove, and seagrass ecosystems (Table 1). The map can direct further research into evaluating the evidence base, through systematic reviews and meta-analyses of results.

We limited the geographic scope of the study to tropical coastal marine ecosystems. In doing so, we distinguished among ecological (e.g. species present, ecosystem characteristics), social-economic (e.g. GDP, direct reliance of communities on coastal marine resources), and governance (e.g. role of state and non-state actors in governance, poverty alleviation mandates) characteristics in tropical, primarily low-income and lower-middle-income countries of the Global South. Although the distinction is imperfect and

Table 1 Key elements of review question

Population	Intervention	Comparator	Outcome
Individuals animals, populations, species, ecological communities, and/or human communities that live within and/or rely on tropical coral reef, mangrove, or tropical seagrass habitats	Adoption or implementation of coastal marine conservation intervention (see Table 3)	Comparison of intervention types, impacts over time, over space, against a control, or among groups	Impacts on human well-being, attitudes, behavior, or knowledge OR on individual animals, populations, species, ecological communities, or habitats (see Table 4)

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coarse, narrowing in on the tropics allowed us to capture a broader suite of outcomes in our map (e.g. both ecological and social outcomes) than would be possible otherwise. Further, as noted above, the vulnerability and resource dependency of people using TCMEs suggest that they should be a high priority for both science and conservation practice.

Our goal is to provide a map that details the extent of the literature directed at assessing evidence of the social or ecological outcomes of a broad range of conservation interventions in TCMEs, and specifically coral reefs, mangroves, and seagrasses. The map will highlight promising areas for further detailed investigation to assess the nature of the relationships (e.g. strength of evidence, directionality, durability, etc.) between interventions and outcomes. It will also highlight interventions for which there is little existing research. Ultimately, we hope to provide direction for scientific, philanthropic, government, and non-government organizations as they decide how to invest limited resources in programs, policies, research and interventions in these critical tropical coastal marine ecosystems.

This systematic map seeks to answer the following review question:

1. *What is the extent and occurrence of articles that examine the effects of conservation interventions on ecological or social outcomes within tropical coral reefs, mangroves, and seagrass ecosystems?*

We will also address the following secondary review questions:

a. *What are the characteristics of the evidence base in terms of habitats, geography, study design, geographic scale, and outcomes studied?*
b. *What linkages between interventions and outcomes are most represented in the evidence base, and thus promising areas for further evaluation, analysis and synthesis?*
c. *What interventions and outcomes are less represented in the evidence base, thus requiring additional investigation?*

Methods

ROSES forms and reporting standards [41] were followed to ensure compliance with CEE systematic synthesis guidelines (Additional file 3: ROSES form for systematic map protocols).

Search for articles

Search terms

We developed a search string comprising five distinct sub-strings. The five sub-strings represent: coastal qualifiers, population, intervention, outcome, and change strings. We developed individual search terms based on our population and conservation interventions and outcomes of interest. We tested each search term for sensitivity, wildcards (e.g. conserv*), and alternate wording (Additional file 4: Evolution of search string).

Marine-coastal qualifying terms

TS = ("marine" OR "coastal" OR "fisheries" OR "fishery")

AND

Population terms

TS = (coral OR mangrove OR seagrass OR SAV OR "submerged aquatic vegetation" OR communit* OR stakeholder OR habitat OR people OR resource OR ecosystem)

AND

Intervention terms

TS = (conserve OR conserving OR conserved OR conservation OR restoration OR restore OR reintroduction OR gear OR quota OR "catch limit" OR "size limit" OR moratorium OR "fishing ban" OR "endangered species" OR "threatened species" OR advocacy OR awareness OR communication OR patrol* OR compliance OR enforcement OR ecotourism OR "alternative livelihoods" OR stewardship OR "payments for ecosystem services" OR PES OR subsidies OR LMMA OR "marine park" OR "marine reserve" OR MPA OR "marine protected area" OR "biosphere reserve" OR "restricted area" OR "marine sanctuary" OR "no take" OR "area closure" OR "buffer zone" OR "access rights" OR "marine spatial plan*" OR "marine plan*" OR "action plan" OR "pollution mitigation" OR "wastewater treatment" OR "runoff treatment" OR law OR policy OR govern* OR CITES OR ESA OR "endangered species act" OR train* OR education OR capacity-build* OR partnership OR "blue carbon" OR CBNRM OR co-management OR media OR certification OR (invasive NEAR/3 (removal OR manag*)) OR (management NEAR/3 (fisher* OR "locally managed" OR "watershed" OR community-based OR "natural resource" OR "natural resources" OR "ecosystem-based" OR "ecosystem based" OR "harvest" OR "area")))

AND

Outcome terms

TS = (awareness OR adoption OR "willingness to" OR ((population OR species) NEAR/3 (abundance OR biomass OR density OR diversity OR "genetic diversity" OR productivity OR fecundity OR reproducti* OR

distribution OR range OR dispersal OR migration)) OR "genetic diversity" OR "ecosystem service" OR "ecosystem services" OR "coral cover" OR "habitat cover" OR degradation OR recovery OR "functional diversity" OR "community composition" OR well-being OR "well being" OR well-being OR welfare OR security OR livelihood OR job OR employment OR asset OR income OR decision-making OR govern* OR empowerment OR participat* OR equity OR "human health" OR nutrition OR mortality OR disease OR consumption OR skill OR degree OR training OR literacy OR access OR "water clarity" OR "water quality" OR sanitation OR "building materials" OR housing OR fuel OR expenditure OR safety OR adapt* OR resilienc* OR engagement OR "carbon sequestration" OR "carbon sink" OR "carbon storage" OR "coastal protection" OR "shoreline protection" OR erosion OR "air quality" OR "air pollutants" OR biodiversity OR richness)

AND

Change terms

TS = (change OR effect* OR impact OR recover* OR contribute)

Searching the literature

We will conduct searches using this string across a range of resources including: publication databases, organizational websites, key informants, relevant bibliographies, and grey literature. Search results will be limited to the English language, the language of our review team.

Publication database searches

Four publication databases will be searched:

Web of Science

1. An *Advanced Search* of *All Databases* will be conducted within Web of Science.
   a. Databases include: Web of Science Core Collection, BIOSIS Citation Index, Current Contents Connect, Data Citation Index, Derwent Innovations Index, KCI-Korean Journal Database, Medline ®, Russian Science Citation Index, SciELO Citation Index, and Zoological Record.
2. *All Years (beginning 1864)* will be searched.
3. The language selected will be *English.*
4. The field tag *TS* will be used. This tag searches document title, abstract, and keywords for the selected search terms.

Scopus

1. Advanced Search

2. The field code TITLE-ABS-KEY will be used. This code searches for terms in the document title, abstract, and keywords.

CAB Abstracts

1. An *Advanced Search* of *Cab Abstracts** and *Cab Abstracts Archive** will be conducted within CAB Abstracts.
2. Search Modes and Expanders
   a. Search modes: *Boolean/Phase*
3. Limit your results
   a. Publication Type: *All**
4. Special limiters for CAB Abstracts
   a. Broad Category: *All**
5. Special limiters for CAB Abstracts Archive
   a. Subject Subset: *All**
6. Select a Field

   a. TI Title
   b. AB Abstract
   c. SU Subject Terms

Aquatic Sciences and Fisheries Abstracts (ASFA)

1. Advanced Search
   a. All databases, publication dates (1940–2018), sources, subjects, and document types will be searched, including peer reviewed and non-peer reviewed literature.
2. The field tags, TI, AB, and IF will be used to limit searches to document title, abstract, and keywords/identifiers for search terms.

Targeted searches and grey literature

We will search organizational websites (identified by key informants and through a review of other systematic reviews) for relevant additional literature (both peer-reviewed and grey unpublished literature) (Table 2). We will also check web-based bibliographies identified during the web searching phase for additional references.

Comprehensiveness of the search

Initial scoping exercises performed in Web of Science, Scopus, CAB abstracts, and ASFA yielded approximately 104,987 potentially relevant articles. A reference library

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Table 2 Organizational websites

Organization	Website
A Rocha International	http://www.arocha.org/en/
Biodiversity Support Program	https://rmportal.net/library/content/tools/biodiversity-support-program
California Cooperative Oceanic Fisheries Investigations	http://www.calcofi.org/
Caribbean Natural Resources Institute	https://www.canari.org/
Centre for Environment, Fisheries & Aquaculture Science	http://www.cefas.defra.gov.uk/
Conservation International	https://www.conservation.org/
Collaboration for Environmental Evidence library	http://www.environmentalevidence.org/
Conservation Evidence	https://www.conservationevidence.com/
Coral Reef Alliance	https://coral.org/
Coral Reef MPAs of East Asia and Micronesia	http://mpa.reefbase.org/
Department of Conservation, New Zealand	http://www.doc.govt.nz/
Department for Environment, Food and Rural Affairs	http://www.defra.gov.uk
Department of Sustainability, Environment, Water Australia	http://www.environment.gov.au/
Food and Agriculture Organization	http://www.fao.org/
Global Mangrove Alliance	http://www.mangrovealliance.org/
International Institute for Environment and Development	https://www.iied.org/
The Nature Conservancy	https://www.nature.org/
International Union for the Conservation of Nature	https://www.iucn.org/
Joint Nature Conservation Committee	http://jncc.defra.gov.uk/
Locally-Managed Marine Area Network	http://lmmanetwork.org/
NatureServe	http://www.natureserve.org/
NCCOS Center for Coastal Monitoring and Assessment	https://coastalscience.noaa.gov/
NOAA National Marine Protected Areas Center	http://mpa.gov/
Rare	https://www.rare.org/
United Nations Environment Programme (UNEP)	https://www.unenvironment.org/
UNEP World Conservation Monitoring Center	https://www.unep-wcmc.org/
United Nations Development Programme	http://www.undp.org/content/undp/en/
United States Agency for International Development	https://www.usaid.gov/
USAID Development Experience Clearinghouse	https://dec.usaid.gov/dec/home/
Wildlife Conservation Society	https://www.wcs.org/
World Bank	http://www.worldbank.org/
World Wide Fund For Nature	https://www.worldwildlife.org/

of 20 articles was developed to check to the comprehensiveness of the search strategy (Additional file 5: Article test library). Reference articles were compiled from previous systematic maps and reviews, key informants, and general searches on the internet. Searches were refined until at least 75% of the of the reference articles were retrieved.

Review phases

To accommodate the large number of articles returned by our search strategy, we plan to work in phases, for example, by limiting our initial screening and data coding to a 10% random sample of the returned articles. The subset will be identified using Excel's random number generator to select article Record IDs in EndNote. A 10% sample provides a number of articles that exceeds the threshold required for a 95% confidence level, with 1 margin of error, that the sample represents the total population of articles. Working in phases will help to ensure that student team members realize progress and participate in both article screening and data coding over the course of their participation in the project.

Reference management

The titles and abstracts of candidate articles identified through the search strategy will be downloaded from the four bibliographic databases and uploaded into Endnote X8. Duplicate articles will be identified and removed via Endnote's *Find Duplicates* tool. Once duplicates are removed, search hits will be imported and screened (title/abstract, full text) in Colandr, an open-access, machine-learning assisted tool for conducting evidence syntheses [42]. A single member from the research team will manage the EndNote library and assign articles to the various Colandr accounts for members of the review team to screen.

Article screening and study eligibility criteria
Screening process

All articles will be screened by members of the review team, which includes the Duke research team and students participating in the Bass Connections project. Each screener will be extensively trained during weekly project meetings and in smaller work groups. Articles will first be screened at the title/abstract level. Each article will be double-screened to ensure consistency between reviewers; each individual screener will screen with other members of their group, and we will avoid pairs of screeners always working together. Uncertainties and conflicts in screening decisions at both title/abstract and full text review stages will be discussed and resolved between reviewer pairs, with larger discussion by the review team

if necessary. Weekly discussion meetings will ensure that screeners share an understanding of screening and data coding protocols, and will help avoid 'drift' (i.e. where some screeners develop their own interpretation of protocols). All screening decisions at both stages will be recorded and made available. Review team members will not be permitted to screen articles they have co-authored.

Eligibility criteria

Articles meeting the following criteria will be included:

Population

In order to fully capture the extent of impacts on social or ecological components of tropical coastal marine systems, we include articles examining both species and human populations (e.g. individuals, households communities, and/or nation states) that directly rely on these habitats. Specifically, we include articles that examine species that rely on these habitats for survival (e.g. key life stages) and human populations that are directly reliant, adjacent, or inextricably connected to tropical coral reef, mangrove, or seagrass habitats. We will exclude articles that do not have a clearly defined affected population (e.g. global good, coastal ecosystems broadly, etc.) or focus on non-tropical or deep sea habitats/species (e.g. cold water corals, temperate seagrasses) or highly migratory species where these ecosystems do not represent a major part of their life history (e.g. tuna).

Intervention

We will focus on articles that evaluate the establishment, adoption, or implementation of conservation interventions that aim to manage, restore, improve, or increase the capacity of a site, area, natural process, or species within coral, mangrove, or seagrass ecosystems. Intervention types are: land/water management; species management; awareness raising; enforcement and prosecution; livelihood, economic, and other incentives; conservation designation and planning; legal and policy frameworks; research and monitoring; education and training; and institutional/organizational development (Table 3; Full table with examples in Additional file 1: Intervention framework).

Outcome

We will include articles that describe impacts on one or more domains of ecosystem health (population/species abundance/diversity, community structure, ecosystem condition/habitat cover, ecosystem services), knowledge and behavior change, human well-being, and governance.

Specifically, we will include articles that attempt to evaluate or document change in and across these elements for both observed and perceived outcomes (Table 4; Full table with examples in Additional file 2: Outcome framework).

Intervention framework adapted from IUCN CMP Actions Classification v2.0 framework

Study design

We will include articles that attempt to evaluate or document the impacts of a conservation intervention using a relevant comparator. This includes experimental, quasi-experimental, and non-experimental, narrative, and observational studies. We will exclude theoretical studies, theses and dissertations, opinion pieces, studies where outcomes are modeled or predicted, studies where the population is not defined, and non-systematic literature reviews.

Comparator

Studies with a comparator will be included. This includes temporal comparators (before/after, time series), spatial comparators (distance from site, between different sites), among groups (inside/outside intervention areas, demographic groups), between control and intervention (with/without). Quantitative and qualitative studies of natural and social outcomes will be included, provided there is an attempt to evaluate or document change in relation to the interventions of interest. Studies may document actual change, or change as perceived by people. Recognizing that strict comparators are difficult to ensure with in situ conservation work involving ecosystems and people, screeners will err on the side of inclusion during both screening and data coding.

Study validity assessment

A critical appraisal of study quality and strength will not be formally undertaken at this stage of the study, although the internal validity of included articles can be heuristically evaluated using information from the data coding questionnaire. The primary objective of our map will be to characterize the extent and distribution of the evidence base through identifying all relevant literature using our comprehensive search, detailed above.

Data coding strategy

The initial data coding questionnaire was developed through an iterative process. We will code data in relation to five broad categories: (1) reviewer information, (2) bibliographic information, (3) basic information on study location, scope, design and habitat, (4) conservation interventions, and (5) ecological and social outcomes (Additional file 6: Data coding questionnaire).

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Table 3 Categories and subcategories of conservation interventions

Intervention category	Intervention definition	Intervention subcategory
1. Land/Water Management	Actions directly managing or restoring sites, eco-systems and the wider environment	1a. Site/Area Stewardship 1b. Restoration 1c. Ecosystem & Natural Process Management
2. Species Management	Actions directly managing or restoring specific species or taxonomic groups	2a. Habitat (seagrass, mangroves, coral reef) management 2b. Fisheries management 2c. Species stewardship 2d. Species Reintroduction and Translocation 2e. Ex-Situ Conservation
3. Awareness Raising	Actions making people aware of key issues and/or feeling desired emotions, attitudes, opinion designed lead to behavior change	3a. Outreach & Communications 3b. Protests & Civil Disobedience 3c. Political Lobbying and Campaigning
4. Enforcement & Prosecution	Actions monitoring and enforcing compliance with existing laws and policies (including customary) at all levels to deter threats or compel conservation action	4a. Monitoring/Detection 4b. Criminal Prosecution & Conviction 4c. Non-Criminal Legal Action 4d. Customary law/rule enforcement
5. Livelihood, Economic, and other Incentives	Actions using livelihood, other economic and moral incentives to directly influence attitudes and behaviors	5a. Linked Enterprises & Alternative Livelihoods 5b. Consumer or producer substitution, through technology or product innovation 5c. Corporate practices and engagement 5d. Market-Based Incentives 5e. Direct Economic Incentives 5f. Social and cultural values 5 g. Agency incentives 5 h. Resource use incentives
6. Conservation Designation & Planning	Actions directly protecting sites and/or species	6a. Protected Area Designation &/Or Acquisition 6b. Easements & Resource Rights 6c. Land/Water Use Zoning & Designation; marine spatial planning 6d. Conservation Planning 6e. Community based planning for resource management and conservation 6f. Site Infrastructure
7. Legal & Policy Frameworks	Actions developing and influencing legislation, policies and voluntary standards affecting conservation	7a. Laws, Regulations, & Codes 7b. Policies & Guidelines 7c. De jure property rights
8. Research & Monitoring	Actions collecting data and transforming it into information to support conservation work	8a. Basic Research & Status Monitoring 8b. Evaluation, Effectiveness Measures, & Learning
9. Education & Training	Actions enhancing the knowledge and skills of specific individuals	9a. Formal education 9b. Informal education 9c. Training
10. Institutional/organizational development	Actions creating the formal institutions and organizations needed to support conservation work	10a. Internal Organizational Management & Administration 10b. External Organizational Development & Support 10c. Alliance & Partnership Development 10d. Financing Conservation

Intervention framework adapted from IUCN CMP Actions Classification v2.0 framework

Data coding for each article will be completed by two reviewers and conflicts will be reconciled between them, consulting the larger review team if needed.

Study mapping and presentation

We will summarize the resulting dataset to compile descriptive statistics, such as article publication by year, frequency of comparator type, geographic distribution of study locations, frequency and distribution of study design for evaluating type of outcomes, or change in study interventions and outcomes over time, using the R statistical software (version 3.6). We will produce a series of intervention-outcome matrices populated with counts of studies within each intervention-outcome (and associated sub-group) pairs (e.g. heat maps). This will allow us to identify where evidence is lacking and potential areas for future research. We will also produce geographic maps showing the spatial distribution of

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Table 4 Categories and subcategories of environmental and social outcomes

Outcome category	Outcome definition	Outcome subcategory
1. Population/Species Outcomes	Outcomes focusing on change in populations of individuals or populations within species	1a. Abundance 1b. Biomass 1c. Age/Size Structure 1d. Behavior 1e. Recruitment 1f. Reproduction 1g. Species Range and Spatial Extent 1h. Dispersal 1i. Connectivity 1j. Body Conditions 1k. Adaptability
2. Ecological Community Outcomes	Outcomes focusing on change in community conditions	2a. Species Diversity 2b. Trophic Structure 2c. Functional Redundancy 2d. Species Interactions 2e. Habitat Quantity (Cover and Extent) 2f. Habitat Quality 2g. Habitat Connectivity
3. Ecosystem Function Outcomes	Outcomes focusing on change in ecosystem processes and conditions	3a. Productivity 3b. Herbivory 3c. Predation 3d. Biogeochemistry 3e. Coastal Processes
4. Ecosystem Services Outcomes	Outcomes focusing on ecosystem services, as defined by Millenium Ecosystem Assessment	4a. Provisioning Services 4b. Regulating Services 4c. Supporting Services 4d. Cultural Services
5. Human Wellbeing Outcomes	Outcomes related to changes in welfare of populations that rely on areas where interventions are implemented; and/or program beneficiaries	5a. Economic 5b. Resource Based Livelihoods 5c. Individual or Community Wellbeing 5d. Food Security 5e. Health 5f. Education 5g. Basic Infrastructure 5h. Social Capital 5i. Culture
6. Knowledge and Behavior Outcomes	Outcomes related to awareness, knowledge, and/or behavior, or response to new practices or technologies, for stakeholders	6a. Knowledge 6b. Behavior/response to new practices or technologies
7. Governance	Structures and processes for decision-making, inc. formal and informal rules, participation in/control of decision making, accountability, transparency, justice, empowerment	7a. Participation and Engagement 7b. Political Capital 7c. Institutions 7d. Property Rights

studies by country or region along with summary plots and tables. This will allow us to identify priority areas for future research, evaluation, and theory development. Trends and patterns along with relevant insights for policy, practice and research will be summarized in a narrative report. The final dataset of included literature will be made available for future use and exploration through an open-access, interactive online portal. A data file of all literature screened, with reason for inclusion/exclusion and associated meta-data will also be made available upon completion.

Supplementary information

Additional file 1. Intervention framework.

Additional file 2. Outcome framework.

Additional file 3. ROSES form for systematic map protocols.

Additional file 4. Evolution of search string.

Additional file 5. Article test library.

Additional file 6. Data coding questionnaire.

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Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

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