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# Exploring the hidden connections between information channel use and pro-environmental behavior among recreational anglers of the shore-based shark fishery in Florida, United States

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**Introduction:** Shore-based shark fishing in Florida is a relatively low-cost and easy-access fishery which attracts a wide variety of experienced and inexperienced anglers leading to concerns about proper handling methods of captured fish that are released either voluntarily or to comply with regulations. Proper handling methods can help reduce post-release mortality among sharks, many of which are threatened with extinction. Therefore, we considered proper handling methods as a pro-environmental behavior, which has been linked with the use of different information channels to increase conservation knowledge.

**Methods:** We used data from an online questionnaire to understand where anglers of this fishery obtain information about fishing skills with a particular focus on fish handling techniques and best practices for catch-and-release. Then we included their main information channels in a series of hierarchical regression models with perceived conservation knowledge and support for fishery management to explain pro-environmental behavior regarding shark conservation.

**Results:** We found that most anglers learned about shore-based shark fishing through interpersonal communications with friends and family, but typically use the internet to learn more about fishing skills. While information channel use was not significantly associated with pro-environmental behavior, it was significantly associated with support for fisheries management, which in turn was associated with pro-environmental behavior among respondents.

**Discussion:** These findings can inform public educational outreach efforts to spread awareness of proper handling techniques and reduce instances of post-release mortality in sharks.

KEYWORDS

**human dimensions, science communication, recreational fisheries, angler behavior, angler perceptions, shark fishing, fisheries management**

## Introduction

A quarter of all sharks and rays are threatened with extinction, mainly due to overfishing and bycatch, but also due to habitat loss, and climate change (Dulvy et al., 2014). Of the threats to sharks, commercial fisheries are large contributors to shark population declines worldwide; however, little is known about the impacts of recreational shark fishing, a niche fishery that is largely under-represented in the literature (Gallagher et al., 2017; Roff et al., 2018; MacNeil et al., 2020). While it is generally assumed that recreational catch and release shark fishing does not significantly impact shark populations, this activity often involves angling sharks (using rod and reel) to exhaustion until it is safe to dehook and occasionally pulling the shark out of water for angler safety. Such practices can cause physiological stress to sharks, leaving them vulnerable to predation or death from injuries or depleted energy (Danylchuk et al., 2014; Gallagher et al., 2014; Weber et al., 2020). Consequently, improper handling practices or use of unsuitable gear could be harmful to both the shark and angler (Brownscombe et al., 2017). Proper management of recreational shark fisheries and promoting best handling practices is thus critical to maximize the protection of sharks, especially for vulnerable species that may be more sensitive to stress.

Management strategies may only be effective if anglers participate or comply with the best practices and regulations. Unfortunately, this is not always the case, especially if anglers disagree with the regulations, regulations are not enforced, or anglers are not aware of the regulations (Page and Radomski, 2011; Cardona and Morales-Nin, 2013). A recent study revealed that non-compliance may be prevalent in a shore-based shark fishery in Florida after highlighting illegal activities posted on an online public forum, such as landing prohibited species of sharks and delaying their release (Shiffman et al., 2017). Shore-based shark fishing (SBSF) is a relatively low-cost mode of shark fishing where the ocean can be accessed by beaches, piers, and bridges, which could attract anglers with minimal experience to participate. Improper handling practices could thus be common, putting both the shark and angler at risk of harm. Moreover, Shiffman et al. (2017) highlights skepticism among anglers from this fishery toward researchers and the science behind regulations, which may impede communication between managers, researchers, and anglers (Dedual et al., 2013). Further impediments to communication within the Florida SBSF fishery may include fear that management actions will limit fishing opportunities, or animosity toward the impacts of commercial fishing on shark populations due to the potential ripple effects on recreational fishing (Dedual et al., 2013; Guay et al., 2021).

A major component of effective fisheries management is successful communication with anglers, which can inform them of current and new regulations, safe and best handling techniques, and potential opportunities that call for angler engagement and participation (Arlinghaus et al., 2013; Hunt et al., 2013; Wester et al., 2022). Effective communication between anglers, managers, and researchers may foster better relationships and trust which could increase involvement of anglers in fisheries management (Arlinghaus, 2006). Since successful communication involves reaching the greatest number of anglers in the fishery and connecting with their values and beliefs, understanding angler values and where anglers acquire fishing-related information is crucial (Dedual et al., 2013). With these data, managers could target their outreach efforts through the most used channels to reach the most anglers, while shaping the content to align with angler values and increase support for fishery management. Presently, there are few studies that investigate anglers' primary information channels (Hunt et al., 2013). Moreover, previous studies have found great diversity in information channels and sources used by individual anglers, which may hinder outreach efforts from managers if they are using a single or few output channels (Gray and Jordan, 2010; Nguyen et al., 2012). Therefore, the first objective of this study is to identify the main channels through which anglers of the Florida SBSF fishery acquire information about fishing skills to help inform and target educational outreach efforts.

Engagement and collaboration with an informed angler community should improve support toward fishery management and conservation goals (Li et al., 2010). Studies have found that anglers who are more knowledgeable on shark-related conservation matters tend to have more positive attitudes toward researchers and management and be more likely to comply with regulations and participate in pro-environmental behaviors (e.g., O'Bryhim and Parsons, 2015; Gallagher et al., 2017). Exposure to information through different channels has been found to shape perceived knowledge, and therefore influence pro-environmental behaviors. For instance, Corbett (2002) found that intention to participate in a conservation program differed based on information exposure from different channels. Furthermore, information channel use has been discussed as a potential background factor acting on factors within the theory of planned behavior framework (Witzling et al., 2015). The theory of planned behavior theorizes that people's behaviors may be predicted or explained by behavioral intentions, which may in turn be explained by a combination of their attitudes, perceived behavioral control, and subjective norms related to the behavior (Ajzen, 1991). Witzling et al. (2015) found links between information channel use and attitudes about conservation challenges, which in turn may have indirectly influenced pro-environmental behaviors. Therefore, there is evidence that suggests anglers' interactions with various information channels may influence their knowledge, attitudes,

and behaviors toward conservation and fisheries management (Corbett, 2002; Witzling et al., 2015).

The Florida SBSF fishery presents a unique case to study these relationships, particularly because the relatively low-cost and easy-access features of this fishery can attract a wide variety of experienced and inexperienced anglers. This can lead to concerns about proper handling methods which can help reduce post-release mortality among sharks, many of which are threatened with extinction (Dulvy et al., 2014). As such, our second objective is to evaluate how these channels might ultimately influence angler support toward fishery management and willingness to participate in pro-environmental behavior (i.e., proper handling methods) through a series of hierarchical modeling. We pose three hypotheses: (1) Information channel use will influence angler perceived conservation knowledge, (2) Information channel use and perceived conservation knowledge will influence support for fishery management strategies, and (3) Information channel use, perceived conservation knowledge, and management support will influence pro-environmental behavioral intention regarding shark conservation.

# Methods

## Data collection: Questionnaire

We distributed an online questionnaire (see Supplementary material for the full questionnaire) *via* email to 11,277 recreational anglers who obtained a shore-based shark fishing permit from the Florida Fish and Wildlife Conservation Commission (FWC) in 2019. The questionnaire was designed for a larger study (see Guay et al., 2021) and included 40 questions assessing angler specialization, motivation, preferences, behavior, perceptions of shark conservation and fishery management, sociodemographic variables and more (see Supplementary material and Guay et al., 2021 for additional information). Our questionnaire was designed based on similar studies surveying recreational shark anglers in other regions, and included a combination of multiple choice, 4-point Likert scales, and open-ended response questions (e.g., National Marine Fisheries Service (NMFS), 2014; Gallagher et al., 2015; Lovell et al., 2016; McClellan Press et al., 2016; Drymon and Scyphers, 2017; Johnson, 2018; French et al., 2019). We included three filter questions to obtain our target participants (i.e., anglers with an FWC SBSF permit, who target sharks, and fish from shore), and sociodemographic variables included angler gender, age, education, employment, and residency. The remaining relevant questions will be described in the sections below. Prior to distribution, we sent the questionnaire to members of the FWC and of the National Oceanic and Atmospheric Administration National Marine Fisheries Service Highly Migratory Species for review. We also piloted the questionnaire with shark anglers in Florida to reduce personal bias and ensure relevant questions (Moon et al., 2019). We initially sent the questionnaire *via* Qualtrics XM (2020) on March 13, 2020, followed by a prompting email on April 2, 2020, before terminating the questionnaire on April 17, 2020. From our list of 11,277 SBSF permit holders (in December 2019), 271 emails returned due to deactivated accounts and 16 emails were returned as duplicates, resulting in 10,990 permit holders receiving the questionnaire. Our questionnaire and research methods adhered the Carleton University Research Ethics Board requirements (CUREB-B Clearance #112118).

## Data analysis

For this study, we focused on three constructs: (I) angler's information channels, (II) angler perceived conservation knowledge, (III) management support, and (IV) pro-environmental behavioral intention which we describe in the sections below.

## Identifying anglers' main information channel

We included an open-ended question assessing anglers' main information channels to learn more about general fishing skills (not specific to shore-based shark fishing), as well as an open-ended question to understand where they specifically learned about shark fishing (Table 1). We manually coded both variables, initially into specific categories that emerged from the data, and then reduced to fewer broader themes based on characteristic similarities and categories used in similar studies assessing anglers' preferred information channels (Nguyen et al., 2012; Witzling et al., 2015). The variable assessing main information channel to learn more about fishing skills was then labeled as "information channel" and used in its reduced (e.g., five categories) form for further analyses.

## Angler perceived conservation knowledge

Perceived conservation knowledge was measured using a 4-point Likert item assessing level of agreement *(disagree, somewhat disagree, somewhat agree, agree*) on the following statement: "*I am knowledgeable about shark conservation related issues*". We reduced the 4-point item into a binary variable by collapsing "*agree*" and "*somewhat agree*" together, as well as "*disagree*" and "*somewhat disagree*" to be used in a binary logistic regression.

TABLE 1 Categorization of main information channels used by respondents to learn about general fishing skills.

| Channels | N | Channels | N |
|---|---|---|---|
| *Friends and Family* | 291 | *Interpersonal Communication* | 477 |
| *Other Anglers* | 173 | *Circumstantial* | 205 |
| *Circumstantial* | 110 | *Internet* | 140 |
| *Accidental bycatch* | 95 | *Other* | 31 |
| *YouTube* | 59 | *Combination* | 65 |
| *Internet* | 45 | | |
| *Governing Body (FWC)* | 26 | | |
| *Fishing Forum/Page* | 10 | | |
| *Tackle Shop* | 8 | | |
| *Fishing Clubs* | 5 | | |
| *Prints* | 5 | | |
| *Other* | 26 | | |
| *Combination* | 65 | | |
| *NA* | 54 | | |

**Where would you go to learn more about fishing skills?**

| Channels | N | Channels | N |
|---|---|---|---|
| Internet | 313 | Internet | 416 |
| YouTube | 162 | YouTube | 162 |
| Other Anglers | 80 | Interpersonal Communication | 138 |
| Governing Body (FWC) | 52 | Other | 37 |
| Fishing Forum/Page | 51 | Combination | 130 |
| Friends and Family | 34 | | |
| Tackle Shop | 20 | | |
| Prints | 7 | | |
| Fishing Clubs | 4 | | |
| Other | 30 | | |
| Combination | 130 | | |
| NA | 89 | | |

## Angler support for fishery management

We measured angler support for fishery management using five Likert statements assessing anglers' level of agreement (same scale as above) toward regulations and the state of the SBSF fishery management (described in Table 2). Here, we used level of agreement as a proxy for level of management support (similarly to Allegretti et al., 2012), but we acknowledge the limitations that agreement with a statement does not necessarily signify general support for management and proceed with cautious interpretation. Therefore, this construct, labeled "*management support*", was measured by creating a composite scale using these five statements. We assigned each angler a score measuring their support for fishery management by rating each statement response from one (*disagree*) to four (*agree*), except for one item which was reverse coded, and calculated the sum of the five statements. This resulted in a single composite variable with a minimum score of 5 and a maximum score of 20, where lower values ($\leq$ 12) indicated lack of or low support for fishery management, and higher values ($\geq$ 13) indicated sufficient or total support for fishery management. We then calculated Cronbach's alpha coefficient to measure the internal consistency reliability of the five variables used to create the scale (Eisinga et al., 2013). The Cronbach's alpha coefficient for the five variables used was 0.64, indicating relatively acceptable internal consistency among variables within the management support scale (Bonett and Wright, 2015). When we included *management support* in a model as a predictor variable, we used it in this scale format as a numerical variable, however when we included it as a response variable, we collapsed the scale into a binary variable for use in a binary logistic regression. To do this, we categorized anglers such that respondents with a score of $\leq$ 12 were categorized as "*not supportive*", and respondents with a score of $\geq$ 13 were categorized as "*supportive*". We opted for this strategy to maintain consistency in model type for this series and for ease of model comparison.

TABLE 2 Angler's level of agreement and support toward shore-based shark fishery management and shark conservation.

| Statements on fishery management | Disagree | Somewhat disagree | Somewhat agree | Agree | Don't know/Does not apply | *N* |
|---|---|---|---|---|---|---|
| Current management measures and restrictions help shark conservation* | 2.80% | 5.30% | 34.00% | 53.90% | 4.00% | 965 |
| More regulations are required for recreational shark fishing* | 31.20% | 29.50% | 20.20% | 12.30% | 6.70% | 965 |
| Current management restrictions are too strict or interfere with my fishing* | 41.20% | 28.20% | 17.60% | 8.80% | 4.00% | 964 |
| Most shore-based shark anglers know what they are doing and will release sharks unharmed | 15.80% | 22.70% | 35.30% | 21.30% | 4.90% | 966 |
| There needs to be more education and training for shore-based shark fishing* | 8.00% | 15.50% | 38.60% | 35.00% | 2.90% | 967 |
| **Statements on shark conservation** | **Disagree** | **Somewhat disagree** | **Somewhat agree** | **Agree** | **Don't know/Does not apply** | ***N*** |
| Sharks need to be better protected* | 3.40% | 9.10% | 29.30% | 55.20% | 3.00% | 968 |
| I am knowledgeable about shark conservation related issues | 0.80% | 5.90% | 39.00% | 53.10% | 1.10% | 968 |
| When SBSF, GHHS always survive after being caught | 50.10% | 17.00% | 9.40% | 3.30% | 20.20% | 966 |
| I would not fish for sharks if I thought it could kill them | 11.30% | 21.90% | 27.10% | 37.30% | 2.40% | 965 |
| Recreational fishing has a negative impact on shark populations | 40.30% | 29.50% | 20.30% | 3.80% | 6.00% | 968 |
| Commercial fishing has a negative impact on shark populations | 4.60% | 6.30% | 21.90% | 62.50% | 4.70% | 967 |
| I want to learn more about how to make sure my shark survives after I release it | 3.30% | 4.70% | 18.20% | 70.00% | 3.80% | 966 |
| Populations of great hammerhead sharks are not at risk of extinction | 33.90% | 22.70% | 9.40% | 4.70% | 29.30% | 967 |
| I would change how and where I fish if it helped shark survival | 4.50% | 6.10% | 28.90% | 57.70% | 2.80% | 965 |

Statements marked with an asterisk (*) were used to create our composite scale variable "Management support". SBSF, Shore-based shark fishing; GHHS, Great hammerhead sharks.



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## Angler pro-environmental intention

Here, we measured pro-environmental behavioral *intention* (e.g., willingness to engage in a behavior) instead of pro-environmental behavior due to the wording constraints of the chosen variable, and because the theory of planned behavior implies a direct link between intention and behavior (Ajzen, 1991). The variable we chose was a 4-point Likert item assessing level of agreement (same scale as above) on the following statement: "*I would change how and where I fished if it helped shark survival*". We reduced the 4-point item into a binary variable by collapsing "*agree*" and "*somewhat agree*" together, as well as "*disagree*" and "*somewhat disagree*" to be used in a binary logistic regression. We used this variable to represent *pro-environmental* intention as it demonstrates willingness to modify current behaviors should it increase post-release survival of sharks.

## Hierarchical modeling of pro-environmental angler behavior

To understand how anglers' main information channels, perceived conservation knowledge, and management support might be associated with pro-environmental behavior regarding shark conservation, we performed a series of three hierarchical binary logistic regressions (Table 3). We also included two sociodemographic variables in each model to measure potential external influences, and to improve the models' fit to the data (determined by comparing Akaike's Information Criterion with and without sociodemographic variables). The two sociodemographic variables we measured were education and age as studies have found links between both variables to higher perceived conservation knowledge, management support and pro-environmental behavior (Sharp et al., 2011; Witzling et al., 2015; Potgieter et al., 2019). Education was modified to reflect as a binary variable with respondents categorized into "secondary education" and "postsecondary education" as their highest level of education achieved. Age was modified into equally distanced groups (< 21 years; 21–30 years; 31–40 years; …; > 60 years) and included as a numerical variable. These modifications were helpful in simplifying the model for clearer interpretation of results.

Model A evaluated the influence of information channel (5 categories), age, and education (predictor variables) on perceived conservation knowledge (response variable). Model B evaluated the influence of the previous predictor variables in addition to perceived conservation knowledge (as a predictor) on management support (response variable). Finally, Model C measured the influence of all prior predictor variables in addition to the numerical management support scale (as a

TABLE 3 Summary of results from the hierarchical binary logistic regression models.

| | Model A (DV = PCK) | | | | Model B (DV = MS) | | | | Model C (DV = PEI) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Independent variables** | **Coef.** | **SE** | ***z*** | ***p*** | **Coef.** | **SE** | ***z*** | ***p*** | **Coef.** | **SE** | ***z*** | ***p*** |
| Block A | | | | | | | | | | | | |
| IC – Int.Com. | – | – | – | – | – | – | – | – | – | – | – | – |
| IC – Internet | 0.57 | 0.39 | 1.45 | 0.146 | 1.04 | 0.25 | 4.16 | < 0.001* | −0.07 | 0.34 | −0.22 | 0.827 |
| IC – YouTube | −0.08 | 0.42 | −0.18 | 0.854 | 0.23 | 0.27 | 0.82 | 0.412 | −0.04 | 0.39 | 0.104 | 0.917 |
| IC – Combination | 0.44 | 0.5 | 0.89 | 0.376 | 0.91 | 0.33 | 2.79 | 0.005* | 0.11 | 0.45 | 0.25 | 0.799 |
| IC – Other | 0.6 | 0.79 | 0.76 | 0.45 | 0.83 | 0.48 | 1.71 | 0.087 | −0.35 | 0.59 | −0.59 | 0.556 |
| Block B | | | | | | | | | | | | |
| PCK – Knowledgeable | | | | | −0.6 | 0.45 | −1.33 | 0.182 | −0.07 | 0.56 | −0.12 | 0.9 |
| Block C | | | | | | | | | | | | |
| MS - Supportive | | | | | | | | | 2.19 | 0.25 | 8.71 | <0.001* |

DV, Dependent variable; IC, Information channel; PCK, Perceived conservation knowledge; MS, Management support; PEI, Pro-environmental intention; Coef., Coefficient; SE, Standard error; *z*, *z*-value; *p*, *p*-value. The asterisk (*) signifies statistical significance ($p < 0.05$).

predictor) on pro-environmental behavior (response variable) (Table 3).

## Results

Our questionnaire received a response rate of 17.2% with 1895 of the 10,990 questionnaires completed. We removed duplicate, invalid, and incomplete questionnaires (<90% completion), and filtered respondents for recreational anglers who target sharks from shore, resulting in a total of 972 questionnaires included in the analysis.

### Sociodemographic description of sample population

The respondents were predominantly male (94%, $N = 964$) residents of Florida (67%, $N = 964$) distributed relatively equally between ages of 21 and over 60 with an underrepresentation of anglers aged 20 or younger (5%, $N = 961$). When compared to the demographic variables of the entire SBSF permit list (14,809 anglers who held an FWC SBSF permit in May 2020), our sample exhibited relatively similar patterns other than minor deviances in age distribution. Therefore, our sample respondents appeared to represent a sufficient approximation of the entire fishery. Most respondents were employed full time (60%, $N = 959$), retired (17%), or self-employed (10%), and most hold either an undergraduate or college degree (40%, $N = 955$) or a secondary education diploma (26%).

### Identifying main information channels

After initial categorization based on common themes among responses, we identified 11 individual information channels from which anglers specifically learned about shark fishing (Table 1). In addition to the 11 channels, we formed two categories: *Combination* to distinguish anglers who use multiple channels, and *Other* to gather uncommon responses such as television series or movies, social media, or listing a specific location. The most common channels among our sample were through interpersonal communication/interactions with friends and family (32%, $N = 918$) or other anglers (19%). The least common channels were prints (magazines, pamphlets, signs, etc.), fishing clubs, and tackle shops (2% combined). We further reduced these 11 channels into five broader categories, as outlined in Table 1.

As for information channels through which anglers seek to learn about fishing skills, we identified 8 channels, in addition to the two formed categories: *Combination* and *Other*, which primarily included responses such as personal experience through fishing. The most common individual information channel used among our sample was the general internet (35%, $N = 883$), however 18% of respondents also listed YouTube on its own, making it the second most common individual channel. The least common channels were prints and fishing clubs (1% combined). We further reduced these eight channels into five broader categories as outlined in Table 1, which were used in further analyses outlined below.

### Hierarchical modeling of pro-environmental angler behavior

Prior to performing the series of hierarchical models, we tested all predictor variables to verify there was no multicollinearity. The majority of respondents (92%) perceived themselves to be knowledgeable of shark-related conservation matters, were supportive of management activities (Table 2), and were willing to modify their fishing habits to increase shark survival post-release (88.2%). Angler education and age were ultimately excluded from each regression model as they introduced increased standard errors, either increased or did not significantly reduce each model's AIC, and they were not significant predictors in any model. Model A revealed that information channel was not significantly associated with perceived conservation knowledge. Model B revealed the information channels "*internet*" and "*combination*" to be significantly associated with support for fisheries management initiatives (Figure 1, Table 3). The log odds of an angler being supportive toward fishery management increased by a factor of 1.04 (95% CI [0.55, 1.53]) for anglers who used the internet as a channel to learn more about fishing skills and increased by a factor of 0.91 (95% CI [0.28, 1.58]) for anglers who used a combination of channels. We calculated McFadden's Pseudo $R^2$ ($R^2 = 0.03$, $p < 0.001$) and the Hosmer and Lemeshow goodness of fit test ($X^2 = 0.4068$, df = 8, $p$-value= 0.9999) and found no significant evidence of poor model fit. Model C revealed management support as being significantly associated with pro-environmental intention (Figure 2, Table 3), in which the log odds of an angler willing to modify their fishing habits to increase shark survival increased by a factor of 2.19 (95% CI [1.70, 2.70]) for every unit increase in management support score. Again, we calculated McFadden's Pseudo $R^2$ ($R^2 = 0.14$, $p < 0.001$) and the Hosmer and Lemeshow goodness of fit test ($X^2 = 2.7154$, df = 8, $p$-value= 0.9509) and found no significant evidence of poor model fit.

## Discussion

Our study identifies the main channels through which recreational shark anglers from the SBSF fishery in Florida obtain information on fishing skills, filling an area of research in fisheries science which receives little attention. The desire to learn more about or gain expertise in an activity of interest is not exclusive to recreational shark angling, hence these findings may

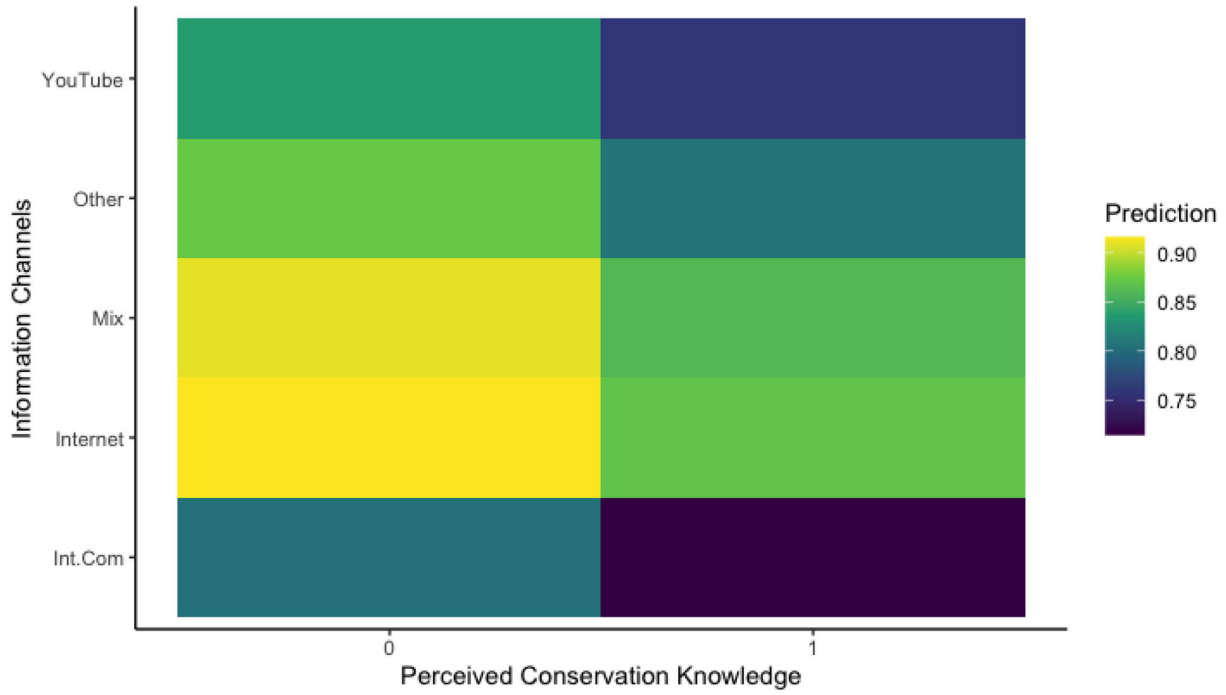


FIGURE 1
Color-coded binary logistic regression model predictions (Model B) for Management Support considering all predictor variables. Information Channel categories displayed along the y-axis (Mix = Combination of channels, Int.Com = Interpersonal Communication), and Perceived Conservation Knowledge displayed along the x-axis (0 = Perceived themselves as not knowledgeable and 1 = Perceived themselves as knowledgeable). Model prediction values closer to a value of 1 (lighter colors) = Supportive of fishery management, model prediction values closer to 0 (darker colors) = Not supportive of fishery management.

be applicable and comparable to broader recreational fisheries and other social-ecological systems and recreational activities such as hunting.

We aimed to reduce sampling bias by distributing the questionnaire to the full FWC SBSF permit list, however our study presents limitations as we only captured a sample of the entire fishery. Non-response bias may have been due to skepticism toward researchers (Shiffman et al., 2017), missed emails or emails sent to junk or spam folders, respondents abandoning the questionnaire partway through, forgetting to complete the questionnaire, or being too busy to respond (Gigliotti and Henderson, 2015). Nonetheless, our response rate (17.4%) remained fairly consistent with other targeted online questionnaires (Sheehan, 2001; Nulty, 2008; Shih and Fan, 2009), and sociodemographic comparison of the entire FWC SBSF permit list suggested that our respondents were relatively representative of the fishery (Guay et al., 2021). Young anglers (i.e., under 16 years of age) are not represented in our survey given that they do not require a license to fish in Florida waters. Additionally, anglers who chose not to obtain a shore-based shark fishing permit are not represented in our survey as they would not have received our invitation. Consequently, our study does not capture the full range of perspectives and behavioral intentions of this fishery.

It is also important to acknowledge potential social desirability bias and acquiescence bias in our conservation knowledge, management support, and pro-environmental intention constructs that may have biased results. While we were unable to completely avoid these biases, we designed survey questions to avoid binary responses and obtain more descriptive data, and included both positive and negative wording in Likert statements to identify contradictory respondents (with careful coding of responses, Sauro and Lewis, 2011). We also aimed to elicit truthful responses by informing the participants that their responses would be anonymized, by explaining the importance of this data, and by allowing the participants to pause and return to the questionnaire to avoid survey fatigue (Van Mol, 2016).

We found that while most anglers learned about shark fishing through interpersonal communications with friends, family, or other anglers, most tended to use the internet to learn more about general fishing skills. A study investigating use of information channels among recreational salmon anglers in British Columbia, Canada, found similar results, in which most anglers sought information about proper handling techniques on the internet (Nguyen et al., 2012). Moreover, over 25% of our respondents reported the use of YouTube to learn about fishing skills, a global free video-sharing website in which virtually anyone may upload public video content. While the use of the

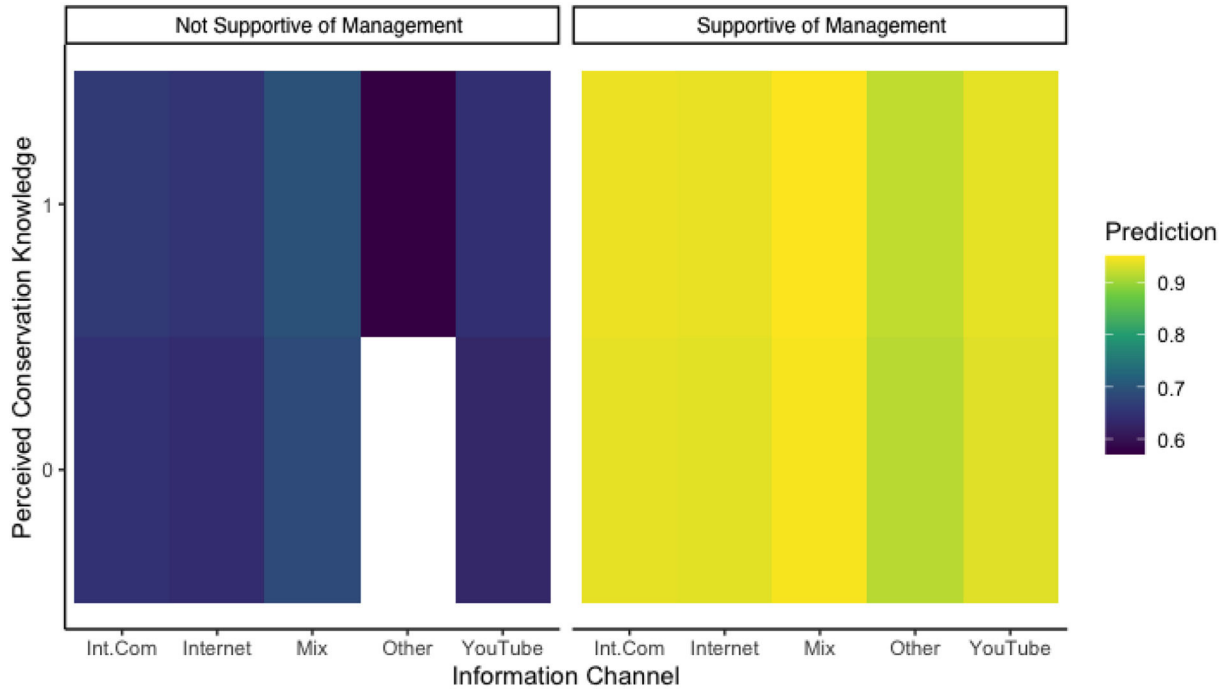


FIGURE 2
Color-coded binary logistic regression model predictions (Model C) for Pro-Environmental Behavioral Intention considering all predictor variables. The graphs are divided based on Management Support. Perceived Conservation Knowledge is displayed along the y-axis (0 = Perceived themselves as not knowledgeable and 1 = Perceived themselves as knowledgeable), and the Information Channel categories are displayed along the x-axis (Mix = Combination of channels, Int.Com = Interpersonal Communication). Model prediction values closer to a value of 1 (lighter colors) = Likely to engage in pro-environmental behavior, model prediction values closer to 0 (darker colors) = Not likely to engage in pro-environmental behavior.

internet to learn physical skills is fairly common in developed countries, there may be caveats to the lack of direct observation and instruction one does not receive online. It could be possible that when fishing, fishing tips or tricks learned online may not translate as easily into practice and cause harm to the catch. Moreover, anglers primarily using YouTube could be watching videos from recreational anglers in other U.S. states or countries with different regulations and unknowingly participating in illegal shark fishing practices in the state of Florida. In addition, almost 60% of respondents agreed (or somewhat agreed) that most anglers knew what they were doing and would release sharks unharmed, and almost 75% agreed (or somewhat agreed) that more SBSF education and training is needed, suggesting probable malpractice or improper shark handling practices within this fishery, of which the amount is unknown (Table 2). While the internet is a great tool that facilitates ample learning opportunities and provides easier access to information and communication, the potential risks and caveats should not be ignored.

Our analyses did not provide evidence to support our first hypothesis that information channel use would influence perceived conservation knowledge. Exposure to information through different channels has been found to be associated with perceived knowledge in the context of alien invasive species prevention compliance (Witzling et al., 2015). In that study, interpersonal communication, media (television, social media, the internet, etc.), and signs were positively associated with perceived knowledge of alien invasive species, but fishing clubs as a channel were not, suggesting that use of different channels can lead to different levels of perceived knowledge. We may not have seen similar results among our respondents due to questionnaire design restricting our measure of perceived knowledge to only a single variable addressing "*shark conservation related issues*" – a broad subject that can be interpreted in different ways. Anglers may have also answered this question dishonestly due to social desirability bias, acquiescence bias, or fear of not being taken seriously should they not be knowledgeable of such issues. Conversely, it is possible we sampled a highly knowledgeable population of anglers as those who participated in our questionnaire may already be receptive and knowledgeable of scientific findings on this topic, potentially resulting in no relationship found. Lastly, the open-ended nature of our variable measuring information channel allowed for both specific (e.g., "My friend Henry", "FWC website", or naming a specific online forum) and general (e.g., "Internet", "Researchers") responses, which

may have led to generalization of coding and less nuances in categories, thus blurring any potential relationship with perceived conservation knowledge.

Our second hypothesis was partially supported. We found that angler support for fishery management was positively influenced by two information channel categories (internet and combination), but not influenced by perceived conservation knowledge. The use of the internet to learn more about fishing skills may result in increased support for management due to easier access to information. Ease of access to information may help build angler awareness of shark conservation and the importance of fishery management. However, we recognize that 'internet' is quite broad and the nuances may be overlooked, which does not tell the complete story. Similarly, the use of a combination of channels to learn more about fishing skills presumably exposes the angler to a wider variety of information sources, and consequently being more informed. Further, this may suggest that these anglers are seeking more information as they are exposed to and are gathering information from multiple places. Thus, it is possible that a relationship between conservation knowledge and support for fishery management revealed itself through the relationships found with information channel use, however more research on the use of these two channels would be needed to confirm the possible hidden relationship. Previous studies found that anglers who were more knowledgeable of respective conservation issues were more likely to report positive attitudes toward conservation and management (Gallagher et al., 2015; O'Bryhim and Parsons, 2015; Murphy et al., 2018). This was not the case for our study potentially because of biases from self-reported conservation knowledge. While perceived knowledge and actual knowledge do not always correlate, perceived knowledge may still influence beliefs and attitudes, and thus we expected to find similar results with those studies among our respondents. Instead, our results may suggest that increased perceived conservation knowledge does not always signify support for fishery management. Nevertheless, if conservation knowledge were to be associated with support for fishery management, managers could target outreach efforts to educate anglers on conservation-related issues in attempts to garner more support.

Our third hypothesis was also partially supported. We found that angler pro-environmental behavioral intention was positively influenced by support for fishery management, but not influenced by the information channels anglers used, nor by their perceived conservation knowledge. Our results align with many studies that found anglers who were more supportive of shark fishery management were more likely to adopt best handling practices that reduce shark mortality (Gallagher et al., 2015; French et al., 2019). It is important to note that management support could be considered as a pro-environmental intention or behavior itself considering management goals of creating sustainable fisheries (Bennett et al., 1978; Arlinghaus and Cooke, 2009; St John et al., 2018), potentially explaining these results. However, measurements of attitudes included additional variables assessing concepts outside of solely management support (e.g., opinions of regulations interfering with their fishing), and as such we considered attitudes separate from pro-environmental intentions.

The theory of planned behavior framework explains behavioral intention using a combination of attitudes, perceived behavioral control, and subjective norms (Ajzen, 1991). Therefore, if perceived behavioral control and subjective norms aligned, our results would follow the theory's framework in that increased support for fishery management (e.g., positive attitudes toward regulations) should lead to increased pro-environmental behavioral intention, and therefore increased participation in behaviors which meet management conservation goals (e.g., compliance with regulations, best handling practices).

Witzling et al. (2015) investigated how exposure to information from different channels may act as background variables within the theory of planned behavior framework. Our study found similar results to theirs, in which no associations were found between information channels and behavioral intentions, but associations were found between specific information channels and attitudes (i.e., fishery management support). These findings suggest that information channel use may indirectly influence pro-environmental behaviors among our respondents by acting as a background factor to beliefs (Figure 3) (Ajzen, 2011). Moreover, O'Bryhim and Parsons (2015) found that anglers who were knowledgeable on sharks were more likely to participate in behaviors supportive of shark conservation. The lack of association between perceived conservation knowledge and pro-environmental intention regarding shark conservation in our results may be a result of the limitations in how the constructs of conservation knowledge or pro-environmental intentions were measured (as described above). Alternatively, it may also suggest that other factors we did not measure are more strongly influencing behavioral intent, such as those in the theory of planned behavior framework; angler's capacity to engage in such behaviors (i.e., behavioral control), and social norms from those they surround themselves with (Ajzen, 1991).

## Conclusions and management implications

Our study identified where anglers from the SBSF fishery in Florida, U.S. obtain fishery-related information and discovered a wide range of channels used among the anglers. Anglers most commonly learned about the fishery through interpersonal communications and used the internet to learn new fishing skills. Evidence of increased participation rates in recreational shark fishing (Drymon and Scyphers, 2017; Kilfoil et al., 2017;

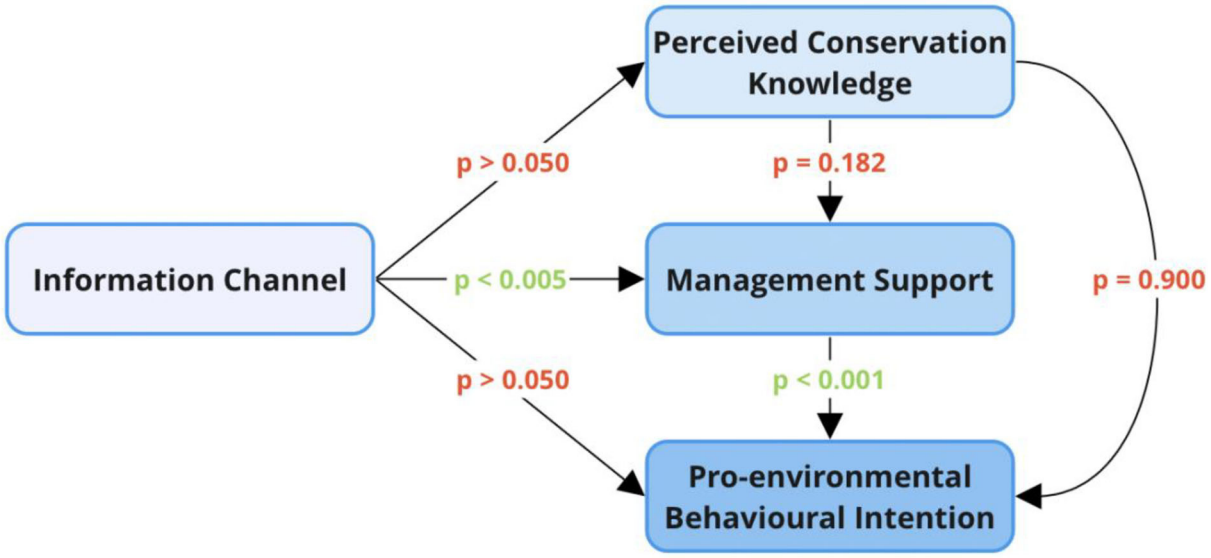


FIGURE 3
Conceptual flowchart demonstrating the statistical relationships between tested variables. *P*-values from the three binary logistic regression models are shown in red (not significant) and green (significant) colored text for clear interpretation.

Guay et al., 2021) may result in novice anglers handling their catch improperly, resulting in growing concerns for increased injury and mortality rates in released sharks. The SBSF fishery in Florida has gear, harvest, and handling restrictions as well as a mandatory online educational course on safe handling practices to obtain a permit, however there are currently no restrictions on the number of sharks anglers may catch provided they are released (FWC, 2022). While post-release shark mortality from recreational fishing is not yet quantified for most species, extrapolated values in our previous study reveal potentially hundreds of thousands of sharks caught per year within this fishery, which, if coupled with improper handling practices, could result in significant impacts to coastal shark populations of Florida (Guay et al., 2021). Our respondents, however, expressed positive attitudes toward fishery management and desires for more education on best handling practices and ensuring shark survival post-release. Managers could thus use our findings to target educational outreach through the most-used channels (e.g., the internet, YouTube) to reach the most anglers.

We also found that anglers who use the internet or a combination of channels (e.g., *both* internet and interpersonal communications) to learn more about fishing skills might be more supportive of fisheries management initiatives, and therefore more willing to modify their behavior to ensure shark survival post-release. These findings may be used to improve communication and outreach efforts through other channels which did not associate with management support (e.g., prints such as signs, or interpersonal connections only) in an effort to generate more support for management and therefore increase behaviors that favor shark survival. For instance, the use of signs near fishing access points (e.g., bridges, piers, shorelines, boat launches) has been shown to influence behavior by engaging a sense of social norms (Witzling et al., 2015). Additionally, with evidence of skepticism toward managers and researchers among the SBSF angler community in Florida, engaging anglers in meaningful interactions through interpersonal connections, educational programs focused on conservation, public stakeholder meetings and workshops (Wester et al., 2022), or even collaborative research may soften the divide and increase support. Careful design of such efforts should be taken however, as public trust in government sources remains questionable (May and Burger, 1996; Brewer and Ley, 2013). Moreover, the lack of significant associations between conservation knowledge and pro-environmental behavioral intention in our study poses the question of whether educational programs actually influence behavior. Future research on what anglers consider to be meaningful interactions with management and on the angler attitudes toward educational programs focused on conservation can help clarify these uncertainties. We encourage fishery managers to use these data to inform current and future outreach, educational and training opportunities.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving human participants were reviewed and approved by Carleton University Research Ethics Board. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

## Author contributions

While this study was conceptualized by JG and carefully guided by VN, the data used for this manuscript was part of a larger study which was conceptualized by all authors. All authors assisted in the questionnaire design, and JB and HM piloted the questionnaire with recreational shark anglers in Florida, United States. All data analysis was conducted by JG with VN and JC assistance. The writing was led by JG. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2022.1059113/full#supplementary-material

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