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PERSPECTIVE

"This research is important for the conservation and Management of Sharks": A proposed framework for ensuring that this is actually true

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Abstract

Sharks and their relatives are ecologically important animals that face serious conservation challenges. Scientists studying chondrichthyans have expressed a desire to generate data that helps to conserve threatened species, but environmental advocates and natural resource managers have expressed frustration that significant portions of supposedly policy-relevant and conservation-relevant scientific research are not useful at accomplishing these goals. The phrase "this research is important for the conservation and management of sharks," which appears frequently in scientific papers and conference presentations about research that managers consider to be of limited or equivocal conservation application, has become a point of frustration, and sometimes even mockery. This perspective article uses data from surveys of shark-focused conservation advocates and natural resource managers, analysis of existing publications, and the authors' own experience in policy-relevant scientific research to discuss strategies for strengthening connections between research and policy applications. It synthesizes feedback into a framework that provides advice to scientists who wish to generate conservation-relevant data, designed for scientists with limited knowledge of the practices or data needs of natural resource management policymaking and environmental advocacy. It also presents the results of a review of papers identified as effectively relating scientific findings to the needs of policymakers or advocates.

KEYWORDS

advice, conservation science, evidence-based conservation, endangered species, policy-relevant science, sharks, science-policy interface

1 | INTRODUCTION

Sharks and their relatives are some of the most threatened animals on Earth, with over 1/3 of described species assessed as threatened with extinction by the IUCN Red List (Dulvy et al., 2021). There are calls for the use of science and scientific evidence to inform government policy processes in every area of decisionmaking (Pearson, 2024). Additionally, in many cases, additional scientific research is necessary to generate useful and effective conservation and management plans for sharks and their relatives (Simpfendorfer et al., 2011). Surveyed shark and ray scientists have expressed interest in performing policy-relevant research (Ferry & Shiffman 2014, Shiffman & Hammerschlag, 2016).

However, much of the research performed by shark and ray scientists is not as relevant to policy as scientists may hope (Shiffman et al., 2020). Surveyed expert environmental advocates (Shiffman et al., 2021) and government natural resource managers (Shiffman et al., 2022) have repeatedly expressed frustration that supposedly policy-relevant research is either not as helpful as it could be, or is functionally unusable for policymaking.

It should be noted that "policy" is a broad term that means many different things in different contexts, and a full review of the science-policy interface is beyond the scope of this perspective article (see Bardach & Patashnik, 2023 for a recommended introduction and review). Sometimes "policy" refers to legislation, sometimes to regulations passed by an environmental or natural resources management or fisheries agency in support of ongoing legislation (or compliance with existing legislation), sometimes to international agreements through bodies like CITES or a regional fisheries management organization (Koehler et al., 2022; Shiffman & Hammerschlag, 2016). Some conservation and management instruments are legally binding, while others are voluntary. Some focus on managing endangered species by alleviating threats to those species (e.g., banning certain gear types, creating a fully protected marine protected area in key habitats), while others focus on making a fishery more sustainable (e.g., a total allowable catch quota that prevents overfishing, Koehler & Lowther, 2025, Giovos et al., 2024). Here, we define "policy" generally, broadly, and inclusively as any law or regulation with a potential impact on the populations or habitats of shark species of concern. Here, we define "policy-relevant science" generally, broadly, and inclusively as scientific research that can be used to inform the creation of new policy, or help make that policy more effective in achieving goals established by policymakers.

We note that many of the surveyed experts whose advice we summarize in this paper come from the United States or other relatively wealthy nations in the Global North, which are nations with relatively well-developed natural resource management and environmental conservation policy infrastructure in place. Some of this advice may not apply to scientists or managers in data-poor countries or those working in areas in which there is limited infrastructure or capacity for enacting science-based management, or in countries where there have been relatively few scientific studies of local chondrichthyan species, while some of it is broadly applicable including to policy-relevant studies of other taxa. Although many examples here are drawn from the United States, this problem has been noted elsewhere—in India, one of the largest shark fishing nations on Earth, a substantial portion of research conducted on local species is not useful for the conservation and management of fished species (Gupta et al., 2022). Though not yet analyzed and documented, personal communications with colleagues around the world suggest that this is a widespread problem.

Here we present previously unpublished responses from past surveys of conservation and management experts, along with examples of text from papers that have helped to influence policy. Additionally, we present a novel framework that can help scientists self-assess the relevance of their work to conservation policy. The goal of this perspective article is to provide advice for scientists who intend for their work to be relevant to conservation and management but have limited experience with policy-making processes.

2 | METHODS

Our research team has completed past surveys of shark conservation advocates around the English-speaking world (including respondents from North America, Europe, Asia, Africa, Australia, South America, the Pacific Islands, Shiffman et al., 2021, Simon Fraser University Office of Research Ethics permit # 2017-S0524) and United States-based experts on US shark management policy (Shiffman et al., 2022, Arizona State University Institutional Review Board permit #00011976). See Table 1 for details on which experts were targeted for those studies, how experts were identified and recruited for participation, and sample sizes.

These voluntary online surveys included questions about respondents' perspectives on the state of scientific research, shark conservation policies, and how scientific papers are used (or not) in policy and decision-making processes. Here, we present previously unpublished responses from those surveys focusing on diverse experts' concerns about supposedly policy-relevant

TABLE 1 Additional background information about two previously published surveys seeking expert perspectives on the state of shark science and conservation, and how those two areas intersect. Both papers are open access and readers are encouraged to read them directly for additional information.

Previously published survey source	Shiffman, D.S., et al. "The role and value of science in shark conservation advocacy." Scientific Reports 11.1 (2021): 16626
Experts targeted	Environmental advocates and educators working on shark conservation in the English-speaking world
How were experts identified from Methods section	"We identified 78 environmental non-profits that participate in shark conservation advocacy or public education in the English-speaking world. Representatives of each non-profit were contacted via email and asked to provide a list of contact information for anyone at their organization or partner organizations who works directly on these issues. We compiled a base list of 155 names of employees of environmental non-profit groups whose job focuses on shark conservation advocacy and/or public education (henceforth "environmental advocates"). Shark conservation advocacy and public education was defined broadly to capture as much of the diversity of thought and action in this space as possible, but did not include employees of nonprofit groups whose primary duties included scientific research, as the intended focus of this study is individuals engaged in advocacy, outreach, and education."
Number of respondents	84
Survey permit #	Simon Fraser University's Office of Research Ethics permit # 2017-S0524
Previously published survey source	Shiffman, D. S. et al. (2022). The next generation of conservation research and policy priorities for threatened and exploited chondrichthyan fishes in the United States: An expert solicitation approach. *Conservation Science and Practice*, *4*(3), e12629
Experts targeted	Experts in the endangered species conservation or sustainable fisheries management of shark species in US waters. This includes people who participate in the science-policy interface at several different points, including as scientists studying these species, as environmental advocates lobbying for change, as natural resource managers implementing policy change, and as representatives of the fishing industry
How were experts identified from Methods section	"To identify academic researchers with relevant expertise, a literature review was conducted, focusing on studies from US waters in the past decade (2010–2019) on any identified focal species (Keyword searches can be found in supplementary materials.) Any author or coauthor from the identified studies who is based in the United States for whom we could find current contact information was approached for participation in this study. Any environmental activist based in the United States portfolio includes (broadly defined) conservation of or public education related to chondrichthyans (following Shiffman et al., 2021) was approached to participate in this survey. Representatives from the fishing industry who serve on Fisheries Management Councils or associated advisory panels for chondrichthyan fisheries were invited to participate in this study. Government natural resources management agency representatives who serve on Fisheries Management Councils, have coauthored fisheries management plans, or who have presented at SEDAR (Southeast Data Assessment and Review, a multi-stakeholder fishery science and management process) meetings were approached to participate. Contacted potential participants were also offered the opportunity to suggest people within their own organization or partner organizations that we should approach in addition to them. As the goal was determining the entire universe of US-based experts on these topics, identifying and contacting everyone with relevant expertise, this process did not focus on ensuring geographic, disciplinary, or demographic diversity"
Number of respondents	86
Survey permit #	Arizona State University Institutional Review Board permit #00011976.

research of questionable or limited relevance to policy, and provide advice for scientists who intend to perform policy-relevant research.

Please see Appendix A, or examine those open-access papers themselves, for more details on surveys' designs and demographics of respondents. Experts are generally defined here as those working professionally in natural resource management or environmental advocacy, or having published relevant scientific papers on these topics, and experts were identified and surveyed with the expectations that they would present a range of perspectives, opinions, and experiences. Direct quotes from survey responses presented in-text are. Since we are using previously unpublished responses from surveys focusing on other questions, sample sizes and response rates are presented only occasionally and should be interpreted

with caution and not used to assess how commonly held these expressed views are.

Additionally, we present a novel framework based on survey responses and informed by our team's experience at the science-policy interface, which includes a variety of training, leadership, and service in domestic and international shark conservation and management, that aims to support or guide scientists who wish to perform more policy-relevant research themselves. This was inspired by the Heilmeier catechism, a set of questions used by US government research funders to identify which proposed research projects had potentially high returns on investment. It incorporated questions like "What are you trying to do? How is it done now, and why is that approach limited? What's new about your approach to this problem?" (Heilmeier, 1975).

Finally, we analyze trends from a literature review corpus from a past study (Shiffman et al., 2022). This corpus includes 183 papers from 2010 to 2019 focusing on chondrichthyan (i.e., sharks, rays, and chimaeras) species of conservation concern in United States waters. The papers identified in Shiffman et al., 2022's literature review focused on species that are IUCN Red List Vulnerable, Endangered, or Critically Endangered, and/or those with a significant commercial fishery in the United States.

Those papers' author lists were previously used to identify experts to survey for a conservation horizon scan in Shiffman et al. (2022). Following training, authors PL and RB were assigned a random subset of papers to both code and score (see Codebook in Appendix B). Coding followed our novel framework for policy-relevant research, where we assessed to what extent the reviewed work/papers were relevant to conservation and collected additional metadata for each paper. When intercoder reliability on a subset of 20 papers was calculated at over 95% (or "near-perfect" based on the standards of Landis & Koch, 1977) PL and RB were each assigned half of the remaining corpus of papers. Key results were manually double-checked by author DSS, and less than 1% of entries needed any correction.

3 | RESULTS

3.1 | Conservation and management policy experts' concerns about current research practices, and advice for scientists

Surveyed environmental advocates, natural resource managers, and scientists with experience and expertise in conducting policy-relevant research (henceforth, "surveyed experts," $N = 170$ respondents between the two studies, with only a handful of individual experts potentially included in both studies) expressed a variety of concerns about the current state of purportedly policy-relevant scientific research. One noted that "I see a lot of science positioned as 'informing policy' that won't." Another noted that "most papers on elasmobranchs claim to be policy relevant, but few even tangentially support management in any way." Additionally, these surveyed experts had several specific and constructive suggestions for scientists who study sharks and want their research to be policy-relevant or contribute to the conservation of their study species (Figure 1).

Surveyed experts believe that some types of research can be policy-relevant, providing data that helps shape the specifics of policies affecting a variety of topics. Some types of research that surveyed experts do believe have directly helped to influence policy include stock assessments, work on physiological stress responses and post-release survival that influences handling and release guidelines, gathering of fisheries-independent population trend data, life history and reproductive biology studies (especially for commercially fished species), and habitat use studies related to proposed or actual protected area boundaries. One noted "monitoring movements of elasmobranchs in and out of various marine protected areas in the US Caribbean has justified the existence of those MPAs," while another said "UC Davis research in the Rev islands in Mexico led to changes in the marine protected area boundaries surrounding those islands."

The most common concern expressed by surveyed experts (by far) was that scientists never spoke with managers or conservation advocates before choosing research questions to study ($N = 11$), and the most common advice presented (by far) was that scientists should do this ($N = 8$). Advice offered was remarkably consistent: if scientists want their work to be useful to policymakers or to shark conservation advocacy, they should speak with policymakers (e.g., government fisheries management agency or environmental conservation agency officials responsible for creating and implementing new regulations) and/or conservation advocates before starting a research project, and explicitly ask these end-users what sorts of data they need and do not need. One surveyed expert noted that "many scientists just assume that their science will be taken up by those responsible for managing a species, but very specific types of data are needed." Several surveyed experts ($N = 6$) expressed frustration with this as an ongoing problem, noting that even if scientists are somehow unable to speak directly to a decision-maker, they could at least consult publicly published lists of research priorities to determine if their work indeed answers a relevant question, and "base their work off of what managers have identified as the

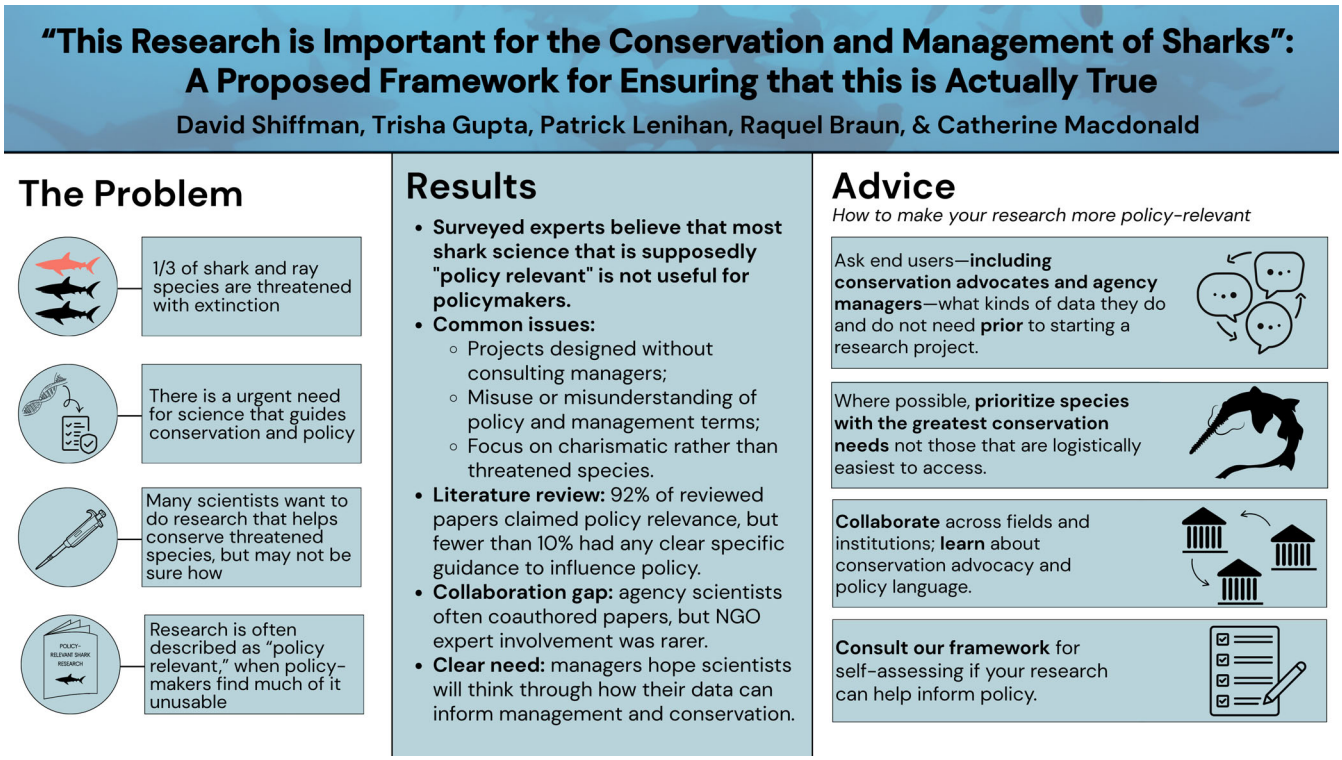

FIGURE 1 A graphical summary of expert advice presented by survey respondents for scientists who wish their research to be more relevant to policy. The problem is also summarized, and other key results are highlighted.

most-needed data." For example, in the United States, NOAA fisheries creates and distributes lists of research priorities for shark species they manage (e.g., NOAA Fisheries Atlantic Highly Migratory Species Management-Based Research Needs and Priorities, available online). Additionally, many countries have a National Plan of Action for sharks which explicitly lists research priorities. It is worth noting that some scientists may have limited flexibility in their selection of research projects due to logistical constraints (e.g., which species are found in local waters, laboratory facilities, or available funding) but even researchers with a great deal of flexibility have often chosen to work on questions not directly useful for policy, or questions which have limited policy application.

Surveyed experts expressed repeated frustration with the misuse of important conservation and management terminology by scientists who claim their work is relevant for conservation and management policy. One surveyed expert noted specifically that the IUCN Red List status "Data Deficient" means that there is insufficient data on the population trends of a species over multiple generations to assign a specific Red List status, but some scientists seem to wrongly believe that it means that any information about any aspect of that species' biology is automatically conservation relevant. Another expressed frustration about the misuse of the term "endangered," which notably means different things in different contexts (e.g., an IUCN Red List assessment of "Endangered" means something different from a listing under the United States Endangered Species Act). Technical terminology is complex, but it is important to learn how to use it correctly to maximize potential impact. There were also concerns that many scientists have a "lack of familiarity with basic fisheries management processes," and suggestions for scientists "to better understand the management process and dynamics of implementing fisheries regulations." One surveyed policy expert noted that they had been berated by a scientist for misusing a scientific term, but that the same scientist misused basic management terms regularly.

Past reporting of data from these surveys has noted a concern that so many scientists focus their work on already-well-studied species in already-well-studied regions, while there are many species of greater conservation concern and/or species for which almost no data is available (Shiffman et al., 2021). A surveyed expert noted that "many scientists focus their work within countries that have some of the lowest impact on sharks and rays, and this work is not necessarily transferable or replicable in other regions/countries." Another suggested that instead of working on the easiest topic to study, scientists should instead "consider the most pressing conservation knowledge gaps when prioritizing their own research."

Though not explicitly stated by any respondents, we feel we should note that policy experts and conservation advocates may not recognize the various constraints that scientists face when it comes to choosing what to study. When limited funds for travel are available, it may make perfect practical sense to study local species and systems even if they are not the species of greatest conservation concern. Studying local species also leads to higher sample sizes and limited paperwork for transporting biological samples across national borders, and may create important educational opportunities for local students. When there are no relationships with international collaborators, starting work on a faraway system scientists are unfamiliar with can be extremely logistically challenging and ethically fraught. When this is done poorly, it can lead to parachute/helicopter science, a practice in which researchers from wealthy countries collect data or conduct research in a Global South country without meaningfully engaging with local experts. Parachute science can have negative social justice implications, overlooks important local contributions, and ultimately may hinder conservation efforts (de Vos & Schwartz, 2022) We recognize that it is easy to advise people to work on the species with the most pressing data needs even if they are not as practically accessible, but much harder to actually do that, especially in an ethical and equitable way. However, as with engagement with conservation experts, some of these challenges can be overcome with thoughtful planning.

There were concerns among management experts about the amount of resources dedicated to satellite telemetry tagging of great white and tiger sharks specifically, noting that habitat use of these species is relatively well known (in Global North countries with significant research infrastructure, not necessarily the case in Global South nations), and that managers lack any kind of movement and habitat use data for the vast majority of species of conservation concern. One surveyed expert wondered about the conservation value of "tagging tiger sharks where they are already protected, not targeted, and not overfished," and another wondered "do we really need to know where great white sharks go to the bathroom?" One surveyed expert noted that "scientists need to do more focused research on small coastal species and less on large charismatic species," while another noted that while they have their uses, "satellite tags provide a lot less policy-relevant data than their advocates claim they do or can provide." Again, we note that there are many structural incentives within academia, such as availability of funding, encouraging scientists to work on certain species or use certain methods, or that may discourage participation in conservation-relevant activities not traditionally counted toward tenure and promotion. But we also note that the cost of a single high-end satellite telemetry tag can be equivalent to several months of salary for a scientist in many countries in the Global South.

Additionally, surveyed experts ($N = 7$) noted that generating the type of data needed to meaningfully inform policy is a task unlikely to be completed by one scientist or lab working alone. There were repeated suggestions to engage in large-scale collaboration with other scientists and other types of stakeholders, stressing that bringing together the resources of many teams makes it possible to answer questions that would otherwise be impossible to address. The importance of bringing together multiple types of expertise through interdisciplinary and multi-disciplinary collaborations was also stressed. Such collaborations, especially with colleagues in other fields or in other countries, can be complex to initiate, but can be extremely rewarding and valuable if successful.

Finally, there were concerns about a lack of specific, clear, and thorough communication about how managers could and should use the results that were arguably policy-relevant in context. "Often I see papers claim that their research will inform management, but it is not clearly or well described HOW," one surveyed expert noted. Another suggested that scientists need to "clearly explain in their manuscripts how their research contributes directly to policy, management, or conservation goals." We note here that not all scientific research needs to be relevant to conservation and management policy and that basic science is a public good in its own right—this guidance is only for scientists explicitly stating that they want their work to influence policy and benefit policymakers.

In summary, scientists wanting to maximize the potential policy relevance of their work should consider the following actions:

1. Ask end users what kind of data they need and do not need before designing and starting a research project, or at least consult already-published lists of management-relevant research priorities.
2. Engage more directly and more frequently with conservation advocates and government natural resources managers when possible.
3. When choosing a study species or system, consider which species have the greatest conservation data needs and not just what species are logistically easiest to access.
4. Pursue collaborations with colleagues in different fields and institutions. Learn more about the conservation advocacy and policymaking process including proper use of terminology.

TABLE 2 Ways that papers note that the work they are doing is important for the conservation and management of the species being studied (top) and representative statements showing specific conservation issues that the paper is addressing.

Statements from papers noting that the work they are doing is important for the conservation and management of the species being studied ($n = 169$)	Telemetry studies remain uniquely powerful ways to inform marine conservation through data-based demonstrations of when and where marine megafauna are located
	These findings also provide a means to inform decision makers and marine conservation planning efforts as to the types of management actions available and potential efficacy of spatial protections for these marine predators.
	These findings are of particular relevance at this time given the ecological and conservation importance of characterizing habitat use patterns of marine apex predators
	Such a multi-level analysis can enhance global management and conservation
	Our results, coupled with recent advances in knowledge regarding differences in life-history parameters of this species, are important considerations for effective species management within US waters
	The proper identification, delineation, and management of nursery areas are crucial for the conservation of the species that use them
	For management and conservation purposes, knowledge of the relative contributions of both natural and human induced causes to total mortality is important
	Information on connectivity among breeding groups within shark species over their geographic range, therefore, is essential to inform management and conservation efforts
	Understanding the biology of both adult and juvenile life stages is necessary for the development of effective management strategies
	The results of this study hold important implications for the management and conservation of blacktip and lemon sharks
	Collectively, new white shark movement data from this study, and recently published work, have expanded the body of information available to inform conservation efforts
	Understanding how endangered marine species rely on coastal habitats is vital for population recovery planning
	We outline relevance of the findings for management and conservation of this internationally exploited species.
	The analyses presented herein provide evidence of range reduction in the western Atlantic, provide an important tool for resource managers to focus research, monitoring, and conservation efforts
Representative example phrasing showing conservation issues that a paper is addressing with their specific methodology and aims ($n = 162$)	Discard mortality (DM) estimates are vitally important to fisheries management. Commercial fishery DM estimates, for example, can help calculate total fishing mortality and biologically acceptable catch limits.
	Although landing of sand tigers is prohibited in US waters, their capture in a variety of commercial and recreational fisheries on the US east coast persists and undoubtedly results in at least some mortality even if sharks are released alive.
	Understanding the ecology and behavior of apex predators such as sharks is crucial to clarifying a broad range of ecosystem interactions (Dill et al., 2003; Heithaus et al., 2008) and represents a critical component of any rigorous ecosystem-based management plan wherein they reside (Pikitch et al., 2004; Levin et al., 2009).
	Information on movement and habitat use of marine apex predators is needed to better understand population structure and to implement spatially explicit management strategies
	The lack of reliable estimates of mortality continues to be a major obstacle to understanding and modeling population dynamics of virtually all marine fish species
	By providing updated size and age at maturity data for *Squalus acanthias* in conjunction with our recent reassessment of age and growth in this species (Bubley et al., 2012), a more effective management strategy for them can be implemented
	However, these changes have never been studied in batoids after substantial changes in their population abundance. This lack of understanding is problematic, particularly in skate, because

(Continues)

TABLE 2 (Continued)

	this group of elasmobranchs appears to be susceptible to fishing pressures and exhibit variable rates of recovery after management plans have been enacted
	Understanding how endangered marine species rely on coastal habitats is vital for population recovery planning
	To aid recovery efforts of smalltooth sawfish (*Pristis pectinata*) populations in US waters a research project was developed to assess how changes in environmental conditions within estuarine areas affected the presence, movements, and activity space of this endangered species. Given the importance of salinity, changes in freshwater flow regimes into estuaries as a result of climate change or water management practices will affect populations by potentially changing their distributions.
	Locations of nursery grounds are not well defined and identification of these areas is of importance for management of the resource and conservation of the species

Additionally, on the institutional side, changing the metrics by which academic scientists' work is evaluated and making dedicated funding available for less-flashy research with a greater conservation impact will help support these changes.

3.2 | A framework for ensuring policy relevance of scientific research on sharks

For research to be policy relevant, we propose that the scientists conducting that research should be able to answer the following questions (both internally as part of project planning processes, and perhaps explicitly in the introduction and/or discussion of the resulting paper).

1. What is the underlying problem that this research hopes to address? This should be more specific than "sharks as a group are threatened."
2. What is the goal of current conservation or management policy in this case? (E.g., stopping a population decline, protecting key habitat for a species of concern, population recovery, reducing bycatch, mitigating a specific threat, etc.)
3. What is the current relevant policy, if any? (E.g., a specific fisheries quota, a gear requirement, the current boundaries of a marine protected area designed to conserve a species, handling and release requirements if that species is caught, etc.)
4. How does your data demonstrate that the current policy is insufficient for achieving the management goal?
5. What does your data suggest that the policy should be instead? (E.g., the quota of 10,000 mt is too high to allow for population recovery and it should instead be 8000 mt; increasing the boundaries of an MPA by 10% will result in protecting a significantly larger amount of key habitat than is currently protected; changing the permitted gear type will result in dramatically reduced bycatch, etc.)

We also note that depending on the specific policy issue being discussed, a possible alternative series of questions for #4 and #5 could be "how do my results contributing to achieving current policy goals?"

Scientists should also be able to clearly identify not only who the relevant management authority is, but also the mandate of that management authority, and the processes by which they change regulations.

While clear and detailed answers to these questions do not guarantee that a scientist's work will influence policy, being unable to answer them increases the likelihood that the work will not have intended real-world impacts.

This framework, in addition to the advice offered by surveyed experts above, should result in generating data that is more likely to be useful for conservation activists and policymakers.

It should be noted that the specific phrasing of this framework generally applies to places where there is management in place already and scientists are seeking to improve its effectiveness, and should be modified in places where no management of any kind currently exists.

3.3 | Literature coding and scoring: How many papers follow this advice?

Forty-six percent of papers from Shiffman et al., 2022 ($N = 84$) explicitly mentioned the conservation status of their study species, and 59% ($N = 109$) of papers noted that there was a significant fishery for their study species. Eighty percent of papers ($N = 147$ papers) mentioned at least one of these two facts.

TABLE 3 Representative example phrasing from reviewed papers that mention regulatory frameworks or statements that show that current regulations are inadequate and need to be improved.

Statements that clearly mention the specific regulation or management framework that governs the shark or ray species in question ($n = 76$)	Blacknose sharks are both overfished and undergoing overfishing, the highly migratory species (HMS) division of the NMFS is required to implement management actions that will end overfishing for this species.
	In 1997, as a precautionary measure and to curtail fishing mortality, the National Marine Fisheries Service (NMFS) prohibited the possession of this species in United States federal waters (NMFS 1999) and, in 2004, designated the sand tiger a species of concern. More recently, the Atlantic states marine fisheries commission (ASMFC) mandated the same prohibition of sand tiger retention in all state waters along the Atlantic coast of the United States from Florida to Maine (ASMFC 2008).
	Regulatory requirements of ESA listing mandate designation of critical habitat for any listed species.
	In response to purported 80%–90% population declines in the 1980's and 1990's (Musick et al. 1993; Castro et al. 1999; Musick et al. 2000), managers prohibited the harvest of the species in both US federal (NMFS 1999) and state (ASMFC 2008) waters.
	In recognition of this increased vulnerability, in march 2010, lemon sharks were listed as a prohibited species in Florida state waters
	One of seven species managed by the New England fishery management council, the winter skate, Leucoraja ocellata, (hereafter referred to as skate) is subject to a directed fishery for its wings in the North Atlantic US waters (hereafter referred to as the skate wing fishery). This species is managed by the use of annual catch limits (ACLs) and accountability measures (management measures enacted in response to exceeding an ACL) consistent with the requirements of the reauthorized Magnuson-stevens fishery conservation and management act (Magnuson-stevens act) (NEFMC, 2011).
	A rebuilding plan consisting of a 1814 mt annual quota [35] and reduced possession limits for vessels fishing in federal waters was established in 2000 with the aim to increase the SSB above threshold levels (45,000 mt)
Statements identifying why current regulations are inadequate and/or what the regulations should be instead	The results of this study will permit the designation of juvenile sand tiger EFH north of Cape Cod, a region previously devoid of sand tiger EFH in existing management documents
	Given the overall importance of nursery habitat to the growth and survival of young individuals, particularly from threatened populations, the identification of PKD Bay as juvenile sand tiger nursery area (i.e., EFH) is of particular importance for the future management and conservation of this species
	The use of incorrect ages and resulting growth rates in demographic analyses can lead to errors in estimates of natural mortality rates, population growth rates, and management actions based upon those estimates (Beamish and McFarlane 1983; Cailliet and Andrews 2008). Given the high management profile of the species, age and growth parameters from the validated curves should be used as the basis for the species until more samples can be processed and the estimates refined.
	We argue that it is important to continue to focus scientific attention on establishing shark nursery areas as essential fish habitat (NMFS 1999) to allow overerploited coastal shark populations to rebound, in conjunction with protecting other life stages (Kinney & Simpfendorfer 2009)
	Our findings extend the known essential habitat for the white shark in the North Atlantic beyond existing protection, with implications for future conservation
	If the most recent trends in biomass continue, it is likely that the prohibited status will be removed, allowing for commercial harvest of Barndoor Skate to resume (NEFMC 2011)
	Delaying the opening of the shrimp season to July 1 would provide additional protection to small sharks during a critical month
	The creation of small MPAs that prohibit or highly restrict coastal development within the northern and eastern portions of Fish Bay and within Inner Coral Harbor (Zone 1) and Johnson's Bay (Zone 3) of Coral Bay would seemingly be highly effective at minimizing negative anthropogenic impacts on core shark habitat
	The implementation of regulations preventing the harvest of bull sharks within these areas would provide adequate spatial protection

Seventy-four percent of papers ($N = 136$) had at least one co-author who worked outside of academia, with NOAA as the most common non-academic employer by far ($n = 77$ papers with at least one NOAA-affiliated coauthor). State natural resources management agencies from various coastal states were also commonly represented ($N = 35$ papers with at least one state agency coauthor). Only 7 papers featured an environmental nonprofit employee as a coauthor. Other non-academic affiliations included private consulting firms, aquariums, and science museums.

Nearly 92% ($N = 169$) of papers explicitly said that their data was important for the conservation and/or management of the species being studied, while 162 papers (88.5%) clearly identified the specific conservation problem they aimed to address with their work. Representative examples of phrasing can be found in Table 2.

Seventy-six papers (41.5%) clearly mention the specific regulation or management framework that governs the shark or ray species in question. Just 17 papers (9.2%) clearly identified why current regulations are inadequate and/or what data from that paper shows the regulations should be instead. See Table 3 for representative examples phrasing.

4 | CONCLUSIONS

Scientists who study threatened species of sharks and rays often want their work to help conserve species by influencing policy change. However, common mistakes and misconceptions about the policymaking process result in limited success in achieving this worthy goal. Though almost all studies (92%) included in the previous literature review noted that the authors believed their work to be policy relevant, less than 10% clearly identified why current regulations are inadequate and what they should be instead, limiting the potential policy implications of their work. Additionally, surveyed environmental advocates and government managers remarked that a great deal of supposedly policy-relevant research is not useful for policy, for a variety of reasons. We note that while our surveyed experts represent different perspectives on many issues (e.g., a shark fisherman who volunteers for a Fisheries Management Council position and a shark conservation activist would likely have serious disagreements on other topics) they were united in the idea that scientists incorrectly claim that research is policy-relevant, and consistent in the range of advice they gave to resolve this issue.

This mismatch is at least partly driven by a limited understanding of the policymaking process among academic scientists, a limited understanding of how science is communicated to policymakers (e.g., Rose & Parsons 2015) and misunderstanding what types of data policymakers need and do not need. There are several potential solutions here. To learn more about the policy process, scientists should approach policymaking the same way they approach learning a new research methodology: by reading relevant papers and reports, by talking with colleagues who are more knowledgeable than they are in those fields, and by taking training courses when necessary. We also recommend that management agencies work to simplify this process, perhaps by creating "crash course" type trainings or recorded webinars, making themselves more available and accessible to scientists who want to help but don't know how, or perhaps even creating professional management positions explicitly for the purpose of liaising with scientists, training them in the basics of conducting policy-relevant research, and helping to ensure that their data becomes available to managers.

In cases where scientists from Global North nations pursue research in Global South nations, it is essential to handle international scientific research in a responsible and ethical manner, and avoid engaging in parachute science. Creating equitable collaborations and partnerships with local experts, helping to build local capacity where needed, and practicing reciprocity will have a more lasting impact than traveling somewhere, collecting data and samples, and leaving (Asase et al., 2022; de Vos & Schwartz, 2022; Singeo & Ferguson, 2023).

Similarly, scientists should be working to increase their scientific skillsets beyond the disciplines in which they are primarily trained. Many of the policy-relevant research questions that need to be answered will require large teams of collaborators, so learning how to work flexibly as part of a team—including knowing what you do not know—is an increasingly essential skillset.

There are also some real institutional barriers to scientists performing the kind of work that policymakers and environmental advocates would prefer for scientists to engage in. Funding can be dramatically easier to obtain for local species and systems or for "flashy" methods and larger-bodied and more "famous" study species than for far-away species that are less well known. There is relatively limited support for any kind of applied research even for endangered species, though this is changing with programs like the US National Science Foundation's "conservation science and practice" grants and the work of conservation-focused Foundations like the Save Our Seas Foundation's Keystone Grant program. Systems of professional rewards within academia favor getting more papers and grants, and not necessarily conservation policy impact—changing this would change

incentives for what types of research studies to perform. It should be noted that a recent analysis found that papers from lower-impact journals have a much more significant impact on conservation policy than those in the types of higher-impact journals where academics are often pressured to aim for or are most rewarded for publishing in Choi et al. (2024). And finally, just as limited understanding of policymaking among scientists is a problem, limited understanding of science and academia among decision-makers is a problem, and calls for better communications and understanding should go both ways.

In some cases, the reasons why scientists do not engage with conservation advocates may be more nuanced than how they are perceived by those advocates. Scientists vary in the degree to which engaging publicly in activities which can be perceived as "advocacy" will be acceptable to them, their employers, or their peers. The breadth of positions scientists occupy on these topics can be wide, with some feeling that although "[s]cientists are uniquely qualified to participate in public policy deliberations and they should...advocating for their policy preferences is not appropriate." (Lackey, 2007 p. 12). Others stake out other positions, pointing to the moral responsibilities experts may have to share their knowledge, the potential implications of both advocating and not advocating for policies as inescapably political, with silence supporting the status quo, and note that even decisions about what to study and what methods to use are "...necessarily a value-laden, social, political decision as well as a scientific decision" (O'Brien, 1993 p. 706). This is made still more complex by the array of urgent, "wicked" environmental problems scientists and society must grapple with, and by growing conflicts associated with a "post-truth" world in which scientists and their expertise occupy increasingly contested roles in policy conversations (Boon, 2019). However, in cases where scientists want their work to have a policy impact, such engagement beyond the ivory tower is necessary.

Finally, we note that while some of this advice is broadly relevant and applicable, some of it is specific to particular countries and their systems of scientific-evidence-based natural resource management. The surveys from which we pulled this advice targeted experts in the English-speaking Global North or just in the United States, experts who work in different socio-ecological systems than those found in parts of the Global South, and their advice and perspectives should be understood and interpreted in the context of the management and socio-ecological systems they work within. While some conservation policy considerations and processes are likely to remain unchanged across contexts, aspects of this proposed framework may not be relevant, or may be less relevant, for scientists in countries or regions with lower availability of scientific and management resources.

While results reported here are drawn from experts and managers in the global North, their key insights are broadly applicable across cultural contexts—scientists wanting to enhance conservation efforts with their data will always benefit from direct conversations with managers about what would be useful and an understanding of management processes. It is recognized that

> "...management approaches to conservation are often exported from developed to developing countries...despite the different set of economic, political, and ecological forces operating in these areas. [...] With limited technical information and relatively few resources...decisions are usually based on what is politically astute and socioeconomically tolerable, rather than using systemic planning." (Ban et al., 2009 p. 795).

For data-poor species or regions, many data types may provide value to managers, and interdisciplinary research that engages with local knowledge and expertise is essential (Haenn et al., 2014). Local support for conservation often relates to the perceived social impacts of conservation actions and perceptions of the quality of governance processes, so social science research may be as critical to managers in these contexts as evaluations of ecological effectiveness (Bennett et al. 2019).

Additionally, while some of this advice may be equally applicable to scientists working on marine mammals, coral reefs or other threatened species or systems, some of it is likely shark-specific.

It is our hope that the advice presented in this paper, including our self-assessment framework, can help improve the likelihood of research successfully informing policy, for the benefit of both threatened species of sharks, the managers charged with conserving them, and the scientists who study them.

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DATA AVAILABILITY STATEMENT

All survey responses come from previously published surveys and are included in the supplementary materials of those files. The results of the content analysis of United States shark conservation and management papers is available upon request to the corresponding author.

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APPENDIX A

A.1 | INFORMATION FROM PREVIOUS SURVEYS, INCLUDING THE DEMOGRAPHICS OF RESPONDENTS AND THE SURVEY QUESTIONS

Demographics:

Shiffman, D. S., Macdonald, C. C., Wallace, S. S., and Dulvy, N. K. (2021). The role and value of science in shark conservation advocacy. Scientific Reports, 11(1), 16626.

"We identified 78 environmental non-profits that participate in shark conservation advocacy or public education in the English-speaking world using a combination of internet search engine searches for shark conservation advocacy, our own records from combined decades working on ocean conservation science issues, and snowball sampling (i.e., asking contacted advocates to suggest other organizations we should be sure to include)."

Representatives of each non-profit were contacted via e-mail and asked to provide a list of contact information for anyone at their organization or partner organizations who works directly on these issues. We compiled a base list of 155 names of employees of environmental non-profit groups whose job focuses on shark conservation advocacy and/or public education (henceforth "environmental advocates"). Shark conservation advocacy and public education was defined broadly to capture as much of the diversity of thought and action in this space as possible, but did not include employees of non-profit groups whose primary duties included scientific research, as the intended focus of this study is individuals engaged in advocacy, outreach, and education.

More than half of contacted environmental advocates completed the survey (54.2% response rate, $N = 84$). Fifty-seven percent of respondents identified as female, and one respondent preferred not to answer this question. Respondents ranged in age from 24 to 70, with a mean age of 41 years old. Age or gender were not significantly correlated with any variables measuring understanding of current science or support for any management policy and were not analyzed further. Thirty-seven respondents have a Master's degree, seventeen have a PhD, and the remainder have undergraduate degrees or did not answer this question. Of those who did not claim that the scope of their work was global, the largest proportion of respondents worked in North America and Europe, followed by the Caribbean, South Africa, and Southeast Asia. Some respondents also worked in Central America, Brazil, the South Pacific, and Australia.

Shiffman, D. S., Elliott, J. N., Macdonald, C. C., Wester, J. N., Polidoro, B. A., and Ferry, L. A. (2022). The next generation of conservation research and policy priorities for threatened and exploited chondrichthyan fishes in the United States: An expert solicitation approach. Conservation Science and Practice, 4(3), e12629.

"Experts from a variety of fields including scientific research, conservation advocacy and environmental education, natural resource management, and industry were identified and contacted via e-mail to assess willingness to participate in a two-part survey on emerging research and policy priorities for chondrichthyan species of concern. To identify academic researchers with relevant expertise, a literature review was conducted, focusing on studies from US waters in the past decade (2010–2019) on any identified focal species (Keyword searches can be found in supplementary materials.) Any author or coauthor from the identified studies who is based in the United States for whom we could find current contact information was approached for participation in this study. Any environmental activist based in the United States whose portfolio includes (broadly defined) conservation of or public education related to chondrichthyans (following Shiffman et al., 2021) was approached to participate in this survey. Representatives from the fishing industry who serve on Fisheries Management Councils or associated advisory panels for

chondrichthyan fisheries were invited to participate in this study. Government natural resources management agency representatives who serve on Fisheries Management Councils, have coauthored fisheries management plans, or who have presented at SEDAR (Southeast Data Assessment and Review, a multi-stakeholder fishery science and management process) meetings were approached to participate. Contacted potential participants were also offered the opportunity to suggest people within their own organization or partner organizations that we should approach in addition to them. As the goal was to determine the entire universe of US-based experts on these topics, identifying and contacting everyone with relevant expertise, this process did not focus on ensuring geographic, disciplinary, or demographic diversity, though questions related to these issues were included in the survey and are reported below. This process resulted in a total of 388 names..."

Eighty-six identified experts participated in round 1 of the survey... Our respondents include multiple representatives from every identified category of expertise (e.g., industry, management, environmental conservation, and academic research) and every region within the contiguous United States (using the Fishery Management Council regions delineated by the Magnuson–Stevens Fishery Conservation and Management Act, Figure 1). The most common employer type of respondents was academia, with 28 respondents including 19 faculty and eight graduate students. Eighteen respondents were government-employed scientists, including four state-level agency scientists. Eleven were government managers, including three state-level agency managers. Eight respondents were environmental NGO-employed scientists and seven were NGO-employed advocates or public educators. Four industry representatives responded, as did one classified as "other" (who reported working as a consultant across multiple fields). The most common regions of focus were the South Atlantic ($n = 15$), and the Gulf of Mexico and Pacific regions ($n = 13$ each). Three respondents identified their employer as "consultant/contractor," and two of those specified that they work primarily with industry groups and are therefore counted as industry here. One government manager who indicated that they worked in multiple regions noted that their regions of focus included New England, and one government scientist each who indicated that they worked in multiple regions noted that their regions of focus included the Caribbean and the Western Pacific, respectively. Two academics who indicated that they worked in multiple regions noted that their regions of focus included the Caribbean. The US Caribbean region, North Pacific region, and Western Pacific region are generally the subject of less management and research attention than other regions, so lower response numbers may be illustrative of issues regarding the size of the professional community working in these regions rather than survey sample bias.

Forty-five respondents published (as lead or coauthor) at least one paper on a threatened or heavily fished species of US chondrichthyan, thirty-seven participated in at least one SEDAR workshop, and twenty-three served on a fisheries management council. Thirteen participated in at least one IUCN Red List shark specialist group workshop, and eight served in a formal capacity as part of the shark specialist group. Eighteen respondents answered "no" to each of these questions about their direct participation in the management process, five answered "yes" to all of these questions, and sixty-eight answered "yes" to at least one.

Survey questions used here:

From Shiffman et al. (2021):

Have you personally worked with scientists, either independent scientists not employed by your NGO or scientists employed by your NGO? If so, please describe that experience in your own words.

Do you believe that science and scientists make a positive contribution to shark conservation efforts? Why or why not?

If you could change one thing about how independent scientists not employed by your NGO interact with the conservation community, what would it be and why?

If you could change one thing about the current focus of shark research, what would it be and why?

In your opinion, what is the proper role of science and scientists in marine conservation?

From Shiffman et al. (2022):

This survey is being sent to experts who are (broadly) from the areas of industry, management, advocacy, and academic research. Please briefly describe some things that you believe people in the other areas (not yours) could improve upon in terms of working together for more effective management.

What mistakes, if any, have you observed from scientists claiming to perform policy-relevant research? In your opinion, is there anything that scientists who wish to perform policy-relevant research should do differently from current research practices?

What's an example of supposedly policy-relevant research that in your opinion will not really help policy?

What's an example of supposedly policy-relevant research that in your opinion really did help policy?

In your opinion, is there anything that scientists who wish to perform policy-relevant research are doing well, that should be continued/emulated/expanded upon?

How do you personally define "policy relevant research?"

APPENDIX B: CODEBOOK USED IN THIS STUDY. ALL PAPERS IDENTIFIED IN Shiffman et al. (2022) WERE CODED AND SCORED BY AUTHORS RB AND PL USING THIS CODEBOOk

What shark species is the paper about? (List up to 5, common names not scientific names).

Do any of the authors of this paper work for a government agency or non-profit? If yes, which authors and which government agency/non-profit?

Where does the study take place?

What research methods are used? Check all that apply.

Does this paper say any version of "this data is important for conservation or management?" If yes, please copy/paste the text where this statement is made.

Does the paper explicitly mention whether the study species is endangered or threatened? If yes, please copy/paste the text where this statement is made.

Does this paper explain in general why this data is important? If yes, please copy/paste the text where this statement is made.

Does this paper mention a specific law or regulation governing this species, or a specific management agency in charge of managing or protecting this species? If yes, please copy/paste the text where this statement is made.

Does this paper clearly explain what the current law or regulation is, why it is inadequate, and what the new law or regulation should be instead?

Does the paper explicitly mention the specific conservation problem that it hopes to address? If yes, please copy/paste the text where this statement is made.

Is there anything else noteworthy about this paper?