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Source: Copeia, 108(1) : 122-131

Published By: The American Society of Ichthyologists and Herpetologists

URL: https://doi.org/10.1643/OT-19-179R

Copeia 108, No. 1, 2020, 122–131

Trends in Chondrichthyan Research: An Analysis of Three Decades of Conference Abstracts

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Given the conservation status and ecological, cultural, and commercial importance of chondrichthyan fishes, it is valuable to evaluate the extent to which research attention is spread across taxa and geographic locations and to assess the degree to which scientific research is appropriately addressing the challenges they face. Here we review trends in research effort over three decades (1985–2016) through content analysis of every abstract (*n* = 2,701) presented at the annual conference of the American Elasmobranch Society (AES), the oldest and largest professional society focused on the scientific study and management of these fishes. The most common research areas of AES abstracts were reproductive biology, movement/telemetry, age and growth, population genetics, and diet/feeding ecology, with different areas of focus for different study species or families. The most commonly studied species were large and charismatic (e.g., White Shark, *Carcharodon carcharias*), easily accessible to long-term established field research programs (e.g., Lemon Shark, *Negaprion brevirostris*, and Sandbar Shark, *Carcharhinus plumbeus*), or easily kept in aquaria for lab-based research (e.g., Bonnethead Shark, *Sphyrna tiburo*). Nearly 90% of all described chondrichthyan species have never been mentioned in an AES abstract, including some of the most threatened species in the Americas. The proportion of female* first authors has increased over time, though many current female* Society members are graduate students. Nearly half of all research presented at AES occurred in the waters of the United States rather than in the waters of developing nations where there are more threatened species and few resources for research or management. Presentations based on research areas such as paleontology and aquarium-based research have declined in frequency over time, and identified research priorities such as social science and interdisciplinary research are poorly represented. Possible research gaps and future research priorities for the study of chondrichthyan fishes are also discussed.

CHONDRICHTHYAN fishes (including the sharks, rays, skates, and chimaeras) are considered one of the most threatened vertebrate groups by the International Union for the Conservation of Nature (IUCN) Red List (White and Last, 2012; Dulvy et al., 2014). Many chondrichthyans are considered to be ecologically important (reviewed in Heithaus et al., 2008), morphologically diverse and distinctive (Stein et al., 2018), and both culturally (e.g., Dell'Apa et al., 2015) and economically valuable (e.g., Gallagher and Hammerschlag, 2011 for wildlife tourism). Due to the threatened status of many species and the class's diversity of ecological roles, chondrichthyans have often been the focus of considerable research, management, and advocacy attention (reviewed in Simpfendorfer et al., 2011). Given these ecological, cultural, and commercial values, it is important to review and evaluate the extent to which research attention is allocated across taxa and geographic locations, and to assess the degree to which scientific research is appropriately addressing the challenges these fishes face. Here we consider patterns of chondrichthyan research as presented at the annual scientific conference of a professional society dedicated to the research and manage-

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Submitted: 14 January 2019. Accepted: 28 November 2019. Associate Editor: W. L. Smith.
 DOI: 10.1643/OT-19-179R Published online: 6 March 2020

ment of these fishes in order to assess trends in research over time and identify research gaps. These gaps could be used to help with chondrichthyan conservation efforts and to help a professional society to better achieve its stated goal.

The American Elasmobranch Society (AES, https://elasmo.org) was founded in 1983 with the goal of "promoting the scientific study and management of chondrichthyan fishes." The AES has held an annual scientific conference since 1985, and the abstracts of all talks and posters presented at these conferences are publicly available online (https://elasmo.org/abstracts). The AES seeks to be a professional home for any researcher studying chondrichthyan fishes regardless of their primary research discipline or institutional affiliation (Ferry and Shiffman, 2014) and is thus a taxon-focused research society rather than a discipline-based society (e.g., Ecological Society of America, https://www.esa.org) or ecosystem-based society (e.g., Deep-Sea Biological Society, https://dsbsoc.org/). Though it was founded by North Americans and annual meetings take place in the Americas, membership is open to anyone directly involved in chondrichthyan research or management, and annual meetings frequently have representatives from around the globe. In recent years, AES has met as part of the Joint Meeting of Ichthyologists and Herpetologists (JMIH), a multi-society gathering, and it is worth noting that some talks focusing on chondrichthyans have been presented in the sessions of the American Society of Ichthyologists and Herpetologists (ASIH, another professional society that meets as part of JMIH) rather than in AES sessions. However, not all ASIH abstracts are accessible, so they were not analyzed in this study.

Previous studies have analyzed AES abstracts to examine trends in study species, such as Ajemian and Neer (2014) for durophagous rays and Cotton and Grubbs (2015) for deep-sea chondrichthyans. Additionally, a 2015 analysis identified themes in chondrichthyan research by reviewing abstracts from three international multi-society conferences called Sharks International in 1991, 2010, and 2014 (Huveneers et al., 2015), and see McCallen et al. (2019) for an example of this type of analysis in ecology. Additionally, there is an editorial focusing on general trends in some aspects of shark research throughout the 20th century (Castro, 2016). However, no previous studies have examined such a large collection of chondrichthyan science abstracts over such a long time frame nor as comprehensively (the entire lifetime of a professional society) as undertaken here.

A further aim of this analysis is to understand the changing demographics of AES presenters at meetings since the Society began. Nationally, the number of bioscience degrees awarded to women has risen since 1985, and women earned approximately 58% of the bachelor's degrees, 57% of the master's degrees, and 53% of the doctorates in the biosciences in 2014 (https://www.nsf.gov/statistics/2017/nsf17310/). While these trends indicate increased integration of female scientists across disciplines, it is unknown whether these individuals are limited to certain disciplines or scientific societies. To date, there has not been a demographic study of chondrichthyan researchers.

We seek to fill these data gaps by identifying patterns in chondrichthyan research and research demographics over time using AES abstracts. Research questions included: 1) What research areas, topics, and methods do most AES abstracts focus on? 2) Which chondrichthyan species and/or families are most commonly the focus of AES research? 3) What is the gender of presenting authors? 4) With what type of institutions are first authors affiliated? 5) Is there a geographic bias with respect to where research presented at AES is conducted? 6) How have the answers to these questions changed over time?

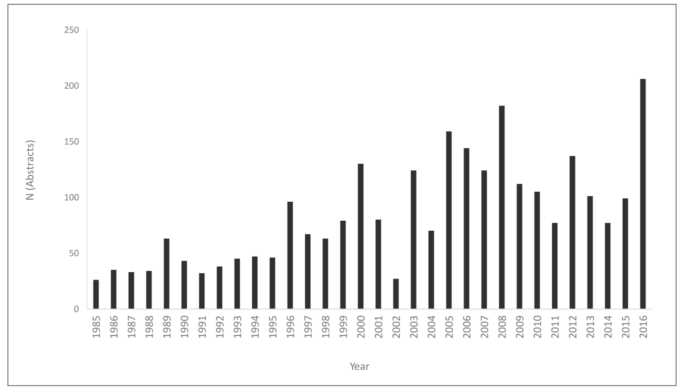

Fig. 1. The number of abstracts each year.

MATERIALS AND METHODS

Dataset.—All abstracts of research presented at American Elasmobranch Society conferences are publicly available on the AES website at https://elasmo.org/abstracts ($n = 2{,}701$, 1985–2016; Fig. 1). These abstracts were read, coded, and scored by author DSS following a coding scheme developed by all coauthors (described in detail with representative examples in Supplemental Appendix 1; see Data Accessibility).

Abstracts for poster and oral presentation abstracts were analyzed together. Any abstracts that were submitted but not presented due to an author withdrawing from the conference were included by default, as such information is not available in the database of abstracts. Only abstracts that were part of an AES section at the Joint Meeting of Ichthyologists and Herpetologists are included in the database, though some ASIH talks may mention or focus on chondrichthyan fishes. It is important to note that research presented at AES is not the only chondrichthyan research (some important research from North America and around the world may be presented at other conferences or may be published without ever having been presented at a conference), but analyzing the entire lifetime of the oldest and largest professional society in this discipline is still a useful source of insights into research trends.

Research area.—Each abstract was sorted into a predetermined research area (Supplemental Appendix 1; see Data Accessibility) based on the primary focus of the study as described in the abstract. Some research areas were methods-focused, while others were discipline-oriented or question-oriented. Forty-eight abstracts (1.77%) fit equally well in two different research areas and were counted towards both; those that focused heavily on one research area but briefly mentioned the other were only counted towards the research area of heavier focus (Supplemental Appendix 1; see Data Accessibility). Abstracts from the movement/telemetry and diet/feeding research areas were analyzed on a finer scale according to the primary method or research tool used to perform the study (satellite or acoustic telemetry in move-

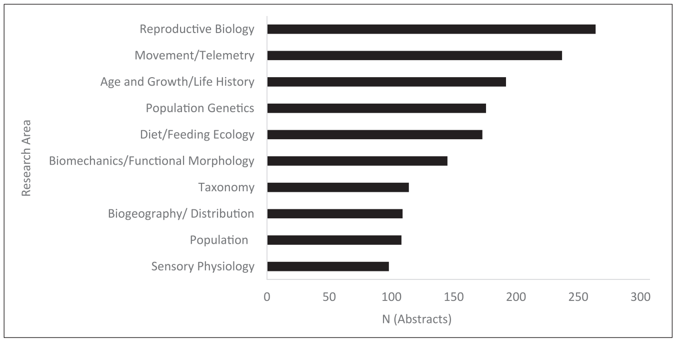

Fig. 2. The most common research areas of abstracts submitted to the American Elasmobranch Society. For definitions and examples of each, see Supplemental Appendix 1 (see Data Accessibility).

ment studies, stable isotope analysis or stomach content analysis in diet studies) because of the availability of such data in the abstracts in order to understand trends in the adoption of newer research methods.

Study species.—The focal study species of each abstract was noted when applicable. If an abstract reported a long list of species (e.g., which chondrichthyans were caught as part of a sampling survey), no focal study species was recorded from that abstract. In the case of three species groups (mako sharks *Isurus* spp.; sawfishes *Pristis* spp. and *Anoxypristis* spp.; and manta rays [Mobulidae] not including non-manta mobula rays, *Mobula* spp.), the individual species was not always mentioned in the abstract, and therefore these genera were grouped together for analytical purposes (i.e., any mention of any species of mako shark was recorded as "mako shark"). The IUCN Red List status of each commonly mentioned species or grouped-together genus (at the time of this analysis) was noted.

Demographics and affiliation.—When possible to identify, the gender of the first author of each abstract was recorded, using a list of common male and female first names from the U.S. Census Bureau (https://www.ssa.gov/oact/babynames/limits.html) with a binary male/female gender score system. While we recognize and acknowledge that gender is not binary and this assessment of first names may not match someone's self-identified gender, we cannot assess self-identified gender from first names alone. Additionally, no member has ever identified as non-binary in our membership demographic surveys. Therefore, each mention of the gender-coded data in this study will be marked with an asterisk (*) to indicate that the gender code does not indicate self-identified gender. In cases where only the author's initials were used, or in cases where the author's gender was not possible to determine by first name, no gender was recorded.

When available, the primary professional affiliations of abstract first authors were sorted into categories (e.g., college or university, National Oceanic and Atmospheric Administration [NOAA], aquarium, museum, state-level government agency, non-profit). Mote Marine Laboratory, an independent facility, was considered its own category. The Bimini Biological Field Station is currently an independent research facility (though it was not for most of its existence), but nearly all research conducted at this research facility listed the author's home college or university as the primary affiliation, so only the primary affiliation was categorized.

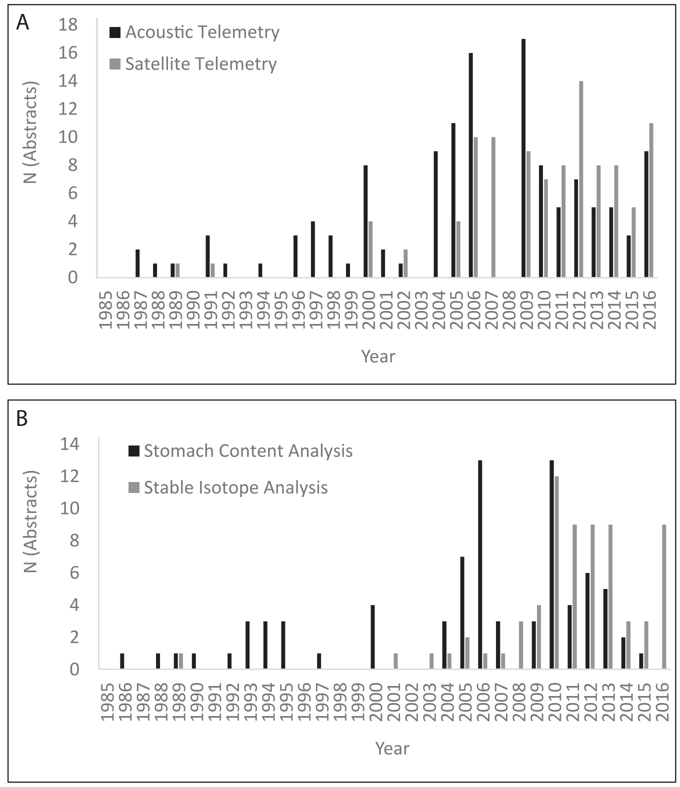

Fig. 3. (A) The number of Movement/Telemetry research area abstracts that used acoustic or satellite telemetry by year. (B) The number of Diet/Feeding Ecology research area abstracts that used stable isotope analysis or stomach content analysis by year.

Geographic scope of work.—When provided, the region, nation, or US state where research took place was recorded (excluding aquarium-based chondrichthyan research), though this is not necessarily where the author's primary affiliation is located. Globally, Canada, Mexico, and the United States were analyzed as separate countries, while other regions were analyzed as a group due to low sample size in countries within those regions as well as frequent lack of specificity within abstracts. States and regions within the waters of the United States were analyzed by state, and in three cases (Gulf of Mexico, New England, and Chesapeake Bay) a body of water rather than a state political boundary was mentioned.

RESULTS

Research area.—All abstracts except for 49 could be categorized into one of the identified research areas. The most common research areas (Fig. 2) that AES abstracts sorted into were reproductive biology ($n = 264$ abstracts), movement/telemetry ($n = 237$), age and growth ($n = 192$), population genetics ($n = 176$), and diet/feeding ecology ($n = 173$). Though Figure 2 mentions only the most common research areas, see Supplemental Appendix 1 (see Data Accessibility) for the breakdown of all presentations by research area.

Overall, more abstracts within movement/telemetry (Fig. 3A) and diet/feeding ecology (Fig. 3B) used the relatively older methods (acoustic telemetry and stomach content analysis, respectively). However, since 2011, in both cases, more abstracts have focused on the relatively newer method (satellite telemetry and stable isotope analysis, respectively).

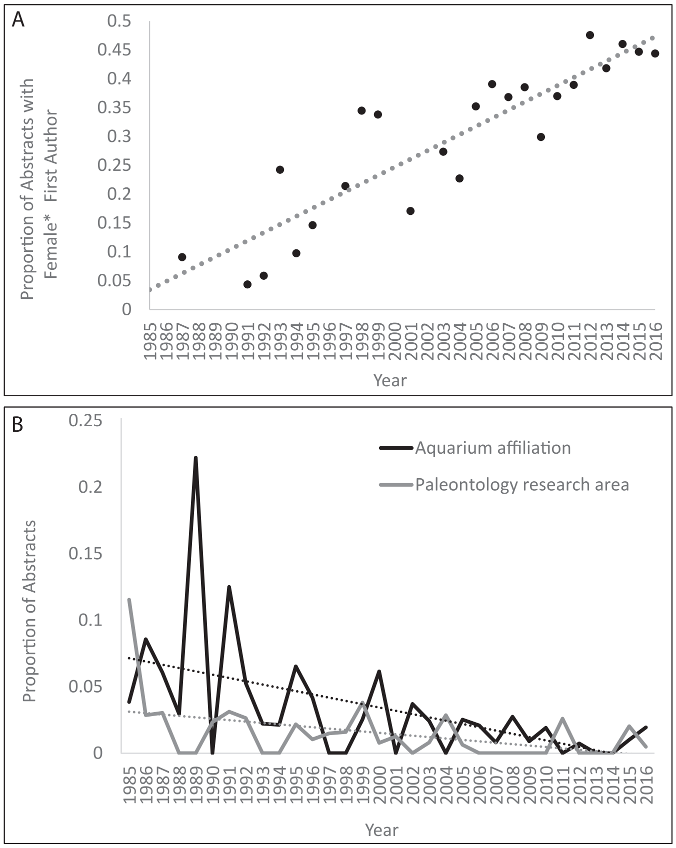

Fig. 4. (A) The proportion of abstracts with female* first authors by year. (B) The percentage of AES abstracts each year that focused on paleontology research and that were presented by a researcher affiliated with an aquarium, with linear regression fitted.

There were no noteworthy trends in the framing or content of reproductive biology, population genetics, or age and growth abstracts identified during this study.

Within studies on biomechanics and functional morphology, 68 abstracts focused on the biomechanics of feeding or biting or the biology of teeth or jaws, 26 abstracts focused on swimming biomechanics including associated muscles or fins, and 20 focused on skeletal structure or function. No other research areas were broken down further due to low sample sizes.

Twenty-one abstracts were categorized as social science or interdisciplinary, despite the identification of this discipline as a conservation research priority (Jacques, 2010; Simpfendorfer et al., 2011). Paleontology-focused talks were more common (Fig. 4B) prior to the year 2000 ($n=15$, 1.8% of pre-2000 abstracts) than they have been in the years since ($n=11$ since 2000, 0.05% of post-2000 abstracts).

Study species.—Five hundred eleven abstracts (18.9%) either did not include a focal study species or included a list of more than five; all other abstracts included study species that were categorized. One hundred fifty-three chondrichthyan species were mentioned in at least one abstract, and 74 were mentioned in at least five abstracts. The overwhelming majority of abstracts focused on species that are a member of superorder Galeomorphii (n = 1,465; most commonly those in the families Lamnidae, $n=197$; Sphyrnidae, $n=204$; and Carcharhinidae, $n=648$; Fig. 5), followed by those in the superorder Batoidea (n = 749; most commonly those in the families Myliobatidae, $n=68$; Mobulidae, $n=75$; Dasyatidae, n = 103; and Rajidae, n = 217; Fig. 5). Within abstracts mentioning the superorder Squalomorphii, 63% were for the

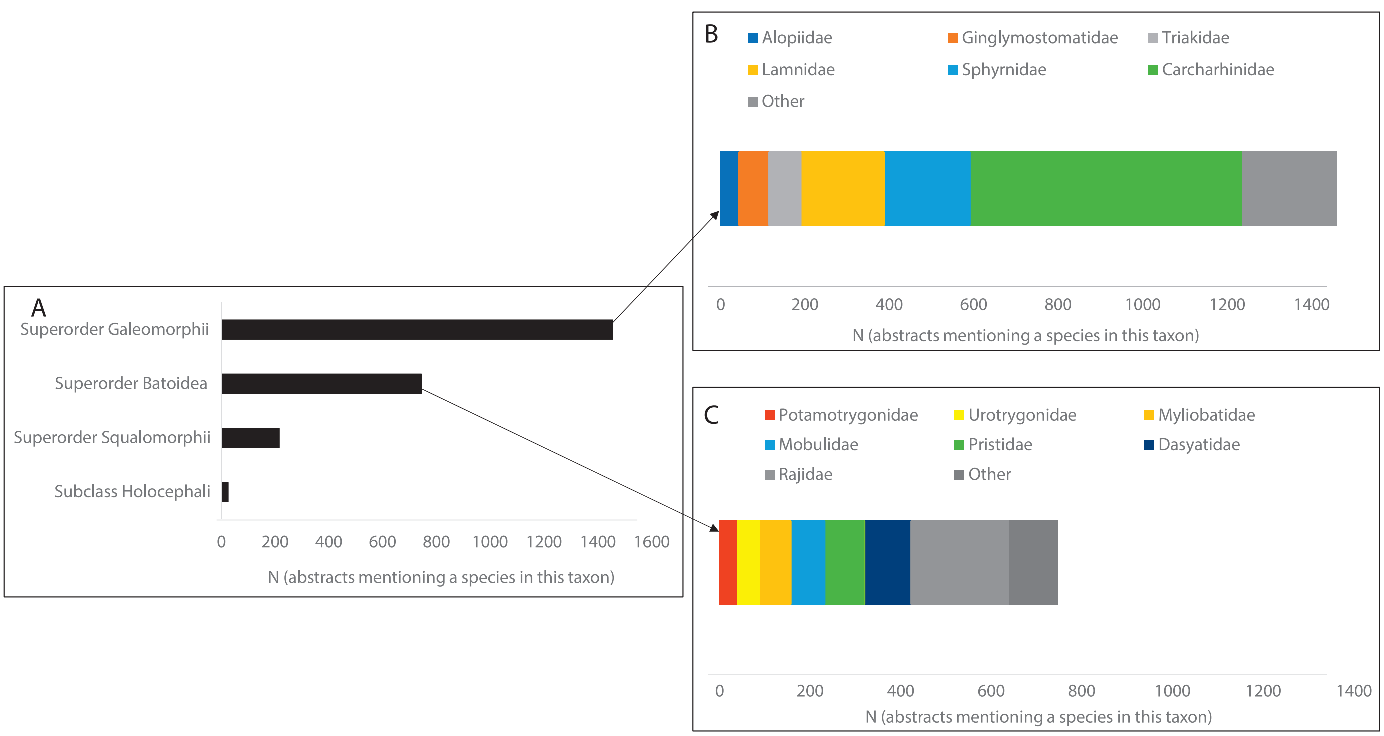

Fig. 5. (A) The number of abstracts that mention a species in each elasmobranch superorder as well as the subclass Holocephali. (B) Within abstracts mentioning the superorder Galeomorphii, the number of abstracts mentioning a species in each family. (C) Within abstracts mentioning the superorder Batoidea, the number of abstracts mentioning a species in each family.

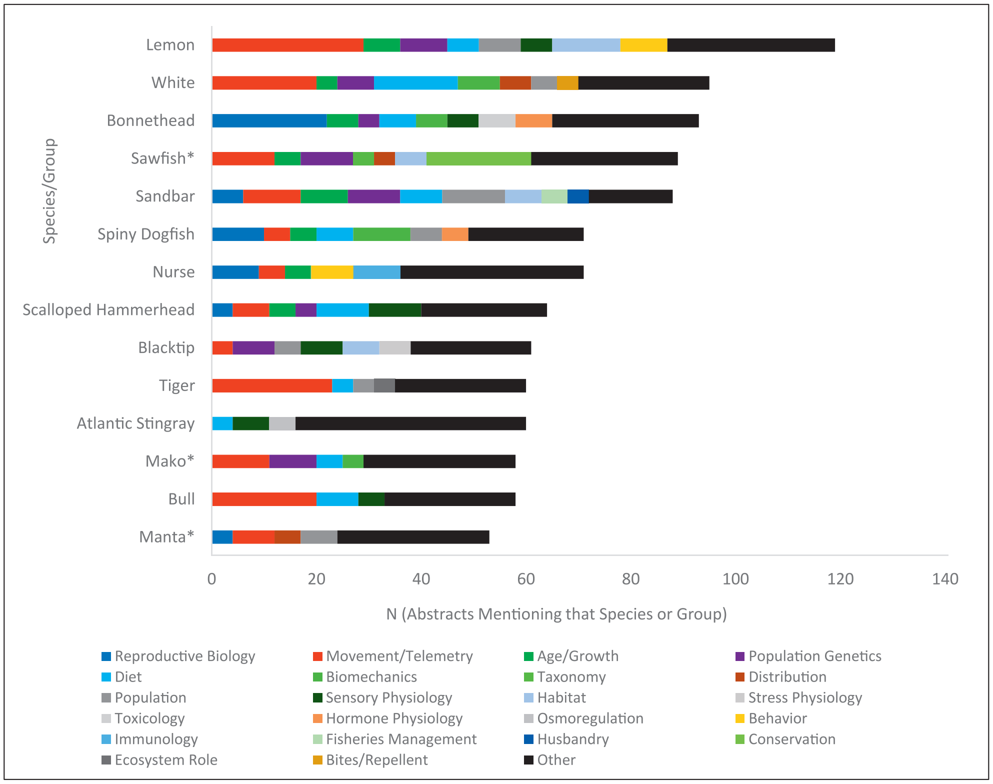

Fig. 6. The species (or groups of species indicated by an *) that were mentioned in more than 50 abstracts, and the research areas most commonly applied to each. Any research area $n > 4$ is indicated; all others are grouped together as "other." See Supplemental Appendix 1 (see Data Accessibility) for a detailed description of each research area with examples.

family Squalidae and the rest were mostly for the families Hexanchidae and Somniosidae.

Seven of the species or groups that were featured more than 50 times are considered by the IUCN Red List to be threatened (White Shark, Sandbar Shark, Spiny Dogfish, Scalloped Hammerhead, mako sharks, manta rays, and sawfishes; Fig. 6). One Critically Endangered species (Daggernose Shark *Isogomphodon oxyrhynchus)* found in the waters of the Americas has never been mentioned in an AES abstract. It should be noted that nearly half of all sawfish abstracts in the history of AES were from a 2016 organized symposium ($n = 37$, 41.6% of all sawfish abstracts) focusing on the biology and conservation of sawfishes, showing the value of a single focused effort such as an invited symposium to address an identified research gap.

Demographics and affiliation.—The Society began with 109 founding members and, as of 2018, had 444 members (507 members in 2016 through this analysis). The AES collected its first-ever Society-wide demographic data in 2017, which found that 55.8% of members filling out the survey identify as female (202 out of 362 member respondents) and no member responded as identifying as a non-binary gender. Additionally, this 2017 demographic survey found that 34 members identify as Hispanic/Latino, 14 as Asian, three as African-American, 13 as "other," one as American Indian or Alaska Native, and one as Pacific Islander, compared to 279 that identify as white (not Hispanic or Latino). Additionally, 123 members report being the first in their family to attend graduate school.

First author binary gender based on first name could be determined for 2,247 abstracts (83%); the rest were presented in years where only first initials were listed or were presented by someone with a first name that was not categorizable as male or female using our scheme. Overall, 31.3% of AES abstracts for which the first author's gender could be categorized were delivered by women* (Fig. 4A). The proportion of AES abstracts with female* first authors has increased steadily over time (as low as 4.3% in 1991) and was approaching 50% (44.4%) in 2016.

Affiliation was listed for 2,390 abstracts. Seventy-nine percent of AES abstracts for which an affiliation could be determined listed a university or college as the first author's primary affiliation. NOAA, Mote Marine Laboratory, aquariums, state wildlife management agencies, and museums were the primary affiliation for between 2% and 5% of the remaining talks. One talk was delivered by the owner of a SCUBA business, and four talks were delivered by presenters affiliated with the US Navy. Talks delivered by first authors with aquariums as their primary affiliation were more common in the past ($n = 38$ abstracts pre-2000, 5.4% of pre-2000 abstracts) than in recent years ($n = 34$ abstracts since 2000, 1.4% of post-2000 abstracts) despite an increasing trend in the total number of abstracts presented (Fig. 4B).

Geographic scope of work.—The geographic scope of work was categorizable for 1,124 abstracts. Of these, 49% percent of field research submitted as AES abstracts took place in the waters of the United States (Table 1), primarily within the waters of California and Florida, though it should be noted that both California and Florida contain diverse ecosystems and multiple research institutions. The next most frequent nations or regions outside of the US where AES abstract research took place were the waters of South America, the waters of the Greater Caribbean (including the Bahamas), and the waters of Mexico. Within South America ($n = 113$ abstracts), the most common country where research took place was Brazil ($n = 53$), though abstracts with research taking place in the waters of Brazil are less common in recent

Table 1. The countries or geographic regions where the research described in abstracts took place. Countries are the United States, Canada, and Mexico. All other areas on the map were grouped together as regions (due to low sample size in individual countries or a lack of country-specific reporting in abstracts, though $n \geq 5$ is noted parenthetically). The Chesapeake Bay (including Virginia and Maryland), New England (including Maine and Massachusetts), and the Gulf of Mexico (including Alabama, Louisiana, and Texas) were grouped together due to lack of specificity in many abstracts in these regions, all others refer to the waters of individual states.

Study location/region (waters of)	*n* (abstracts)
United States	552
South America	113 (53 Brazil, 15 Argentina, 12 Belize, 8 Colombia, 5 Galapagos)
Caribbean Islands	89 (70 Bahamas)
Mexico	88
Australia	69
Africa	45 (31 South Africa, 5 Mozambique)
Europe	41 (12 Portugal, 8 UK)
Asia	39 (22 Japan, 11 Taiwan)
Pacific Islands	32 (7 Philippines, 6 Palmyra)
Canada	23
New Zealand	9
Middle East	8
Within the United States	
California	121
Florida	113
Gulf of Mexico	86
New England	36
South Carolina	32
Hawaii	28
Chesapeake	26
Delaware	23
Alaska	16
North Carolina	11

years (24 abstracts pre-2000, 2.7% of pre-2000 abstracts, 29 abstracts since 2000, 1.6% of post-2000 abstracts).

DISCUSSION

This study identified several patterns in research focus and the demographics of researchers in chondrichthyan science, and it also identified research gaps. Specifically, this analysis showed that certain study species and study methods dominate the abstracts submitted to AES and that some identified research priorities receive comparatively less attention. Additionally, this analysis shows that abstracts presented at AES focusing on some research areas have declined over time, as has the proportion of presenters with certain affiliations. The percentage of female-presenting authors has increased over time, but AES still shows underrepresentation of several minority groups. This information can be used to help set future research priorities for the discipline of chondrichthyan science in general and can help the American Elasmobranch Society specifically to better achieve its stated goals.

While focusing on conference abstracts does not capture every research trend in our field, analyzing the entire scope of the largest and oldest professional society in our field does highlight interesting and relevant trends. While it is unknown how many of these abstracts were eventually published, an analysis (Verde Arregoitia and González-Suárez, 2019) found that about 60% of abstracts submitted to the Society of Conservation Biology were published within approximately two years of the conference.

Research area.—Many of the abstracts presented at AES are part of research areas related to threatened species conservation or fisheries management. Studies related to age and growth, reproductive biology, and populations are important to generating effective science-based fisheries management regulations, while studies related to movement are important for establishing spatial protections like marine protected areas (reviewed in Shiffman and Hammerschlag, 2016a).

Our study demonstrates an increase in the use of stable isotope analysis and a shift away from reliance on stomach content analysis, reflecting advances in stable isotope methodology and the use of non-lethal methods to investigate feeding ecology (see Shiffman et al., 2012). Huveneers et al. (2015) reported a similar finding in the relative frequency of these methods in abstracts for Sharks International. Our study also illustrates an increase in the use of satellite telemetry as a research method compared with acoustic telemetry. This trend was not observed with Sharks International abstracts (Huveneers et al., 2015), and Hussey et al. (2015) found that acoustic telemetry was more commonly used than satellite telemetry for studies on elasmobranch movement. Our results also suggest that satellite telemetry studies are biased towards comparatively well-understood species. Greater use of satellite telemetry in research submitted to AES meetings may be due to distinct study species of interest, or greater financial resources available to researchers working in the Americas compared to less developed areas.

It is increasingly recognized that the social sciences are necessary to generate data important for the conservation and management of chondrichthyan fishes (Jacques, 2010; Simpfendorfer et al., 2011). Management success is likely to be limited without understanding the social-ecological systems driving chondrichthyan population declines (Jacques, 2010). Given that social science methodologies are an established research priority and that AES seeks to be an institutional home for all types of chondrichthyan research, the low representation of social science talks at AES is noteworthy and potentially worthy of corrective action. Huveneers et al. (2015) noted that the number of social science focused talks at Sharks International is both higher than that of AES, and increasing over time, suggesting that this important research is indeed happening but not being presented at AES. This research gap can be interpreted as a call to action for the Society to encourage additional social science and interdisciplinary research.

Research on elasmobranch biomechanics and functional morphology have largely focused on the evolution of their feeding modes (although swimming is a close second). Perhaps this is driven by public fascination of many elasmobranchs as top predators, because elasmobranchs are a major lineage of jawed vertebrates often used as models of early gnathostome evolution, or due to the taxonomic diversity associated with various jaw morphologies. More recent studies of elasmobranch functional morphology and biomechanics have used material testing to compare shark teeth performance (e.g., Whitenack and Motta, 2010) and vertebral strength (e.g., Porter et al., 2006) across multiple taxa, finite element analysis to study mechanical properties (e.g., Jayasankar et al., 2017), computational fluid dynamics (e.g., Divi et al., 2018), and computed tomography scanning (e.g., Kolmann et al., 2016).

Although other research disciplines focused on nearshore species or species of high commercial interest, studies on functional morphology and biomechanics included studies on some of the clades most underrepresented in AES abstracts, particularly torpediniforms (e.g., Lesser Electric Ray, *Narcine bancrofti* [Dean and Motta, 2004a, 2004b; Dean et al., 2006, 2008], torpedo rays [Lowe et al., 1994]), freshwater potamotrygonid rays (Kolmann et al., 2016), and less frequently studied species of orectolobiform sharks (Ramsay and Wilga, 2007; Motta et al., 2010). Interestingly, elasmobranch feeding morphologists seem to have found means of studying some of the largest and most experimentally intractable species, such as the planktivorous Megamouth Shark (*Megachasma pelagios*), Whale Shark (*Rhincodon typus*), and mobulid rays (Tomita et al., 2011; Motta et al., 2010; Paig-Tran et al., 2013). Scientists have also studied jaw protrusion in deep-water species such as the Goblin Shark (*Mitsukurina owstoni*; Nakaya et al., 2016) and cranial biomechanics of the White Shark (Wroe et al., 2008). AES authors also have conducted research in comparing the functional ecology of extant and extinct taxa, i.e. representing not just current trends in biodiversity but historical ones as well (Whitenack and Motta, 2010; Whitenack et al., 2011). However, functional morphology and biomechanical research on underrepresented groups like guitarfishes (excluding *Pristis*), panrays (Zanobatidae), many squalomorph sharks (but see Claes et al., 2013), and deepwater skates are still lacking.

Other methods, such as molecular techniques, are categorized as their own method-based category of research talks at AES meetings rather than being grouped according to their application. As a result, studies showing the integration of genetics with more traditional tools to study questions related to systematics, dispersal, and reproduction may appear to be less common among AES abstracts than they truly are. Additionally, while abstracts in the research areas of reproductive biology, age and growth, and population genetics have remained largely unchanged over time, this does not imply a lack of progress in these disciplines.

Some research methods, including paleontology and research performed at aquariums or zoos, have declined in frequency among AES abstracts over time. However, this research is definitely still being published, it is just not being presented at AES. Over 700 chondrichthyan paleontology papers have been published since the year 2000 (Google Scholar search by author LW), and the Association of Zoos and Aquariums (AZA) reports that US and Canadian aquarium-based researchers are currently running approximately 75 research projects at AZA facilities, plus many more field-based research projects (H. Fatzinger, North Carolina Aquariums, pers. comm.). Aquarium professionals have many possibly competing conferences including the Regional Aquatics Workshop (RAW), International Aquarium Conference (IAC), and the International Elasmobranch Husbandry Symposium; attending those meetings instead of AES may partially explain the decline in aquarium-based research presentations at AES.

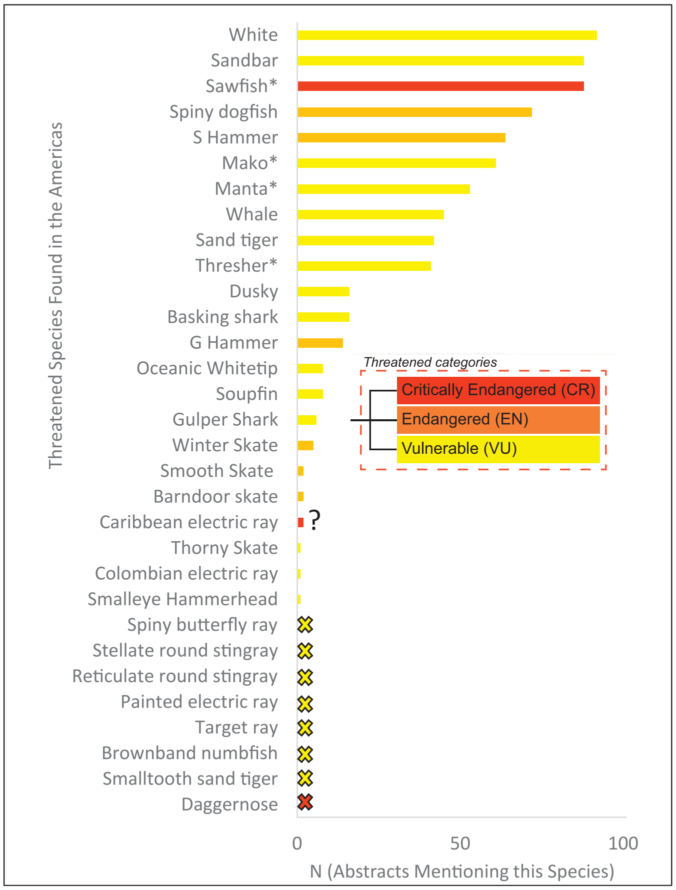

Fig. 7. The number of abstracts focusing on each species found in North American, Central American, and Caribbean waters that is listed as Threatened by IUCN Red List standards, from Kyne et al. (2012). An X indicates the Red List status of each species that has not been the focus of any abstracts. Red indicates Critically Endangered, Orange indicates Endangered, and Yellow indicates Vulnerable. The question mark by Caribbean electric ray reflects more recent published research suggesting that the species should instead be evaluated as "Least Concern," but as of this writing it remains evaluated as "Critically Endangered" by the IUCN Red List database. Additionally, the abstracts presented about Caribbean electric rays were prior to a taxonomic shift.

Study species.—Sharks in the superorder Galeomorphii were studied far more frequently than other chondrichthyan groups, and the most studied species were coastal and frequently encountered, and/or commercial important to fisheries. The relative focus on these species may be due to logistical or funding considerations. Similarly, Ajemian and Neer (2014) noted that very few AES abstracts focused on rays, and Cotton and Grubbs (2015) noted that relatively few AES abstracts focused on deep-sea chondrichthyans despite the taxonomic richness and ecological diversity of these lineages, likely due to relative logistical difficulties in accessing these species. Huveneers et al. (2015) also noted a bias towards larger and more well-known species in abstracts presented at Sharks International conferences. It should be noted that these species, while logistically easier to access for study purposes, are perhaps not the most in need of scientific research to support their management.

Nearly 90% of all recognized chondrichthyan species, including many IUCN Red List Endangered or Critically Endangered species found in the waters of the Americas, have never been mentioned in an AES abstract (Fig. 7). This bias towards the most charismatic or most easily accessible (e.g., coastal species vs. deep-sea or pelagic species) study species has resulted in an obvious taxonomic research gap. Skates and rays, which are historically and currently underrepresented in AES abstracts, are as a group more threatened than sharks as a group (Dulvy et al., 2014) and therefore could benefit from additional research attention if conservation of these species remains a goal of AES researchers. Our understanding of taxonomic priorities depends largely on our evolutionary or systematic understanding of taxa; the oversampling of some lineages and the undersampling of others in the larger chondrichthyan phylogeny hinders scientific and management progress in this case (Stein et al., 2018). Many AES members report a desire to generate scientific data to save threatened species (Ferry and Shiffman, 2014) and report personal involvement in ocean conservation efforts (Shiffman and Hammerschlag, 2016b), making the research gap in our understanding of particularly threatened or little known species an obvious priority for future research.

Studies on rays (morphology or otherwise) have largely been limited to families represented by perhaps one or two 'model' species, such as Urotrygonidae being largely represented by studies on *Urobatis halleri* and *U. jamaicensis*, to the exclusion of any species from the more diverse sister genus *Urotrygon*. Representation of the largest stingray family, Dasyatidae, was also driven by studies on a few select taxa, namely eastern United States taxa like *Hypanus americanus* and *H. sabinus*. Similarly, while presentations on sawfishes have become increasingly common, any research on other guitarfishes (Rhinopristiformes) is lacking. As mentioned previously, low representation of certain taxa in studies presumably reflects their ease of capture, which may explain why deeper water and continental shelf taxa such as electric rays, deepwater myliobatiforms (e.g., *Hexatrygon*, *Plesiobatis*) and the skate families Anacanthobatidae, Arhynchobatidae, and Gurgesiellidae are discussed infrequently at meetings, and studied infrequently in general (except when encountered as by-catch). In other words, research has not been led according to which clades are the most species-rich or evolutionarily distinctive (Stein et al., 2018), but rather by which taxa are easiest to procure, either by researchers or through targeted-fisheries and by-catch. Research on the lesser studied but harder to access species should be considered a research priority in the future.

Demographics and affiliation.—The current percentage of abstracts with female*-categorized authors (44.4%), while it has increased over time, is less than the overall demographics of the Society (55.8% of members self-identify as female) and with the number of bioscience degrees awarded to women* (53–58%, NSF). This trend is not unique to AES (Simon et al., 2007), although causal factors have not been fully explored. From these limited data, the reasons for this trend are unclear, and follow-up survey targeting AES members could clarify reasons for demographic trends in this Society. Abstracts for non-symposium talks and posters are generally accepted upon submission, so it is unlikely that bias in abstract acceptance is in play.

Within the Society, work has begun through an equity and diversity committee to devise efforts to combat this failure to retain female and minority members. It may also benefit the Society to engage in education to help AES members, especially those in leadership roles, to learn how to better recognize and combat instances of bias in chondrichthyan science and the profession at large. Efforts could be made for symposia, where presenters are invited, to ensure diversity with respect to gender, race, or other factors. For example, the American Society for Microbiology annual meeting has shown gains in the gender balance of speakers after examining its own invited presenter gender data and sharing it with their program committee (Casadevall and Handelsman, 2014). It is also possible that women are either attending AES, but not presenting, or not attending at all. In addition to examining past attendance records, it may be helpful to survey the membership about how members make decisions to present at and/or attend AES. Other studies show that women may find more barriers to conference travel, such as family-care duties (Moss-Racusin and Rudman, 2010) and gender biases in grant awards that may fund conference travel (Bornmann et al., 2007). It is important to note that while the percentage of female AES members and presenting authors has increased over time, the Society has low representation of African-American and Hispanic/Latino members compared to the United States as a whole and compared to NSF statistics of life sciences degree recipients. Further study should seek to address these issues of representation and inclusivity to ensure that AES conferences are a safe and welcoming event for everyone.

Geographic scope of work.—Some geographic regions are underrepresented as an area of study among abstracts submitted to AES, including some areas with high numbers of threatened species or widespread overfishing (see Momigliano and Harcourt, 2014). While this may be a consequence of the North American focus of the Society, it has also been noted that many developing countries have little infrastructure for chondrichthyan research, and that much of the research performed in these countries is performed by researchers based in the United States (Huveneers et al., 2015). Some of these regions may benefit from research partners based in the developed world to increase local capacity. The decline in presentations taking place in nations such as Brazil matches membership trends in the Society, which have been attributed to Brazil founding its own local chondrichthyan research societies (SBEEL, founded in 1997), and therefore perhaps no longer attending the American Elasmobranch Society conference (J. Wyffels, AES Secretary, pers. comm.).

Conclusions and recommendations.—If the goal of AES is to be a home for chondrichthyan researchers of any discipline, purposeful action may be required to welcome researchers from these disciplines back into the community or into the community for the first time. This can take many forms, including invited symposia focusing on topics of interest or offering travel rewards. The fact that half of the sawfish-related abstracts in the entire history of the Society were associated with one invited symposium shows that this approach can be an extremely effective way to increase the Society's focus on a research topic, though symposia may result only in a temporary bump in Society attention.

The trends in chondrichthyan research discerned from AES abstracts may be useful for setting research priorities or determining future directions for the Society itself. These abstracts may also be useful for countless other research projects, and we invite any other interested researchers to explore this publicly accessible dataset at https://elasmo.org/abstracts.

DATA ACCESSIBILITY

Supplemental material is available at https://www.copeiajournal.org/ot-19-179.

ACKNOWLEDGMENTS

The authors represent current, former, and emerging leaders of the American Elasmobranch Society. Author DSS would like to acknowledge funding and support from the Liber Ero Postdoctoral Fellowship Program, the Earth to Oceans Group at Simon Fraser University, and the Save Our Seas Foundation. Author MAK was supported by a Friday Harbor Labs Post-doctoral Fellowship (NSF-DBI PRFB 1712015), and author NKD was supported by Natural Science and Engineering Research Council Discovery and Accelerator Awards, Canada Research Chairs Program, and the Shark Conservation Fund. Author MPT would like to thank NSF grant IOS-1932757 for funding some of the open access fees. The authors would all like to thank the members of the American Elasmobranch Society for generating the data used in this study, and for helpful feedback on the presentation of these data at the 2017 meeting. Other than lead author DSS, authorship order is alphabetical by last name.

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