BioOne COMPLETE

Gulf-Wide Decreases in the Size of Large Coastal Sharks Documented by Generations of Fishermen

Author: Powers, Sean P.

Source: Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 5(5) : 93-102

Published By: American Fisheries Society

URL: https://doi.org/10.1080/19425120.2013.786001

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 5:93–102, 2013
© American Fisheries Society 2013
ISSN: 1942-5120 online
DOI: 10.1080/19425120.2013.786001

ARTICLE

Gulf-Wide Decreases in the Size of Large Coastal Sharks Documented by Generations of Fishermen

Sean P. Powers*
Department of Marine Sciences, University of South Alabama, LSCB Room 25, 5871 USA Drive North Boulevard, Mobile, Alabama 36688, USA

F. Joel Fodrie
Institute of Marine Sciences, University of North Carolina at Chapel Hill, 3431 Arendell Street, Morehead City, North Carolina 28557, USA

Steven B. Scyphers
Department of Marine Sciences, University of South Alabama, LSCB Room 25, 5871 USA Drive North Boulevard, Mobile, Alabama 36688, USA

J. Marcus Drymon
Center for Ecosystem Based Fisheries Management, Dauphin Island Sea Lab, 101 Bienville Boulevard, Dauphin Island, Alabama 36528, USA

Robert L. Shipp
Department of Marine Sciences, University of South Alabama, LSCB Room 25, 5871 USA Drive North Boulevard, Mobile, Alabama 36688, USA

Gregory W. Stunz
Harte Research Institute for Gulf of Mexico Studies, Texas A&M University–Corpus Christi, 6300 Ocean Drive, Corpus Christi, Texas 78412, USA

Abstract
Large sharks are top predators in most coastal and marine ecosystems throughout the world, and evidence of their reduced prominence in marine ecosystems has been a serious concern for fisheries and ecosystem management. Unfortunately, quantitative data to document the extent, timing, and consequences of changes in shark populations are scarce, thwarting examination of long-term (decadal, century) trends, and reconstructions based on incomplete data sets have been the subject of debate. Absence of quantitative descriptors of past ecological conditions is a generic problem facing many fields of science but is particularly troublesome for fisheries scientists who must develop specific targets for restoration. We were able to use quantitative measurements of shark sizes collected annually and independently of any scientific survey by thousands of recreational fishermen over the last century to document decreases in the size of large sharks from the northern Gulf of Mexico. Based on records from fishing rodeos in three U.S. coastal states, the size (weight or length) of large sharks captured by fishermen decreased by 50–70% during the 20 years after the 1980s. The pattern is largely driven by reductions in the occurrence and sizes of Tiger Sharks *Galeocerdo cuvier* and Bull Sharks *Carcharhinus leucas* and to a lesser extent Hammerheads *Sphyrna* spp. This decrease occurred despite increasing fishing effort and advances in technology, but it is coincident with the capitalization of the U.S. commercial shark long-line fishery in the GOM.

Subject editor: Debra J. Murie, University of Florida, Gainesville

*Corresponding author: spowers@disl.org
Received April 10, 2012; accepted March 7, 2013

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

The need for quantitative descriptors of temporal change has been increasingly recognized as a fundamental requirement for ecological assessment and global fisheries management initiatives. Scientific studies that use novel syntheses of past and largely anecdotal data sources to reconstruct ecological conditions on decadal and century scales are now landmark contributions to ecosystem and conservation science (e.g., Jackson et al. 2001). The development of proxies for assessing ecological change has its roots in paleobiology, oceanography, and climatology, where discrete measurements (e.g., trace chemicals, abundance, presence–absence of fossilized organisms or parts) have enabled characterization of environmental and biological conditions on century to millennial scales. Development of similar rigorous measurements of past ecological conditions has proven more difficult, especially for large animals. Syntheses of anecdotal observations has led to more qualitative measures of past ecological conditions (e.g., top consumers were more abundant in the past; Jackson et al. 2001; Pandolfi et al. 2003) that are of limited use for establishing restoration and stock rebuilding targets and have been viewed with skepticism by many scientists (e.g., Boesch et al. 2001; Aronson et al. 2003). Extrapolation of quantitative measurements from anecdotal sources, surveys (Mora et al. 2005), or public interviews can be biased by generational changes in personal perceptions of environmental baselines (Pauly 1995; Sáenz-Arroyo et al. 2005) and often provide only limited quantitative metrics for assessing change. Re-examination and parameter estimation of past fishery-dependent (Baum et al. 2005), fishery-independent (Myers et al. 2007), and ecological (Paddack et al. 2009) data sets not originally collected for quantitative assessments have indicated declining trends for many fisheries but have also been met with substantial criticism (Hilborn 2006). Ideally, decadal or century data sets that can be analyzed in a similar context as the original intended use would be the most valuable. Although, few such data sets have been identified by marine ecologists and fisheries scientists, records of size or weights may fulfill this criterion for many species that are exploited (e.g., McClenachan 2009).

A key goal of restoration and stock rebuilding plans for many species is the proliferation of older (and hence larger) individual in populations. For many species, particularly marine fishes, conservation of larger individuals can be expected to increase per capita reproduction rates because larger fish can put more energy into reproduction and may produce eggs with higher probabilities of survival (Berkeley et al. 2004a, b). Reversing the decades-long trend of reduction in average size of fish will require aggressive management intervention (Birkeland and Dayton 2005). Unfortunately, many efforts have been hampered by disagreement among fisheries scientists, fishermen, and conservationists on the magnitude, timing, and consequences of these declines (Baum et al. 2003; Baum and Myers 2004; Burgess et al. 2005; Hilborn 2006). Detailed records of exploitable fish and shellfish populations that could be used to resolve these disagreements and set definitive goals are unavailable or unreliable to reconstruct the history of most fisheries – a point multiple scientists agree upon (Baum and Myers 2004; Burgess et al. 2005). The lack of quantitative data also hampers the establishment of specific quantitative conservation and stock rebuilding goals.

Although systematic and rigorous collections of fisheries dependent and independent data are a relatively recent endeavor in the USA, fishermen have collected fish from coastal and marine waters for millennia. Size and weight are often measured by fishermen to gauge their success among their peers. When these competitive interactions are organized into fishing tournaments, a potential historic record for the sizes of the largest catchable fishes is recorded in fishing journals and newspaper articles. We used data sets generated annually by generations of fishermen participating in the three oldest and largest fishing rodeos in the northern Gulf of Mexico to examine whether the size (weight or length) of large sharks has decreased over time. These data sets do not meet the rigorous criteria for incorporation into traditional stock assessment because they are fundamentally biased. In tournaments, fishermen do not sample in a random manner, they target a specific size (largest) and use experience and traditional knowledge to direct their efforts. Although these biases must be considered in any analyses, many of these biases may facilitate ecological investigations. For example, rigorous fisheries independent sampling rarely captures sufficient quantities of large and older fish to resolve trends in the largest size-classes. In fishing tournaments, a tremendous effort is focused on sampling this largest size-class and, hence, could provide important information on trends while standardizing many aspects of fishermen behavior (e.g., time of year, geographic area, etc.) via tournament rules.

METHODS

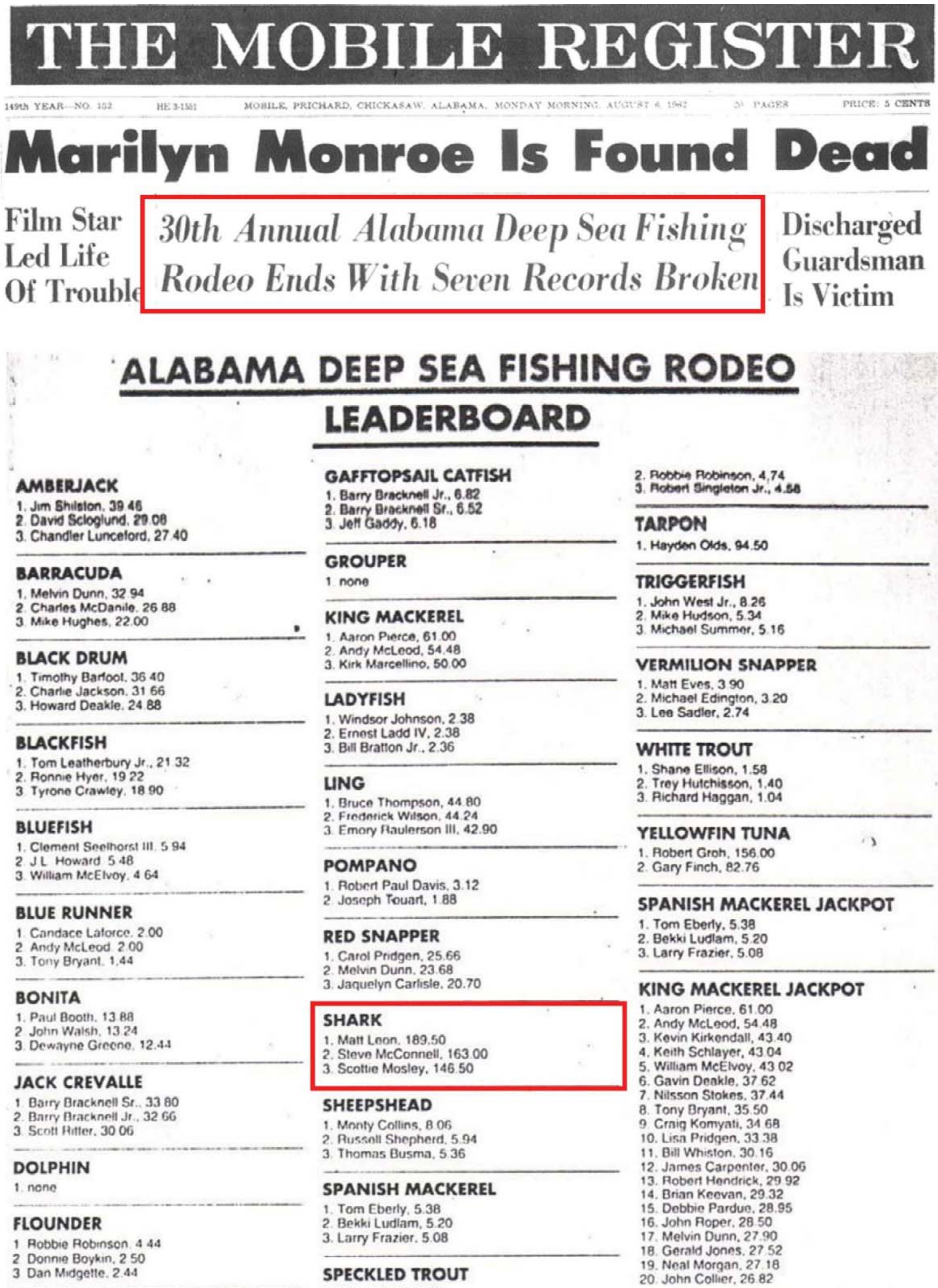
We used 80 years of records (1929–2009) from the three oldest fishing rodeos within the USA, all of which occurred in the Gulf of Mexico: (1) the Alabama Deep-Sea Fishing Rodeo (ADSFR; spanning 79 years), (2) Mississippi Deep-Sea Fishing Rodeo (MDSFR, 60 years), and (3) Texas Deep-Sea Roundup (TDSR; 76 years). We examined trends in the weight (ADSFR, MDSFR), length (TDSR) and species identity of the largest sharks caught by fishermen as an indicator of the relative abundance and size of large sharks within the Gulf. All three rodeos have similar characteristics, including timing (late July to early August), length (3 d), and rules (all sharks aggregated into a single category and three largest fish win prizes). Effort can also be assessed by examining trends in ticket sales.

Long-term tournament records for sharks and other big game fish from the three rodeos, as well as NOAA commercial fisheries data, were gathered and synthesized into one database for analysis. Rodeo records were reconstructed from daily leaderboards (Figure 1) published in the Mobile Press-Register (ADSFR) and Mississippi Sun-Herald (MDSFR), as well as archived weigh-station registry cards (TDSR). Final leaderboard and registry-card data were entered in a digital database, and the

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

A.

B.



THE MOBILE REGISTER

149th YEAR—NO. 152 HE 3-1501 MOBILE, PRICHARD, CHICKASAW, ALABAMA, MONDAY MORNING, AUGUST 6, 1962 30 PAGES PRICE: 5 CENTS

Marilyn Monroe Is Found Dead

Film Star Led Life Of Trouble

30th Annual Alabama Deep Sea Fishing Rodeo Ends With Seven Records Broken

Discharged Guardsman Is Victim

ALABAMA DEEP SEA FISHING RODEO LEADERBOARD

AMBERJACK
1. Jim Shilston, 39.46
2. David Scloglund, 29.08
3. Chandler Lunceford, 27.40

BARRACUDA
1. Melvin Dunn, 32.94
2. Charles McDanile, 26.88
3. Mike Hughes, 22.00

BLACK DRUM
1. Timothy Barfoot, 36.40
2. Charlie Jackson, 31.66
3. Howard Deakle, 24.88

BLACKFISH
1. Tom Leatherbury Jr., 21.32
2. Ronnie Hyer, 19.22
3. Tyrone Crawley, 18.90

BLUEFISH
1. Clement Seelhorst III, 5.94
2. J.L. Howard, 5.48
3. William McElvoy, 4.64

BLUE RUNNER
1. Candace Laforce, 2.00
2. Andy McLeod, 2.00
3. Tony Bryant, 1.44

BONITA
1. Paul Booth, 13.88
2. John Walsh, 13.24
3. Dewayne Greene, 12.44

JACK CREVALLE
1. Barry Bracknell Sr., 33.80
2. Barry Bracknell Jr., 32.66
3. Scott Ritter, 30.06

DOLPHIN
1. none

FLOUNDER
1. Robbie Robinson, 4.44
2. Donnie Boykin, 2.50
3. Dan Midgette, 2.44

GAFFTOPSAIL CATFISH
1. Barry Bracknell Jr., 6.82
2. Barry Bracknell Sr., 6.52
3. Jeff Gaddy, 6.18

GROUPER
1. none

KING MACKEREL
1. Aaron Pierce, 61.00
2. Andy McLeod, 54.48
3. Kirk Marcellino, 50.00

LADYFISH
1. Windsor Johnson, 2.38
2. Ernest Ladd IV, 2.38
3. Bill Bratton Jr., 2.36

LING
1. Bruce Thompson, 44.80
2. Frederick Wilson, 44.24
3. Emory Raulerson III, 42.90

POMPANO
1. Robert Paul Davis, 3.12
2. Joseph Touart, 1.88

RED SNAPPER
1. Carol Pridgen, 25.66
2. Melvin Dunn, 23.68
3. Jaquelyn Carlisle, 20.70

SHARK
1. Matt Leon, 189.50
2. Steve McConnell, 163.00
3. Scottie Mosley, 146.50

SHEEPSHEAD
1. Monty Collins, 8.06
2. Russell Shepherd, 5.94
3. Thomas Busma, 5.36

SPANISH MACKEREL
1. Tom Eberly, 5.38
2. Bekki Ludlam, 5.20
3. Larry Frazier, 5.08

SPECKLED TROUT
1. Mike Tindal, 5.40
2. Robbie Robinson, 4.74
3. Robert Singleton Jr., 4.58

TARPON
1. Hayden Olds, 94.50

TRIGGERFISH
1. John West Jr., 8.26
2. Mike Hudson, 5.34
3. Michael Summer, 5.16

VERMILION SNAPPER
1. Matt Eves, 3.90
2. Michael Edington, 3.20
3. Lee Sadler, 2.74

WHITE TROUT
1. Shane Ellison, 1.58
2. Trey Hutchisson, 1.40
3. Richard Haggan, 1.04

YELLOWFIN TUNA
1. Robert Groh, 156.00
2. Gary Finch, 82.76

SPANISH MACKEREL JACKPOT
1. Tom Eberly, 5.38
2. Bekki Ludlam, 5.20
3. Larry Frazier, 5.08

KING MACKEREL JACKPOT
1. Aaron Pierce, 61.00
2. Andy McLeod, 54.48
3. Kevin Kirkendall, 43.40
4. Keith Schlayer, 43.04
5. William McElvoy, 43.02
6. Gavin Deakle, 37.62
7. Nilsson Stokes, 37.44
8. Tony Bryant, 35.50
9. Craig Komyati, 34.68
10. Lisa Pridgen, 33.38
11. Bill Whiston, 30.16
12. James Carpenter, 30.06
13. Robert Hendrick, 29.92
14. Brian Keevan, 29.32
15. Debbie Pardue, 28.95
16. John Roper, 28.50
17. Melvin Dunn, 27.90
18. Gerald Jones, 27.52
19. Neal Morgan, 27.18
20. John Collier, 26.82

FIGURE 1. Example accounts from Mobile Press-Register in **(A)** 1962 and **(B)** 1998 describing deep-sea fishing rodeo results of prize-winning sharks, which were the data source used to construct temporal shark size data sets for the last eight decades in the Alabama and Mississippi rodeos. Newspaper accounts were compiled from the final rodeo leaderboards at the end of each year.

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

largest (TDSR) or three largest (ADSFR, MDSFR) sharks from that year's rodeo were entered. For the ADSFR and MDSFR, weights were used to determine winners, whereas length was used for the TDSR. Shark identifications for the last 15–25 years of each tournament were made by fish biologists on site, whereas earlier identifications were based on the examination of newspapers and archived photos and additional taxonomic experts as needed. In addition to trends in shark sizes, we also compared long-term trends in ADSFR data between sharks and other big game fishes (Blue Marlin *Makaira nigricans*, King Mackerel *Scomberomorus cavalla*, Wahoo *Acanthocybium solanderi* and Yellowfin Tuna *Thunnus albacares*) that require specialized (heavy) tackle and experience. Weights for the three largest specimens of each species for each year were averaged. To make direct interspecific comparisons, weights were standardized (within each species) by scaling records against the year in which the heaviest fish was observed. Therefore, annual data for each species scale between 0 and 1. This comparison was used to evaluate whether observed shark trends were specific to these elasmobranch fishes or rather part of a larger phenomenon resulting from changes in either (1) rodeo practices, or (2) the ability of the Gulf of Mexico to support large apex fishes. Finally, annual commercial landing statistics for all sharks within the Gulf were obtained by querying the NOAA-Fisheries database.

Individual long-term trends in shark catches were fitted for ADSFR, MDSFR and TDSR data. In each instance, we used the Akaike information criterion (AIC) to determine the model order that provided the best goodness of fit for the data (balancing model specificity and generality): $\text{AIC} = 2k + n[\log_e(\text{RSS}/n)]$, where k is the model order, n is the number of observations, and RSS is the residual sum of squares between the observed and fitted data. The annual standardized catch records for the four big game fishes were averaged, and these data were compared with the long-term data for sharks. As before, we used AIC analyses to determine the best fit for the big game fishes time series.

Our historical reconstruction of the sizes of coastal sharks was supplemented by interviews of anglers participating in the 2008 and 2009 ADSFR. Approximately 400 anglers were indiscriminately selected upon exiting the weigh-in booth at the rodeo. Overall, selection was driven by the desire to achieve dispersion across ages and recreational fishery experience. The objective of the interviews was to measure perceptions of size trends in winning species of fish. In addition to a series of demographic and socioeconomic questions, fishermen were asked several species-specific questions (see Appendix) regarding size trends in major fish categories for the ADSFR and asked to use one of five different trend lines to describe their opinion of how size has changed over time.

RESULTS

Despite increasing fishermen effort over time, dramatic changes were seen in the size of the winning sharks in recent years. The average size of the three largest sharks captured in all three rodeos increased from the rodeos' inceptions until the early 1980s, but decreased by >60% in the late 1980s and remained low through 2009, the last year included in the data set (Figure 2A–C). Choosing the fit producing the lowest AIC value, rodeo trends based on weight were best fit by a cubic polynomial with R^2 values of 0.56 for ADSFR and 0.48 for MDSFR ($P < 0.01$). The TDSR data showed the same trend based a quadratic polynomial of length data ($R^2 = 0.53$, $P < 0.01$). Effort in the two rodeos that documented ticket sales (ADSFR and MDSFR) has increased linearly ($R^2 > 0.79$, $P < 0.01$) since their inceptions and increased from hundreds of fishermen to greater than 4,000 today. The substantial decrease in size of the prize-winning sharks was not seen in other big game fish. A linear increase in size of big game fish is seen in the ADSFR data ($R^2 = 0.78$, $P < 0.01$; Figure 3). In contrast, shark size increased until the late 1980s and then abruptly decreased.

Species composition of the winning large sharks also changed over the 80 years of rodeo records. Large Tiger Sharks *Galeocerdo cuvier* and Bull Sharks *Carcharhinus leucas* predominated the winner boards until 1990, whereas much smaller Bull Sharks, Hammerheads *Sphyrna* spp., and Blacktip Sharks *Carcharhinus limbatus* predominated during the last 20 years (Table 1). Species-level identifications for sharks were rarely included in the newspaper accounts of the rodeos prior to 1970. Winning sharks for the ADSFR were almost exclusively Tiger Sharks prior to the 1990s. Post 1990 Tiger Sharks occasionally made the leaderboard, but their weights were considerably less. For the nearby MDSFR, large Tiger Sharks followed by Bull Sharks composed the majority of the winning sharks until 1990. From 1990 to 2007, each species made the winners board only once. Instead, smaller Blacktip Sharks and Hammerheads made the leaderboard, but their weights were considerably less than that of the prize winning sharks captured during the 1970s and 1980s. The Texas rodeo showed a similar trend, predominated by Bull Sharks and occasionally Tiger Sharks pre-1990 and a larger diversity of smaller species of sharks post-1990.

Interviews with over 400 fishers (>90% participation rate) conducted at the ADSFR indicate that the retrospective memory of most fishermen would have predicted an increasing or stable trend in size of winning sharks. Less than half the fishermen would predict a decreasing size of sharks based on their aggregate knowledge of the fishery (Figure 4). Among the 215 anglers that answered the shark-related questions and provided their age, the percentage of anglers predicting a declining trend increased with age of the respondent. The only group that had a majority of respondents describing a negative trend was composed of individuals over 60 years of age.

DISCUSSION

The inability to examine long-term (decadal) trends for shark populations has imposed a high degree of uncertainty on the status of sharks. Our fishermen-generated data are evidence for a drastic reduction in the size of large sharks in the Gulf

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

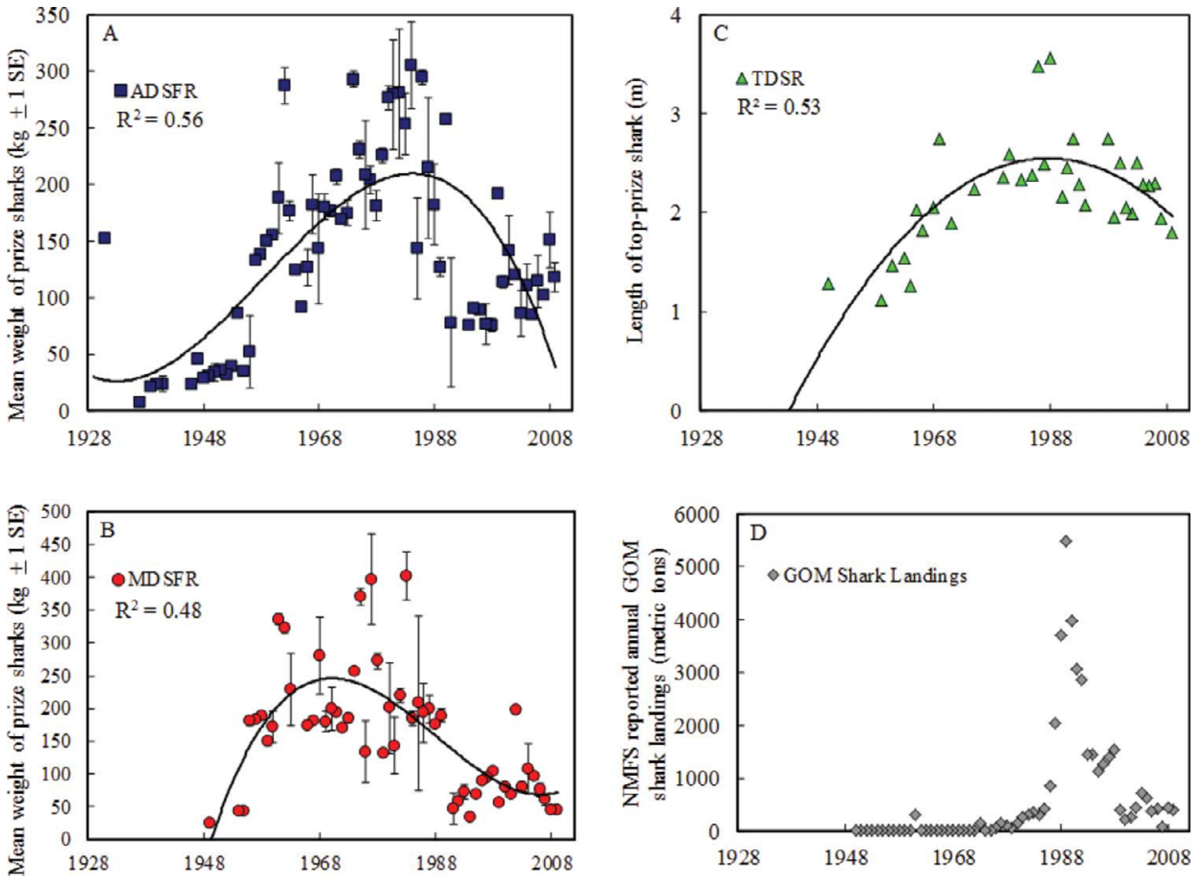


FIGURE 2. Temporal trends for the three heaviest or longest sharks landed annually during the last eight decades in the **(A)** Alabama (ADSFR), **(B)** Mississippi (MDSFR), and **(C)** Texas (TDSR) deep-sea fishing tournaments. For each state, the annual records (symbol ± 1 SE) and overall trends (solid lines representing cubic [ADSFR, MDSFR] and quadratic [TDSR] fits for the data) are shown. **(D)** National Marine Fisheries Service (NMFS) records showing changes in commercial landings of sharks during the 1980s in the Gulf of Mexico (GOM), which coincides with a decline in the size of prize-winning sharks available to tournament fishermen from around 1990 to the present.

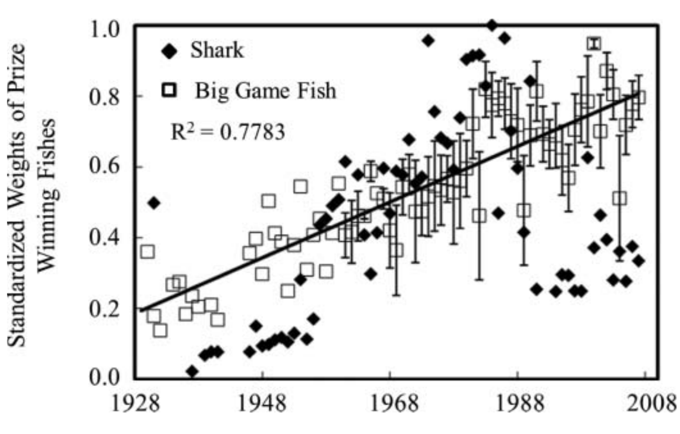


FIGURE 3. Temporal trends in the weights of prize-winning sharks and big game fishes captured each year in the Alabama Deep-Sea Fishing Rodeo. Big game fishes include Blue Marlin, King Mackerel, Wahoo, and Yellowfin Tuna. Weights were standardized (within each species) by scaling the records against the year in which the heaviest average weight of prize fish was observed. The decrease in shark weights following the mid-1980s is counter to this expectation.

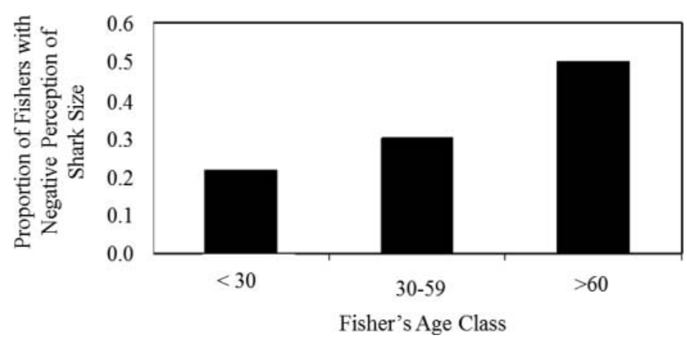


FIGURE 4. Perceptions among three generations of fishers regarding the long-term trend in sizes of sharks available to be caught in the northern Gulf of Mexico ($n = 215$); a value >0.5 would indicate that more than half of fishermen surveyed believed that shark size has declined.

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

TABLE 1. Species identification of winning sharks in the Alabama (ADSFR), Mississippi (MDSFR), and Texas (TDSR) deep-sea fishing tournaments, 1947–2009.

	Species Identification of Largest Shark				Species Identification of Largest Shark		
Year	ADSFR	MDSFR	TDSR	Year	ADSFR	MDSFR	TDSR
2009	Hammerhead		Hammerhead	1968			Mako *Isurus sp.*
2008	Tiger Shark	Blacktip Shark		1967			
2007	Bull Shark		Hammerhead	1966	Tiger Shark	Hammerhead	
2006	Bull Shark	Bull Shark	Dusky Shark	1965			
2005	Hammerhead	Silky Shark	Silky Shark	1964			Hammerhead
2004	Bull Shark	Hammerhead	Spinner Shark *Carcharhinus brevipina*	1963			
2003	Hammerhead	Hammerhead	Bull Shark	1962			
2002	Tiger Shark	Blacktip Shark	Hammerhead	1961		Tiger Shark	
2001	Bull Shark	Hammerhead	Sandbar Shark *Carcharhinnus plumbeus*	1960			
2000	Bull Shark	Tiger Shark	Spinner Shark	1959			
1999	Tiger Shark	Dusky Shark		1958			
1998	Hammerhead	Hammerhead	Bull Shark	1957			
1997	Nurse Shark *Ginglymostoma cirratum*	Hammerhead	Hammerhead	1956			
1996	Bull Shark	Hammerhead		1955		Hammerhead	
1995	Lemon Shark *Negaprion brevirostris*	Blacktip Shark	Bull Shark	1954			
1994	Bull Shark	Hammerhead	Sandbar Shark	1953			
1993			Blacktip Shark	1952			
1992			Dusky Shark	1951			
1991		Hammerhead	Bull Shark	1950			
1990	Tiger Shark	Bull Shark		1949			
1989	Tiger Shark	Bull Shark		1948			
1988		Bull Shark	Tiger Shark	1947	Hammerhead		
1987		Bull Shark	Bull Shark	1946			
1986	Tiger Shark	Bull Shark	Tiger Shark	1945			
1985		Tiger Shark	Bull Shark	1944			
1984	Tiger Shark	Tiger Shark		1943			
1983	Tiger Shark			1942			
1982	Tiger Shark	Bull Shark	Bull Shark	1941			
1981	Tiger Shark	Bull Shark		1940			
1980	Tiger Shark	Tiger Shark	Bull Shark	1939			
1979	Tiger Shark	Tiger Shark	Bull Shark	1938			
1978	Tiger Shark	Tiger Shark	Bull Shark	1937			
1977		Tiger Shark	Tiger Shark	1936			
1976		Bull Shark	Bull Shark	1935			
1975		Tiger Shark	Bull Shark	1934			
1974	Tiger Shark			1933			
1973			Bull Shark	1932			
1972			Hammerhead	1931			
1971	Tiger Shark		Hammerhead	1930			
1970		Tiger Shark	Mako	1929			
1969			Mako				

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

of Mexico by the early 1990s. Reduction in the size of these sharks has substantial population-level and ecosystem-level implications. Several aspects of shark life history indicate a greater sensitivity to overfishing and prolonged population recovery time (long maturation period, low fecundity, older ages at first reproduction; Music 1999). For example, none of the Tiger Sharks caught in the last 20 years would have been classified as reproductively mature (>150 kg; Branstetter et al. 1987; Whitney and Crow 2007). For those species of sharks that mature at smaller sizes, recovery of shark populations may be delayed if a positive correlation between size and reproductive fitness exist, as is the case for bony fish (Berkeley et al. 2004a, b). Reduction in the abundance of large sharks also has the potential to cascade down the food web by releasing mesopredators from top–down control (Myers et al. 2007).

The pattern of declining size of sharks is largely driven by decreases in the occurrence and size of Bull and Tiger Sharks. Whereas the leaderboards were predominated by these two species prior to the late 1980s, the winning sharks came from a larger pool of species that included smaller coastal species (e.g., Blacktip Sharks, Spinner Sharks, and Scalloped Hammerheads *S. lewini*) as well as smaller Tiger and Bull Sharks. Because so few species besides Tiger and Bull Sharks won the earlier tournaments it is difficult to assess whether our pattern is exclusive to these two species or encompasses other coastal sharks. The occurrence of large Hammerheads in the earlier records of the TDSR does suggest that the pattern encompasses more than just Tiger and Bull Sharks. From an ecological perspective, the answer may be somewhat irrelevant given that Tiger and Bull Sharks as well as Hammerheads are common large (>150 kg) sharks that fill the niche of large mobile predators in the coastal foodweb in the Gulf of Mexico (see Drymon et al. 2010), and their reduced prominence would be troublesome in and of itself.

The interpretation of our data sets requires reasonable assumptions be made regarding the efficiency of fishermen and tournament behavior to make inference concerning trends in shark size. The initial 50-year increase in weight is most likely a function of increasing effort and improved fishing technology as evidenced by a similar pattern in big game fish (Figure 3). Substantial fisheries literature exist documenting increases in the efficiency of fishermen with both increases in technology and communication among fishermen. For fisheries assessments, catchability (q) is used to quantify the relationship between the efficiency of a fishery (in our case, recreational fishermen) and population abundance (Arreguín-Sánchez 1996). Given an increasing or unchanging efficiency, decreases in landings would be a function of changes in abundance. The substantial decrease in size of prize-winning sharks is not seen in other big game fish, species that would require similar size boats and specialized tackle. The departure of sharks from the increasing or asymptotic relationship provides further evidence that large sharks were in decreased supply to anglers.

Fishermen behavior cannot be explained exclusively by q. The popularity of sharks as a targeted species, as well as the financial cost of fishing these species, must also be considered during the period over which decline has been documented. The number of fishermen in these multispecies tournaments increased twofold over the period of the decline (1990–2009). Ticket sales do not fully resolve trends for the sector of fishermen targeting sharks. The popularity of shark fishing increased in the mid 1970 through 1980s after the movie "Jaws" (Babcock 2008) and may have resulted an increased fishermen participation in this sector for a period of time. As populations declined and conservation of sharks received increasing public attention, shark-kill tournaments probably declined (Hueter 1991), although some tournaments adopted tag-and-release rules. None of our three tournaments would be considered major shark tournaments; instead their multispecies categories and modest entry costs and prizes (<$200 in value) attracted local fishermen who opportunistically targeted sharks. Although most relied on chance encounters while fishing for other finfish species, some anglers did routinely target sharks within the tournament and were less successful at capturing large sharks later in the time series. Fuel prices, which are often a consideration in evaluating offshore fishing effort, sharply increased in the mid-1970s and again in the late 2000s (U.S. Department of Labor, Bureau of Labor and Statistics). In the intervening years between these two spikes, a modest and steady increase was seen in fuel prices and, hence, did not cause an abrupt and major change in shark fishing in the tournaments, a notion supported by increased tickets sales and increased size of big-game fish.

Similar to our conclusion regarding fishermen behavior (i.e., no plausible explanation for changes could parsimoniously explain the abrupt decline in shark size seen in the early 1990s), no major rule changes to the tournaments occurred during the period of decline that could account for the shark size pattern. Regulation and harvest prohibitions for shark species in the Gulf of Mexico are relatively recent. Prohibitions on recreational harvest of Sandbar Sharks *Carcharhinus plumbeus*, Dusky Sharks *Carcharhinus obscurus*, and Silky Sharks *Carcharhinus falciformis* did not occur until early in the 2000s. Further, the dramatic decline in shark size in our three data sets occurred before stock assessments were commenced for large coastal sharks in the northern Gulf. Hence, no major changes in fisheries regulation could explain the decline.

Given the basin-wide nature of the pattern we detected, climate change or longer-term oscillations of climate could be plausible drivers. For instance, recent studies have shown that significant variability in blue crab *Callinectes sapidus* recruitment within the Gulf of Mexico could be explained by the oscillation between wet and dry periods driven by the a combination of the effects of the Atlantic Multidecadal Oscillation and the North Atlantic Oscillation (Sanchez-Rubio 2011a,b), but the major shifts in these indices occurred in 1994, which postdates the rapid decline in size of sharks in the late 1980s. The findings of another recent study in the region suggested that the structure of northern Gulf of Mexico seagrass fish communities may have already been affected by warmer water temperatures

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

(Fodrie et al. 2010). In any respect, an altered prey base could have potentially slowed a recovery of sharks.

While changes in angler behavior, tournament rules, fishing regulation, and climate oscillations fail to provide strong temporal correspondence with the precipitous decline in shark size evident in the three fishing rodeos, the decreasing trend in shark size shows a distinct temporal correspondence with increased landings in the shark longline fishery in the Gulf of Mexico. The spike in landings of sharks occurred in the late 1980s and early 1990s as a result of increasing effort in the commercial longline shark fishery in the Gulf. Many of the older tournament anglers noted the temporal correspondence between decreased landings of large sharks and increases in the commercial harvest: "Long liners have made it progressively more difficult to catch big sharks" (quote from an unidentified fisherman interviewed in the Mobile Press Register, 1986).

Differences among generations were consistent with predictions of the "shifting baseline" theory in that older fishermen viewed changes in size of sharks more accurately than younger fishermen who felt that shark sizes had not changed over the last 9 decades. Misperceptions of such trends by many fishermen not only illustrate the need for assessing age and experience level in social surveys of ecological conditions, but more importantly point to the need for quantitative measures of change. We anticipate that the source of these data (i.e., fishermen) will serve to promote greater acceptance of the current status of shark populations by resource managers and the general public, and it illustrates the importance of incorporating traditional knowledge in a quantitative way.

After a long history of encouraging harvest (Barrett 1928) and an absence of harvest regulations, significant improvements have been made in stock assessment and have resulted in regulations to rebuild shark stocks. It is important to note that the changes we document in the average size of sharks occurred prior to stock assessments for most coastal sharks (e.g., Cortés et al. 2006; NMFS 2006, 2008; Hayes et al. 2009). Improved management is critical to recovery of these stocks. Our data set provides discrete and tangible rebuilding targets that could be achieved. It is somewhat ironic that fishing tournaments that target sharks, which may be part of the reason for the decline, are one of the best indications of their decline; however, this irony extends to most exploited species. Our data suggest that the commercial long-line fishery was the primary driver for the decline in size of sharks and that the decline is relatively recent (1990s). Declines in apex predators can alter entire food webs (Estes et al. 2011), and increasing the abundances of the largest members of the apex predator community should be a fisheries and ecosystem management priority.

ACKNOWLEDGMENTS

We thank the Mobile Jaycees for their help and guidance with Alabama tournament data. We also thank the Port Aransas Boatmen Inc., particularly G. Henley, for assistance with Texas tournament data. We acknowledge the assistance of S. Williams, M. Brodeur, C. Hightower, and M. Robillard for data compilation, as well as L. Jones, and D. McKee for shark identifications. Funding support was provided by a Marine Fisheries Initiative grant (NA08NMF4330404).

REFERENCES

Aronson, R. B., J. F. Bruno, W. F. Precht, P. W. Glynn, C. D. Harvell, L. Kaufman, C. S. Rogers, E. A. Shinn, and J. F. Valentine. 2003. Causes of coral reef degradation. Science 302:1502–1504.

Arreguín-Sánchez, F. 1996. Catchability: a key parameter for fish stock assessment. Reviews in Fish Biology and Fisheries 6:221–242.

Babcock, E. A. 2008. Recreational fishing for pelagic sharks worldwide. Pages 193–204 *in* M. D. Camhi, E. K. Pikitch, and E. A. Babcock, editors. Sharks of the open ocean: biology, fisheries and conservation. Blackwell Scientific Publications, Oxford, UK.

Barrett, O. W. 1928. Shark fishing in the West Indies. Scientific Monthly 27:125–133.

Baum, J. K., D. Kehler, and R. A. Myers. 2005. Robust estimates of decline for pelagic shark populations in the northwest Atlantic and Gulf of Mexico. Fisheries 30(10):27–29.

Baum, J. K., and R. A. Myers. 2004. Shifting baselines and the decline of pelagic sharks in the Gulf of Mexico. Ecology Letters 7:135–145.

Baum, J. K., R. A. Myers, D. G. Kehler, B. Worm, S. J. Harley, and P. A. Doherty. 2003. Collapse and conservation of shark populations in the northwest Atlantic. Science 299:389–392.

Berkeley, S. A., C. Chapman, and S. M. Sogard. 2004a. Maternal age as a determinant of larval growth and survival in a marine fish, *Sebastes melanops*. Ecology 85:1258–1264.

Berkeley, S. A., M. A. Hixon, R. J. Larson, and M. S. Love. 2004b. Fisheries sustainability via protection of age structure and spatial distribution of fish populations. Fisheries 29(8):23–32.

Birkeland, C., and P. K. Dayton. 2005. The importance in fishery management of leaving the big ones. Trends in Ecology and Evolution 20:356–358.

Boesch, D., E. Burreson, W. Dennison, E. Houde, M. Kemp, V. Kennedy, R. Newell, K. Paynter, R. Orth, and R. Ulanowicz. 2001. Factors in the decline of coastal ecosystems. Science 293:1589–1591.

Branstetter, S., J. A. Musick, and J. A. Colvocoresses. 1987. A comparison of the age and growth of the Tiger Shark, *Galeocerdo cuvieri,* from off Virginia and from the northwestern Gulf of Mexico. U.S. National Marine Fisheries Service Fishery Bulletin 85:269–279.

Burgess, G. H., L. R. Beerkircher, G. M. Cailliet, J. K. Carlson, E. Cortés, K. J. Goldman, R. D. Grubbs, J. A. Musick, M. K. Musyl, and C. A. Simpfendorfer. 2005. Is the collapse of shark populations in the northwest Atlantic Ocean and Gulf of Mexico real? Fisheries 30(10):19–26.

Cortés, E., E. Brooks, P. Apostolaki, and C. A. Brown. 2006. Stock assessment of Dusky Shark in the U.S. Atlantic and Gulf of Mexico. National Marine Fisheries Service, Southeast Fisheries Science Center, Panama City Laboratory, Contribution 06-05, Panama City, Florida.

Drymon, J. M., S. P. Powers, J. Dindo, B. Dzwonkowski, and T. A. Henwood. 2010. Distributions of sharks across a continental shelf in the northern Gulf of Mexico. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 2:440–450.

Estes, J. A., J. Terborgh, J. S. Brashares, M. E. Power, J. Berger, W. J. Bond, S. R. Carpenter, T. E. Essington, R. D. Holt, J. B. C. Jackson, R. J. Marquis, L. Oksanen, T. Oksanen, R. T. Paine, E. K. Pikitch, W. J. Ripple, S. A. Sandin, M. Scheffer, T. W. Schoener, J. B. Shurin, A. R. E. Sinclair, M. E. Soulé, R. Virtanen, and D. A. Wardle. 2011. Trophic downgrading of planet earth. Science 333:301–306.

Fodrie, F. J., K. L. Heck Jr., S. P. Powers, W. M. Graham, and K. L. Robinson. 2010. Climate-related, decadal-scale assemblage changes of seagrass-associated fishes in the northern Gulf of Mexico. Global Change Biology 16:48–59.

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

Hayes, C. G., Y. Jiao, and E. Cortés. 2009. Stock assessment of Scalloped Hammerheads in the western North Atlantic Ocean and Gulf of Mexico. North American Journal of Fisheries Management 29:1406–1417.

Hilborn, R. 2006. Faith-based fisheries. Fisheries 31:554–555.

Hueter, R. E. 1991. Survey of the Florida recreational shark fishery utilizing shark tournament and selected longline data. Mote Marine Laboratory and Aquarium, Technical Report 232A, Sarasota, Florida.

Jackson, J. B. C., M. X. Kirby, W. H. Berger, K. A. Bjorndal, L. W. Botsford, B. J. Bourque, R. H. Bradbury, R. Cooke, J. Erlandson, J. A. Estes, T. P. Hughes, S. Kidwell, C. B. Lange, H. S. Lenihan, J. M. Pandolfi, C. H. Peterson, R. S. Steneck, M. J. Tegner, and R. R. Warner. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293:629–637.

McClenachan, L. 2009. Documenting loss of large trophy fish from the Florida Keys with historical photographs. Conservation Biology 23:636–643.

Mora, C., R. A. Myers, M. Coll, S. Libralato, T. J. Pitcher, R. U. Sumaila, D. Zeller, R. Watson, K. J. Gaston, and B. Worm. 2005. Management effectiveness of the world's marine fisheries. PLoS (Public Library of Science) Biology [online serial] 7(6):e1000131.

Musick, J. A., editor. 1999. Life in the slow lane: ecology and conservation of long-lived marine animals. American Fisheries Society, Symposium 23, Bethesda, Maryland.

Myers, R. A., J. K. Baum, T. D. Shepherd, S. P. Powers, and C. H. Peterson. 2007. Cascading effects of the loss of apex predatory sharks from a coastal ocean. Science 315:1846–1850.

NMFS (National Marine Fisheries Service). 2006. SEDAR 11 stock assessment report: large coastal shark complex, Blacktip and Sandbar shark. NMFS, Highly Migratory Species Management Division, Office of Sustainable Fisheries, Silver Spring, Maryland.

NMFS (National Marine Fisheries Service). 2008. Final amendment 2 to the consolidated Atlantic highly migratory species fishery management plan. NMFS, Highly Migratory Species Management Division, Office of Sustainable Fisheries, Silver Spring, Maryland.

Paddack, M. J., J. D. Reynolds, C. Aguilar, R. S. Appeldoorn, J. Beets, E. W. Burkett, P. M. Chittaro, K. Clarke, R. Esteves, A. C. Fonseca, G. E. Forrester, A. M. Friedlander, J. García-Sais, G. González-Sansón, L. K. B. Jordan, D. B. McClellan, M. W. Miller, P. P. Molloy, P. J. Mumby, I. Nagelkerken, M. Nemeth, R. Navas-Camacho, J. Pitt, N. V. C. Polunin, M. C. Reyes-Nivia, D. R. Robertson, A. Rodríguez-Ramírez, E. Salas, S. R. Smith, R. E. Spieler, M. A. Steele, I. D. Williams, C. L. Wormald, A. R. Watkinson, and I. M. Côté. 2009. Recent region-wide declines in Caribbean reef fish abundance. Current Biology 19:590–595.

Pandolfi, J. M., R. H. Bradbury, E. Sala, T. P. Hughes, K. A. Bjorndal, R. G. Cooke, D. McArdle, L. McClenachan, M. J. H. Newman, G. Paredes, R. R. Warner, and J. B. C. Jackson. 2003. Global trajectories of the long-term decline of coral reef ecosystems. Science 301:955–958.

Pauly, D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology and Evolution 10:430.

Sáenz-Arroyo, A., C. M. Roberts, J. Torre, M. Cariño-Olvera, and R. R. Enríquez-Andrade. 2005. Rapidly shifting environmental baselines among fishers of the Gulf of California. Proceedings of the Royal Society of London B 272:1957–1962.

Sanchez-Rubio, G., H. M. Perry, P. M. Biesiot, D. R. Johnson, and R. N. Lipcius. 2011a. Climate-related hydrological regimes and their effects on abundance of juvenile blue crabs (*Callinectes sapidus*) in the northcentral Gulf of Mexico. U.S. National Marine Fisheries Service Fishery Bulletin 109:139–146.

Sanchez-Rubio, G., H. M. Perry, P. M. Biesiot, D. R. Johnson, and R. N. Lipcius. 2011b. Oceanic–atmospheric modes of variability and their influence on riverine input to coastal Louisiana and Mississippi. Journal of Hydrology 396:72–81.

Whitney, N. M., and G. L. Crow. 2007. Reproductive biology of the Tiger Shark (*Galeocerdo cuvier*) in Hawaii. Marine Biology 151:63–70.

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use

APPENDIX: ALABAMA DEEP-SEA FISHING RODEO PARTICIPANT SURVEY

2008 Alabama Deep Sea Fishing Rodeo (ADSFR) Participant Survey: Long-Term Trends in the Sizes of Winning Fishes
A survey conducted by the Dauphin Island Sea Lab and University of South Alabama

Part. I: Background information of ADSFR survey participants. Please circle one answer for each. ***WU / DS*** ***KRSat / Sat / Sun***

1. How old are you? 19 or younger / 20-29 / 30-39 / 40-49 / 50-59 / 60-69 / 70 or older 2. Gender? M / F

3. How many years fishing experience do you have? 4 or Less / 5-9 / 10-19 / 20 or More

4. How many days each year, on average, do you spend fishing? 4 or Less / 5-9 / 10-19 / 20-49 / 50 or More

5. In which state are you a resident? AL / MS / FL / LA / TX / Other Coastal State / Other Landlocked State

6. How long, in feet, is the boat that you typically fish from? No Boat (Dock or Shore) / 10 or Less / 10-20 / 20-30 / 30 or More

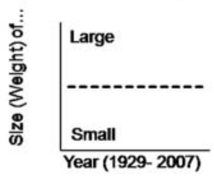
7a. Where do you fish mostly? State Waters (< 3 Miles Offshore) / Federal Waters (> 3 Miles Offshore) / Equally in State/Federal Waters

7b. If you answered "state waters" above, where do you fish mostly? Estuarine/Bay / Gulf of Mexico (South of Mobile Bay Inlet) / Lakes or Rivers

Part II: Survey participant's opinions and expectations for the long-term (1929-2007) ***SIZE*** *trends of ADSFR prize-winning fishes. Please note that questions in this section pertain only to the* ***SIZES*** *(weights) of fishes caught in the ADSFR, and do not concern long-term abundances of species.*

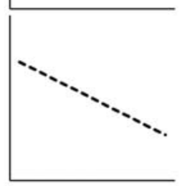
For the questions to the right of the following descriptions (A to E), please consider the possible long-term trends for the **SIZES** (weights) of ADSFR prize winning fishes registered each year

A. Over time, there has been no change in the size of winning fish

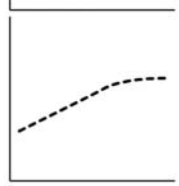


B. Over time, the size of winning fish has become progressively larger

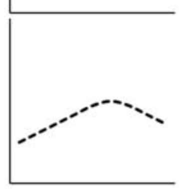
C. Over time, the size of winning fish has become progressively smaller



D. The size of winning fish increased for some time, but more recently has reached a plateau and stayed there



E. The size of winning fish increased for some time, but reached a maximum at some point in the past and has decreased steadily since then



Oral / Handout

Based on the graphs and explanations to the left, please enter one letter (A-E) that you think best describes the long-term (1929-2007) trend in the SIZES (weights) of prize-winning fishes registered during the ADSFR for each of the following species/groups:

ANSWERS NOT REQUIRED FOR ALL

_______ Yellowfin Tuna
_______ King Mackerel
_______ Wahoo
_______ Amberjack
_______ Barracuda
_______ Bonita
_______ Dolphin/Dorado
_______ Jack Crevalle
_______ Cobia/Ling
_______ Red Snapper
_______ Tripletail/Blackfish
_______ Spanish Mackerel
_______ Shark
_______ Tarpon
_______ Flounder
_______ Speckled Trout

Part III: Survey controls. Please answer each of the following by circling a number that best reflects your opinion.

How clear were the descriptions and questions used in this survey?
Not Very Clear 1 2 3 4 5 6 7 8 9 10 Very Clear

How confident are you in the answers you provided in Part II of this survey regarding long-term **SIZE** trends?
Not Very Confident 1 2 3 4 5 6 7 8 9 10 Very C

How interesting or valuable are these long-term, species-by-species **SIZE** trends?
Low Interest / Value 1 2 3 4 5 6 7 8 9 10 High In

Downloaded From: https://complete.bioone.org/journals/Marine-and-Coastal-Fisheries:-Dynamics,-Management,-and-Ecosystem-Science on 18 Apr 2024
Terms of Use: https://complete.bioone.org/terms-of-use