



Preferred conservation policies of shark researchers

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Abstract: *There is increasing concern about the conservation status of sharks. However, the presence of numerous different (and potentially mutually exclusive) policies complicates management implementation and public understanding of the process. We distributed an online survey to members of the largest professional shark and ray research societies to assess member knowledge of and attitudes toward different conservation policies. Questions covered society member opinions on conservation and management policies, personal histories of involvement in advocacy and management, and perceptions of the approach of conservation nongovernmental organizations (NGOs) to shark conservation. One hundred and two surveys were completed (overall response rate 21%). Respondents considered themselves knowledgeable about and actively involved in conservation and management policy; a majority believed scientists have a responsibility to advocate for conservation (75%), and majorities have sent formal public comments to policymakers (54%) and included policy suggestions in their papers (53%). They believe sustainable shark fisheries are possible, are currently happening today (in a few places), and should be the goal instead of banning fisheries. Respondents were generally less supportive of newer limit-based (i.e., policies that ban exploitation entirely without a species-specific focus) conservation policy tools, such as shark sanctuaries and bans on the sale of shark fins, than of target-based fisheries management tools (i.e., policies that allow for sustainable harvest of species whose populations can withstand it), such as fishing quotas. Respondents were generally supportive of environmental NGO efforts to conserve sharks but raised concerns about some NGOs that they perceived as using incorrect information and focusing on the wrong problems. Our results show there is an ongoing debate in shark conservation and management circles relative to environmental policy on target-based natural resources management tools versus limit-based conservation tools. They also suggest that closer communication between the scientific and environmental NGO communities may be needed to recognize and reconcile differing values and objectives between these groups.*

Keywords: conservation planning, fishes, fisheries, marine, protected areas, threatened species

Las Políticas de Conservación Preferidas por los Investigadores de Tiburones

Resumen: *Existe una preocupación creciente sobre el estado de conservación de los tiburones. Sin embargo, la presencia de numerosas políticas diferentes (y potencialmente mutuamente excluyentes) complica la implementación del manejo y el entendimiento público del proceso. Distribuimos una encuesta en línea a los miembros de las sociedades más grandes de investigación profesional sobre tiburones y rayas para valorar el conocimiento y las actitudes de los miembros hacia las diferentes políticas de conservación. Las preguntas cubrieron las opiniones de los miembros de las sociedades sobre la conservación y las políticas de manejo, historias personales de participación en la defensa y el manejo, y las percepciones de las estrategias de conservación de tiburones de las organizaciones no gubernamentales (ONGs). Se completaron 102 encuestas (la tasa general de respuesta fue de 21%). Los respondientes se consideraron a sí mismos como informados sobre e involucrados activamente en la conservación y las políticas de manejo; una mayoría creyó que los científicos tienen la responsabilidad de apoyar a la conservación (75%) y la mayoría ha enviado comentarios públicos formales a quienes elaboran las políticas (54%) y han incluido sugerencias de políticas en sus artículos (53%). Los respondientes creen que las pesquerías sustentables de tiburones son posibles, que actualmente existen (en unos cuantos lugares) y que deberían ser el objetivo en lugar de prohibirlas. En general, los respondientes dieron menos apoyo a las nuevas herramientas de políticas de conservación basadas en límites (es decir, políticas que prohíben la explotación en su totalidad y que no tienen un enfoque específico de especie), como*

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los santuarios de tiburones y los vetos a la venta de tiburón y aleta de tiburón, que a las herramientas de manejo basadas en pesca enfocada (es decir, políticas que permiten la cosecha sustentable de especies cuyas poblaciones pueden soportarlo), como las cuotas de pesca. Los respondientes en general dieron apoyo a los esfuerzos de las ONGs ambientales por conservar a los tiburones pero despertaron conciencia sobre algunas ONGs que percibieron que usaban información incorrecta y se enfocaban en los problemas equivocados. Nuestros resultados muestran que hay un debate continuo en la conservación de tiburones y los círculos de manejo en relación a las políticas ambientales de las herramientas de gestión de los recursos naturales por objetivos versus las herramientas de conservación basadas en los límites. Los resultados también sugieren que una comunicación más cercana entre las comunidades científicas y de ONGs ambientales puede ser necesaria para reconocer y reconciliar los valores y objetivos discrepantes entre estos grupos.

Palabras Clave: áreas protegidas, especies amenazadas, marino, peces, pesqueras, planeación de la conservación

Introduction

Many commercially exploited species of sharks are overfished or threatened with extinction (Worm et al. 2013; Dulvy et al. 2014). Public concern for the conservation of sharks, defined herein as species in subclass Elasmobranchii that are not members of the family Rajiformes (skates and rays), is growing (Simpfendorfer et al. 2011; Friedrich et al. 2014). There have been several recent high-profile shark conservation successes (Techera 2014). However, additional legal protections are still needed in many places for many species (Klein & Techera 2014). Numerous environmental nongovernmental organizations (NGOs) and other advocacy groups have shark conservation campaigns, and several NGOs focus entirely on shark conservation. These groups vary widely in expertise, focus, resources, and effectiveness (Lawrence 2014). There are also many individuals unaffiliated with environmental NGOs who argue for shark conservation, fueled in part by the opportunity provided by the rise of social media (Thaler et al. 2012; Hamerschlag & Gallagher 2014; Parsons et al. 2014).

The potential conservation policies that can be applied to sharks differ widely in scope, intent, and effectiveness (Techera & Klein 2011). These policies can be broadly divided into target-based policies and limit-based policies (Caddy & McGarvey 1996). Target-based policies (Table 1) are the most commonly implemented for shark conservation and management to date. They allow for the sustainable fisheries harvest of some shark species, for example, through harvest quotas (Walker 1998; Klein & Techera 2014). Limit-based policies ban some kind of fisheries harvest entirely without a species-specific focus, such as no-take marine reserves (Table 1). Limit-based policies have been gaining support in recent years due to a long history of unsustainable shark fisheries and associated population declines (Cunningham-Day 2001; Worm et al. 2013).

Knowledge and attitudes of stakeholder groups are important factors in the choice of the most appropriate management policy (Jacques 2010; Simpfendorfer et al. 2011). When economically important species are threatened with extinction due to commercial overfishing, scientists with different areas of expertise may not agree

on the best approach to resolve the problem. Natural resource managers and scientists with natural resource management expertise may value wildlife in a fundamentally different way than conservation biologists and environmental activists (Mace & Hudson 1999). Limit-based policies are sometimes different from, or even incompatible with, target-based policies designed to maximize sustainable use of an ecosystem (Jennings 2007). Whether someone supports target-based or limit-based policies may be tied to whether they believe sustainable use is possible (Jennings 2007), to their understanding of the outcome of previous management policies, or to their area of professional training. Some scientists believe it is important to advocate for specific regulations or assist environmental advocacy organizations in doing so, whereas others consider getting directly involved unscientific (Singh et al. 2014). Which policies are most effective and appropriate are debated. What conservation professionals see as a much-needed new management paradigm may be viewed as emotional and antiscientific advocacy to scientists trained in traditional resource management (e.g., Hilborn 2006). This potential philosophical divide between support of limit-based and target-based policies has not been assessed previously with respect to shark conservation and management policies.

We used targeted surveys to evaluate the knowledge and attitudes of professional shark researchers with respect to conservation and management policies. We evaluated scientists' knowledge of and attitudes toward conservation and management policies, their personal histories of involvement in advocacy and management, and their perceptions of the conservation NGO community. We also tested whether support for different types of target-based or limit-based policies was influenced by whether respondents believed sustainable fisheries harvest was possible, by their area of professional expertise, or by their highest academic degree. Accordingly, we tested the following four null hypotheses: there is no relationship between a respondent's belief in the possibility of sustainable fisheries harvest and their preference for either target-based or limit-based shark-conservation policies; there is no relationship between a respondent's preference for sustainable fisheries harvest or banning all harvest and their preference for either target-based

Table 1. Definitions of available shark conservation and management policies used in this paper, categorized into traditional fisheries management tools and conservation tools arranged in order of decreasing support from survey respondents (see Fig. 1).

| <i>Policy*</i> | <i>Definition</i> |
|---|--|
| Target-based management tools | policies allow sustainable exploitation of some species while protecting particularly threatened co-occurring species |
| Strict bans on take for particularly threatened species | banning fisheries exploitation of species whose populations are low while allowing exploitation of other co-occurring species (e.g., a zero quota, a prohibited species list, U.S. Endangered Species Act listing) |
| Fisheries quotas | restrictions on the total number (or weight) of a species or species complex that can be exploited by fisheries based on scientific assessment of the population status and life history of that species |
| Year-round closures in certain areas | banning fishing (or fishing for specific species or fishing using specific gear) in a particular area (e.g., a bycatch hotspot, a nursery area, an important migration route) permanently |
| Gear restrictions and required gear modifications aimed at reducing bycatch | regulations that require fishers to modify fishing gear (or ban certain types of gear) to reduce accidental catch of nontarget species |
| Time-restricted area closures | banning fishing (or fishing for specific species or fishing using specific gear) in a particular area (e.g., a bycatch hotspot, a nursery area, an important migration route) during some times of the year |
| Shark-finning bans | banning removal of shark fins and disposing of the carcass at sea, including fin:carcass ratios and fins naturally attached policies |
| CITES Appendix II listing | listing on Appendix II of the Convention on International Trade in Endangered Species requires countries to certify that trade in that species did not harm the population and requires monitoring |
| CITES Appendix I listing | listing on Appendix I of the Convention on International Trade in Endangered Species bans international trade in that species |
| Limit-based conservation tools | ban or restrict some sort of exploitation in a region entirely without a species-specific focus |
| No-take marine protected areas | area of the ocean where all commercial fishing is banned |
| Shark-fin bans | illegal to buy, sell, or trade shark fins |
| Nation-wide bans on any commercial fishing or landing of sharks (shark sanctuaries) | shark sanctuaries ban commercial fisheries exploitation of sharks within the entire exclusive economic zone of a country |

*Some policies could defensibly be categorized as either fisheries management or conservation (or both). We included policies that protect particularly threatened species while allowing sustainable harvest of other co-occurring species as target-based tools and that ban some sort of harvest entirely, without a species-specific focus, as limit-based tools.

or limit-based policies; there is no relationship between a respondent's area of research expertise and their support for target-based or limit-based policies; and there is no relationship between a respondent's highest academic degree and their support for target-based or limit-based policies.

Methods

Survey

We distributed a voluntary online survey (administered through the free online tool surveyMonkey.com) to the members of the three largest professional shark and ray research societies: the American Elasmobranch Society (AES) (founded in 1983, approximately 350 members), the Oceania Chondrichthyan Society (OCS) (founded in 2005, approximately 120 members), and the European Elasmobranch Association (EEA) (founded in 1996 as a collaboration between ten European-based elasmobranch research and conservation organizations, total membership unknown). The goal of AES is "to advance

the scientific study of living and fossil sharks, skates, rays, and chimaeras, and the promotion of education, conservation, and wise utilization of natural resources." The goal of OCS is "to promote and facilitate education, conservation and scientific study of chondrichthyan fishes." The goal of EEA is "to coordinate the regional and international activities of its member organizations to advance research, sustainable management, conservation and education on cartilaginous fishes throughout Europe."

We considered these society members to be a representative sample of experts working in the fields of elasmobranch research and management. They were contacted through their listservs, and no compensation was offered to survey participants. They were asked about their demographic background (including current employer and job title, age, and home country), area of expertise (including other professional societies to which they belong), opinions concerning a series of conservation and management policies commonly used for sharks, personal involvement in conservation advocacy, and opinions of the environmental NGOs (defined above) focusing on shark conservation (Table 2).

Table 2. Survey questions distributed to members of the largest professional societies focusing on the scientific study and management of sharks and rays concerning shark conservation policies, the community of environmental nongovernmental organizations, and respondents' personal demographic background, research expertise, and history of getting involved in conservation advocacy.

| <i>Question</i> | <i>No. of responses</i> |
|---|-------------------------|
| Please indicate which of the following choices describes your employment status (many options). | 90 |
| Please indicate the highest degree you've attained (many options). | 100 |
| Please indicate which of the following professional societies you are a member of (AES, OCS). | 101 |
| Please indicate which of the following disciplines you have published a paper or technical report about in the last 10 years (many options). | 89 |
| In your opinion, are sustainable commercial fisheries that target sharks possible (yes, no)? | 83 |
| In your opinion, are there sustainable commercial fisheries targeting sharks in the world today? If so, please provide examples. | 74 |
| Please indicate the degree to which you feel the following shark-conservation and management-policy tool is important and effective: fisheries quotas (limiting catch based on scientific population assessments and life history data), | 81 |
| gear restrictions and required gear modifications aimed at reducing bycatch, | 82 |
| strict bans on take for particularly threatened species, such as the U.S. Endangered Species Act, | 83 |
| CITES (Convention on the International Trade in Endangered Species) Appendix II listing (limits on international exports based on determinations that related take is sustainable and legal), | 82 |
| CITES Appendix I listing (total bans on most international trade), | 81 |
| shark-finning bans (making it illegal to remove the fins from a shark while at sea and dumping the carcass overboard), | 82 |
| time-restricted area closures (restricting fishing in certain regions during certain times of the year, i.e., mating or pupping aggregations, migration bottlenecks), | 83 |
| year-round closures to detrimental types of fishing in certain areas (bycatch hotspots, nurseries), | 83 |
| shark-fin bans (making it illegal to buy, sell, or possess shark fins), | 81 |
| nation-wide bans on any commercial fishing and landing sharks (shark sanctuaries), | 82 |
| no-take marine protected areas/or marine reserves (areas where no fishing is permitted). | 80 |
| Which statement best describes your beliefs about scientists' roles in elasmobranch conservation and management policy: (many responses). | 80 |
| Have you ever submitted a formal public comment to a policy maker or government body concerning the conservation and management of sharks (yes/no)? | 79 |
| Have you ever signed a petition concerning the conservation and management of sharks (yes or no)? | 78 |
| Have you ever included a specific policy suggestion in a scientific paper or technical report you've been a co-author on (yes/no)? | 77 |
| In your opinion, do ocean conservation (and shark-conservation focused) advocacy nongovernmental organization, in general, demonstrate knowledge of shark conservation topics by sharing factually accurate information with the public and with policy makers (yes, no, or other)? | 72 |
| In your opinion, do ocean conservation (and shark-conservation focused) advocacy nongovernmental organizations focus on the most important shark conservation issues (yes, no, or other)? | 72 |

Target-Based versus Limit-Based Policies

We categorized shark conservation and management policies as target-based or limit-based policy tools (Table 1). Although there can be a great deal of overlap between these tools, we used the definitions below in our analysis. Following Caddy and McGarvey (1996), policies that allow for sustainable fisheries harvest of specific species whose populations and life histories can withstand it, while protecting particularly threatened species, were considered target-based tools. Policies that ban some sort of exploitation entirely within a region, without a species-specific or population-specific focus, were categorized as limit-based tools.

To determine general support for the principles behind target-based versus limit-based policies, respondents were asked whether they believed sustainable fisheries harvest of sharks is possible. Additionally, respondents

were asked whether the goal of shark conservation and management policies should be sustainable fisheries harvest or banning all harvest. Support for the different policies was analyzed based on these measures of general support for target-based versus limit-based policies, as well as by research specialty (related to fisheries management vs. other) and highest degree (PhD vs. other).

Results

Demographics and Research Expertise of Survey Respondents

We had 102 responses to our survey (response rate approximately 21%, based on total membership from AES and OCS because no EEA members who were not also AES members responded). Most ($n = 96$) were members of AES. Fourteen were members of the OCS, and eight were members of both AES and OCS. Four were members of

Table 3. Responses to the survey question, “Which of the following disciplines have you published a paper or technical report in within the last ten years?”.

| Answer options | % of respondents |
|--|------------------|
| Ecology | 65.2 |
| Fisheries management or conservation policy* | 44.9 |
| Behavior | 43.9 |
| Life history or reproduction* | 41.6 |
| Population assessment* | 27.0 |
| Morphology | 27.0 |
| Physiology | 25.8 |
| Genetics | 24.7 |
| Taxonomy | 20.2 |
| Ecosystem structure and function | 16.9 |
| Education and outreach | 9.0 |

* Related to fisheries management.

EEA (each was also a member of AES). The most common other professional societies respondents belonged to were the American Fisheries Society ($n = 26$), the Society for Integrative and Comparative Biology ($n = 12$), and the Society for Conservation Biology ($n = 5$). Four belonged to the Ecological Society of America, the American Association for the Advancement of Science, and the Western Society of Naturalists. Twenty-three were members of the International Union for Conservation of Nature Shark Specialist Group.

Thirty-nine percent were university researchers (including faculty and nonstudent research staff), around one-third (30%) were graduate students, and one-sixth (16%) were employed by natural resources management agencies. The remaining approximately 15% were a mixture of educators, conservation activists, and undergraduate students. Almost half (46%) had earned a PhD as their highest academic degree, and 37% had earned a master's degree. Their ages ranged from 17 to 70 (mean of 36). Most worked in the United States ($n = 74$), 10 worked in Australia, 6 worked in Canada, and 2 worked in the United Kingdom. One worked in each of the following nations: Argentina, Bahamas, Mexico, Portugal, South Africa, and Sweden.

Two-thirds were ecologists, as defined by the field in which they had published peer-reviewed papers or technical reports in the last 10 years (65%, Table 3). The second most common area of expertise was fisheries management or conservation policy (45%). Almost half (45%) were considered fisheries management experts for further analysis because they had published a paper or technical report on fisheries management in the past 10 years. Those with research expertise in fisheries management most frequently also published in the disciplines of ecology ($n = 19$), life history or reproduction ($n = 17$), and population assessment ($n = 12$).

Of the 16 respondents employed by fisheries management agencies, ecology (50%) was the most common

discipline in which respondents had published a paper. Five employees of natural resource management agencies had published about life history or reproduction (31%), 4 (25%) had published about population assessment, and 4 (25%) had published about fisheries management.

In total, 64% of surveyed society members had some degree of traditional fisheries management background. They were either employed by a natural resources management agency or had published a paper or technical report on fisheries management or a closely related discipline. Some society members did not respond to some survey questions (Table 2).

Sustainable Shark Fisheries Harvest

A majority of surveyed society members believed that sustainable fisheries for sharks are possible (84%), that current real-world examples of sustainable shark fisheries exist (83%), and that sustainable fisheries harvest should be the goal of shark conservation policy instead of banning all fisheries harvest (90%) (Fig. 1). These patterns existed when responses were broken down by highest degree attained and whether or not that respondent had research expertise in fisheries or related disciplines (Fig. 2).

Those who believed sustainable shark fisheries are possible were significantly more likely to have published a paper on fisheries or a related discipline than those who believed sustainable shark fisheries are not possible (33.5% more likely, 95% CI 1.4 to 51.5). No other analyses comparing support for sustainable fisheries management by research expertise or highest degree attained resulted in significant values. Of those who believed sustainable shark fisheries are impossible, some cited “historically low shark populations” or “not high enough fecundity,” whereas others blamed issues with enforcement of regulations.

Forty-seven percent of those who believed sustainable shark fisheries are possible and 78% of those who believed there are current real-world examples of sustainable shark fisheries provided an example of a sustainable shark fishery. Seven fisheries were provided as examples: blacktip (*Carcharhinus limbatus*), dogfish (*Squalus acanthias* and *Mustelus canis*), thresher (*Alopias vulpinus*), and blue (*Prionace glauca*) sharks in the United States and gummy (*Mustelus antarcticus*) and blacktip sharks in Australia.

Scientist Support for Policy Tools

Although a majority of respondents supported 2 of the 3 limit-based management tools, limit-based tools had lower average support than target-based tools (Fig. 3). All target-based policies received more support than any limit-based policy, and 6 of the 8 target-based management policies received significantly more support than

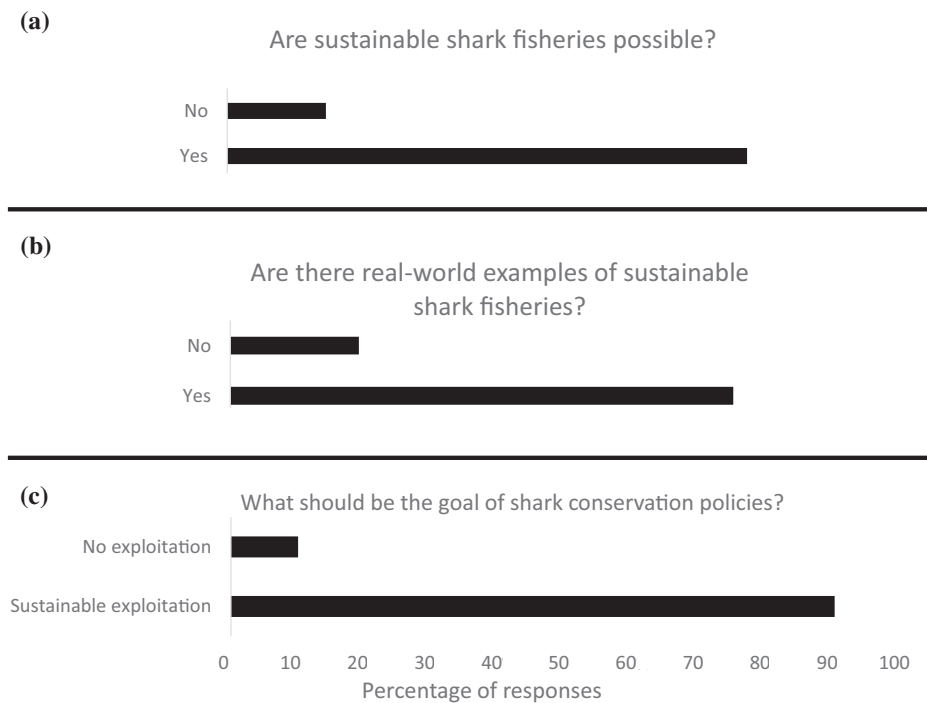


Figure 1. Response percentages to the questions (a) “Are sustainable shark fisheries possible?” ($n = 69$ responses), (b) “Are there any current real-world examples of sustainable shark fisheries?” ($n = 55$ responses), and (c) “What should be the goal of shark conservation policies?” ($n = 80$ responses). Different sample sizes are because some respondents left some questions unanswered.

any of the limit-based conservation policies (Fig. 3). Shark sanctuaries received significantly less support than any other policy, and bans the sale of shark fins received less support than any other policy other than shark sanctuaries (Fig. 3).

Of the eight respondents who believed “sharks should be protected from all commercial fisheries,” 87% agreed or strongly agreed with bans on the sale of shark fins, and 87% agreed or strongly agreed with establishment of shark sanctuaries. Of the 70 who believed “shark fisheries should be governed with the goal of sustainable fishing,” 60% agreed or strongly agreed with bans on the sale of shark fins, and 49% agreed or strongly agreed with establishment of shark sanctuaries.

Among the target-based policies, fisheries quotas paradoxically received the greatest support and the greatest opposition (Fig. 3) because the fisheries quota policy had the fewest number of respondents who had no opinion about the policy. No comments were left by those who supported quotas, but two who disagreed that quotas are effective tools commented that they are not always based on accurate scientific data on life history and population size. This means they disapproved of quotas established incorrectly, not of quotas in general. The Convention on International Trade in Endangered Species (CITES) Appendix I and Appendix II listings received the fewest strongly agree and agree responses of the target-based policies (Fig. 3).

The only policy in either category that no one strongly disagreed with were strict bans on take for particularly threatened species (which did receive one disagree response; no comments were left [Fig. 3]). More comments were submitted explaining respondents’ views on shark

sanctuaries (Supporting Information) and bans on the sale of shark fins (Supporting Information) than on any other policy.

Scientist Support for Policy Tools

Supporters of shark sanctuaries were significantly more likely to support banning all shark fishing (24.4% more likely, 95% CI 8.6 to 42.1) than sanctuary opponents. We rejected the null hypotheses that preference for banning all exploitation has no relationship with policy preferences for this case. Those with a PhD were significantly more likely than those without a PhD to oppose sanctuaries (21.9% more likely, 95% CI 2.5 to 39.7). We rejected the null hypotheses that the highest academic degree earned has no impact on policy preference for this case. There was no significant relationship between research expertise in fisheries management and support for sanctuaries, and we failed to reject that null hypothesis.

Although it received nearly 40% support as an effective and appropriate policy tool, shark sanctuaries received the lowest level of agreement (and highest level of disagreement) of any policy among respondents and was the only policy that received more strongly disagree and disagree responses than agree and strongly agree responses (Fig. 3). However, only 13% strongly disagreed with sanctuaries. Several concerns were raised by survey respondents about sanctuaries (Supporting Information).

All those who disagreed or strongly disagreed with shark sanctuaries believed sustainable fisheries harvest is preferable to a ban on all shark fishing, and 100% of those who believed all shark fishing should be banned supported (agreed or strongly agreed with) shark sanctuaries. Thirty-five percent of those who believed sustain-

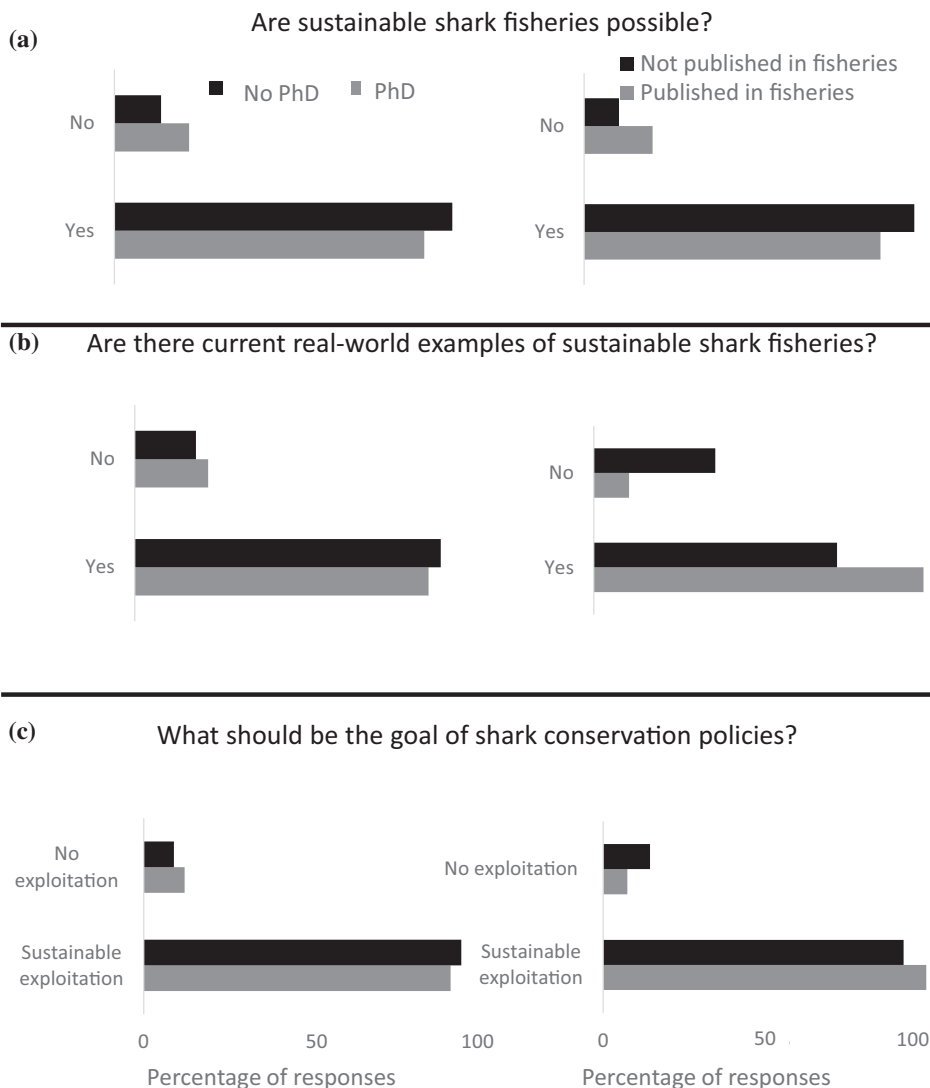


Figure 2. Response percentages to the questions (a) “Are sustainable shark fisheries possible?” (PhD, $n = 36$; no PhD, $n = 30$; published in fisheries, $n = 48$; not published in fisheries, $n = 21$), (b) “Are there any current real-world examples of sustainable shark fisheries?” (PhD, $n = 25$; no PhD, $n = 30$; published in fisheries, $n = 31$; not published in fisheries, $n = 24$), and (c) “What should be the goal of shark conservation policies?” (PhD, $n = 34$; no PhD, $n = 46$; published in fisheries, $n = 43$; not published in fisheries, $n = 37$). Different sample sizes are because some respondents left some questions unanswered.

able shark fisheries are impossible opposed sanctuaries, whereas there was 48% opposition to sanctuaries from those who believed sustainable shark fisheries are possible. Of shark sanctuary supporters, 79% believe sustainable harvest policies are preferable to a ban on all shark fishing.

Many opponents of shark sanctuaries stated that their opposition was rooted in a preference for sustainable harvest over a complete ban on fishing. For example, comments included, “If a fishery is sustainable, why not take sharks?” and “A nationwide ban on shark fishing is unwarranted . . . There are populations that are capable of supporting a sustainable fishery” (Supporting Information). Others suggested stakeholders such as commercial fishers should be included in policy making and that banning all fishing does not accomplish this (e.g., “. . . a pointless way of making NGOs very unpopular with commercial fishing industry” and “There needs to be a balance and local people (relative to the fishery) need to be involved”). One supporter suggested ecotourism could

replace fisheries as an income source, and another suggested that sanctuaries be temporary until populations rebuild enough to allow harvesting.

Opponents of a ban on the sale of shark fins were significantly more likely to have published a paper on fisheries management than supporters of a ban on the sale of shark fins (37.6% more likely, 95%CI 10.8 to 56.7). We rejected the null hypotheses that research expertise has no effect on policy preference for this case. Everyone who agreed with the statement “all shark fishing should be banned” either supported bans on the sale of shark fins or did not respond to the question. There was no significant relationship between highest academic degree and support for bans on the sale of fins, and we failed to reject that null hypothesis for this case.

Although 63% strongly agreed or agreed with bans on the sale of shark fins, these policies had the second highest level of disagreement (and the second lowest level of agreement) (Fig. 3). Several specific concerns were raised about bans on the sale of fins (Supporting Information).

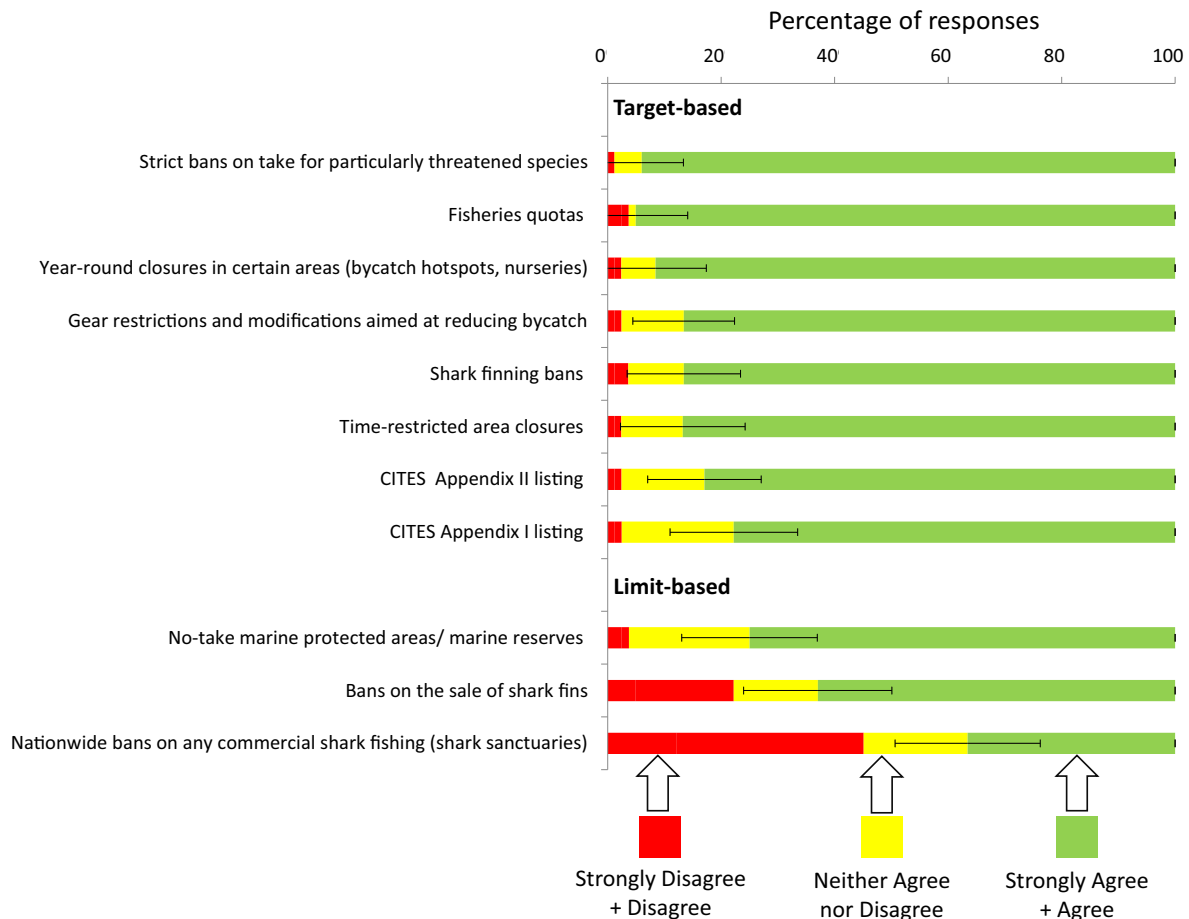


Figure 3. Respondents' level of agreement with particular shark conservation and management policies (divided into target-based and limit-based policies). Error bars indicate a 95% CI surrounding the proportion of respondents who agreed or strongly agreed with each policy (CITES, Convention on International Trade in Endangered Species).

Of those who disagreed or strongly disagreed with bans on the sale of fins, 100% believed “shark fisheries should be governed with the goal of sustainable” fisheries harvest and 0% believed “all shark fishing should be banned.” All those who did not believe sustainable shark fisheries are possible supported bans on the sale of fins or had no opinion, whereas 63% of those who believed sustainable shark fisheries are possible supported bans on the sale of fins. Eighty-five percent of supporters of bans on the sale of fins preferred sustainable fisheries harvest policies over banning all shark fishing.

Many opponents referenced the idea of “full use” of dead sharks to explain their opposition to bans on the sale of fins (e.g., “If the carcass is eaten, I have no problem with the use of the fins” and “Full utilization of sharks taken in sustainable fisheries would logically require that some of the fins get used”). Others were concerned about the limited focus of these tools (e.g., “We should focus on protecting sharks . . . we are not in the business of conserving fins”). Four of five supporters who left comments suggested their support was qualified. Three suggested

enforcement would limit effectiveness of bans on the sale of fins, and another suggested fisheries management would be preferable.

Conservation Advocacy

Respondents considered themselves knowledgeable about and involved in conservation and management. They did not consider shark conservation advocacy an academic debate; rather, they thought it was their responsibility to act, both professionally and personally, to conserve sharks by working with environmental nonprofit organizations and through individual advocacy. Seventy-five percent agreed with the statement “scientists have a responsibility to actively advocate for sound management policies.” Fifty-four percent had submitted a formal public comment to a government body or policy maker and 53% included a specific policy suggestion in a scientific paper or technical report. Seventy-seven percent had signed a petition. Responses to these questions and the belief that sustainable fisheries are possible, area of

research expertise, and highest academic degree were not significantly related.

Attitudes toward Conservation NGOs

Overall, survey respondents were generally supportive of NGOs that focus on shark conservation. Many stated that they have volunteered their expertise or donated money to help these organizations, but some expressed concerns about the practices of some perceived bad actors in the NGO community.

Although 24% believed shark and ocean conservation NGOs generally share factually accurate information, 35% believed shark and ocean conservation NGOs generally do not share factually accurate information. Forty-one percent believed at least some NGOs did not share factually accurate information. Comments on ocean conservation NGOs included “they use worst-case scenarios to boost donations,” “ramp up rhetoric for effect,” and share “misleading or incorrect information” or “pure made-up garbage.”

Fifty-five percent believed at least some NGOs do not focus on the most important issues, 20% believed they generally do not, and 25% believed they generally do. Respondents expressed concern that NGOs are “. . . missing key pieces of the puzzle,” that there is “a general lack of understanding fueled by self-proclaimed experts,” and that NGOs “focus on widely known species, not the most critically effected species.” Similar concerns were expressed with respect to shark sanctuaries (Supporting Information) (e.g., “Some members of the NGO community seem to think that all sharks are ‘hallowed’ animals that should not be killed, eaten or hurt” and “Overzealous movements to stop all shark fishing do more harm than good”).

Discussion

Survey respondents overwhelmingly believed sustainable fisheries harvest of sharks is possible, is occurring currently, and should be the goal of conservation and management instead of banning shark fishing entirely. In addition, all target-based policies had generally more support than limit-based policies.

We found some evidence that a scientist’s area of expertise influenced whether she or he supported target-based or limit-based policies. Those who believed sustainable fisheries are possible were more likely to have expertise in the research discipline of fisheries management, and the majority of those who published a paper in this discipline believed sustainable shark fisheries are possible. Those opposed to bans on the sale of fins were more likely to have published in the discipline of fisheries management than supporters of bans on the sale of fins. All CIs of significance results were relatively wide,

however, suggesting low precision (due primarily to low sample size of some responses).

The majority of respondents supported almost all potential shark conservation policies. This suggests that no single policy is always best for every situation and that a mix of policies may be needed to fully protect threatened sharks, depending on the situation. However, respondents supported sanctuaries and bans on the sale of fins, two limit-based policies, the least. Those who believed all shark fishing should be banned were more likely to support these policies than those who supported sustainable shark fishing. This may be a result of an inherent bias toward the tools scientists trained in (or employed by) fisheries management were more familiar with and of most respondents coming from developed nations with substantial fisheries management and research infrastructure. The relatively low support for newer limit-based conservation policies may be an artifact of the majority of society members having experience, training, and employment in traditional target-based fisheries management.

Many respondents who believed that sustainable fishing should be the goal rather than that all shark fishing should be banned supported shark sanctuaries (which focus on banning all shark fishing within a particular area). This may be explained by the fact that our survey asked only about the appropriateness and effectiveness of these policies in general, not in specific cases. Therefore, these respondents may generally have preferred sustainable fisheries management but thought that it was not possible or appropriate in every situation or that there was little current practical evidence of sustainable shark fisheries. Some objections to sanctuaries were philosophical (e.g., a belief that sharks are resources that should be exploited), whereas others were logistical (belief that enforcement is a problem). Concerns about sanctuaries may also suggest a lack of familiarity with this relatively new policy tool, potentially because most shark research takes place in countries with effective fisheries management regimes (countries where most of our survey respondents were from) (Momigliano & Harcourt 2014). Shark sanctuaries that have been established so far are in developing nations without effective fisheries management (Lack & Sant 2011). These shark sanctuaries have not been systematically evaluated by scientists (Hoyt 2014). A preliminary analysis by Ali and Sinan (2014) suggests that at least one has not been well implemented to date. Recent discussions in the literature have raised concerns similar to those raised by our results (Davidson 2012; Dulvy 2013).

Despite the stated goal of sustainable shark fisheries, relatively few sustainable shark fisheries have been identified currently or historically in the literature (Walker 1998; Klein 2014; Lawrence 2014), but those identified by respondents match this list. Gummy shark (Australia) and blue shark (U.S. Atlantic) fisheries were noted as

examples of sustainable shark fisheries by Walker (1998). The U.S. National Marine Fisheries Service FishWatch website notes that blacktip shark stocks are not over-harvested (Fishwatch 2014a) and that Atlantic spiny dogfish stocks have been rebuilt (Fishwatch 2014b). These examples of sustainable fisheries each target a small-bodied relatively fast-growing shark, and each is from a country with well-funded fisheries management infrastructure (United States, Canada, and Australia). There are many global shark fisheries targeting larger-bodied slower-growing sharks that do not occur in countries with well-funded fisheries management infrastructure (Worm et al. 2013). Although respondents believed sustainable shark fisheries can and should be achievable with proper management, this small list of current examples suggests sustainable shark fisheries are largely not occurring currently. This suggests that more work, both in terms of research and advocacy, is needed to ensure sustainable shark fisheries (Klein 2014).

Three of the four policies that most respondents had no opinion about were limit-based policies, and few comments were left about policies other than shark sanctuaries and bans on the sale of fins. More recently introduced (e.g., CITES, shark sanctuaries) policies had more neither agree nor disagree responses than more frequently used (e.g., fisheries quotas) policies. It would be interesting to see how preferences may change in the future after these tools are established and evaluated scientifically. Some respondents may believe that limit-based policies could be used in some places and target-based policies in others as part of an ocean zoning plan (Techera 2014).

The majority of respondents considered themselves knowledgeable about and actively involved in shark conservation policy making. Seventy-five percent agreed that scientists have a responsibility to actively advocate for sound management policies. When Steel et al. (2004) asked a group of ecologists whether “scientists should actively advocate for specific natural resource management policies they prefer,” 16% agreed. Seventy-seven percent agreed that “scientists should work closely with managers to integrate scientific results in management decisions.” This may be partially explained by the fact that many elasmobranch researchers report they chose to study elasmobranchs because they are threatened (Ferry & Shiffman 2014). It may also be a result of a lower response rate in our study. If only scientists who consider themselves knowledgeable about these topics chose to respond to the survey, it skews the results of our study in that direction. Steel et al. (2004) had a much higher response rate (82% of contacted ecologists) than we did (approximately 21%). Any survey may have an associated response bias because people who feel less strongly about an issue may be less likely to take the time to respond. It is possible that our survey, which had a lower response rate but a higher proportion of respondents involved in advocacy than Steel et al. (2004), may have a

response bias. However, the demographics of our survey respondents were similar to the American Elasmobranch Society membership as a whole (J. Wyffels, American Elasmobranch Society Secretary, personal communication), which gives us confidence in the broader applicability of our results and supports our assertion that although it is not the only factor, the preferences of expert researchers should be considered in conservation policy making.

In addition to getting involved in conservation advocacy themselves, most society members supported environmental conservation NGOs and their efforts to conserve sharks. However, some concerns were raised about the practices of some NGOs and their perceived efforts to use misleading information focusing on issues that some respondents believed to be flashy and effective at getting people’s attention but not the most critically important conservation issues. Many environmental NGOs and advocates in recent years have focused on limit-based bans on the sale of shark fins and shark sanctuaries (Klein & Techera 2014).

Scientists and environmental NGOs occasionally support mutually exclusive policies (banning fisheries harvest entirely is incompatible with ensuring sustainable fisheries harvest, at least in the same place and time) and would therefore seem to be in conflict. To be most effective, scientists and environmental NGOs need to be better informed about the scope of the conservation problem and the best policy tools to solve it. It is also important for science and policy experts to help inform NGOs and the larger scientific community about which tools are effective and need public support. Increased cooperation and communication between experts and the concerned public can further the goals of both groups.

Respondents to our survey strongly supported management of shark fisheries for sustainability. Given increasing concern about the conservation of sharks, we hope our results provide insights that will aid in the understanding, utility, and implementation of shark conservation policies.

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Supporting Information

Comments left by respondents about shark sanctuaries (Appendix S1) and about bans on the sale of shark fins (Appendix S2) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

Literature Cited

- Ali K, Sinan H. 2014. Shark ban in its infancy: successes, challenges and lessons learned. *Journal of the Marine Biological Association of India* **56**:34–40.
- Caddy JF, McGarvey R. 1996. Targets or limits for management of fisheries? *North American Journal of Fisheries Management* **16**:479–487.
- Cunningham-Day R. 2001. Sharks in danger: global shark conservation status with reference to management plans and legislation. Universal Publishers, Parkland, FL.
- Davidson LNK. 2012. Shark sanctuaries: Substance or spin? *Science* **338**:1538.
- Dulvy NK. 2013. Super-sized MPAs and the marginalization of species conservation. *Aquatic Conservation* **23**:357–362.
- Dulvy NK, et al. 2014. Extinction risk and conservation of the world's sharks and rays. *eLife* **3**:(ee590) DOI: dx.doi.org/10.7554/eLife.00590.
- Ferry LA, Shiffman DS. 2014. The value of taxon-focused science: 30 years of elasmobranchs in biological research and outreach. *Copeia* **4**:743–746.
- Fishwatch. 2014a. Atlantic blacktip shark. National Oceanographic and Atmospheric Administration, Washington, D.C. Available from <http://www.fishwatch.gov/profiles/atlantic-blacktip-shark> (accessed January 2016).
- Fishwatch. 2014b. Atlantic spiny dogfish. National Oceanographic and Atmospheric Administration, Washington, D.C. Available from <http://www.fishwatch.gov/profiles/atlantic-spiny-dogfish> (accessed January 2016).
- Friedrich LA, Jefferson R, Clegg G. 2014. Public perceptions of sharks: gathering support for shark conservation. *Marine Policy* **47**:1–7.
- Hammerschlag N, Gallagher AJ. 2014. Shark declines fuel for a decade of conservation effort. *Ocean views*. National Geographic online. Available from <http://voices.nationalgeographic.com/2013/11/18/shark-declines-fuel-for-a-decade-of-conservation-effort/> (accessed January 2016).
- Hilborn R. 2006. Faith-based fisheries. *Fisheries* **31**:554–555.
- Hoyt E. 2014. The role of marine protected areas and sanctuaries. Pages 263–285 in Klein N, Techera EJ, editors. *Sharks: conservation, governance and management*. Earthscan Press, New York.
- Jacques PJ. 2010. The social oceanography of top oceanic predators and the decline of sharks: a call for a new field. *Progress in Oceanography* **86**:192–203.
- Jennings S. 2007. Reporting and advising on the effects of fishing. *Fish and Fisheries* **8**:269–276.
- Klein N. 2014. The existing global legal regimes. Pages 27–45 in Klein N, Techera EJ, editors. *Sharks: conservation, governance and management*. Earthscan Press, New York.
- Klein N, Techera EJ. 2014. Synergies, solutions and the way forward. Pages 309–323 in Klein N, Techera EJ, editors. *Sharks: conservation, governance and management*, Earthscan Press, New York.
- Lack M, Sant G. 2011. The future of sharks: a review of action and inaction. Report TRAFFIC International, Cambridge, United Kingdom, and Pew Environment Group, Washington, D.C.
- Lawrence A. 2014. Collaborations for conservation. Pages 135–156 in Klein N, Techera EJ, editors. *Sharks: conservation, governance and management*. Earthscan Press, New York.
- Mace GM, Hudson EJ. 1999. Attitudes towards sustainability and extinction. *Conservation Biology* **13**:242–246.
- Momigliano P, Harcourt R. 2014. Shark conservation, governance, and management: the science-law disconnect. Pages 89–106 in Klein N, Techera EJ, editors. *Sharks: conservation, governance and management*, Earthscan Press, New York.
- Parsons ECM, Shiffman DS, Darling ES, Spillman N, Wright AJ. 2014. How twitter literacy can benefit conservation scientists. *Conservation Biology* **28**:299–301.
- Simpfendorfer CA, Heupel MR, White WT, Dulvy NK. 2011. The importance of research and public opinion to conservation management of sharks and rays: a synthesis. *Marine and Freshwater Research* **62**:518–527.
- Singh GG, Tam J, Sisk TD, Klain SC, Mach ME, Martone RG, Chen KMA. 2014. A more social science: barriers and incentives for scientists engaging in policy. *Frontiers in Ecology and the Environment* **12**:161–166.
- Steel B, List P, Lach D, Shindler B. 2004. The role of scientists in the environmental policy process: a case study from the American west. *Environmental Science & Policy* **7**:1–13.
- Techera EJ. 2014. Approaches to conservation and governance of marine species. Pages 9–26 in Klein N, Techera EJ, editors. *Sharks: conservation, governance and management*, Earthscan Press, New York.
- Techera EJ, Klein N. 2011. Fragmented governance: reconciling legal strategies for shark conservation and management. *Marine Policy* **35**:73–78.
- Thaler AD, Zelnio KA, Freitag A, MacPherson R, Shiffman D, Bik H, McClain C. 2012. Digital environmentalism: tools and strategies for the evolving online ecosystem. In *SAGE Reference-Environmental leadership: a reference handbook*. Sage Publications, London.
- Walker TI. 1998. Can shark resources be harvested sustainably? A question revisited with a review of shark fisheries. *Marine and Freshwater Research* **49**:553–572.
- Worm B, Davis B, Kettner L, Ward-Paige CA, Chapman D, Heithaus MR, Kessel ST, Gruber SH. 2013. Global catches, exploitation rates, and rebuilding options for sharks. *Marine Policy* **40**:194–204.