Evidence Synthesis in Recreational Fisheries Science and Management

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Abstract Researchers have studied the behaviours of recreational fishers and conducted science to support recreational fisheries management for over 50 years, resulting in a large volume of literature. Yet, evidence users (e.g., practitioners and fishery managers) rarely have the time to sift through and reconcile the literature, leading to biased approaches from selective use of evidence. To help evidence users make sense of these studies in a manner that minimizes bias, various evidence synthesis methods can be used. However, these methods are not all robust, can themselves be subject to bias, and their uncritical use could lead to poor management decisions and outcomes. Evidence synthesis has been applied in recreational fisheries management in several contexts (e.g., to understand how social–ecological systems theory applies to recreational fisheries; to evaluate the effectiveness of angler gear choice on biological outcomes for fish or the impact of recreation angling on other taxa than fish), yet is often conducted using less rigorous, informal synthesis methodologies. By contrast, meta-analysis to support stock assessment is reasonably common, but these approaches are uncommon in recreational fisheries. Here, we briefly review the suite of evidence-synthesis methods available, consider their strengths and weaknesses, and outline key steps involved in their conduct. We explore synthesis methods including traditional narrative literature reviews, systematic maps, rapid evidence syntheses, (quantitative) meta-analysis, and systematic reviews (which often include meta-analysis). In doing so, we also briefly review past evidence syntheses on this topic and summarize ways in which evidence synthesis can be best used to support recreational fisheries management in the future.

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K. L. Pope et al. (eds.), *Understanding Recreational Fishers*, Fish & Fisheries Series 45, https://doi.org/10.1007/978-3-031-99739-6_19

Keywords Decisions · Evidence · Fisheries management · Literature review · Meta-analysis · Systematic review

1 Introduction

Empirical research is very much the foundation of knowledge generation, whether it be in the health sciences (Bowling 2014), education (Drew et al. 2007), or the environmental sciences (Montello and Sutton 2012). Such studies—whether observational or experimental—generate important understanding of how the world works, ideally when informed by underlying theory. Yet, we also know that a similar study conducted on a different system or in a different context could result in vastly different findings. One empirical study is but one perspective on how the world works (Yanow and Schwartz-Shea 2015). There are many opportunities for bias or error to be introduced into empirical research (Sica 2006; Smith and Noble 2014). Moreover, the ecological and social world is complicated and that is particularly the case when studying distinct species, assemblages, ecosystems, and social systems as well as their interactions, as is so common in fisheries science. The resulting complexities represent routine struggles of practitioners and decision makers. In the context of this chapter, practitioners and decision makers are those involved in the governance and management of recreational fisheries, often but not always as part of government agencies. They tend to operate at local scales (e.g., waterbodies, basins) but may be involved in more regional, state, or provincial level, national, or even international activities. Although decision makers and practitioners tend to be tasked with making decisions and implementing various interventions (e.g., harvest regulations, restoration), they may also be involved in fisheries assessment. A practitioner or decision maker that relies on a single empirical study could be misguided: e.g., one may inadvertently or intentionally select the one study that reveals that a given intervention is beneficial for a given issue, yet ignore the many other studies that were equivocal. It is now well understood that greater understanding and potential to minimize bias come from synthesizing the evidence on a given topic through some form of evidence synthesis of the published record (Briner and Denyer 2012). We acknowledge that decisions involve considering various outcomes and always involve uncertainty, but evidence synthesis has the potential to reduce such uncertainty (Downey et al. 2022b).

Evidence syntheses come in many forms. From mini-reviews conducted in a matter of days and that are subject to many biases to the "gold standard" systematic reviews that use rigorous, repeatable methods in an attempt to minimize bias and often include meta-analysis (when the evidence base is amenable to it—e.g., quantitative rather than qualitative data), with many other forms in between. Some reviews are entirely narrative, whereas others use meta-analytical approaches to analyse existing data to determine the collective effect of a given impact or outcome. The relative strengths and weaknesses of each form of evidence synthesis are varied and need to be considered carefully when deciding which evidence synthesis method to use, or for interpreting the relative bias associated with existing evidence syntheses. Assuming evidence synthesis is being done in the service of decision makers, involving them in the process from the beginning to help determine which type of evidence synthesis is necessary is an important first step. Social science research focused on environmental decision makers (including fisheries managers) has revealed that they value evidence syntheses, understand that evidence syntheses are not all created equal, and would use systematic reviews if they were available on topics relevant to the decisions they make (Thomas-Walters et al. 2021). In other disciplines such as education and healthcare, robust evidence syntheses have become the foundation of decision-making (e.g., Pullin and Knight 2001), with this concept still novel for other realms, such as those related to environmental management (Sutherland et al. 2004) or recreational fisheries. What is clear is that for a variety of reasons (expansion of evidence base, recognition of the value of evidence synthesis), evidence syntheses are being increasingly recognized as important vehicles for improving decisions.

Recreational fishing is a popular fisheries sector. It is defined by the United Nations (UN) Food and Agriculture Organization (FAO) as "fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets" (FAO 2012). Although recreational fishing varies in popularity among regions, in developed nations it is often the dominant sector targeting fish in inland and some nearshore coastal waters (Arlinghaus et al. 2002). Recreational fisheries are considered good examples of complex social–ecological systems (Arlinghaus et al. 2017) whereby recreational fishers influence aquatic ecosystems while aquatic ecosystems influence people engaged in fishing. In the context of recreational fisheries science and management, there is growing recognition that effective management requires adoption of social–ecological systems frameworks and thinking, given the inherent interconnections between the environment (including fish) and people (i.e., the recreational fishers), and the reality that many systems are constantly changing (Arlinghaus et al. 2016). As such, there is a need to conduct science of all forms (i.e., spanning the natural and social sciences) and generate evidence to inform decision-making (FAO 2012), to ensure that recreational fisheries are sustainable, as well as beneficial to people and ecosystems today and in the future (Elmer et al. 2017). Given the complexities of managing recreational fisheries, evidence synthesis is a potentially powerful tool for understanding disparate evidence and identifying what it means when aggregated. Evidence synthesis also serves to determine the generalizability of observations and understand the contexts in which evidence from one context can be applied to another. More broadly, evidence synthesis (in particular meta-analysis) has been embraced in other domains of fisheries science and management (reviewed in Hilborn and Liermann 1998; Myers 2001; Thorson et al. 2015), suggesting that evidence synthesis could easily be mainstreamed for recreational fisheries and the human dimensions of this sector.

The objective of this chapter is to summarize the suite of evidence synthesis methods available, consider their strengths and weaknesses (Table 1 and 2), and outline key steps involved in their conduct with a particular focus on recreational fisheries science and management. We explore synthesis methods including

Table 1 Features of different evidence synthesis (components that are specific strengths of each type are highlighted in bold, and weaknesses are underlined; based on summaries by Dicks et al. 2014b; Cook et al. 2017; Dicks et al. 2017; CEE 2018)

	Traditional Narrative Review	Meta-analysis	Systematic Review	Rapid Review	Systematic Map	Evidence Synopses
Description	**Exploratory syntheses used in cases where specific/testable questions may be lacking** (i.e., historical contexts, theory building) or where literature is too diverse for other synthesis techniques.	Aggregative syntheses combining **comparable studies statistically** to test a hypothesis	Aggregative evidence syntheses **answering defined questions using transparent, repeatable methods, in an unbiased way** through narrative and potentially quantitative or qualitative synthesis (may or may not include meta-analysis).	An accelerated evidence synthesis similar to a systematic review, but on a **short time scale** to meet emergency decision-making requirements.	Exploratory syntheses that **collate and describe the state of knowledge** and available literature on a topic.	**Summarizes** existing evidence syntheses **for managers and policy makers** (i.e., short summaries or briefs)
Scope	Broad	Specific	Specific	Specific	Broad	Variable[a]
Defined methodology applied	Rarely	Sometimes	**Always**	Sometimes	**Always**	Variable
A priori protocol published	Rarely	Rarely	**Always**	**Always**	**Always**	Variable
Systematic literature search used	Rarely	Sometimes	**Always**	Sometimes	**Always**	Variable
Specific inclusion	Sometimes	**Always**	**Always**	**Always**	**Always**	Variable

criteria applied						
Critical appraisal of study validity conducted	Rarely	Rarely	**Always**	Sometime	Sometimes	Variable
Quantitative synthesis conducted	Never	**Always**	Sometimes	Sometimes	Not applicable	Variable
Qualitative synthesis conducted	Never	Not applicable	**Sometimes**	Sometimes	Not applicable	Variable
Narrative synthesis conducted	**Always**	Sometimes	Always	**Always**	**Always**	Variable
Resources (time, money, expertise)	**Low**	Moderate	Very high	Moderate	Moderate/High	**Low**
Type of outcomes	Narrative synthesis[b]	May include brief description of literature included in meta-analysis **Measures of effect**[b]	Literature database Narrative synthesis Meta-analysis with measure of effect **Measures of quality of the available literature base**	Preliminary literature database Preliminary narrative or quantitative synthesis May include measure of overall effect or quality of the literature base	**Extensive literature database** Narrative synthesis	**Easy-to-read, quick summary** of outcomes of a synthesis May include specific recommendations for managers and decision makers
Risk of bias	High	Moderate/High	**Low**	Moderate	**Low**	Variable
Objectivity	Low	Moderate/Low	**High**	**High**	**High**	Variable
Transparency	Low	Moderate/Low	**High**	**High**	**High**	Variable

(continued)

Table 1 (continued)

	Traditional Narrative Review	Meta-analysis	Systematic Review	Rapid Review	Systematic Map	Evidence Synopses
Replicability	Low	Moderate/Low	**High**	**High**	**High**	Low
Example questions	How did X develop in a specific topic?	What is the effectiveness of an intervention? What is the effect of X on Y? What is the prevalence of a phenomenon? How reliable is a specific method?	What is the effectiveness of an intervention? What is the effect of X on Y? What is the prevalence of a phenomenon? How reliable is a specific method?	What is the effectiveness of an intervention? What is the effect of X on Y? What is the prevalence of a phenomenon? How reliable is a specific method?	What evidence currently exists? How much evidence is available? What interventions and outcomes are studied most frequently? What methods are used?	Dependent on the synthesis being summarized

[a]Dependent on the type of synthesis being summarized
[b]In some instances, authors use "vote-counting" (e.g., counting studies with significant vs non-significant results) to compare the number of positive or negative effects across studies. This should be avoided whenever possible because results can often be misleading. Vote-counting is highly subjective due to the difficulty of defining positive and negative outcomes and it does not provide a measure of magnitude of effect or take study validity and power into account (CEE 2018)

Table 2 Further information for the features of different evidence synthesis presented in Table 1 (components that are specific strengths of each type are highlighted in bold, and weaknesses are underlined (based on summaries by Dicks et al. 2014b; Cook et al. 2017; Dicks et al. 2017; CEE 2018))

	Traditional Narrative Review	Meta-analysis	Systematic Review	Rapid Review	Systematic Map	Evidence Synopses
Scope: Describes whether questions are normally formatted to determine an effect (specific) or are more flexible and can be used to explore various aspects of the literature base (broad) beyond testing a hypothesis or determination of an effect.						
	Broad	Specific	Specific	Specific	Broad	Variable[a]
Components of evidence synthesis: The inclusion of different components of evidence syntheses are determined by the type of evidence syntheses [i.e., systematic reviews need not always include meta-analysis), but where possible, the inclusion of these components can improve the relatability, repeatability, and transparency of the synthesis (Cook et al. 2017; CEE 2018)]. Here, we highlight whether different evidence syntheses commonly include particular components, or never include them, and identify whether this inclusion or exclusion of components is a strength or weakness of a synthesis. Note that some evidence syntheses may claim to meet the standards of different types, but in some instances may fall short. Tools such as the CEE's CEEDER (https://environmentalevidence.org/ceeder/; Pullin et al. 2022) can help decision makers determine if the evidence they are using meets high standards in conduct and reporting.						
Defined methodology applied: Defined methodologies assist authors in following a consistent approach that improves transparency and reproducibility. They can also decrease bias. Defined methodologies may be provided by organizations such as the Collaboration for Environmental Evidence (CEE 2018), or the Cochran Collaboration (Higgins et al. 2019).						
	Rarely	Sometimes	**Always**	Sometimes	**Always**	Variable
A priori protocol published: A priori protocols act as a guide for the conduct of an evidence synthesis from question formulation to analysis, decreases bias and decreases the risk of mission creep.						
	Rarely	Rarely	**Always**	**Always**	**Always**	Variable
Systematic literature search used: Systematic methods of literature searching from multiple sources (i.e., databases, search engines) help to ensure that the database created during synthesis is comprehensive and contains as much relevant literature as possible. If strategies are not comprehensive, bias may be introduced when relevant evidence is omitted. To be systematic, there should be a documented search strategy with clear, repeatable search strings that includes searches for grey literature.						
	Rarely	Sometimes	**Always**	Sometimes	**Always**	Variable
Specific inclusion criteria applied: Pre-defined inclusion criteria that avoid ambiguous terms help decrease reviewer bias and ensure articles are included in a transparent manner during the review process. Inclusion criteria ensure that subjectivity during screening is decreased, especially if multiple individuals are involved. Screening criteria should be tested through consistency checking among reviewers to avoid reviewer bias.						

(continued)

Table 2 (continued)

	Traditional Narrative Review	Meta-analysis	Systematic Review	Rapid Review	Systematic Map	Evidence Synopses
	Sometimes	**Always**	**Always**	**Always**	**Always**	Variable
Critical appraisal of study validity conducted: Enables weighting of evidence included in a synthesis based on the reliability of a study. Helps decrease the impact of bias within primary literature itself, while also ensuring that the generalizability of studies, as they relate to the synthesis question, is considered.						
	Rarely	Rarely	**Always**	Sometimes	Sometimes	Variable
Quantitative synthesis conducted: If sufficient information is available in the published literature, quantitative analysis (i.e., meta-analysis) may be conducted to determine an overall effect of an intervention.						
	Never	**Always**	Sometimes	Sometimes	Not applicable	Variable
Qualitative synthesis conducted: Syntheses of primary literature using qualitative techniques require different methods of synthesis than those reporting quantitative results. These are newer techniques in evidences synthesis and are normally found only in systematic reviews.						
	Never	Not applicable	**Sometimes**	Sometimes	Not applicable	Variable
Narrative synthesis conducted: Describes the literature base to provide context for further analysis (if possible).						
	Always	Sometimes	Always	Always	Always	Variable
Resources (time, money, expertise): Evidence syntheses take variable amounts of time and effort and require different expertise depending on the types of analyses conducted (e.g., to conduct a full systematic review requires both topic and methodological expertise) and vary significantly in person hours depending on resources available and the features of the evidence syntheses being considered (Haddaway and Westgate 2019). When technical expertise is moderate (i.e., systematic maps or meta-analysis), the size of the evidence base can strongly influence the resources needed (Cook et al. 2017).						
	Low	Moderate	Very high	Moderate	Moderate/High	**Low**
Type of outcomes:						
	Narrative synthesis[b]	May include brief description of literature included in meta-analysis **Measures of effect**[b]	Literature database Narrative synthesis Meta-analysis with measure of effect **Measures of quality of the available literature base**	Preliminary literature database Preliminary narrative or quantitative synthesis May include measure of overall effect or quality of the literature base	**Extensive literature database** Narrative synthesis	**Easy-to-read, quick summary of outcomes of a synthesis** May include specific recommendations for managers and decision makers

Risk of Bias, Objectivity, Transparency, and Replicability: Methods used should always aim to minimize risk of bias through inclusion of checks and balances (i.e., consistency checks, inclusion of critical appraisal etc.), while maximizing objectivity (CEE 2018). Transparency and replicability through robust, well-documented methods ensure that readers fully understand all critical steps used during the synthesis process and that other reviewers can repeat the synthesis when new evidence becomes available (Cook et al. 2017).						
Risk of bias:						
	High	Moderate/High	**Low**	Moderate	**Low**	Variable
Objectivity:						
	Low	Moderate/Low	**High**	**High**	**High**	Variable
Transparency:						
	Low	Moderate/Low	**High**	**High**	**High**	Variable
Replicability:						
	Low	Moderate/Low	**High**	**High**	**High**	Low
Example questions	How did X develop in a specific topic?	What is the effectiveness of an intervention? What is the effect of X on Y? What is the prevalence of a phenomenon? How reliable is a specific method?	What is the effectiveness of an intervention? What is the effect of X on Y? What is the prevalence of a phenomenon? How reliable is a specific method?	What is the effectiveness of an intervention? What is the effect of X on Y? What is the prevalence of a phenomenon? How reliable is a specific method?	What evidence currently exists? How much evidence is available? What interventions and outcomes are studied most frequently? What methods are used?	Dependent on the synthesis being summarized

[a]Dependent on the type of synthesis being summarized

[b]In some instances, authors use "vote-counting" (e.g., counting studies with significant vs non-significant results) to compare the number of positive or negative effects across studies. This should be avoided whenever possible because results can often be misleading. Vote-counting is highly subjective due to the difficulty of defining positive and negative outcomes and it does not provide a measure of magnitude of effect or take study validity and power into account (CEE 2018)

traditional narrative literature reviews, systematic maps, rapid evidence syntheses, meta-analysis, and systematic reviews (which often include meta-analysis). In doing so, we also briefly review past evidence syntheses that deal with recreational fisheries and summarize ways in which evidence synthesis can be best used to support recreational fisheries management today and in the future. In many ways, this chapter serves as a primer given that there are lengthy guidance documents (e.g., the Collaboration for Environmental Evidence guidelines for conducting systematic reviews) and entire textbooks on topics like meta-analysis.

2 Why Is Evidence Synthesis Relevant to Recreational Fisheries Science and Management?

2.1 Fisheries Managers and Other Practitioners Lack Time to Keep Up with the Entirety of an Evolving Evidence Base

The evidence base is continually expanding. This is, of course, beneficial but makes it more challenging for evidence users to keep up with new knowledge. Fisheries managers and other practitioners rarely have time to devote to reading new material, given that time itself is a precious resource (Pullin et al. 2004). To be clear, this is not about laziness or lack of commitment. It would take several days per week to try and keep on top of the evolving recreational fisheries literature, which is simply not reasonable. Evidence syntheses serve as collations of evidence to help practitioners focus their limited time on key resources.

2.2 Fisheries Managers and Other Practitioners Often Lack Access to the Entirety of an Evidence Base

Even if a fisheries manager has time to keep up with new research, that assumes that they have access to the entirety of the evidence base. Yet, it is well known that most of the evidence base is in the form of peer-reviewed papers that require subscription access. Some managers embedded within larger agencies have access to library support, but that is not always the case (e.g., small angling club context in central Europe, Daedlow et al. 2011). Although open access publishing is transforming access (albeit slowly; Willinsky 2006), the reality is that journal pay walls still limit access. Social science surveys of fisheries managers in North America have explicitly identified access as a major barrier (Nguyen et al. 2019). Without access to the entirety of the evidence base, key information can be missed. Evidence syntheses bring together evidence that can otherwise be difficult to access. Moreover, evidence syntheses are often published as open access so they can be accessible to evidence users.

2.3 Fisheries Managers and Other Practitioners Tend to Rely on Experience and May Ignore New Evidence

For a variety of complex reasons, it is common for fisheries managers and other environmental practitioners to rely on experience rather than using the entirety of the evidence base—especially new information (Pullin et al. 2004; Kadykalo et al. 2021). There are many barriers to including new evidence in decision-making that extend from the individual to the institution (for a summary in stocking, see Arlinghaus et al. 2022). This is problematic in that objective perspectives can be constrained, given that tradition and experience become codified as norms in decision-making. Evidence syntheses can illuminate alternative ways of doing things and provide the rationale for doing so, even if it means change.

2.4 Individual Empirical Studies Vary in Quality and Thus Can Be Biased in Various Ways

Research is not easy, and for assorted reasons (e.g., poor experimental design, errors, low sample sizes, other contextual influences), each study varies in quality, potentially introducing bias (Delgado-Rodriguez and Llorca 2004). Moreover, authors may take liberties and draw conclusions that are not well-supported by their findings. Although peer review attempts to improve the quality of research, it too is imperfect (Smith 2006). Indeed, criticisms can be found with every study; therefore, replication of individual study questions is important. If one were to read just one paper and uncritically accept that the author's conclusions are valid, there is potential for major bias that could lead to managers making poor (or even incorrect or counterproductive) decisions. Some evidence synthesis methods (e.g., systematic reviews) include quality appraisal phases intended to assess the potential for bias. Moreover, adoption of best practices for evidence syntheses can reduce biases related to searches and inclusion.

2.5 Fish and Fisheries Are Diverse and There is Need to Understand the Context in Which Different Pressures or Interventions Result in Various Outcomes

Fish are diverse, with ~30,000 known species (Helfman et al. 2009). There is also great variation in environments, ranging from small, inland waters to estuaries and the high seas. The fisheries sectors also vary dramatically (e.g., subsistence, commercial, recreational), and there is also much variation within sectors related to regional, cultural, geopolitical, or socio-economic factors. As such, it is necessary to determine the contexts in which various pressures (e.g., habitat loss, water quality, exploitation) and interventions (e.g., harvest controls, effort controls, habitat restoration) are effective. Evidence synthesis can be done in ways that consider how context influences impacts and outcomes, thus helping managers to determine when findings from one system can be applied to another. Meta-analytical approaches can be used to assess stock status, which has become common in the marine commercial sector (Hilborn and Liermann 1998; Myers 2001) and is increasingly being used in the recreational sector (Thorson et al. 2015; Cahill et al. 2022). Meta-analysis can also be used to synthesize classical human dimension context, such as studying the drivers of angler satisfaction (Birdsong et al. 2021) or preferences (Hunt et al. 2019).

2.6 Decisions Made by Fisheries Managers Are Often Controversial Such That There Is Need for Robust Evidentiary Support

Conflict and controversy are common when dealing with natural resources and environmental issues (Lewicki et al. 2003), including those relevant to recreational fisheries management (Arlinghaus 2005). Indeed, some recreational fisheries issues are so challenging that they are deemed to be "wicked problems" (Bower et al. 2017). It is common for recreational fishers that occur on a given waterbody to have various segments that may target distinct species or derive satisfaction in diverse ways that lead to conflict over fisheries management decisions (Hunt et al. 2023). Sometimes recreational fisheries management actions conflict with biodiversity conservation goals (Cowx et al. 2010). The more controversy or conflict, the greater the need for robust evidentiary support to inform management. Evidence syntheses, especially when conducted using robust methods, can provide fisheries managers with the evidence they need to make tough decisions—even if those decisions may not be popular among stakeholder groups (Cooke et al. 2017a).

2.7 Evidence Synthesis Reveals Gaps in the Evidence Base That Can Be Addressed Through Targeted Empirical Research

The evidence landscape is highly variable, with some topics being very well studied with an abundance of high-quality studies, whereas for other topics, there may be nothing. In the recreational fisheries realm, this is common, with much known about a few species (i.e., the most popular species in developed countries or research emphasizing specific countries and cultures, Birdsong et al. 2021). Although evidence synthesis is often done to identify what we do know about a given topic, it is equally useful for identifying what we do not know. These evidence gaps can serve to inform future research that could be conducted by (or funded by) the management agencies in need of such evidence. It is also a signal to the research community where there may be profitable partnerships and research topics when engaging in applied research (Cooke et al. 2020).

2.8 Evidence Synthesis Can Identify Deficiencies in How Empirical Research Is Conducted That Can Yield Direction for Future Researchers to Develop a Robust Evidence Base

Evidence syntheses that include aspects of critical appraisal can be useful for identifying the characteristics of research that are important for generating a robust evidence base (Sutton et al. 2009). Critical appraisal requires careful thought on aspects of experimental design that represent the “gold standard” for a given discipline or question while also recognizing inherent challenges that are common with some topics, including many relevant to environmental science and recreational fisheries (Cooke et al. 2017b). It is not uncommon for a systematic review to conclude that the overall evidence base for a given topic is weak (e.g., as Taylor et al. (2019) report for use of habitat restoration to improve substrate for spawning fish), and in doing so, set the bar for what researchers should strive for. In the context of human dimensions of recreational fisheries, for which there have been relatively few evidence syntheses (but see Johnston et al. 2006; Hunt et al. 2019; Birdsong et al. 2021; Schafft et al. 2021), this represents an important opportunity for enhancing the evidence base so that the evidence that is generated is of high quality and thus can be used in future evidence syntheses.

2.9 Evidence Syntheses Provide the “Big Picture” on What Works and What Doesn’t to Guide Evidence-Based or Evidence-Informed Decision-Making

Evidence-based decision making involves embracing evidence fully, whereas evidence-informed decision-making tends to acknowledge that other factors (e.g., politics, socio-economic reasons) may influence decisions. It is easy to cherry-pick findings or ignore vast swaths of the evidence base. Yet, what we need to keep our eye on is the “big picture” of what works and what does not. Almost always, one can find a study to refute or support one’s worldview. Yet, a robust evidence synthesis can bring together diverse sources of evidence to yield insight into what works and what does not—and in which contexts. There are always exceptions with science, and uncertainty is common in environmental decision-making (Ricci et al. 2003). Yet, it is those characteristics of science that reinforce the importance of evidence syntheses that bring together diverse studies and use robust methods (e.g., meta-analysis) to identify the primary signals in the evidence base (Sutton et al. 2009; Bartolucci and Hillegass 2010). In the context of recreational fisheries, it is equally easy to cherry-pick, given a reasonably substantial evidence base. Moreover, many recreational fisheries issues are emotionally charged, emphasizing the importance of objective, synthetic guidance (Elmer et al. 2017).

3 Types of Evidence Syntheses and an Overview of Their Conduct

Here, we provide an overview of the primary types of evidence synthesis and summaries of their conduct. The order in which they are presented does not reflect their relative rigor, but rather the concepts that are foundational to different forms of review. For example, rapid reviews are presented after systematic reviews because they involve a subset of steps found in other approaches, so it is sensible to first present the full systematic review model. We also wish to be clear that meta-analysis is a form of analysis that can be conducted with evidence and can be incorporated into other evidence synthesis methods (e.g., systematic review with meta-analysis).

3.1 Traditional Narrative Reviews

Narrative or traditional reviews are largely unstructured ways to synthesize literature. These reviews are generally comprehensive, cover a variety of topics, but often lack clarity of methods, such as how literature searches are conducted and how the relevance and validity of reviewed materials are assessed (Collins and Fauser 2005). The lack of structure when conducting narrative reviews results in criticisms of unreliability of results (Baethge et al. 2019) and concerns about subjectivity and bias affecting the validity of conclusions (e.g., Ferrari 2015; Siddaway et al. 2019).

We use a simple approach to differentiate narrative and systematic reviews (described in detail below). Systematic reviews focus on both structured ways that literature is searched and compiled and the presence of clearly identified and testable research questions. Narrative studies can include instances where researchers use structured methods for searching for literature but lack specific and testable research questions. Our distinction here is not universally accepted. For example, Green et al. (2006) differentiate qualitative systematic reviews from narrative reviews, whereas Siddaway et al. (2019) include narrative reviews as a potential type of systematic review. Our general definition is, however, consistent with calls by researchers to add structure when conducting narrative reviews (e.g., Ferrari 2015; Baethge et al. 2019).

Systematic reviews offer some advantages over narrative reviews in terms of transparency, reproducibility, explicitness, and clarity (Collins and Fauser 2005). Researchers conducting systematic reviews are explicit and transparent in their disclosure of methods and their purpose, thus making them reproducible (Siddaway et al. 2019). By contrast, researchers conducting narrative reviews seldom divulge (and often do not include) methods, heightening concerns about subjectivity, bias, and lack of reproducibility. Despite these advantages of systematic over narrative reviews, we believe that a few cases exist where narrative reviews are warranted.

The first case where narrative reviews offer an advantage over systematic reviews is when the literature review focuses on describing a field of study. Providing a historical context of literature is one such case where narrative reviews are commonly applied (Baumeister and Leary 1997). Systematic reviews are ill-conditioned in this case, as their limited scope and reliance on highly prescribed methods (Collins and Fauser 2005; Ferrari 2015) are at odds with the more exploratory focus of a historical context review. Arlinghaus et al. (2007) provide one such example of a narrative-based, historical context review from recreational fisheries through their comprehensive review of catch-and-release fishing, which included a human dimensions component about the drivers of catch-and-release behaviour of anglers.

The second case involves reviews that rely on inductive, rather than deductive reasoning. Deductive reasoning is synonymous with inference, whereby one moves from the general to the specific. For example, the science-based process of hypothesis testing starts with a general hypothesis that is evaluated using inferences drawn from specific methods and observations. In inductive reasoning, the researcher starts from the specific and works their way to the general. A literature review focused on developing theory is an example of inductive reasoning, whereby the observations (reviewed literature) are used to develop general theory or hypotheses. Narrative reviews are a valuable technique for theory building (Baumeister and Leary 1997). An example of this type of narrative review that is applied to recreation fisheries is from Hunt (2005), who reviewed literature from resource economics to theorize how recreational fishers choose fishing sites.

The third case for using narrative reviews is when results from the literature are based on different methods or conceptualization (e.g., Baumeister and Leary 1997; Siddaway et al. 2019). Quantitative systematic reviews fail in this case because of a lack of comparability among the reviewed studies. This failure can be overcome with narrative reviews that permit researchers to increase the scope of the review and to rely on less prescribed methods. Hyder et al. (2020) provide an example with their general review of marine recreational fisheries using literature and researchers' expressions of interest for contributing to a special issue to identify key themes and knowledge gaps.

Although narrative reviews are suitable in a few cases, researchers strongly recommend that additional structure be added to these reviews to address concerns with subjectivity and bias (e.g., Green et al. 2006; Ferrari 2015). Inconsistent guidance for conducting these reviews yields inconsistent methods. It is possible to produce reviews based on expert opinion rather than evidence from the literature (Wright et al. 2007) but that also comes with biases. Consequently, researchers conducting narrative reviews should better conduct (and communicate) their methods in ways that are reproducible and follow the growing advice on how to conduct these reviews (e.g., Ferrari 2015; Siddaway et al. 2019).

3.2 Meta-Analysis

A meta-analysis statistically aggregates effect sizes from studies investigating the same or related topics. Effect sizes represent the degree of evidence and are often statistics measuring relationships between two variables (e.g., correlation and its transformation, Fisher's Zr) and differences between two groups in continuous measurements (e.g., response ratio and standardized mean difference [SMD], also known as Cohen's *d* or Hedges' *d*) or in mortality or survival (e.g., odds ratio or risk ratio; White et al. 2021). Most (non-medical) meta-analyses use "unitless" statistics (e.g., all the effect size statistics mentioned above) so that meta-analysts can synthesize results measured in different units from different studies in a statistical model (note that one's research question dictates what effect size one chooses for their meta-analysis; see Nakagawa et al. 2017).

A formal meta-analysis weighs each effect size by the inverse of its corresponding sampling variance. How sampling variance is calculated differs among effect size statistics (e.g., Zr, SMD, and response ratio), but sampling variance always comprises sample size. Perhaps, it is intuitive that effect sizes (i.e., evidence) need weighting according to their sample sizes. Some meta-analyses are unweighted, but such meta-analyses have two shortfalls. First, unweighted meta-analyses are less precise because they give every effect size the same weight, rather than giving more weight to more precisely estimated effect sizes. Therefore, unweighted meta-analysis is more susceptible to publication bias. Second, unweighted meta-analysis cannot estimate heterogeneity among studies, which is due to differences in sample size (more on each concept [i.e., publication bias and heterogeneity] below; Nakagawa et al. 2023a, b).

Meta-analysis has become an essential part of the scientific process across different fields, especially in medical, social, and biological sciences (including in stock assessment for commercial fisheries (Hilborn and Liermann 1998) and even in recreational fisheries (Thorson et al. 2015; Cahill et al. 2022)). Although approximately a quarter of a million meta-analyses exist, the main aims of meta-analyses should usually fall into two categories: (1) estimating the overall effect size (evidence) and its heterogeneity, and (2) explaining the observed heterogeneity (Gurevitch et al. 2018). We can quantify an overall mean and heterogeneity among effect sizes using the "random-effects" model (another traditionally used model is called the "fixed-effect" model, but this model is now rarely used because it assumes zero heterogeneity). We may realize that an overall estimate itself may mean extraordinarily little without a measure of heterogeneity. This is because zero overall means with low heterogeneity likely represent the lack of an effect, whereas zero mean with high heterogeneity could mean true positive and negative effects depending on the contexts. An example of meta-analysis in the human dimensions of recreational fisheries is the meta-analysis by Birdsong et al. (2021), who looked at all the available evidence on drivers of angler satisfaction across the globe. A more ecological example is Schafft et al. (2021), taking a recreation ecology lens to look at the ecological impacts of recreational fishing and other water-based recreation on freshwater taxa. A final example is Hunt et al. (2019), who summarized all studies on angler preferences, but the way preferences are assessed in utility models prevented the use of formal meta-analytical approaches based on effect sizes.

There is a need for a meta-regression model to explain heterogeneity among effect sizes. A meta-analysis can be thought of as a model with just an intercept (i.e., overall mean), whereas a meta-regression is a linear model with predictors. In meta-regression, predictors are often referred to as “moderators.” Moderators can be any variables contributing to variation among effect sizes (e.g., separate locations, methods, and subject characteristics). A meta-regression can reveal patterns called “review-generated” evidence to contrast with “study-generated” evidence. For example, meta-regression can identify consistent differences between different methods or taxa or among different angler groups fishing different environments (Birdsong et al. 2021). Of relevance, Nakagawa and Santos (2012) stated that there are three types of moderators: biological, methodological, and contextual; the last kind of moderator relates to publication bias (see below). In a similar vein, Thorson et al. (2015) discussed three sources of heterogeneity that meta-regression could deal with: experimental variability (sampling differences), parametric (contextual differences), and functional variability (assumed underlying social or biological mechanistic differences). By identifying appropriate moderators, the importance of these different variabilities can be quantified and used to make context-dependent and species-specific predictions (Spake et al. 2022; for an example in human dimensions of angling, see Birdsong et al. (2021)).

Though often overlooked (Nakagawa et al. 2022), all meta-analyses (including a systematic review with meta-analysis) should have the third aim of quantifying publication bias in the dataset. Publication bias is almost certainly present in the data set (sample of studies); it comes in different forms, but the most famous one is due to the selective publication of statistically significant results. Such selective publication skews meta-analytic results, leading to biased conclusions. In a meta-analysis, this kind of publication bias manifests as the “small-study” effect, wherein studies with small sample sizes often have large effect sizes (Sterne et al. 2011). Another common type of publication bias is known as the “decline” effect, where the magnitude of the effect declines over time (Koricheva and Kulinskaya 2019). Recently, Nakagawa et al. (2022) reviewed methods for detecting and assessing the impacts of publication biases. Also, they proposed that in multilevel or hierarchical meta-regression models, one could detect and correct both the small-study and the decline effects by fitting the inverse of “effective” sample sizes and publication year, respectively, as moderators (Yang et al. 2023; cf. Andrews and Kasy 2019). Furthermore, they have noted that the most sophisticated, complex class of the methods are “selection models,” which considers the underlying process of how publication and selection bias occur, although implementations for relevant models for ecological and environmental research remain a challenge. Therefore, it is a common misunderstanding that publication bias renders meta-analytic results invalid. Notably, testing for publication bias allows one to quantify bias across studies, whereas critical appraisal attempts to estimate the risk of bias for each study. It is possible to include some elements of critical appraisal about each study in a meta-regression analysis as moderators (e.g., whether studies use randomization or blinding).

Finally, for a meta-analysis, or more accurately, a systematic review with meta-analysis, there is a well-known reporting guideline: PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses; Moher et al. 2009), or its recent update PRISMA 2020 (Page et al. 2021). However, PRISMA focuses on medical studies, so more relevant reporting guidelines for ecological and environmental studies are PRISMA-EcoEvo—a PRISMA extension for ecology and evolution (O'Dea et al. 2021). Another useful framework is ROSES (RepOrting standards for Systematic Evidence Syntheses), which is tailored reporting guidelines for systematic reviews and maps in environmental research, but it is equally relevant to meta-analysis (Haddaway et al. 2018).

3.3 Systematic Reviews (With or Without Meta-Analysis)

In the evidence synthesis world, systematic reviews are considered the gold standard for reliability (Haddaway et al. 2015). This is because they are a highly structured form of evidence synthesis where methods are detailed a priori in a protocol that has been externally peer-reviewed and published. The protocol is essential to minimize bias introduced from those conducting the review (e.g., resulting from ad-hoc decisions made or "mission creep" during the synthesis process). The common types of questions amenable to systematic reviews are: What is the effectiveness of an intervention? What is the effect of X on Y? What is the prevalence of a phenomenon? How reliable is a specific method?

The overarching goal of a systematic review is to answer a well-defined question as precisely and transparently as possible in an unbiased way. To accomplish this, the process includes the following key stages (detailed further in CEE 2018):

1. Creation of an advisory team with relevant stakeholders (including evidence users such as recreational fisheries managers).
2. Comprehensive searches for all relevant evidence on the specific topic from a variety of sources, including commercially published scientific literature and grey literature (that may or not be peer-reviewed).
3. Careful screening of all evidence according to predetermined inclusion criteria.
4. Critical appraisal of study validity (i.e., internal validity: a detailed assessment of the risk of bias by examining aspects of the methodology used to generate the study data [e.g., representative sampling, appropriate methods of measurement, and robust statistical analyses]; as well as external validity: an assessment of the generalisability of each study as it relates to the review question).

5. Transparent coding of study characteristics and extraction of study findings.
6. Well-documented and comprehensive synthesis of the qualitative or quantitative study findings.
7. Transparent reporting (and communication) of the review results with use of extensive supplementary information.

One of the components that often distinguishes systematic review from other forms of evidence synthesis is the inclusion of the critical appraisal of study validity (fourth key stage). When this component is not included in a synthesis, reviewers are essentially treating each study equally with respect to its reliability. If bias is present in primary studies, their results will be incorrect. Subsequently, if an evidence synthesis is based on incorrect evidence, synthesis results will also be incorrect, resulting in misleading conclusions (Boutron et al. 2019; Rytwinski et al. 2021). By following the above (stepwise and rigorous) methodology (including critical appraisal of study validity), systematic reviews identify risks of bias in the evidence itself, minimize bias in the way that evidence is identified, selected, and discussed, allow for repeatability, and thus provide reliable findings that could inform decision-making (Pullin et al. 2016; CEE 2018). These factors are what make systematic reviews more comprehensive and less open to potential bias than other review formats that summarize the literature in an unstructured way (e.g., traditional reviews and stand-alone meta-analyses) (Roberts et al. 2006; Koricheva and Gurevitch 2014; Pullin et al. 2020). However, systematic reviews are, as a result, more resource-intensive and easily take one year or more to complete (Haddaway and Westgate 2019).

Different forms of synthesis are possible with systematic review: narrative, quantitative, and qualitative. The type of synthesis used depends on the specific review question, as well as the available evidence base to address that question with respect to the amount and reliability of evidence, and the type of study data (i.e., qualitative, quantitative, or mixed study findings) (CEE 2018).

3.3.1 Narrative Synthesis

All systematic reviews include some form of narrative synthesis whereby findings of individual primary studies are synthesized with tables and figures (often with descriptive statistics) and supporting text to explain the context (e.g., study and population characteristics, study design, relevant outcomes). Included in the narrative synthesis should be a statement on the assessment of study validity. Sometimes, narrative synthesis is all that is feasible in terms of drawing study findings together (e.g., when faced with a pool of disparate studies of relatively high susceptibility to bias). Other times, quantitative synthesis (meta-analysis) or qualitative synthesis is also possible and appropriate.

3.3.2 Quantitative Synthesis

When attempting to measure the effect of an intervention or exposure, a quantitative synthesis is sought to provide a combined effect and a measure of its variance within and between studies, as well as to explore potential sources of heterogeneity (see Sect. 3.2 above). When the evidence base of a systematic review is comprised of studies with both higher and lower risks of bias, as noted previously, it is important to understand the potential impact of this bias on review results. This can be accomplished with meta-analysis, for instance, by means of developing study weights that account for study quality (Schafft et al. 2021) or sensitivity analysis (i.e., comparing results of models that include all studies, studies at lower risk of bias only, and studies at higher risk of bias only; see Rytwinski et al. 2021). To date, most systematic reviews in environmental management are syntheses of quantitative study findings (i.e., those with the intention of doing a meta-analysis but that was not possible given the available evidence base or those that were able to include a meta-analysis).

3.3.3 Qualitative Synthesis

In the environmental and conservation social science realm, it is common to use qualitative methods (e.g., interviews, observations of behaviour) to capture data (usually textual) on the views or reactions of individual people in relation to a question. Here, the goal of the qualitative synthesis is to describe the potential range of views to increase understanding of the context of some policy- and practice-relevant issue or issues (CEE 2018). A synthesis of evidence from qualitative research can add value to research and decision-making by exploring various questions. For example: how might a management strategy be best implemented? What are people's beliefs and attitudes towards an intervention? What is the extent of adoption of a conservation intervention? What are the barriers and facilitators to acceptability for an intervention? What are the priorities and challenges for local communities? (CEE 2018; Macura et al. 2019). Qualitative synthesis may stand alone or complement quantitative synthesis and contribute to a mixed methods approach that brings these evidence types together. Qualitative research related to the human dimensions of conservation and environment, though growing in popularity, has rarely been subject to evidence synthesis (CEE 2018). This is largely due to limited methodological guidance for environmental researchers to undertake such exercises, though progress is being made here (see Macura et al. 2019).

There are various resources available to support researchers undertaking a systematic review. For instance, the Collaboration for Environmental Evidence (CEE; www.environmentalevidence.org) provides step-by-step methodological guidelines (CEE 2018), a critical appraisal tool for evaluating risk of bias (prototype: https://environmentalevidence.org/cee-critical-appraisal-tool/), a set of reporting standards of review conduct (Haddaway et al. 2018), and an online tool for supporting conduct of evidence syntheses to follow the established CEE standards (Kohl et al. 2018).

We failed to find any examples of systematic reviews done to a high standard related to recreational fisheries management or the human dimensions within it. There are some that deal with other aspects of fisheries management, such as habitat enhancement and restoration (e.g., Taylor et al. 2019), but none that consider the tools typically used to understand recreational fishing impacts or interventions (e.g., harvest regulations, recreational fisher education).

3.4 Rapid Reviews

Rapid reviews, as their name suggests, are intended to be done with sufficient speed that they can be used to support decision-making when there is insufficient time (or funding) to enable a more comprehensive, systematic review. To save time, rapid reviews involve taking various "shortcuts" that represent the usual steps in a systematic review. For example, the scope of a search can be limited by species (e.g., only marine fish or only fish from the family Centrarchidae) or geography (e.g., only reservoirs in Europe or only estuaries in Australia). Similarly, the search string can be focused on a reduced subset of more focused search terms. Efforts to search websites or incorporate grey literature may also be omitted. All the aforementioned actions will yield a smaller suite of papers and, subsequently, reduce the time needed for screening and analysis. Yet, using a more limited evidence base also has consequences that could lead to bias. Other ways to expedite the review process include dropping the critical appraisal component of reviews. Doing so means that all evidence is treated equally, which fails to acknowledge the range of study "quality." Not surprisingly, this also introduces bias and makes it difficult to identify what aspects of study design are particularly important for subsequent studies that aim to improve or increase the evidence base.

Because of the shortcuts and associated biases that arise in rapid reviews (relative to full, systematic reviews), this approach receives much criticism, based largely on comparative studies between these and full, systematic reviews. Gannan et al. (2010) conducted a systematic review on the use of rapid reviews and revealed that they took from three weeks to six months to conduct (compared to systematic reviews, which tend to require 1 or more years, depending on resources). The authors determined that the most common methods for accelerating the review process were largely related to search limitations (e.g., only using certain years, focusing on a single database, using only a single language [usually English], and only using electronic sources). However, a variety of other methods have been used, including using a single reviewer for activities such as title and abstract screening or critical appraisal, or not preparing a formal protocol prior to conducting the review. The authors concluded that biases may be introduced due to shortened timeframes for literature searching, article retrieval, and appraisal, with the potential to impact outcomes.

For recreational fisheries topics, the evidence base is generally small, and there tends to be equally large quantities of studies published as technical reports. For that reason, limiting searches to "academic" databases or intentionally excluding technical reports could lead to substantial bias. Nonetheless, rapid reviews are still preferable compared to basing decisions on cherry-picked empirical studies. Decisions that need to be made quickly may not have the benefit of waiting for extended periods for a full review. The key to rapid review is that end-users of that review are aware of biases and limitations therein. We are unaware of any rapid reviews specific to recreational fisheries, and the nearest example is a rapid review of the recreational, cultural, and environmental meanings of water resources for Australian river communities (Downey et al. 2022a).

3.5 Systematic Maps

Systematic maps are a form of evidence synthesis used to describe published literature on a topic of interest. They use structured methodologies similar to those of systematic reviews to collate and describe (i.e., map) the evidence available, identifying where, what type, and how much evidence is present in the literature (James et al. 2016; CEE 2018). Systematic maps do not attempt to measure an effect (e.g., the impact of X on Y) or answer a specific research question, but instead work to illustrate the state of the literature in a comprehensive, objective, and transparent manner. Questions are often broad and can include several elements. For example, what evidence currently exists? How much evidence is available? What interventions or outcomes are studied most frequently? What methods are used? Systematic maps may also be used to address questions of impact where systematic reviews are not feasible (Pullin et al. 2016). Systematic maps consider both the breadth and depth of available evidence (i.e., peer-reviewed, grey literature, primary, secondary, quantitative, or qualitative) and are frequently a preliminary step to assess evidence prior to initiating more effect-specific or hypothesis-driven reviews (Pullin et al. 2016).

The stages of a systematic map follow closely those of a systematic review (see Sect. 3.3 above) with some modification (CEE 2018). After team development (including methodological and topical experts, as well as stakeholders) and question formulation, an a priori protocol detailing the steps of the mapping exercise and steps to decrease bias during the process is developed (Haddaway et al. 2016). Protocols are peer-reviewed to ensure high quality methodologies are used during the mapping process and registered (i.e., through registries such as CEE's PROCEED https://environmentalevidence.org/proceed/), which reduces the risk of duplicate maps from different teams and allows the research community to provide comments prior to the completion of the synthesis (Haddaway et al. 2016). The mapping process generally follows five steps (for methodological guidelines, see CEE 2018), although a sixth step (critical appraisal) may be added in some cases:

1. Comprehensive searches for relevant evidence on specific topics, based on explicit, scoped search strings formulated during the protocol, and considering multiple sources of commercially published and grey literature.
2. Screening to ensure studies relate directly to the mapping question, based on predetermined inclusion criteria.
3. Metadata coding to describe each study in relation to the mapping question, based on predetermined coding criteria updated iteratively during the process (not including extraction of outcome measures such as effect sizes).
4. Exploratory data synthesis (normally narrative-based with descriptive statistics, well documented and comprehensive, and covering all components of the mapping question).
5. Transparent reporting and communication, especially in relation to any changes in the mapping process as they relate to the published protocol, with extensive use of supplementary information (including the full systematic map database) to maximize transparency.

Unlike systematic reviews, where critical appraisal of study validity (e.g., measuring internal validity [risk of bias within a study] or external validity [generalizability of a study to the review question]) is required, critical appraisal is optional for systematic maps (CEE 2018). Some validity indicators may be captured during metadata coding (see Rytwinski et al. 2020), but the decision to include critical appraisal in systematic mapping does not influence the mapping process. Although systematic maps only include metadata coding rather than extracted data for assessment of effects (James et al. 2016), systematic maps often have larger scopes and literature bases than the more specific questions asked during systematic reviews and can have moderate to high resource requirements (Cook et al. 2017). Careful scoping during protocol development can keep the map size manageable. Systematic maps and reviews are often up to date for just a brief period after the initial search, so map updates may be required periodically, especially if the primary research continues to expand rapidly (Bayliss et al. 2016).

The outcomes of a systematic map include a descriptive, exploratory synthesis of available evidence, highlighted knowledge clusters (i.e., subsets of the evidence base that are sufficiently covered to allow for further, secondary research such as systematic reviewing), or knowledge gaps (i.e., areas that are underrepresented in the current literature that require further primary research before secondary research can occur) (Haddaway et al. 2016). These syntheses include tables and figures (often with descriptive statistics) to contextualize the available literature. This output can aid decision makers in determining where there is evidence for further systematic review that would aid in current management decisions, or where future efforts should be targeted (i.e., knowledge gaps). In addition, most systematic maps provide a searchable database that can be used by decision makers looking for specific supporting evidence within their topic of interest.

3.6 Evidence Synopses

Evidence synopses take evidence aggregation a step further by condensing evidence syntheses in any of the above-mentioned forms into comparatively short summaries. The purpose of this is to provide management or policy briefings to front-line decision makers, for whom sifting through long reviews is impractical (e.g., due to time constraints). Recreational fishery managers tend to fit this description and already face numerous challenges related to recreational users (e.g., conflicts, non-compliance with regulations; Arlinghaus and Cooke 2009). These tall tasks make staying up to date on fisheries science exceedingly difficult and create a demand for more "rapidly digestible" evidence synopses.

Demands for rapidly digestible evidence syntheses have been realized and met outside of natural resource management and conservation. Healthcare, for example, now benefits from improved evidence synthesis and synopsis services in combination with more and higher quality clinical research (Haynes 2001). Put simply, evidence synopsis allows the benefits of rapidly accumulating clinical research to be realized more fully. Evidence synopses in clinical science are numerous, and centre on wide-ranging topics such as the effectiveness of early versus late tracheostomy in critically ill patients (Keeping 2016), the effect of general health checkups on total mortality (Sox 2013), and treatment of the common cold using zinc (Hemilä 2015). In 2013, the Journal of the American Medical Association introduced Clinical Evidence Synopsis as a new type of article to be published monthly. The purpose of this was to make accessible the most important information from high-quality systematic reviews for clinicians in their day-to-day practice (McDermott and Livingston 2013). Here, as elsewhere, the target audience is front-line decision makers (i.e., practicing clinicians) whose decisions must be, more than anything else, timely.

From healthcare to recreational fishery management, evidence synopses contain the most essential, practicable information gleaned from the existing research on a topic. As such, evidence synopses omit much of the basic information underlying that which is most relevant to end-users (i.e., practitioners). Good synopses, however, contain clear links to foundational information should the user require them. The key quality and advantage of these synopses is that they are "fast and frugal," i.e., fit for use "on the run" (Haynes 2001). Evidence synopses can be created for various purposes and at various scales (e.g., for specific actions, for single species or other taxa). Conservation Evidence—a free information source and authority on evidence synopsis in conservation—provides evidence synopses for specific actions within a given context (e.g., conservation of bats; Conservation Evidence 2020). Here, existing scientific information is aggregated and summarized for actions such as water-level management in freshwater wetlands. As in clinical science, examples of evidence synopsis in natural resource management and conservation are numerous: terrestrial mammal conservation (Littlewood et al. 2020) and carnivore conservation (Lockhart and Staurt 2013) are just two of the many topics for which evidence synopsis has proven valuable.

Beyond accessibility, evidence synopsis can facilitate more transparent evidence-based decision-making, provided that the trail of evidence and uncertainty around a topic are documented clearly (Dicks et al. 2014a). Research by Walsh et al. (2015) shows that the impact of scientific research on conservation may depend on its accessibility to end-users as much as or more than the innate qualities of said research—a result which strongly supports evidence synopsis as a means to evidence-based conservation. So long as there are demands for fast and frugal decision-making tools in recreational fisheries management, evidence synopsis will prove valuable to front-line practitioners.

4 Mainstreaming Evidence Synthesis in Recreational Fisheries Science and Management

In general, evidence syntheses have been poorly embraced in the recreational fisheries science and management communities, despite their many benefits, particularly in the human dimensions of the sector (with some notable exceptions, e.g., Hunt et al. 2019; Birdsong et al. 2021). This needs to be overcome to harness the inherent power that arises from bringing together disparate empirical studies. There is not one method that should be applied to all scenarios. As outlined here, there are a variety of tools, each with its strengths and weaknesses. In science, no matter the method used, there will always be limitations. So, the key to evidence synthesis is knowing the extent to which those limitations result in biases that could impact outcomes. One way to approach this is to consider the costs of "getting it wrong." What if that management approach that is deemed effective by a rapid review is in fact ineffective? What if a decision is delayed, waiting for a systematic review with meta-analysis to be conducted? The reality is that because recreational fisheries systems are complex and dynamic, fisheries decision makers are used to dealing with uncertainty (Cabanellas-Reboredo et al. 2017) and information-poor scenarios (Post et al. 2002), which is partly responsible for the reliance on adaptive management approaches (Arlinghaus et al. 2017). Evidence syntheses can be strengthened and their relevance ensured by including evidence users (e.g., recreational fisheries managers) in the process. Ideally, this would begin at the question formulation stage and while determining which evidence synthesis method is most appropriate.

Given that recreational fisheries are spatially, biologically, and socially diverse, managers have no alternative but to adopt an evidence-synthesis approach. Resources are sufficiently limited that it is not possible to "research" every issue in every context or to adaptively manage one's way through every recreational fishery management decision. Social science studies have revealed that environmental decision makers tend to be aware of the range of evidence synthesis tools and will use them if available (Thomas-Walters et al. 2021). Nonetheless, there is room for professional development training opportunities for both evidence users (i.e., fisheries managers) as well researchers that would be most likely to do such syntheses.

There is more work to do before evidence synthesis will be “mainstreamed,” including changing institutional practices for how decisions are made and creating a culture of evidence use. There are opportunities to interface evidence synthesis with decision support tools such as adaptive management frameworks (see Robinson et al. 2026). Because of a tendency for fisheries management decisions to be based on tradition or rely upon input from colleagues rather than use the entire evidence base (Young et al. 2016), it is almost certain that some of the decisions being made are contrary to the evidence base. The best approach to increasing uptake of evidence synthesis in fisheries management will be through case studies that demonstrate how this has been applied and the benefits of doing so. Unfortunately, such cases remain elusive in the recreational fisheries sphere, despite being common in other domains such as health and education.

5 Conclusion

Recreational fisheries are complex social–ecological systems that are challenging to understand and manage (Arlinghaus et al. 2017; Elmer et al. 2017). Also notable is the fact that recreational fisheries managers are often tasked with making decisions that involve trade-offs, controversy, or even what are considered “wicked problems.” Hence, decisions that are made need to consider the best available evidence to guide them. Recreational fisheries management has long been approached from a trial-and-error perspective, i.e., slowly learning what works and then using that experience to shape individual and institutional norms. Only recently have rigorous active adaptive experiments that also track the response and learning outcome of practitioners been developed (Fujitani et al. 2017). Social science surveys reveal that fisheries managers are failing to make use of the broader evidence base and tend to rely on tradition (Young et al. 2016). We submit that recreational fisheries management could be improved if it were to adopt more of an evidence-based approach that was partially supported by evidence synthesis. As outlined above, evidence syntheses come in many forms, each with their own strengths and weaknesses. Each of these methods has a place, but we wish to emphasize the particular importance of systematic reviews that incorporate meta-analysis. Systematic reviews (ideally with meta-analysis, although this may not always be possible given characteristics of the evidence base) are considered the gold standard of evidence synthesis, as they are rigorous, repeatable, and focus strongly on reducing bias. When quantitative data can be extracted, it is possible to conduct powerful meta-analyses that can provide managers with important insight into how the world works. But also, qualitative inferences are hugely relevant if they follow a rigorous search and synthesis approach. We hope that our paper will help to equip recreational fisheries managers and scientists with sufficient information to make decisions about why evidence syntheses could be of use, how to select and even conduct the appropriate form of synthesis, and to interpret the findings arising from them.

Acknowledgments We thank several anonymous referees as well as the book editorial team for their thoughtful comments on this manuscript. No funding sources are declared.

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