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Contributed Paper

Documenting Loss of Large Trophy Fish from the Florida Keys with Historical Photographs

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Abstract: *A loss of large vertebrates has occurred in aquatic and terrestrial ecosystems, but data to measure long-term population changes are sparse. Historical photographs provide visual and quantitative evidence of changes in mean individual size and species composition for groups of marine fish that have been targeted by sport fishing. I measured such trends for 13 groups of recreationally caught "trophy" reef fish with photographs taken in Key West, Florida, from 1956 to 2007. The mean fish size declined from an estimated 19.9 kg (SE 1.5) to 2.3 kg (SE 0.3), and there was a major shift in species composition. Landings from 1956 to 1960 were dominated by large groupers (*Epinephelus *spp.), and other large predatory fish were commonly caught, including sharks with an average length of just <2 m. In contrast, landings in 2007 were composed of small snappers (*Lutjanus *spp. and* Ocyurus chrysurus*) with an average length of 34.4 cm (SE 0.62), and the average length of sharks declined by more than 50% over 50 years. Major declines in the size of fish caught were not reflected in the price of fishing trips, so customers paid the same amount for a less-valuable product. Historical photographs provide a window into a more pristine coral reef ecosystem that existed a half a century ago and lend support to current observations that unfished reef communities are able to support large numbers of large-bodied fish.*

Keywords: coral reefs, historical ecology, overfishing, reef fish, shifting baselines

Documentación de la Pérdida de Peces de Trofeo en los Cayos de Florida con Fotografías Históricas

Resumen: *Una pérdida de vertebrados mayores ha ocurrido en ecosistemas acuáticos y terrestres, pero los datos para medir los cambios poblaciones a largo plazo son escasos. Las fotografías históricas proporcionan evidencia visual y cuantitativa de cambios en el tamaño individual promedio y de la composición de especies en grupos de peces marinos que han sido blanco de la pesca deportiva. Medí esas tendencias en 13 grupos de peces de arrecife capturados recreativamente como "trofeos" mediante fotografías tomadas en Key West, Florida, desde 1956 a 2007. El peso promedio de los peces declinó de unos 19.9 kg (ES 1.5) a 2.3 kg (ES 0.3), y hubo un cambio mayor en la composición de especies. Las capturas entre 1956 y 1960 estuvieron dominadas por meros (*Epinephelus *spp.) grandes, y otros peces depredadores eran capturados comúnmente, incluyendo tiburones con una longitud promedio de poco menos de 2m. En contraste, las capturas en 2007 fueron compuestas de pargos (*Lutjanus *spp. y* Ocyurus chrysurus*) pequeños con una longitud promedio de 34.4 cm (ES 0.62), y la longitud promedio de los tiburones declinó más de 50% en 50 años. La gran declinación en el tamaño de los peces capturados no se reflejó en los precios de los viajes de pesca, así que los clientes pagaron la misma cantidad por un producto menos valioso. Las fotografías históricas proporcionan una visión de un ecosistema arrecifal coralino prístino que existió hace medio siglo y proporcionan soporte a los comentarios actuales de que las comunidades arrecifales no explotadas son capaces de soportar numerosos peces de talla grande.*

Palabras Clave: arrecifes de coral, ecología histórica, directrices cambiantes, peces de arrecife, sobrepesca

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Introduction

A gradual loss of large vertebrates, ranging from bison to monkeys to sharks, has occurred in aquatic and terrestrial ecosystems (Hill et al. 1997; Isenberg 2001; Baum et al. 2003) so that the density at which populations of megafauna existed in pristine ecosystems is often unknown (Jackson et al. 2001). Comparative ecological studies in degraded and protected areas provide evidence of the size and abundance of the largest vertebrates in less disturbed environments (e.g., Hill et al. 1997; Peres 2000; Dulvy et al. 2004), and records of hunting and fishing suggest historical population sizes (e.g., Jackson 1997; Myers & Worm 2003; McClenachan & Cooper 2008). Nevertheless, data related to exploitation are not always available over long enough timescales to measure change accurately, and too few regions exist with pristine megafauna populations. Thus, long-term declines in populations of the largest animals often go undocumented or are supported by anecdotes alone. Where they have been preserved, historical photographs taken by trophy hunters or fishers provide striking visual evidence of the size of the largest animals in the past, which can be quantified and used to help determine changes over long timescales. In this case study, I used historical photographs of trophy fish caught from waters around coral reefs surrounding Key West, Florida to determine the decrease in size of the largest predators from this marine environment.

In the ocean long-term population declines owing to fishing and hunting have been shown for species targeted by or caught as bycatch in commercial fisheries. Such studies have been limited by a lack of data, but as a general rule, data sets compiled over longer periods detect greater degrees of loss for large marine vertebrates, regardless of species. For example, Baum et al. (2003) showed declines of 75% in populations of several species of large pelagic and coastal sharks over just 15 years. Myers and Worm (2003) found that large predatory fish biomass has been reduced by 90% over the last 50 years, and Rosenberg et al. (2006) determined that biomass of today's Atlantic cod (*Gadus morhua*) populations on Canada's Scotian Shelf is just 4% of values in the 1850s. For green turtles (*Chelonia mydas*), length of observation of population size is strongly correlated with degree of loss assessed; nesting populations observed for at least 40 years were always assessed by the IUCN (Seminoff 2002) to be <40% of historical abundances, whereas the status of those populations observed for fewer years varied greatly with respect to historical abundance (McClenachan et al. 2006). Thus, for large marine vertebrates that have been hunted and fished over long timescales, historical data sets are needed to assess long-term population change.

Coral reef fish populations have been heavily exploited over long timescales (Pandolfi et al. 2003), and the level of fishing intensity influences community composition (Koslow et al. 1988; Russ & Alcala 1989). Comparative ecological studies in degraded and protected areas show that the abundance of the largest-bodied animals, which are frequently top predators, varies greatly under different fishing regimes. For example, the biomass density of apex predators in coral reef environments in the northwestern Hawaiian Islands is more than 60 times greater than in the more heavily fished main Hawaiian Islands (Friedlander & DeMartini 2002). In the Pacific Line Islands the biomass of top predators ranges from 85% of total coral reef fish biomass in well-protected and remote reefs to 19% in more heavily fished reefs in the same archipelago (Sandin et al. 2008). Larger-bodied animals are exploited preferentially and take longer to recover (Jennings et al. 2001; Reynolds et al. 2005), so large fish are depleted before smaller individuals (Pauly et al. 1998). Thus, the size structure of fish communities provides an indirect measurement of fishing intensity and degree of overexploitation at the species level (Beverton & Holt 1956; Ricker 1975; Gulland & Rosenberg 1992) and the community level (Pope & Knights 1982; Gislason & Rice 1998). Multispecies analyses of size structure are particularly applicable to high-diversity fish communities in tropical regions (Gislason & Rice 1998; Dulvy et al. 2004; Graham et al. 2005), although their efficacy is inconsistent (Rochet & Trenkel 2003; Stobberup et al. 2005).

The Florida Keys contains a coral reef ecosystem in which fish communities have been subject to commercial, recreational, and subsistence fishing for hundreds of years (e.g., Romans 1775; Davidson 1889) and a sharp increase in the amount of recreational fishing pressure over the last 4 decades (Ault et al. 1998). A previous retrospective analysis (1979–1996) of the Florida Keys' reef fish communities showed that the largest and most desirable species of fish have been depleted and remain in an overfished state (Ault et al. 1998, 2005). Results also suggest that many fishery declines occurred prior to the 1980s because several fish stocks remained at constant low levels throughout the study period. Such patterns make sense because fishing effort was intense before 1979.

Traditional ecological and fisheries data do not exist to measure declines that occurred in Florida Keys reef fish communities before 1979, but photographs of trophy fish caught around Key West have been preserved since the mid-1950s. These photographs contain information on the species composition and size structure of landings from a time before ecological and fisheries-dependant data existed. Photographs were taken of fish caught on headboats (i.e., large charter boats that carry up to 75 passengers on day trips) by a single photographer from 1956 to 1985 and were preserved in historical archives. I took similar photographs of modern trophy fish caught on Key West headboats in 2007 and compared the historical photographs with these modern pictures to assess changes in the largest fish present on the reef. Secondarily, I assessed species composition of the catch to determine whether changes in the average size of the largest fish were due to shifting taxonomic composition of the catch or reduction in size within groups. Analyses based on these nontraditional data sources offer a baseline size structure for a time period for which there are no quantitative fisheries catch data.

Methods

I quantified changes in size structure of reef fish communities over the past 5 decades (1956–2007) with photographic data from the recreational fishing industry in the Florida Keys. Historical photographs represented 865 individual trophy fish caught between 1956 and 1985 aboard headboats in Key West, Florida (Fig. 1). These fish were caught by passengers on 2 companies' boats and landed at the Key West docks. The same 2 charter boat companies continue to operate in much the same fashion in Key West, and in January and August of 2007, I took a second set of photographs representing 410 individual trophy fish landed at the Key West docks and displayed in a similar manner (Fig. 1). In both modern and historical photographs, I considered for analysis all individuals hung on the display boards that were visible from head to tail.

To transform historical photographs into quantifiable data, I ensured that the photographs were comparable across time periods. First, I determined that the photographs were taken in a consistent manner and for the same purpose. The archival photographs were taken by a professional photographer, Charles Anderson, and represent the largest individuals caught on any particular day on 1 of 2 fishing boats. After each fishing trip, the largest trophy fish were displayed on hanging boards, and customarily a voluntary, nominal monetary pool was awarded to the passenger who caught the largest fish. Hanging the fish for display represented the process of determining the largest individual, provided an opportunity for passengers to pose with their trophies, and allowed captains to advertise for future trips. Piles of smaller fish below the display board were present in many photographs, further distinguishing the trophies from the average fish caught. Thus, the fish hung on the display boards in each photograph represented a set of the largest individuals caught daily.

All trophy fish were caught on boats fishing on and around coral reefs, so the photographs represent individuals caught in an area of similar habitat in the vicinity of Key West. The fishing sites remained relatively constant over time because distance traveled to the fishing grounds was limited by speed of the vessel, hours available to fish, and reef location. These headboats took day and half-day trips, typically within an hour's travel time of the dock (Gulfstream III Fishing Inc. 2007). Furthermore, the captain, rather than the passengers, determined the fishing sites. Although different captains may have favored different reef areas, it was typical for captains to have a regular circuit of known reef sites. These sites were more consistent than those fished by smaller charter boats that take longer trips tailored to the desires of the passengers. Use of data from the past did not allow for a randomized sampling design, but these data provided a consistent measure of the relative size of the largest fish

Figure 1. Trophy fish caught on Key West charter boats: (a) 1957, (b) early 1980s, and (c) 2007.

caught from a limited area sampled by the same fishing boats over the last half century.

Next, I determined the dates the photographs were taken. Photographs from 1956 to 1960 had dates printed on their reverse sides, and I recorded the dates of the photos I took in 2007. Those taken between 1965 and 1985 did not have discreet dates, so I used information in the photographs to establish approximate dates. All photos from this time period were taken of fish caught aboard the vessels of a single charter boat company, Gulfstream Fishing, Inc., but 2 different boats were used between 1965 and 1985: the *Gulfstream II* (1965–1979) and the *Gulfstream III* (1980–1985) (T. Hambright, personal communication). All photographs included the name of the boat on which the fish were caught, so it was possible to subdivide photos into 2 categories: 1965–1979 and 1980–1985. Thus, I delineated 4 discreet time periods: 1956–1960 (period A), 1965–1979 (period B), 1980–1985 (period C), and 2007 (period D).

I identified each fish displayed to species or lowest taxonomic classification possible. Individuals I could not identify because of the condition of the photograph or condition of the fish were not included in the analysis. I determined the total length (TL) of each fish by measuring the fish relative to the height of the display board. I measured the heights of the actual display boards in August 2007 and determined the size had not changed over time (T. Hambright, personal communication). I printed each photograph and measured the fish and the hanging board. If the photograph was taken at an angle, I made several measurements across the hanging board to account for apparent size differences due to visual perspective. I converted the calculated fish lengths to biomass with standard length–weight relationships typical for each species but not specific to the Florida Keys (Froese & Pauly 2007). I identified and measured 1275 fish from these photographs.

The issues to be addressed were whether the size of the largest reef fish caught and displayed decreased over time, and the extent and timing of any measured change. Thus, I pooled the data from all fish and analyzed the combined data in terms of the mean size of trophy fish caught in each time period and the size spectrum of these fish. In size-spectra analyses, the $\log_{10}(x+1)$ number of individuals per size class is regressed on the $\log_{10}$ midpoint of each length class (sensu Graham et al. 2005) and the slopes of these linear regressions are compared. In more heavily fished communities, slopes are expected to be more steeply negative owing to reduced numbers of individuals in the larger size classes (Dulvy et al. 2004; Graham et al. 2005). I grouped trophy fish from the photographs into 10-cm size classes (20 cm through 340 cm) for each time period and performed a one-way analysis of covariance (ANCOVA) on size classes with data across time periods to determine differences among slopes.

I assessed changes in the composition of landings to determine whether changes in mean size of trophy fish were due to shifting taxonomic composition of the catch or to reductions in size within groups. I divided data into 13 taxonomic groups for comparison and determined the composition of the landings as a percentage of individuals and a percentage of biomass for each time period. Sample sizes were not large enough to determine species-specific changes over time.

Because the modern photographs were taken over 2 months, January and August, it was important to know whether this restricted temporal sampling would bias the results, so I analyzed data for seasonal differences in mean size. To determine seasonal trends I used early photographic data from this study and data for the *Gulfstream* headboat collected by the National Oceanographic and Atmospheric Administration (NOAA) headboat sampling program from 1981 to 2006.

Finally, I compared modern data from the photographs of trophy fish from Key West with NOAA landings data from all headboats in the Florida Keys and Dry Tortugas for the year 2006 to determine the extent to which these data were representative of total landings in the headboat industry. I also compared my data with data for the *Gulfstream* collected by the NOAA headboat sampling program from 1981 to 2006 to determine whether the mean size of fish in the photographs was different from the mean size of fish measured by NOAA. I expected that the fish in the NOAA database would be larger than the average fish in the photographs due to the selective subsampling of only trophy fish in my study.

Results

The average length of individual trophy fish declined from 91.7 cm (SE 2.4) to 42.4 cm (SE 1.1), and the average weight declined from 19.9 kg (SE 1.5) to 2.3 kg (SE 0.3) between 1956 and 2007 (Fig. 2; Table 1). Significant differences in mean size were detected among all time periods (one-way analysis of variance [ANOVA], $p < 0.01$), except between the periods of 1956–1960 and 1965–1979. Even when species with current fishing restrictions—such as Nassau grouper (*Epinephelus striatus*), goliath grouper (*E. itajara*), and sawfish (*Pristis* spp.)—were excluded from the analyses, significant ($p < 0.01$) declines in individual size were detected (Fig. 2). Analysis of size spectrum differences among time periods showed that the proportion of small individuals among the trophy fish increased over time. Significant differences in slopes existed among all time periods (one-way ANCOVA $p < 0.01$); post hoc comparisons of slopes revealed significant differences among all pairs of time periods except for A and B, with the strongest differences ($p < 0.001$) between periods A and D.

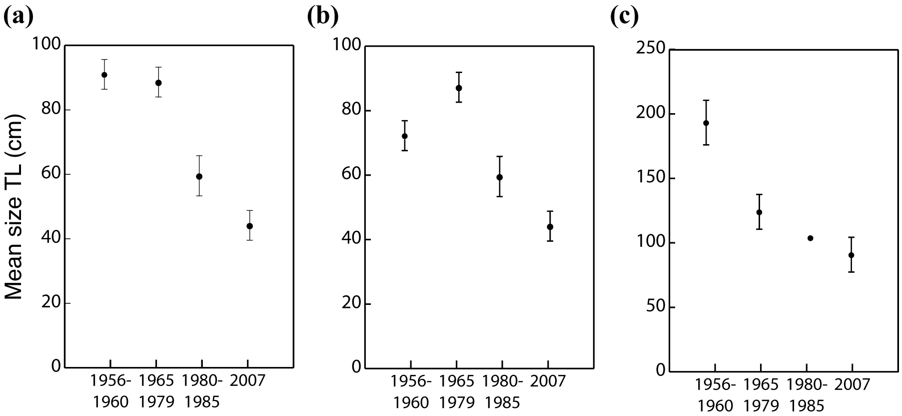

Figure 2. Mean size and standard error of (a) trophy fish in 1956–1960, 1965–1979, 1980–1985, and 2007, (b) trophy fish excluding species whose capture is currently prohibited, and (c) sharks in 1956–1960, 1965–1979, 1980–1985, and 2007 (TL, total length).

Within groups, no significant declines in length were detected except for sharks and *Epinephelus* groupers. The length of sharks, the most diverse taxonomic group and largest type of reef fish targeted, dropped from 195.2 cm (SE 16.4) in 1956–1960 to 90.9 cm (SE 5.5) in 2007 (Fig. 2; Table 1). Significant differences in the mean size of sharks were found among all time periods (one-way ANOVA $p < 0.01$) except between the periods of 1965–1979 and 2007. Sample sizes were small, but these results suggest a loss of large predatory sharks from south Florida waters prior to 1965, particularly when the species caught are considered. Of the 16 individual sharks caught and photographed between 1956 and 1960, 4 individuals were hammerhead (*Sphyrna mokarran* and *S. lewini*.) and 3 were great white (*Carcharodon carcharias*) sharks. Between 1965 and 1979, only 1 hammerhead and 1 great white shark were photographed, despite equivalent numbers of total sharks in the sample. The most commonly caught species in this second time period were reef (*Carcharhinus perezii*) and silky (*C. falciformis*) sharks. In 2007 the only species of sharks caught and photographed were immature sharpnose (*Rhizoprionodon terraenovae*), reef (*Carcharhinus* spp.), and bonnethead (*S. tiburo*).

Declines in the size of *Epinephelus* groupers caught and displayed were detected in 2007 owing to restrictions on harvest of 2 of the largest species targeted, goliath (*E. itajara*) and Nassau (*E. striatus*) groupers. A moratorium on these species was enacted in 1990 and 1997, respectively (Reef Fish Fishery Management Plan 2008 [Gulf of Mexico Fishery Management Council 2008]). Therefore, declines detected in *Epinephelus* groupers did not represent actual declines in the size of fish.

Thus, with the exception of sharks, declines in size of trophy fish caught in the recreational fishery were due to shifts in composition of landings rather than declines in mean size of individuals within groups. A closer examination of the taxonomic breakdown of the landings showed a shift of dominance from large-bodied to smaller-bodied groups over time (Fig. 3). Large *Epinephelus* grouper, whose average size was 135.3 cm (SE 3.2) in this sample, were 25% of the landings by individuals and 66% of the landings by biomass between 1956 and 1960.

Table 1. Sample size (*n*), mean length (L, cm), and standard error (SE) for each group of fish species and time period examined in a study of trophy fish landed in Key West Florida.

	1956–1960		*1965–1979*		*1980–1985*		*2007*	
Species group	n	*L (SE)*	n	*L (SE)*	n	*L (SE)*	n	*L (SE)*
Sharks	16	195.2 (16.4)	15	120.2 (15.1)	1	102.4 (na)	12	90.9 (5.5)
Epinephelus spp.	110	135.3 (3.2)	44	136.2 (6.6)	0	na	6	37.4 (6.9)
Rachycentron canadum	56	89.1 (1.8)	42	122.0 (3.3)	0	na	17	109.1 (2.5)
Sphyraena barracuda	28	92.0 (3.8)	13	110.0 (5.3)	0	na	2	108.5 (6.5)
Scomberomorus spp.	26	91.7 (3.7)	17	93.7 (2.7)	1	68.8 (na)	14	72.4 (9.0)
Seriola spp., *Caranx* spp.	14	88.1 (23.6)	38	99.0 (3.6)	0	na	2	51.5 (2.5)
Mycteroperca spp.	54	57.0 (1.6)	19	75.6 (3.9)	6	62.5 (3.2)	16	62.0 (2.1)
Trachinotus spp.	8	82.9 (4.1)	65	87.2 (2.5)	7	75.5 (5.8)	0	na
Lutjanus spp.	53	51.0 (1.4)	49	55.2 (1.2)	7	51.3 (9.8)	186	33.1 (0.9)
Lachnolamus maximus	18	46.9 (1.7)	27	55.4 (1.7)	3	49.9 (3.7)	3	41.7 (1.2)
Ocyurus chrysurus	17	40.0 (2.2)	16	50.2 (2.1)	2	47.1 (1.6)	100	38.0 (0.7)
Haemulon spp.	19	51.3 (2.2)	36	69.7 (1.5)	11	54.0 (1.5)	11	47.4 (5.0)
Calamus spp.	1	60.7 (na)	0	na	0	na	38	30.9 (8.1)
Other	4		19		3		3	
Total	424	91.7 (2.4)	400	90.0 (2.0)	41	59.5 (2.6)	410	42.4 (1.1)

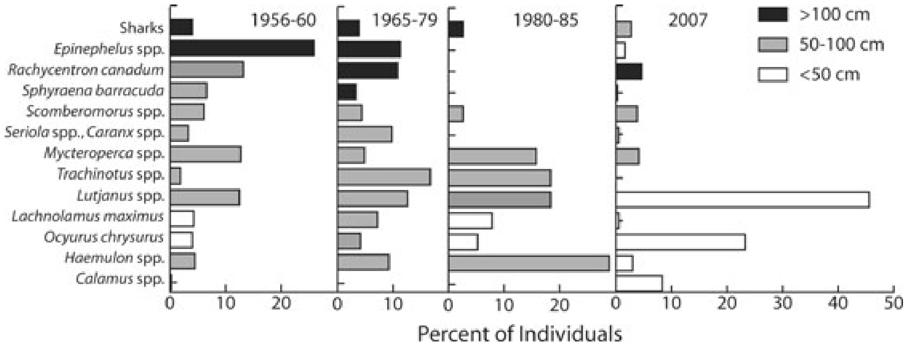

*Figure 3. Species composition of displayed trophy fish in 1956–1960, 1965–1979, 1980–1985, and 2007 arranged in order of size from largest (sharks) to smallest (*Calamus *spp.). The mean size of each group within time period is indicated with shading.*

By the second time period (1965–1979), this group had dropped to 12% of total landings by individuals and 33% by biomass, although no decrease in the average size of individuals occurred. Between 1965 and 1979, trophy fish landings were dominated by reef-associated pelagic fish, such as permits (*Trachinotus* spp.) and jacks (*Seriola* spp.). Together, these groups comprised 26% of the fish photographed and their average size was 87.3 cm (SE 2.5) and 98.5 (SE 3.6), respectively. In 2007, 72% of the trophy fish were snappers (*Lutjanus* spp. and *Ocyurus chrysurus*) with an average length of 32.8 cm (SE 0.83) and 37.7 cm (SE 0.83), respectively (Fig. 3).

Data from NOAA headboat landings confirmed the high abundance of small reef fish caught in modern recreational fisheries and demonstrated that the individuals in the photographs were indeed trophy fish. The mean length of fish measured by the NOAA headboat sampling program from the *Gulfstream* was 33.1 cm (SE 0.9) compared with 42.4 cm (SE 1.1) from the photographs. Differences existed in the species composition between the trophy fish and NOAA landings data for all of the Florida Keys and Dry Tortugas. In particular, the abundance of Lutjanid snappers was 24% greater among the trophy fish than in the total landings, and grunts were 33% more abundant in the landings data (Supporting Information).

No significant difference was detected in mean size of fish caught and photographed in January and August 2007, but some seasonal differences were detected in historical photographs (1956–1960) (Supporting Information). There was no significant difference in mean size of trophy fish caught in January and the rest of the year (86.8 cm [SE 7.1] vs. 92.1 cm [SE 2.5]), but fish caught in August were significantly smaller than those caught the rest of the year (59.1 cm [SE 3.1] vs. 98.8 cm [SE 2.5], $p < 0.0001$). The NOAA headboat sampling program maintains a large database of all types of fish landed, not just the largest individuals with which this study was concerned. Analysis of fish caught on the *Gulfstream* charter boat (1981–2006) showed that significant differences existed between January and August and the rest of the year. Fish caught in January were significantly larger (34.6 cm [SE 5.0] vs. 33.0 cm [SE 0.9], $p < 0.001$), whereas those caught in August were significantly smaller (31.8 [SE 2.3] vs. 34.6 cm [SE 0.9], $p < 0.0001$). These results suggest there may be some seasonal bias in the modern photographic data, particularly for fish caught in August. The sample size for modern photographic data from the month of August ($n = 45$) was lower than from January ($n = 365$), however, so any seasonal bias for smaller fish in the pooled data is likely small.

Discussion

A decrease in the size of trophy fish caught by Key West fishing boats has occurred over the last 50 years, reflecting a loss in the largest fish from the coral reef environment. The results of my analysis of historical photographs support results from prior analyses, which show that major declines have occurred in populations of large fish in Florida Keys' ecosystems and that chronic overfishing was occurring by the 1970s (Ault 1998, 2005). My results further suggest that loss of large sharks occurred before the mid-1960s. Observed historical declines in Florida Keys reef fish populations cannot be attributed to the recreational fishery alone. Both commercial and recreational fishing have contributed to declines, and before the 1970s the number of commercial fishing vessels targeting Florida Keys reef fish exceeded those in the recreational fishery (Ault et al. 1998).

These results provide evidence of major changes over the last half-century and a window into an earlier, less disturbed reef fish community, but communities of coral reef fish of the Florida Keys in the 1950s were themselves not undisturbed. Commercial fishing for reef sharks in the 1930s and 1940s reduced shark populations before the 1950s, and large groupers have been commercially fished since at least the 1880s. Thus, pristine coral reef ecosystems supported far more large fish than are implied by these historical photographs. More early data, such as records from the shark fishing industry in the 1930s and 1940s and information from the accounts of individual fishers from the early 20th century, could help contextualize this measured change in reef fish populations of the Florida Keys.

My results add a temporal component to differences measured in comparative ecological surveys in coral reefs, which show unfished reef communities contain more large predators and more fish biomass per unit area than heavily fished coral reef communities (Friedlander & DeMartini 2002; Newman et al. 2006; Sandin, et al. 2008). Although the photographs I used did not provide a direct measure of overall biomass per unit area in the reef environment, they demonstrated that large fish were more abundant in the past. Furthermore, early photographs show piles of small fish below the hanging racks displaying the large trophy fish. Because they were not displayed as trophy fish, I did not consider them in this analysis, but their presence suggests historical reefs around Key West included large numbers of reef fish, large and small. The increase in small individuals displayed as trophy fish therefore may represent an overall reduction of fish biomass per unit area in the reef surrounding Key West, as would be expected on the basis of results from comparative ecological studies in modern reef communities.

The relationship between increased fishing pressure and declines in fish size is well developed, but the relationship between ecological degradation and marine-based tourism, a multibillion-dollar industry in the Florida Keys (Johns et al. 2001), is ripe for investigation. Conventional economic thought holds that decreased ecological health should lead to decreases in marine-based tourism revenues because customers' willingness to pay for services decreases with declining environmental health (Brown et al. 2001). In the case of fishing-based tourism, changes in the availability or size of fish would be expected to affect the overall value of the sport-fishing industry because the value of smaller fish in degraded reef habitats to anglers is less than that of large fish in a healthy reef environment (Gabelhouse 1984).

In Key West the order of magnitude reduction in size of fish caught by sport fishers over the last 5 decades would be expected to affect the price paid per trip or the number of people participating in the fishery, but neither has occurred. Despite a decline of 88% in fish weight, no significant trend in the cost of fishing trips, as shown in the price advertised in the photographs, was detected over the last 50 years. When adjusted for inflation (U.S. Department of Labor 2007), the trip cost ranged from $40 to $48 (in 2007 U.S. dollars) per person per day between 1956 and 2007. Furthermore, the number of people participating in the fishery did not decline. The data from NOAA headboat surveys from 1982 to 2006 showed no significant change in either the number of headboats trips leaving from Key West or the mean number of passengers per trip between 1982 and 2006.

Although these observations require further analyses, the continued viability of sport fishing based on increasingly small individuals in a degraded reef environment indicates a decoupling of the health of the marine environment from the value of the marine-based tourism industry. This shifted baseline (Pauly 1995) within the recreational fishing community suggests that reduced demand for recreational fishing trips may not occur in response to fish becoming smaller and more difficult to catch, and people will continue to fish while marine ecosystems undergo extreme changes in community structure.

This case study reflects local changes in reef fish communities around Key West, Florida, but anecdotal evidence suggests that similar declines in populations of large fish have occurred throughout the southeast region and along both coasts of the United States. Similar sets of historical data exist for marine and freshwater fish and potentially for terrestrial species hunted for sport as well. These data can be used on a case-by-case basis to provide information on which historical baselines can be established. Such analyses help describe the structure of ecosystems that existed in the recent past and can be used to establish goals for restoration of large predators on land and in the water.

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Supporting Information

Comparison of data from photographs with NOAA landings data for headboats operating in the Florida Keys and Dry Tortugas (Appendix S1) and seasonal differences in the size of fish caught and photographed on Key West headboats, 1956–1960 and 2007 (Appendix S2), are available as part of the on-line article. The author is responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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