



RESEARCH ARTICLE

Tracking public interest and perceptions about smalltooth sawfish conservation in the USA using Instagram

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Abstract

1. The population of smalltooth sawfish (*Pristis pectinata*) in the USA was listed as endangered under the US Endangered Species Act in 2003. Based on objectives identified in the Smalltooth Sawfish Recovery Plan, an interdisciplinary team developed a variety of outreach efforts and products to educate the public and promote sawfish conservation. These include safe viewing, handling, release, and reporting guidelines for boaters, divers, and anglers that may interact with the species.
2. The usefulness of monitoring social media to track public interest and perceptions of smalltooth sawfish was investigated via Instagram posts mentioning sawfish encounters in the USA. We aimed to identify how current outreach efforts and messaging can be improved and expanded to better inform the public and promote positive change in their behaviour to further protect smalltooth sawfish.
3. All encounters occurred in Florida waters and the trend of sawfish-related Instagram posts increased congruently with traditionally reported sawfish encounters from 2012 to 2019. The number of Instagram users who indicated that they reported their encounter or that any sawfish encounter should be reported has increased, suggesting outreach efforts have gained traction and that some members of the public are actively promoting sawfish conservation through encounter reporting. The overall tone, and thereby public perception of and attitude towards sawfish, was largely positive.
4. Though social media can be used to guide outreach initiatives and provides a platform for researchers to engage large public audiences, future research efforts should include electronic surveys within the recreational, commercial, diving, and angling communities. Additionally, social media posts should be compared with traditionally reported encounters, and media professionals working with scientists should focus on increasing the utility of social media as a way to collect encounter reports and create engaging educational content to be included with continued outreach efforts throughout the south-eastern USA.

KEYWORDS

conservation culturomics, elasmobranch, endangered species, human–wildlife interactions, *Pristis pectinata*, public perceptions, scientific outreach, social media

1 | INTRODUCTION

The advent of social media platforms (e.g. Instagram, Twitter, Facebook) has made it possible for near real-time information about human–wildlife interactions or conservation topics to be posted and shared through photographs, videos, and text (Di Minin, Tenkanen & Toivonen, 2015; Sbragaglia et al., 2020). Given the broad data-sharing capabilities and the potential to reach large public audiences, social media can be beneficial for researchers to use as an outreach platform and as a way to collect data on rare species for conservation science (e.g. Bik & Goldstein, 2013; Di Minin, Tenkanen & Toivonen, 2015; Shiffman, 2018; Sullivan, Robinson & Littnan, 2019; Toivonen et al., 2019; McDavitt & Kyne, 2020). Public encounters with rare species that are reported to scientists or posted on public social media platforms can be used to inform researchers and managers about public perception, interest, and knowledge of a species. For example, social media posts revealed the previously undocumented natural geographic range of the critically endangered clown wedgefish (*Rhynchobatus cooki*) (McDavitt & Kyne, 2020).

The population of smalltooth sawfish (*Pristis pectinata*) in the USA experienced a dramatic decline during the 20th century due to bycatch mortality, habitat loss, and the species' limited reproductive potential to offset losses (Brame et al., 2019). As a result, the USA population of smalltooth sawfish has been prohibited from harvest in Florida since 1992 and was listed as endangered under the USA Endangered Species Act (ESA) in 2003 (National Marine Fisheries Service (NMFS), 2009; 68 FR 15674; 50 C.F.R. § 17.11(h)). The ultimate goal of listing is to recover the population to the point that it no longer needs the protections of the ESA. To achieve this, the recovery plan outlines goals and objectives needed to conserve and recover the population (NMFS, 2009). The first objective of the plan is to 'minimize human interactions and associated injury and mortality' (NMFS, 2009). The Smalltooth Sawfish Recovery Implementation Team (SSRIT) was formed to implement and track recovery actions associated with the recovery plan. Over the past decade, the SSRIT has developed a variety of outreach products to educate the public and promote sawfish conservation, including safe viewing, handling, release, and reporting guidelines for boaters, divers, and anglers that may interact with the species.

ESA listing afforded this species protection, and thereby it is illegal to target, harm, harass, or handle them in any way (NMFS, 2009; 68 FR 15674; 16 U.S.C.A. § 1,532(19)). Though it is illegal to catch a sawfish, except with a research permit or in a fishery where incidental bycatch has been authorized, captures do occur while recreationally fishing for other species. Any sawfish caught while fishing must be released as quickly as possible, meaning the sawfish is not removed from the water, ropes are not used to restrain

the sawfish, and release is not delayed for photographs. However, incidental captures provide important information, such as occurrence and distribution, which can be used by researchers to monitor trends in the population and track recovery (NMFS, 2000). Therefore, public reporting of encounters, defined as observing a sawfish in its natural habitat or the incidental capture of a sawfish, are encouraged and have been charted over time (e.g. Seitz & Poulakis, 2002; Wiley & Simpfendorfer, 2010; Waters et al., 2014). Reported encounters to a hotline number (e.g. Seitz & Poulakis, 2002; Wiley & Simpfendorfer, 2010; <http://www.SawfishRecovery.org>) began in 1999, and after 20 years this has become a robust database useful for a variety of purposes. To date, self-reported public encounters with smalltooth sawfish have been used to determine the range and habitat needs of the species (Wiley & Simpfendorfer, 2010), model spatio-temporal distribution patterns (Waters et al., 2014), and designate juvenile critical habitat (Norton et al., 2012). Although there are many caveats that must be considered when analysing and interpreting these data, stakeholder involvement is essential to the recovery of the species and is highly encouraged. Encounter data provided by the public are currently being used in concert with scientific surveys that assess the relative abundance and distribution of smalltooth sawfish (Poulakis et al., 2011; Kroetz, Carlson & Grubbs, 2018) to track recovery of the US population and to steer outreach, research, and management efforts.

User-generated data on social media, in addition to voluntarily reported encounters, can be used to gauge the effectiveness of current outreach efforts (Sullivan, Robinson & Littnan, 2019) and general public views of a species. Here, the usefulness of monitoring social media to track public interest and perceptions of smalltooth sawfish and the species' endangered status was investigated. Specifically, we were interested in (1) public knowledge about the conservation status of smalltooth sawfish, (2) whether illegal activity and improper release and/or handling are occurring, and (3) whether the public are reporting their encounter(s) to researchers. Knowledge of the public's awareness of this endangered species will help guide future outreach efforts of the SSRIT to inform the public on current management and proper viewing, handling, and release techniques should sawfish be encountered. In addition, we aim to identify how outreach efforts can be improved upon or expanded to help inform the public and influence their behaviour to further protect smalltooth sawfish.

2 | METHODS

This study focused on the photograph- and video-sharing social media platform Instagram. Instagram users can generate near real-

time content by posting photographs, videos, text, and tags via mobile devices (Di Minin, Tenkanen & Toivonen, 2015). Instagram uses words or phrases preceded by a hashtag (#) to identify specific topics, locations, or content of the post. Hashtags allow for users to browse other users' content who have used the same hashtags, thereby linking the content. Several hashtags were searched to find posts about smalltooth sawfish encounters, including #sawfish and #smalltoothsawfish. As sawfish are often confused with species of sawshark (family Pristiophoridae), #sawshark was included in the search as well as lesser-used and incorrect common names or misidentifications, such as #carpentershark, #sawtoothshark, and #swordfish. Content was also found by looking at the hashtags used in the text of posts with positively identified sawfish in them and by browsing the profiles of fishing charters under the assumption that these groups would likely have more encounters with sawfish. Upon locating a post detailing a sawfish encounter, a screenshot was taken to preserve the photograph or video image and all poster and user comments for analysis. Species identification was confirmed using fin placement, rostrum shape, and tooth counts of the depicted animal. The focus was on posts of sawfish from the USA, as outreach efforts are concentrated in the south-eastern USA, the only known location of a viable population of smalltooth sawfish and where encounters are the most likely to occur (Brame et al., 2019). Instagram allows users to geotag their posts, and this was used, along with location-relevant hashtags, to identify where encounters occurred. Data were collected from public accounts, and thereby public posts; no private accounts were accessed. Following privacy and ethics guidelines of using publicly available social media content for research, all content acquired was anonymized (Monkman et al., 2018). No private information is shared in this study nor will be made available at any time.

Instagram was launched in October 2010, and thus the temporal scale ranged from October 2010 through June 2020. Data collected from each post included location (i.e. county or specific area if provided) and date. Posts were excluded if they included sawfish from an aquarium, drawings or art of sawfish, images that were misidentified as sawfish (such as swordfish and sawsharks), or images that were taken outside of the USA. To reduce bias of public perception of sawfish, posts were excluded if they were posted by scientific or research-based groups or individuals.

Each post was evaluated for several qualitative criteria based on outreach goals of the SSRIT (Table 1). Elements of interest to the study, such as knowledge of the conservation status, protections, and the campaign of researchers to encourage the public to report encounters, were taken from hashtags as well as text within the captions of original posts. If the user mentioned the words 'endangered' or 'protected' in their original post, it was an indicator that the user had some knowledge of the conservation status of this species. If there was mention of reporting the encounter, if the Florida Fish and Wildlife Conservation Commission (FWC) was tagged, or if #FWC was used in a post, then it was marked as a reported sawfish encounter as FWC has historically collected sawfish encounters.

TABLE 1 Qualitative data extracted from the text of Instagram posts regarding smalltooth sawfish encounters

Data extracted from posts	Specifics
Date	Month, year
Location	State, county, fishing piers, beaches, national parks
Conservation status	Post mentions that sawfish are endangered or that conservation is important
Tone of post	Positive: phrases like 'amazing', 'incredible', and 'lucky' Negative: phrases like 'these dumb animals' or 'these stupid things'
Encounter reported	FWC was tagged in post or it was specifically mentioned that the encounter was reported
Illegal activity	Employing ropes around rostra to secure or tow the animal, removing sawfish from the water (e.g. holding up for photograph or dragging ashore), person sitting on sawfish, actively approaching a sawfish (e.g. sight-casting to catch a sawfish), divers disturbing sawfish (e.g. swimming towards, over, or attempting to touch a sawfish)

FWC: Florida Fish and Wildlife Conservation Commission.

Illegal activity regarding smalltooth sawfish was identified through cues contained in the user-generated photographs, video, and/or comments. Though the ESA broadly defines illegal 'take' as to 'harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct' (16 U.S.C.A. § 1532(19)), we focused on a specific array of potentially stressful improper touching or handling, including removing sawfish from the water, dragging them ashore, employing ropes around rostra to secure or tow the animal, sitting on the sawfish, or actively approaching a sawfish (i.e. divers swimming close enough to disturb a sawfish or attempting to touch it). Content was labelled as apparent illegal activity if the photograph or video indicated that sawfish were targeted; that is, the user actively tried to capture a sawfish using a fishing method such as sight casting or fishing specifically to catch a sawfish. Given the resilience of the species to stress (Prohaska et al., 2018), the intent behind identifying illegal activity was to improve upon education rather than to refer for prosecution, unless the activities depicted were particularly egregious (e.g. rostrum removal, injury through the use of gaffs, or killing of sawfish). If a post illustrated that sawfish were handled properly, through adherence to the safe handling and release guidelines that instruct to leave the sawfish in the water and cut the line (see Section 4), the activity was labelled as not illegal.

Public perceptions of and attitude towards sawfish were gauged by the general tone of the post, determined by the text of the user in the original caption. Tone was classified as positive, negative, or neutral (Sullivan, Robinson & Littnan, 2019). Positive posts were identified by descriptors such as 'amazing', 'incredible', and 'lucky', whereas negative posts were identified by descriptors such as 'stupid

things' and 'dumb fish'. Any posts that did not overtly appear to be positive or negative in tone were deemed as neutral, as identifying descriptor words can be subjective (Sullivan, Robinson & Littnan, 2019).

Comparing two types of reporting systems can provide insight into whether more sawfish encounters are being reported (posted) on social media or if encounters are more likely to be self-reported via the hotline number or through <http://www.sawfishrecovery.org> (hereafter referred to as traditional reporting). Thus, traditional encounter reports were collated to match the time frame of this study (2010–2020) and were compared with total Instagram posts by year for the same time frame.

3 | RESULTS

A total of 333 posts were found on Instagram containing content regarding smalltooth sawfish encounters in the USA. The first post found that mentioned smalltooth sawfish was on November 14, 2012, 25 months after Instagram was launched. In general, the trend in the number of posts of sawfish encounters has increased since the first post in 2012 (Figure 1). There was an increase in posts in 2017 ($n = 59$, 18%) and another increase in 2020 ($n = 100$, 30%), though only representative of 6 months of data for the year. Traditionally reported encounters were an order of magnitude greater than those from social media but showed similar trends through time, including a peak increase in 2017 ($n = 730$) (Figure 1). The number of active Instagram users worldwide has been steadily increasing, reaching more than 1 billion users in 2019 (Figure 1).

The majority of Instagram posts on sawfish encounters did not mention in the text or via hashtags that sawfish are endangered or protected (77%, $n = 255$), whereas the other 23% ($n = 78$) did mention this fact (Figure 2a). There is a general increasing trend over the years of the study of the number of people that mentioned the endangered or protected status of sawfish (Figure 2a). The overall

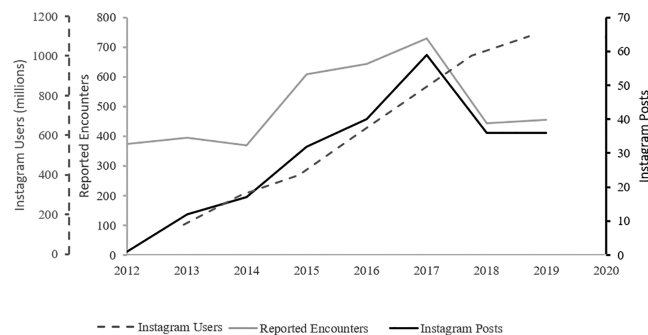


FIGURE 1 Smalltooth sawfish Instagram posts (solid black line) and traditionally reported encounters (solid grey line) over the period of this study. The number of active Instagram users (grey dashed line, in millions of users) is overlaid to represent the increase of users over time. Data on the number of Instagram users were available from 2013 to 2019 (Statista, 2020)

tone, and thereby public perception of and attitude towards sawfish, was largely positive (99%, $n = 330$), with less than 1% of posts being either negative ($n = 1$) or neutral ($n = 2$) (Figure 2d).

Only 11% ($n = 38$) of posts mentioned that the sawfish encounter was reported to researchers, with the remaining 89% ($n = 295$) not mentioning whether the encounter was reported (Figure 2b). Of the 38 posts that mentioned reporting the encounter, 87% ($n = 33$) explicitly stated they reported the encounter to the hotline and 13% ($n = 5$) did not explicitly mention reporting but tagged FWC in their post. Of the posts about sawfish encounters, 68% ($n = 227$) were made by users engaged in recreational activities such as fishing or kayaking and 29% ($n = 96$) were posted by charter and fishing guides. Dive centres and divers comprised 3% ($n = 10$) of posts.

Apparent illegal activity was identified in 32% ($n = 105$) of the posts with a spike in 2017, whereas 68% ($n = 228$) of the posts did not show illegal activity (Figure 2c). Of posts in which illegal activity was documented, 76% ($n = 80$) showed landed sawfish (i.e. improperly handled, dragged, and/or lifted out of water), 13% ($n = 14$) included sawfish that were approached or disturbed by divers and anglers, 6% ($n = 6$) stated sawfish were targeted for capture, and 5% ($n = 5$) showed sawfish with a rope tied around the rostrum (Figure 3).

All of the posts came from the state of Florida ($n = 333$). Monroe County was tagged as the location in 36% ($n = 121$) of posts, followed by 22% ($n = 75$) in Lee County (Figure 4). When a county could not be identified through the location geotag or a hashtag, the post was assigned to the general area of south-west Florida based on hashtags identifying this location (i.e. #ENP or #SWFL). These data were pooled, and 22% ($n = 74$) of encounters occurred in south-west Florida (Figure 4).

4 | DISCUSSION

Understanding public perception of sawfish is important, as it often translates into political interest in them. Conservation culturomics is an emerging field of study that seeks to understand human culture through the quantitative analysis of changes in word frequencies in large bodies of digital texts and can help practitioners in nature conservation respond to cultural trends, building and reinvigorating its societal relevance (Ladle et al., 2016; Jarić et al., 2020). We applied that principle here by evaluating the usefulness of monitoring user-generated data on social media as a way to gauge public perceptions and effectiveness of current outreach efforts for endangered smalltooth sawfish. The varying types of qualitative data that were extracted from Instagram posts have been useful in identifying ways the SSRIT can improve communication with the public as well as identifying illegal activity involving this endangered species. The recovery plan for smalltooth sawfish (NMFS, 2009) details the need to minimize human interactions with sawfish and any possible associated injury and mortality, with specific criteria of (1) 'effective ongoing programs...to educate the public about population status and

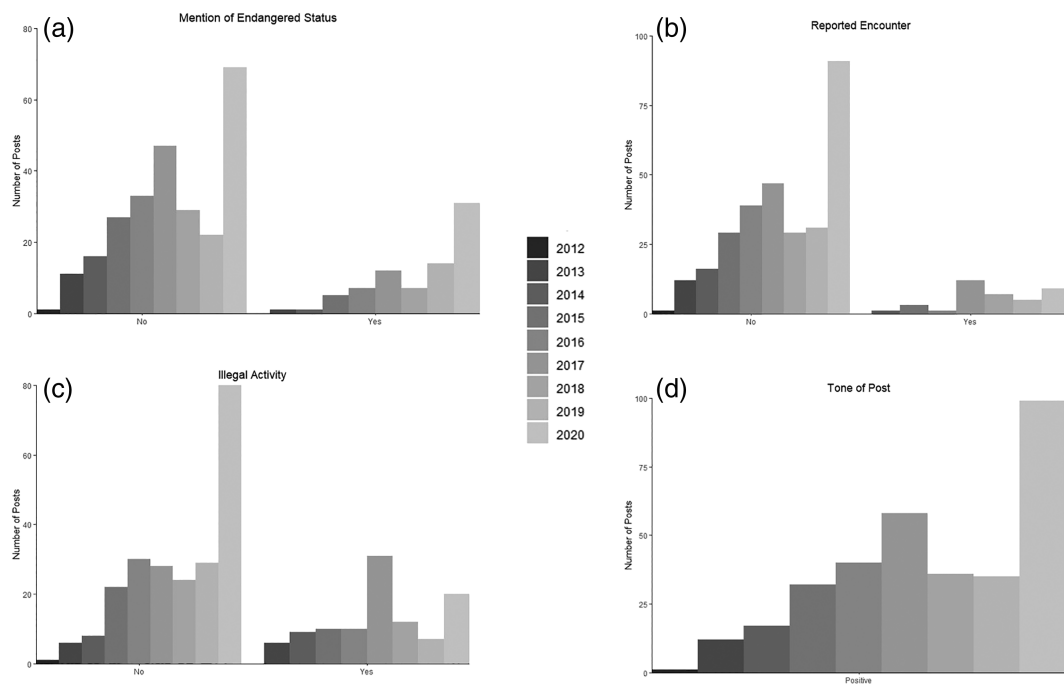


FIGURE 2 Number of smalltooth sawfish encounters posted on Instagram that mention (a) smalltooth sawfish are endangered or protected, (b) the user reported the encounter, (c) the post contained a photograph or video of an apparent illegal activity, and (d) tone of posts over time. Note that (b) and (d) are on a slightly different scale and that (d) only shows positive posts since <1% of posts were composed of negative ($n = 1$) or neutral ($n = 2$) posts

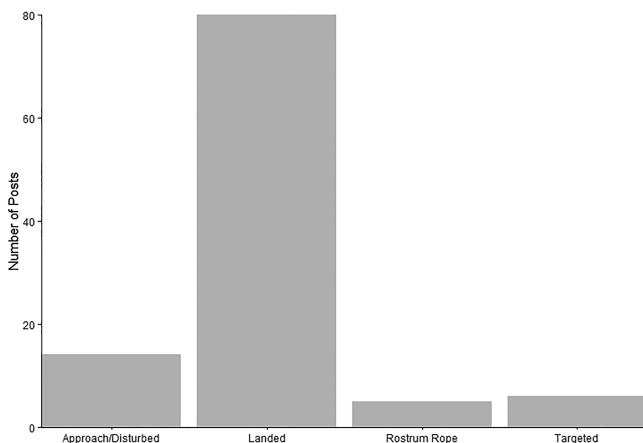


FIGURE 3 Illegal activity involving smalltooth sawfish identified in Instagram posts. Landed refers to improper handling, dragging, and lifting or holding sawfish out of the water

the prohibitions against capturing, harming, or harassing smalltooth sawfish' and (2) 'safe handling and release guidelines [are] developed, adopted, distributed, and are being effectively implemented in all state and Federal fisheries (commercial and recreational) that may interact with smalltooth sawfish ...'. As the population of smalltooth sawfish rebuilds in the USA it is likely that the number of encounters, both sightings and incidental captures, will increase. Therefore, it is imperative that outreach efforts are successful in educating the public about the endangered status of this species, how to safely view or handle and release sawfish, and how to report encounters to

researchers. Additionally, ongoing threats, such as illegal activity from a particular county, marina, or fishing pier, must be identified so that targeted outreach efforts can be implemented.

Social media is a valuable source of stakeholder information that can be used to refine or target outreach efforts by the SSRIT. Though this study did not identify any new locations where sawfish were encountered beyond those currently known from field surveys and traditional reporting, Instagram has proven to be valuable in monitoring the distribution of encounters and how people interact with the species. This study found that many stakeholders are not aware of the conservation status of sawfish or how to safely view or handle and release them; thus, there is a need for improvement in the SSRIT outreach efforts. Ways to extend outreach efforts to stakeholders will be to ensure signage exists at all fishing access (e.g. piers, boat ramps, marinas) and supply (e.g. bait shops, tackle stores) locations to educate the public about safe handling, release, and reporting guidelines and to disseminate materials to dive centres and charter operators to educate themselves and their clients about safe viewing and reporting. Additionally, having media professionals working with scientists to actively engage with the public to maximize knowledge and concern for smalltooth sawfish and the measures required to facilitate protection and recovery would be greatly beneficial. This relationship would foster open dialogue and engage users in discussions of sawfish, provide positive feedback for users who did follow safe handling guidelines, collect additional information of an interaction for the encounter database, and ensure that information is relayed to sawfish researcher(s) in the geographic area

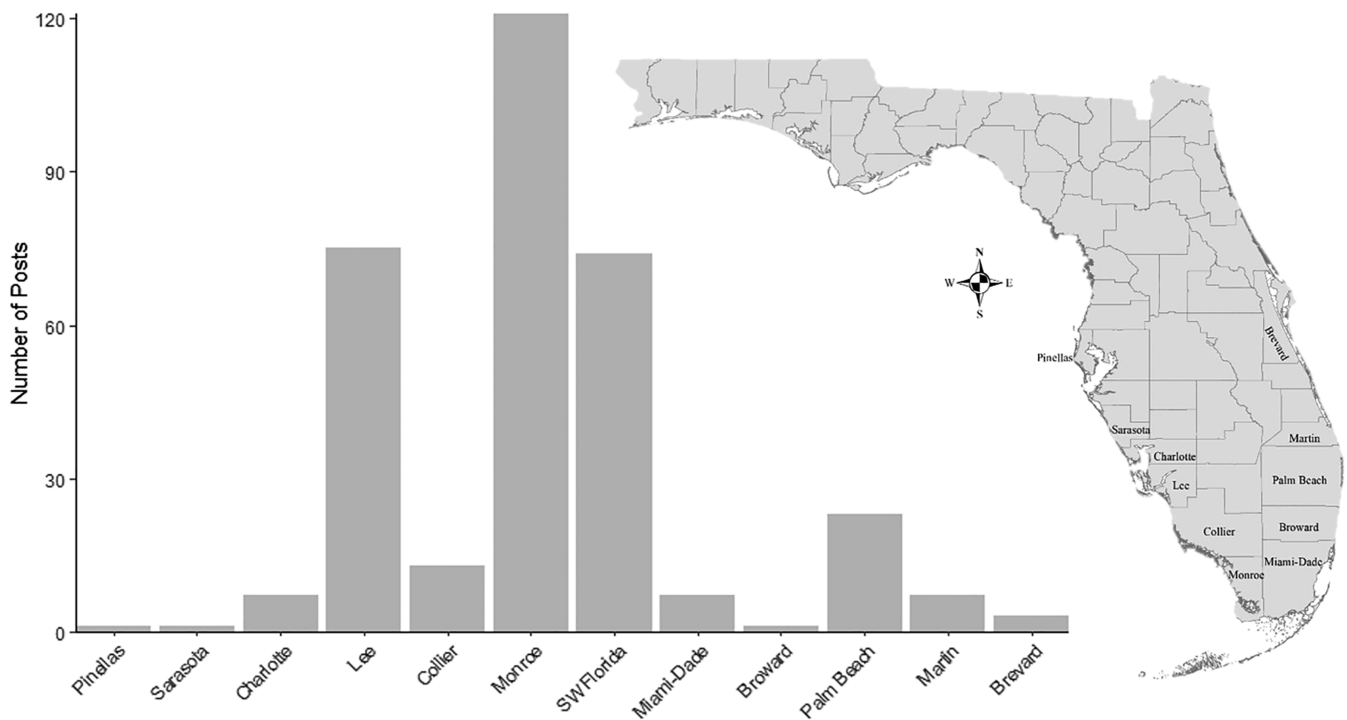


FIGURE 4 Number of smalltooth sawfish encounter posts by county in Florida, USA. Counties are arranged in geographic order starting in the Gulf of Mexico (Pinellas), moving south around the tip of Florida (Monroe), and moving north up the Atlantic coast (Brevard). South-west Florida (SW Florida) posts were pooled together if the Instagram post only tagged south Florida as the location

in which an encounter occurred. Given that a relatively high number of posts indicated that illegal activity had occurred with sawfish, active public engagement and an increased presence by the SSRIT on social media coupled with increasing the broadcast of outreach materials could increase stakeholder knowledge about this species.

The use of social media as a data source is becoming more prevalent in conservation science (Sullivan, Robinson & Littnan, 2019; Toivonen et al., 2019 and references therein; McDavitt & Kyne, 2020; Sbragaglia et al., 2020), though there are limitations and considerations when using this approach. First, the amount of data that can be acquired through social media is likely to be limited, as content can be restricted by private accounts or a lack of hashtags linking pertinent content. Some social media platforms are primarily public facing (e.g. Instagram) whereas others tend to be private (e.g. Facebook) and therefore restrict query results. For this study we chose only to search the more public-facing Instagram platform, though there are undoubtedly additional sawfish posts on other platforms. As of June 2018, there were 1 billion active monthly users on Instagram worldwide and 100 million in the USA (Statista, 2020). The increasingly large number of users, photographs, and videos undoubtedly made it difficult to search all available content for smalltooth sawfish, particularly if content was not identified by use of hashtags such as #sawfish. Second, the quality of data extracted from photographs and videos may not be up to the typical high standards of scientifically collected data through surveys or polls. For example, not every post contained text that would have provided some information as to the user's perception or tone regarding smalltooth

sawfish or location information, and thus the content could not be used in the study. Third, the demographics of social media users may limit available content. For example, in 2019, 69% of adults in the USA used Facebook whereas 37% used Instagram (Pew Research Center, 2020). Of the Instagram users, 67% of younger adults between the ages of 18 and 29 use the platform, whereas older users, between the ages of 30 and 39 (47%) and 50 and 64 (23%), use the platform less (Pew Research Center, 2020). Though beyond the scope of the current analyses, the demographic distribution could bias the data, given that older generations of users may not be posting as much content as younger users, yet these older generations could be more likely to interact with sawfish if they fish or boat more frequently than younger generations. Lastly, some assumptions had to be made at the inception of the study. To collect qualitative data regarding a user's knowledge of smalltooth sawfish, it was assumed that if the user had knowledge of the endangered status of sawfish or that an encounter should be reported to authorities then they would have stated this within the text or in hashtags in the original post. This assumption is likely not certain for every post that was made; however, it was used to glean information as to the general knowledge base of the public regarding this endangered species.

In the analysis, Instagram posts were used to identify public perceptions and knowledge of smalltooth sawfish. The data indicate an increasing trend in the number of public encounters with smalltooth sawfish shared on social media, though the majority of these encounters are seemingly not reported to researchers, as identified by a lack of mentioning this within the text of original

captions. More recently, however, the trend in the number of users who indicate that they reported their encounter or that any sawfish encountered should be reported has increased, suggesting outreach efforts have gained traction. Also increasing is the number of users who commented on posts of sawfish encouraging the original poster to report the encounter and in some cases providing the information to do so. However, only 8% of posters follow the NMFS and 34% follow FWC on Instagram, the primary federal and state agencies respectively responsible for sawfish management. This suggests there is still ample opportunity to increase outreach efforts pertaining to conservation. Yet, positive outcomes suggest that some members of the public are actively promoting sawfish conservation through encounter reporting.

Though it was assumed that encounters were not reported to researchers through the hotline if that was not clearly mentioned within the original caption, it is not possible to be certain of this. Comparing data from this study with traditionally reported encounters to the SSRIT encounter database would provide more in-depth information regarding reporting. However, the lack of reporting details within the study presents an opportunity to engage with and encourage the public to increase reporting of their encounters. The details of public sightings or catches of sawfish help to monitor the population and track recovery progress. Metal signs with safe handling and reporting information have been distributed at marinas, boat ramps, and fishing piers in the south-eastern USA in an effort to promote the importance of reporting encounters and encourage the safe handling and release of sawfish (Figure 5). Additionally, items such as stickers, sunglass straps, and floating key chains, as well as social media graphics promoting the website <http://www.SawfishRecovery.org> and toll-free number 844-4-SAWFISH (+1-844-472-9347) for reporting encounters have been developed and distributed to the public during outreach and scientific sampling events.

Wiley & Simpfendorfer (2010) found that consistent and ongoing outreach efforts are required to ensure continued collection of public sawfish encounter data. Over time, the trend of Instagram posts of sawfish encounters increased along with traditionally reported sawfish encounters. Interestingly, both systems of reporting spiked in 2017, with a subsequent decline in 2018–2019. Though not encompassing a complete year, there seems to be a rebound in both reporting methods (Instagram and traditional encounter reports) during 2020, despite a decline in public outreach events. The rebound is likely due to COVID-19 leading to an increase in people seeking outdoor recreation (<https://data.covid.umd.edu/press/index.html>). The spike in 2017 could be attributed to the first International Sawfish Day being held and promoted by the scientific community, where numerous social media posts about sawfish and their endangered status were placed on various social media platforms. The decline in reports and encounters the following year (2018) could be due to the large red tide and/or the blue-green algae events in south Florida. It is likely that, with these prolonged events, there were fewer anglers/boaters on the water, and thus a reduced probability that sawfish would be encountered and subsequently reported, either by

Sawfish Are Endangered

Respect • Release • Report

Sawfish are protected by State and Federal laws:
It is illegal to harm, harvest, or handle sawfish



You Can Help Save Smalltooth Sawfish

<p>Angler Guidance:</p> <ul style="list-style-type: none"> ▶ Release sawfish immediately ▶ Never lift from the water or drag ashore ▶ Do not use gaffs or ropes to secure ▶ Cut the line as close to the hook as possible 	<p>Diver Guidance:</p> <ul style="list-style-type: none"> ▶ Keep your distance ▶ Avoid disturbing sawfish ▶ Do not chase or pursue ▶ Never feed or touch
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Share Information About Your Encounter
1-844-4SAWFISH
www.SawfishRecovery.org

The information you provide helps scientists track sawfish recovery

FIGURE 5 Signs informing the public of smalltooth sawfish safe handling and release, viewing, and reporting guidelines that have been posted at marinas, boat ramps, fishing piers, tackle and bait shops, and dive centres from Texas to North Carolina. These signs are distributed by the Smalltooth Sawfish Recovery Implementation Team

traditional means or by posting on social media. Regardless, the number of sawfish encounters posted on Instagram has been steadily increasing, likely due to an increase in users along with an explosion in the use of social media. This increase also aligns with an increasing trend in smalltooth sawfish relative abundance (NMFS, unpublished data) and an increase in targeted outreach efforts; so, increased reports (both traditional encounter reports and social media posts) are not unexpected.

In general, members of the public posting about smalltooth sawfish encounters seem to have positive attitudes and perceptions about the species. Except for three instances, every post had positive words written in the text or in hashtags, indicating that the user was excited to observe a sawfish or that they were aware of how rare an encounter is. It is a positive indication that most people posting and viewing on social media have a positive perception towards sawfish and are likely more open to supporting conservation efforts. The majority of posts did not illustrate apparent illegal activity; however, illegal activity was identified in one-third of posts, which is considered to be exceptionally high for an endangered species. Most illegal activity was in the form of landing sawfish (removing sawfish from the water, i.e. take), whereas several users approached sawfish with the intent to capture them by rod and reel (i.e. targeting), and a few

used ropes to secure the rostra of larger sawfish (i.e. delayed release). Notably, no particularly egregious illegal activities, such as rostrum removal or harvest, were documented. Though the overall trend of illegal activity is decreasing, 32% of posts contained illegal activity. These occurred largely from the counties of Lee and Monroe, which are also the geographic areas considered as the core of the species range (Brame et al., 2019) and from where the majority of encounters occur (Wiley & Simpfendorfer, 2010; Waters et al., 2014). Therefore, the SSRIT should direct outreach efforts in these counties by increasing the dissemination of safe handling and release guidelines to the public with the goal of educating anglers and divers and decreasing illegal actions in the future. Additionally, having dedicated social media personnel who would actively engage with stakeholders in near real-time as they post sawfish-related content would greatly increase the SSRIT's presence on social media and allow a quick response to these stakeholders with informational content and encouragement to report encounters.

Although the use of social media can encourage illegal behaviours, such as chasing or mishandling sawfish to get photographs or video for sharing, social media can also be used as a platform to promote awareness, safe viewing and handling and release practices, and encourage public participation in collecting data (Di Minin, Tenkanen & Toivonen, 2015). Further, social media can be used as a platform for users to be empowered to educate others by use of informative hashtags. For example, best practice guidelines for catch and release in recreational fisheries have been promoted by using the hashtag #keepemwet (Danylchuk et al., 2018). This movement on social media, founded on science-based best practices, is linked to specific catch-and-release guidelines (e.g. <http://keepfishwet.org>) and has gained support among users who promote the hashtag. A similar approach could be used to promote sawfish conservation and encourage reporting. For example, 79% of users who posted about sawfish encounters in this study used #sawfish, which we encourage and use in our own social media content. In addition to further promoting that hashtag, use of #RespectReleaseReport would provide users with a way to spread conservation messaging with other users, similar to the Keep Fish Wet organization. Though most social media users do not post content with the intention of contributing as a citizen scientist (Di Minin, Tenkanen & Toivonen, 2015), campaign efforts to promote the importance of public involvement, the public's role in aiding recovery efforts, and promoting conservation can be greatly increased via social media. A combination of educational outreach approaches coupled with publishing information via social media will likely be the most effective way to engage the public (Nguyen et al., 2012) and effect positive change in the way the public perceives and interacts with smalltooth sawfish. Thus, guidelines of safe handling and release practices for anglers have been developed, as well as guidelines for divers on how to safely and legally enjoy encounters with smalltooth sawfish. These guidelines and information on how the public can share their encounter(s) can be found at the SSRIT website <http://www.SawfishRecovery.org> and by calling 844-4-SAWFISH (+1-844-472-9347).

This study shows that social media can be a useful and innovative tool for researchers to collect data on public perception of endangered species. The resulting data can be used to monitor populations, guide outreach, target field surveys, and direct conservation initiatives. Social media can provide a platform for researchers and resource managers to share conservation messaging with a large public audience, particularly with younger generations that participate so thoroughly with these platforms. Future research should consider using electronic socio-economic surveys in conjunction with social media platforms to specifically gauge how the fishing community perceives this species and the need to conserve it. As the use and scope of social media continues to grow, it may be important to incorporate these types of platforms into future conservation initiatives to promote positive changes in people's beliefs, attitudes, and behaviours towards endangered species (Bravo-Marquez, Mendoza & Poblete, 2014; Becken et al., 2017; Lennox et al., 2020; Otsuka & Yamakoshi, 2020). Our recommendations for the next steps are as follows: (1) use an electronic survey that targets licensed anglers to specifically ask about their knowledge of and attitude toward sawfish conservation; (2) compare the results of this study with the SSRIT sawfish encounter database to determine what proportion of social media posts are also being traditionally reported; (3) secure funding for dedicated media personnel to actively engage with the public, search for and respond to sawfish-related posts, and create new educational content; (4) create conservation ads with pertinent information that can be linked via an algorithm on various social media platforms to certain hashtags, such as #sawfish, so that it will appear to any users who use the hashtag; and (5) continue and expand outreach programmes throughout the south-eastern USA to educate the public about the endangered status of sawfish, the prohibitions against capturing, harming, or harassing smalltooth sawfish, and the need to report encounters.

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REFERENCES

- Becken, S., Stantic, B., Chen, J., Alaei, A.R. & Connolly, R.M. (2017). Monitoring the environment and human sentiment on the Great

- Barrier Reef: Assessing the potential of collective sensing. *Journal of Environmental Management*, 203(Pt 1), 87–97. <https://doi.org/10.1016/j.jenvman.2017.07.007>
- Bik, H.M. & Goldstein, M.C. (2013). An introduction to social media for scientists. *PLoS Biology*, 11(4), e1001535. <https://doi.org/10.1371/journal.pbio.1001535>
- Brame, A.B., Wiley, T.R., Carlson, J.K., Fordham, S.V., Grubbs, R.D., Osborne, J. et al. (2019). Biology, ecology, and status of the smalltooth sawfish *Pristis pectinata* in the USA. *Endangered Species Research*, 39, 9–23. <https://doi.org/10.3354/esr00952>
- Bravo-Marquez, F., Mendoza, M. & Poblete, B. (2014). Meta-level sentiment models for big social data analysis. *Knowledge-Based Systems*, 69, 86–99. <https://doi.org/10.1016/j.knosys.2014.05.016>
- Danylchuk, A.J., Danylchuk, S.C., Kosarski, A., Cooke, S.J. & Huskey, B. (2018). Keepemwet Fishing—An emerging social brand for disseminating best practices for catch-and-release in recreational fisheries. *Fisheries Research*, 205, 52–56. <https://doi.org/10.1016/j.fishres.2018.04.005>
- Di Minin, E., Tenkanen, H. & Toivonen, T. (2015). Prospects and challenges for social media data in conservation science. *Frontiers in Environmental Science*, 3, 63. <https://doi.org/10.3389/fenvs.2015.00063>
- Jarić, I., Roll, U., Arlinghaus, R., Belmaker, J., Chen, Y., China, V. et al. (2020). Expanding conservation culturomics and iEcology from terrestrial to aquatic realms. *PLoS Biology*, 18(10), e3000935. <https://doi.org/10.1371/journal.pbio.3000935>
- Kroetz, A.M., Carlson, J.K. & Grubbs, R.D. (2018). NOAA Fisheries smalltooth sawfish monitoring survey FY-17. *Relative abundance and essential fish habitat studies for smalltooth sawfish, Pristis pectinata, in southwest Florida, USA*. National Marine Fisheries Service Panama City Laboratory Contribution 18–01.
- Ladle, R.J., Correia, R.A., Do, Y., Joo, G.J., Malhado, A.C., Proulx, R. et al. (2016). Conservation culturomics. *Frontiers in Ecology and the Environment*, 14(5), 269–275. <https://doi.org/10.1002/fee.1260>
- Lennox, R.J., Harcourt, R., Bennett, J.R., Davies, A., Ford, A.T., Frey, R.M. et al. (2020). A novel framework to protect animal data in a world of ecosurveillance. *BioScience*, 70(6), 468–476. <https://doi.org/10.1093/biosci/biaa035>
- McDavitt, M.T. & Kyne, P.M. (2020). Social media posts reveal the geographic range of the Critically Endangered clown wedgefish, *Rhynchobatus cooki*. *Journal of Fish Biology*, 97(6), 1846–1851. <https://doi.org/10.1111/jfb.14530>
- Monkman, G.G., Kaiser, M. & Hyder, K. (2018). The ethics of using social media in fisheries research. *Reviews in Fisheries Science & Aquaculture*, 26(2), 235–242. <https://doi.org/10.1080/23308249.2017.1389854>
- National Marine Fisheries Service. (2000). *Status review of smalltooth sawfish (Pristis pectinata)*. Unpublished report from the NMFS Sawfish Review Panel. Available at: <https://www.fisheries.noaa.gov/species/smalltooth-sawfish#resources>
- National Marine Fisheries Service. (2009). *Recovery plan for smalltooth sawfish (Pristis pectinata)*. Prepared by the Smalltooth Sawfish Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. Available at: <https://www.fisheries.noaa.gov/species/smalltooth-sawfish#resources>
- Nguyen, V.M., Rudd, M.R., Hinch, S.G. & Cooke, S.J. (2012). Differences in information use and preferences among recreational salmon anglers: Implications for management initiatives to promote responsible fishing. *Human Dimensions of Wildlife*, 17(4), 248–256. <https://doi.org/10.1080/10871209.2012.675412>
- Norton, S., Wiley, T.R., Carlson, J.K., Frick, A.L., Poulakis, G.R. & Simpfendorfer, C.A. (2012). Designating critical habitat for juvenile endangered smalltooth sawfish in the United States. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science*, 4(1), 473–480. <https://doi.org/10.1080/19425120.2012.676606>
- Otsuka, R. & Yamakoshi, G. (2020). Analyzing the popularity of YouTube videos that violate mountain gorilla tourism regulations. *PLoS ONE*, 15(5), e0232085. <https://doi.org/10.1371/journal.pone.0232085>
- Pew Research Center. (2020). *Social media fact sheet*. Available at: <https://www.pewresearch.org/internet/fact-sheet/social-media/> [Accessed 20 September 2020]
- Poulakis, G.R., Stevens, P.W., Timmers, A.A., Wiley, T.R. & Simpfendorfer, C.A. (2011). Abiotic affinities and spatiotemporal distribution of the endangered smalltooth sawfish, *Pristis pectinata*, in a south-western Florida nursery. *Marine and Freshwater Research*, 62(10), 1165–1177. <https://doi.org/10.1071/MF11008>
- Prohaska, B.K., Bethea, D.M., Poulakis, G.R., Scharer, R.M., Knotek, R., Carlson, J.K. et al. (2018). Physiological stress in the smalltooth sawfish: Effects of ontogeny, capture method, and habitat quality. *Endangered Species Research*, 36, 121–135. <https://doi.org/10.3354/esr00892>
- Sbragaglia, V., Coco, S., Correia, R.A., Coll, M. & Arlinghaus, R. (2020). Analyzing publicly available videos about recreational fishing reveals key ecological and social insights: A case study about groupers in the Mediterranean Sea. *Science of the Total Environment*, 765, 142672. <https://doi.org/10.1016/j.scitotenv.2020.142672>
- Seitz, J.C. & Poulakis, G.R. (2002). Recent occurrence of sawfishes (Elasmobranchiomorphi: Pristidae) along the southwest coast of Florida (USA). *Florida Scientist*, 65, 256–266.
- Shiffman, D.S. (2018). Social media for fisheries science and management professionals: How to use it and why you should. *Fisheries*, 43(3), 123–129. <https://doi.org/10.1002/fsh.10031>
- Statista. (2020). Available at: <https://www.statista.com/statistics/253577/number-of-monthly-active-instagram-users/> [Accessed 01 June 2020]
- Sullivan, M., Robinson, S. & Littnan, C. (2019). Social media as a data resource for #monkseal conservation. *PLoS ONE*, 14(10), e0222627. <https://doi.org/10.1371/journal.pone.0222627>
- Toivonen, T., Heikinheimo, V., Fink, C., Hausmann, A., Hiippala, T., Järvi, O. et al. (2019). Social media data for conservation science: A methodological review. *Biological Conservation*, 233, 298–315. <https://doi.org/10.1016/j.biocon.2019.01.023>
- Waters, J.D., Coelho, R., Fernandez-Carvalho, J., Timmers, A.A., Wiley, T., Seitz, J.C. et al. (2014). Use of encounter data to model spatio-temporal distribution patterns of endangered smalltooth sawfish, *Pristis pectinata*, in the western Atlantic. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 24(6), 760–776. <https://doi.org/10.1002/aqc.2461>
- Wiley, T.R. & Simpfendorfer, C.A. (2010). Using public encounter data to direct recovery efforts for the endangered smalltooth sawfish (*Pristis pectinata*). *Endangered Species Research*, 12(3), 179–191. <https://doi.org/10.3354/esr00303>

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