Conservation Biology

Review

Shifting Baselines and The Extinction of The Caribbean Monk Seal

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Abstract: *The recent extnction of the Caribbean monk seal Monachus tropicalis has been considered an example of a human-caused extinction in the marine environment, and this species was considered a driver of the changes that have occurred in the structure of Caribbean coral reef ecosystems since colonial times. I searched archaeological records, historical data, and geographic names (used as a proxy of the presence of seals) and evaluated the use and quality of these data to conclude that since prehistoric times the Caribbean monk seal was always rare and vulnerable to human predation. This finding supports the hypothesis that in AD 1500, the Caribbean monk seal persisted as a small fragmented population in which individuals were confined to small keys, banks, or isolated islands in the Gulf of Mexico and the Caribbean Sea. This hypothesis is contrary to the assumption that the species was widespread and abundant historically. The theory that the main driver of monk seal extinction was harvesting for its oil for use in the sugar cane industry of Jamaica during the 18th century is based primarily on anecdotal information and is overemphasized in the literature. An analysis of reported human encounters with this species indicates monk seal harvest was an occasional activity, rather than an ongoing enterprise. Nevertheless, given the rarity of this species and its restricted distribution, even small levels of hunting or specimen collecting must have contributed to its extinction, which was confirmed in the mid-20th century. Some sources had been overlooked or only partially reviewed, others misinterpreted, and a considerable amount of anecdotal information had been uncritically used. Critical examination of archaeological and historical records is required to infer accurate estimations of the historical abundance of a species. In reconstructing the past to address the shifting baseline syndrome, it is important to avoid selecting evidence to confirm modern prejudices.*

Keywords: historical data, historical ecology, marine mammals, *Monachus tropicalis*, rarity, shifting baseline syndrome, species extinction, vulnerability

Puntos de Referencia Cambiantes y la Extinción de la Foca Monje Caribeña

Resumen: *La reciente extinción de la foca monje caribeña Monachus tropicalis se ha considerado un ejemplo de extinción causada por humanos en el ambiente marino. Esta especie fue considerada un conductor de cambios en la estructura de los ecosistemas de arrecife de coral caribeños desde tiempos coloniales. Busqué registros arqueológicos, datos históricos y nombres geográficos (usados como representación de la presencia de focas) y evalué el uso y calidad de estos datos para concluir que desde tiempos prehistóricos la foca monje del Caribe siempre fue rara y vulnerable a la depredación humana. Este hallazgo apoya la hipótesis de que en 1500 DC, la foca monje del Caribe persistía como una pequeña población fragmentada en la que los individuos estaban confinados a cayos pequeños, bancos o islas aisladas en el Golfo de México y el Mar Caribe. Esta hipótesis es contraria a la suposición de que la especie históricamente tenía una distribución amplia y era abundante. La teoría de que el principal conductor de la extinción de la foca monje era su captura para obtener aceite que se usaba en la industria de la caña de azúcar en Jamaica durante el s. XVIII se basa principalmente en información anecdótica y se sobreenfatiza en la literatura. Un análisis de reportes de encuentros humanos con esta especie indica que la caza de focas monje era una actividad ocasional en lugar de un operativo continuo. Sin embargo, dada la rareza de la especie y su distribución restringida, hasta los niveles mínimos de caza o recolección de especímenes debieron haber contribuido a su extinción, que fue confirmada a mediados del s. XX. Algunas fuentes han sido pasadas por alto o solamente han sido revisadas*

Paper submitted October 24, 2012; revised manuscript accepted March 24, 2013.

Conservation Biology, Volume 27, No. 5, 927–935

DOI: 10.1111/cobi.12107

parcialmente, otras han sido malinterpretadas, y una cantidad considerable de información anecdótica ha sido usada sin cuestionar. La examinación crítica de registros arqueológicos e históricos se requiere para inferir las estimaciones precisas de la abundancia histórica de las especies. En la reconstrucción del pasado para enfocarse al síndrome de puntos de referencia cambiantes es importante evitar escoger evidencia que confirme prejuicios modernos.

Palabras Clave: datos históricos, ecología histórica, extinción de especies, mamíferos marinos, *Monachus tropicalis*, rareza, síndrome de puntos de referencia cambiantes, vulnerabilidad

Introduction

Pauly (1995) coined the term "shifting baseline syndrome." He pointed out to fishery scientists the need to avoid the risk associated with erroneous perceptions about the status of fish populations and emphasized the use of past evidence to reconstruct the history of fisheries. This paper immediately gained wide acceptance and marine ecologists have since turned to the past to answer scientific questions and to model the size of historical populations (e.g., Jackson 1997; Bjorndal & Jackson 2003; McClenachan et al. 2006; McClenachan & Cooper 2008).

The Caribbean monk seal (*Monachus tropicalis*) has been used as an example of the shifting baseline syndrome. Advocates of the syndrome assumed the monk seal played an important role in Caribbean coral reef ecosystems (Jackson 1997, 2001; Jackson et al. 2001; Pandolfi et al. 2003). Modeling the size of the unexploited population reinforced this view, and a simulation model also showed that productivity of coral reef fishes decreased by several orders of magnitude after the monk seal was extirpated (McClenachan & Cooper 2008).

The Caribbean monk seal occurred in the Gulf of Mexico and in the Caribbean Sea. By the time the scientific community started to learn about it, the species was practically extinct (Allen 1887). The last individuals were observed on the Serranilla Bank in 1952 (Rice 1973). Extensive aerial surveillance in Yucatán and Central America (Kenyon 1977) and maritime surveys between the Bahamas and Santo Domingo (Sergeant et al. 1980) and off the Yucatan Penninsula (LeBoeuf et al. 1986) failed to detect a single individual. In 1996, the International Union for Conservation of Nature declared the Caribbean monk seal extinct (IUCN 1996).

Understanding the causes and consequences of the extinction of species, particularly those associated with human presence, is a priority for conservation science. The current mainstream view is that the Caribbean monk seal was a widely distributed and relatively abundant species in the region when Columbus first arrived in the Americas (Allen 1887; Timm et al. 1997; Adam 2000). Its extinction is blamed on intensive hunting for oil extraction during early colonial times (Adam 2000; Adam & García 2003; McClenachan & Cooper 2008). The capture and killing of seals for scientific collections (Allen 1887; Ward 1887; Allen 1942) also contributed to their extincton.

Some believe there is not enough evidence to conclude that the Caribbean monk seal was an abundant species or that it was potentially resilient to human exploitation (Baisre 2010). Why is this large and conspicuous vertebrate so scarce in the archaeological record? Why was this supposedly widely distributed and abundant species seen only during the second voyage of Columbus? Why didn't other European explorers, colonizers, and pirates mention sighting monk seals? Why does the first scientific description of the monk seal come more than 350 years after they were seen for the first time?

We sought to provide a more objective interpretation of the evidence surrounding the extinction of the Caribbean monk seal. I sought to provide new insights into the need for rigor in interpreting historical information when establishing baselines to inform the design of conservation measures for critically endangered species.

Methods

I critically examined all archaeological records, historical observations and data on geographic names that have been included and quoted in previous syntheses about the Caribbean monk seal (Allen 1880; King 1956; Rice 1973; Timm et al. 1997; Adam 2000; Adam & Garcia 2003; McClenachan & Cooper 2008) and added 3 archaeological and 2 historical records.

Overall, I included 115 observations: 21 paleontological and archaeological records, 67 historical observations, and 27 localities named after seals (Table 1). I mapped all records in a geographical information system

Table 1. Number of observations and sources of data on the Caribbean monk seal used in this paper in comparison with previous reviews.

Reference	*Archaeological data*	*Historical data*	*Geographic names*	*Total*
Allen 1887	–	9	1	10
King 1956	–	19	6	25
Rice 1973	–	30	–	30
Timm et al. 1997	–	17	9	26
Adams & Garcia 2003	22	71	27	120
McClenachan & Cooper 2008	approximately 20*	approximately 100*	approximately 20*	140
Baisre, this paper	21	67	27	115

**Number of observations estimated from the figures given by authors.*

Table 2. Pleistocene (1–4) and Holocene (5–21) records of the occurrence of monk seals in the Caribbean Sea and the Gulf of Mexico with information about the material found in archaeological sites.

*Paleontological and archaeological site**	*Fossil records (years ago)*	*Materials*	*Reference*
Melbourne (Brevard County, Florida)	0.7–0.01 million	proximal phalanx	Ray (1961)
Lake Hellen Blazes (Brevard County, Florida)	0.7–0.01 million	right mandible	Ray (1961)
Leisey (Hillsborough County, Florida)	1.77–1.07 million		Berta (1995)
Rigby Shell Pits (Hillsborough County, Florida)	1.77–1.07 million		Berta (1995)
Long Bayou (Saint Petersburg, Pinellas County, Florida)	approximately 4500–2800	left maxilla	Ray (1961), Cumbaa (1980)
South Indian Field (Brevard County, Florida)	approximately 4000	bones of 3 individuals	Cumbaa (1980)
Wightman Site (Sanibel Island, Lee County, Florida)	approximately 2300–1900		Wing (1992)
Marco Island (Collier County, Florida)	2000–1500	bones of 3 individuals	Cumbaa (1980)
Granada (Miami, Dade County, Florida)	2000–500		Wing & Loucks (1984)
Miami Circle (Miami, Florida)	2500–1250		Adam (2000)
Cumberland Island (Camden County, Georgia)	2600–1300		Milanich (1971)
Caracoles Midden in Ponce, Puerto Rico	700–510	lower premolar	Wing (1992)
Cinnamon Bay (Saint John, U.S. Virgin Islands)	1000–510		Adam (2000)
Sint Eustatius (Netherlands Antilles)	1400–1100	mandible	Debrot (2000)
Hichman's Site (Nevis)	1660		Wing (1992, 2001)
Hichman's Shell Heap (Nevis)	2550		Wing (1992, 2001)
Santa Barbara (Curacao)	1500–400	2 foot bones	Debrot (2000)
Sint Michiel (Curacao)	3820–3790	phalanx	Debrot (2000)
Manatí, north coast of Cuba	not dated	incisor without decoration	Arredondo (1996)
Matanzas, north coast of Cuba	not dated	rib fragment	Vento Franco (2001)
Xcambó, coast of Yucatan	700–250	cranial and leg bones of 9 specimens some perforated dental pieces	Götz & Sierra Sosa (2011)

**Canines of Caribbean monk seals have been found in 2 undated sites in Texas, but they may represent trade items of North American indigenous people or colonial Spaniards (Raun 1964; Adam 2000).*

database. But in contrast with previous authors (Timm et al. 1997; Adam 2000; Adam & Garcia 2003; McClenachan & Cooper 2008), I did not combine data from the different sources. Archaeological records and historical observations are presented separately, in chronological order, to avoid confusing temporal and spatial scales. I classified human encounters with the Caribbean monk seal into 4 groups: no interaction, hunting for food, hunting for oil, and collection for research, including capture of live animals for aquariums. The time elapsed between historical observations was calculated for 2 periods, before and after the first published description of the species in 1843.

Difficulties I faced in this review included lack of data and observations and reliability and use of data. Many of the observations available are anecdotal and do not meet the basic requirements of ordinary zoological samples; that is, they do not indicate species locality, number of specimens, or date of collection.

Prehistoric Record

Paleontological and archaeological records with remains of the Caribbean monk seal are rare and limited to very few localities (Table 2). Records before the Holocene are only known from Florida (Adam & Garcia 2003), and there are only 4 records of Pleistocene fossils of this species in Florida sites (Adam 2000). Archaeological remains from the Holocene are also scarce (Cumbaa 1980; Adam 2000; Debrot 2000; Newson & Wing 2004), and seals are notably absent from most archaeological sites in the Lesser Antilles (Pregill et al. 1994). Most of the records are from Florida, whereas Caribbean fossils are known with certainty only from a few localities (Adam 2000; Debrot 2000). Although I included 2 additional records from Cuba and another from Yucatan in this review, the scarcity of archaeological records is still remarkable. Even more striking than the low number of archaeological sites is the low number of specimens (Cumbaa 1980; Adam 2000). Most records consist of only a single specimen and, in some cases, a few dental fragments, which may have been used as trade items among prehistoric peoples in the Caribbean region (Raun 1964).

The low number of archaeological records of individual West Indian monk seals suggests the species was never used as a major source of subsistence (Adam 2000). Despite that, some archaeologists have interpreted the limited record of monk seal remains as a sampling bias, arguing that only the meat would have been brought to the prehistoric settlements and that the skull and bones were left at the butchering sites due to their weight and limited use (Newson & Wing 2004). This argument does not apply to other large animals in the Caribbean (e.g., manatees and sea turtles), for which there are clear indications of their consumption by prehistoric peoples.

It is probable that seals were exposed to hunting only while hauled out on isolated islands and banks and were never an important human food source. An early account claimed monk seals did not seem to be eaten by the indigenous people of Florida and were consumed only by the upper classes (Fontaneda 1575). This account provides indirect evidence that the species was uncommon at that time.

Absence of evidence is not evidence of absence. However, the rarity of monk seal remains in the archaeological

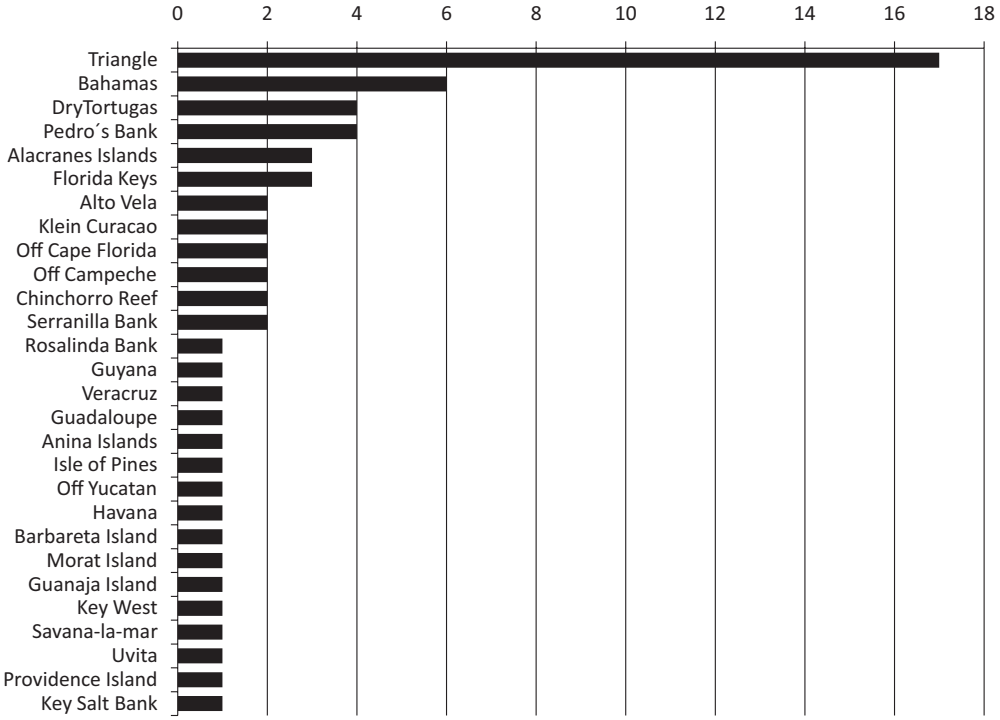

Figure 1. Number of historical observations of monk seals from each locality.

record seems to be real and should not be interpreted as being caused by sampling bias only. Therefore, I took this scarcity of records as the starting point for a working hypothesis: Caribbean monk seals were rare when humans first arrived in the islands and probably played a minor ecological role. My analysis of the historical evidence is a means to test this hypothesis.

Historical Records

There are 67 historical accounts that mention the presence of the Caribbean monk seal. Although these data included first- and second-hand accounts and a few imprecise or inaccurate descriptions, it is noteworthy that in the Triangle Islands in the Gulf of Mexico the presence of seals was not only well documented, but also represented 25% of all the observations of this species. Overall, presence of Caribbean monk seal was recorded at 28 different localities; however, at 16 of these localities, seals were recorded only once (Fig. 1). The elapsed time from the first report in 1494 (Kerr & Edin 1811) to the last observation in Serranilla Bank in 1952 (Rice 1973) was 458 years, with an average time between observations of 7.4 years (SE 1.72). However, there was a significant difference ($p < 0.001$) in the average time between records before (20.1 years [SE 5.03]) and after (2.5 years [SE 0.47]) the first description of the species in 1843. As a species becomes rare, the proportion of false positives increases (McKelvey et al. 2008), and this

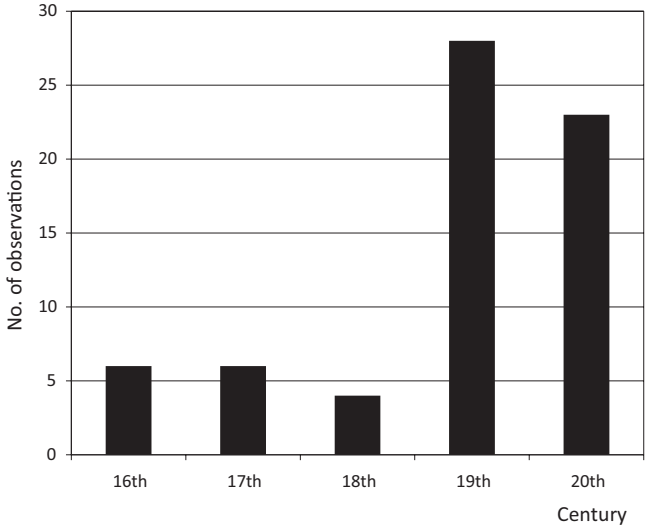

Figure 2. Number of observations of monk seals reported in different centuries. Number in the 16th century includes a data point from the 15th century.

factor may explain the higher number of records after the species was described for the first time. The temporal grouping of all the historical accounts (Fig. 2) showed there were 16 records during the first 3 centuries. Five of these records are first-hand accounts. Considering the large range of the species and the long time frame of the historical record, the scarcity of records of the presence of monk seals is surprising (e.g., Allen 1887; Rice 1973).

Until 1880, the only specimen of the Caribbean monk seal extant in any museum was an imperfect skin in the British Museum (Allen 1880). The lack of mention of monk seals in several books dealing with the natural history of the region during the 18th and 19th centuries indicates monk seals escaped the naturalists' eyes (e.g., Sloane 1707, 1725; Catesby 1731, 1754; Parra 1787; Poey 1851). The materials available in museum collections provide further indirect evidence of this seal's abundance. In England there are 2 specimens from Pedro's Bank in the collections of the British Museum and 1 specimen in the Cambridge Zoological Museum (King 1956). There is 1 skull at the Museum of La Plata, Buenos Aires, obtained from an expedition to the Triangle Islands in 1886 (Daneri & De Santis 2002). The largest collections are at the American Museum of Natural History, where there are 14 specimens, 5 from Yucatán, Mexico, and the others from unknown localities, and the U.S. National Museum of Natural History, where there are 44 specimens, 40 from Mexico, 1 from Cuba, and 3 from unknown localities.

The reports from the 4 long voyages of Columbus, from 1492 to 1504, which were wide-scale exploratory surveys of the whole region, and later the writings and voyages of Dampier also provide indications of the historical rarity of Caribbean monk seals. Dampier's writings have been cited frequently as a credible and valuable source of historical data on marine resources (Jackson 1997, 2001; Jackson et al. 2001; McClenachan & Cooper 2008). Nonetheless, Dampier's reports seem to have been misinterpreted in this case. He was the first to note the scarcity of seals in the Caribbean region and wrote (emphasis added): "Seals are frequent in the northern parts of Europe and America, and in the southern parts of Africa, as about the Cape of Good Hope and at the Straits of Magellan. *I never saw any in the West Indies* but in the Bay of Campeche, at certain islands called the Alacranes, and at others called the Desarts" (Dampier 1699: 90).

Geographic Names

Allen (1887) was the first to use a geographic name as a proxy to indicate the presence of Caribbean monk seals. Several authors subsequently produced maps outlining the historical distribution of the species (e.g., Timm et al. 1997; Adam 2000; Adam & Garcia 2003; McClenachan & Cooper 2008). However, information on geographic names should only be considered a complement to actual sightings. Animal place names do not necessariaLy indicate that an animal was present in high numbers at a particular place; rather, they may reflect similarites between features of the landscape and the animal. For example, places have been named because they are reminiscent of turtles (e.g., Baisre 2010), and this practice may also have occurrred with other large and conspicuous animals such as seals. Adam and Garcia (2003) identified 27 localities supposedly inhabited by Caribbean monk seals. Most of these localities are so small and isolated, that it is very difficult to conclude that dense concentrations of seals could have been recorded there on historical nautical charts of the West Indies (McClenachan & Cooper 2008). Furthermore, the significance of 27 place names must be considered in the context of the size of the Caribbean Sea, which is over 2.5 million km^2 (Richards & Bohnsack 1990) and contains thousands of small islands, keys, and oceanic banks.

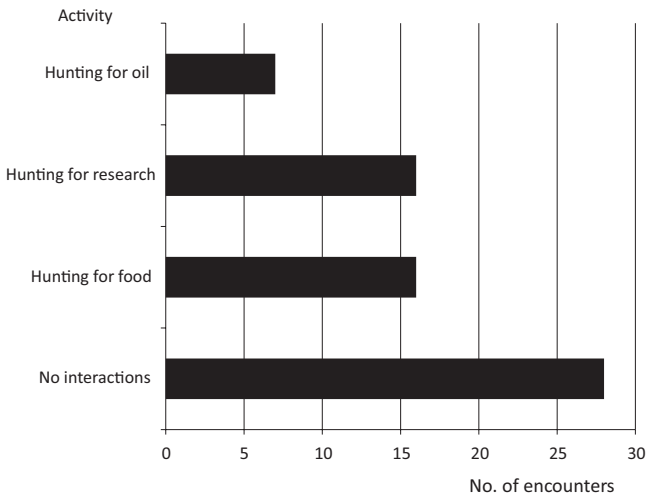

Figure 3. Number of human encounters with the Caribbean monk seal grouped by type of human activity.

Overhunting

I classified historical observations describing human encounters with the Caribbean monk seal into 4 groups to assess the relative importance of these groupings. Contrary to expectation, encounters with no interactions and collection of seals for research purposes comprised the largest number of records (Fig. 3). Accounts of seals being hunted for food, including by shipwrecked persons, were also relatively large; hunting for oil extraction had the fewest records. I made a detailed analysis of the references dealing with the hunting of the Caribbean monk seal for oil extraction (Table 3) to evaluate this practice. Contrary to the conclusions of Adam (2000) and McClenachan and Cooper (2008), an unknown author (Anonymous 1722) provided the only definite mention of the use of the oil of the Caribbean monk seal for the sugar cane industry. The records contain a notable lack of details (dates, localities, number of animals) and unrealistic (e.g., seals killed by night) or fantastic claims (e.g., giant seals). These data do not support the conclusion that seals were the main source of oil in the Caribbean or that they provided the oil for the sugar cane industry of Jamaica

Table 3. Historical accounts of Caribbean monk seal hunting for oil extraction, arranged in chronological order.

Locality	*Observation*	*Reference*
Alacranes Islands	"Seals were especially common in the Alacranes Islands. The Spaniards do often come hither to make oil of their fat. I never saw any [seal] in the West Indies."	Dampier (1699, 1700)
Bahamas	"The Bahamas Islands are filled with seals; *sometimes fishers will catch 100 in a night*. They try or melt them, and bring off their oil for lamps to the Islands."	Sloane (1707)
Bahamas	"Yearly about winter the seals come up the shores of these Islands to breed and are caught. Each of which affords about 20 gallons of oil *which is exported to Jamaica and other plantations for the use of their mills*."	Anonymous (1722)
Bahamas	"They make plenty of oil from the nurses, seals, etc. and a beneficial whale fishery might be established here, as that fish comes in great numbers to wean their young among the islands, and several have been thrown ashore, full of the spermaceti; there is likewise found in the shore much ambergris."	Bruce (1782)
Dry Tortugas	"At the north of Dry Tortugas there is a great plenty of seals, the fat of which the Spaniards pay the bottom of their ships at Havana. The Indians of Ratones and the fourth parts of Florida cure great quantities of this fish, which . . . they exchange in traffic with the Spaniards, who come here from Havana with European goods for the use of natives."	Roberts (1763)
Bahamas	"At the seal banks, they are to be seen, as far as the eye can discern, upward of 500 in number. *They are usually from 15 to 18 feet long and about four feet broad.* The young seal are *commonly born in pairs* and are suckled for about a fortnight at the place of their birth, when they are taken out to the sea by their parents who instruct them in swimming and seeking for food, *which consists chiefly of seaweed. When taken very young, these animals may be domesticated, will follow their master like a dog and come to him when called by name*."	Nesbitt (1836)
Triangle Islands	"In the spring, I was with Captain Lucas at the Triangle for a load of Mexican guano. I only saw two seals there, which left the island in a hurry, so I can give you no information from personal knowledge, although must have been great numbers there, by the skeletons poor hides, etc.; and someone must have carried on an extensive business in that line, for we made a grand bonfire of perhaps hundred barrels of the remains."	Ward (1887)
Off Honduras	"By 1885, fishers from Bonacca (in Guanaja Island) were fishing them for meat and oil."	Gaumer (1917)
Triangle Islands	"the fishermen tell me that at one time there was a tremendous colony of seals . . . but it is their belief that the Mexicans have killed a great many, possibly all of them, for their oil . . . I know of no seals which have been taken from the island in recent years."	Allen (1942)

*Italics highlight unrealistic observations (for further details see text).

(McClenachan & Cooper 2008). The lack of any trace of oil-extraction practices, which needed large amounts of firewood and would have left substantial quantities of bones and skins on beaches, is further evidence against the existince of monk seal oil industry in the Caribbean. This evidence is noted in a report from the National Marine Fisheries Service (NMFS 2008) that recognizesthat "documentation of harvest levels and practices that led to this species' population decline is nearly absent."

Discussion

Two well-established facts in this extinction history of the Caribbean monk seal require no further discussion: the species is extinct (Kenyon 1977; LeBoeuf et al. 1986; IUCN 1996; NMFS 2008) and human exploitation accelerated this process (Allen 1887; Gaumer 1917). The most accepted view is that the Caribbean monk seal, albeit vulnerable, was a relatively abundant species, widely distributed in the region, and massively hunted during the early colonial period until its final extinction (Allen 1887; Gaumer 1917; Timms et al. 1997; Adam 2000). Therefore, the extinction of this large predator substantially affected the Caribbean coral reef ecosystem (Jackson 1997, 2001; Jackson et al. 2001; Pandolfi et al. 2003), which now seems to be several times less productive than before the extinction (McClenachan & Cooper 2008).

I found that most of the information about monk seal distribution and abundance is anectodal. The historical existence of 13 breeding colonies (McClenachan & Cooper 2008) (Table 1), for example, is poorly supported because the existence of several of the colonies was inferred from the existence of 1 (Guadalupe, Guyana, Veracruz, Serranilla Bank), or 2 (Alto Vela, Klein Curacao) historical descriptions. Evidence of breeding colonies in Anina Island (a locality impossible to chart) and on the Cuban southern coast (from an erroneous historical account of a shipwreck) is even more difficult to accept. Some of the evidence included no less than 14 repetitions

of the same report (observations in the same locality and with the same date). Despite the scarcity and inaccuracy of these historical data, it has been concluded that hunting for oil extraction was the driver of the extinction of the Caribbean monk seal, the historical population size of which was alleged to be on the order of 233,000–338,000 individuals on the basis of mathematical modeling (McClenachan & Cooper 2008).

It seems obvious that more data and better models will not address the problem of depleted resources, even if the models include additional and more accurate historical data (Bolster 2006). It is hard to see how adding more data to shift the model baseline is going to solve a problem that modeling has been deeply complicit in creating (Van Sittert 2005). Good history begins with good sources, and any analyses of the past should be based on verifiable sources and recognizable historical methods (Bolster 2006). Despite impressive analytical techniques, poor input data may provide unreliable results (Jennings et al. 2001).

An alternative hypothesis that I outlined previously (Baisre 2010), considers that monk seals were a rare species before European colonization. In *The Origin of Species*, Darwin (1859) insisted that rarity is the attribute of a vast number of species of all classes, in all countries, and both theory and empirical evidence suggest that some species are extremely vulnerable because they have a combination of traits that promote extinction. There is a long and well-known list of biological and ecological attributes associated with rare species, which can be grouped into categories of rarity for regulatory or conservation-planning purposes (Flather & Sieg 2007). Rarity is often defined on the basis of a framework (Rabinowitz et al. 1986) that considers the 3 axes of habitat specialization, local abundance, and range size (Harrison et al. 2008), all of which apply to the Caribbean monk seal. This species was a habitat specialist, confirmed only from small islands and isolated banks in the Gulf of Mexico and in the Caribbean Sea, and there is no evidence that it lived on the mainland. Most of the specimens found in Florida can be attributed to trade. Such extreme habitat fragmentation not only makes encounters with humans difficult, but also does not support the hypothesis of a high abundance. The low number of historical records and the prolonged time between observations are additional evidence of low local abundance. The most credible hypothesis that explains the lack of archaeological and historical records of monk seals, their limited geographic distribution, and the anecdotal information about hunting levels, hunting localities, and oil trade is that the monk seal was a rare species when it was first reported in the 15th century. This is the most parsimonious explanation of why naturalists overlooked a large mammal, obliged to haul out on sandy or rocky beaches, for 350 years.

Extinction is a natural process that can occur without humans being present, but it is often accelerated or driven by human activities. The rarity of the Caribbean monk seal, the intrinsic vulnerability of this large and slow-reproducing mammal, and its largely fragmented distribution all contributed to its rapid extinction. The question is "how naturally rare species have persisted through evolutionary time, and whether particular characteristics have enabled them to avoid extinction despite their small ranges, low abundances, and narrow habitat requirements" (Harrison et al. 2008). What seems most surprising in the case of the monk seal is how slowly the process of extinction progressed. The most plausible explanation is the restriction of this species to small, isolated islands and oceanic banks, which made contact with humans more difficult. In areas with complex geography it is more difficult to locate and kill every individual of a larger organism than it is along more accesible coastlines or on individual islands (Carlton et al. 1999). When European colonizers were shipwrecked on isolated islands of the Caribbean Sea and the Gulf of Mexico, they rapidly exterminated the few individuals of the small population. Unfortunately, the scientific interest in this poorly known species also contributed to organized expeditions that completed the extinction processs (Allen 1887; Ward 1887).

In conservation biology, bad news (e.g., large decreases in populations, extirpations, and extinctions) is often given priority in the highest ranked scientific journals (Hays 2004), and current views about monk seal extinction may have been affected by this bias. Unfortunately, scientific evidence is too often poorly distinguished from the perpsective of the scientist in studies of the effects of fishing (Jennings 2007). This prejudice may raise public awareness about the effects of human predation on extenction risk, but as I have demonstrated here and as has been pointed out by Hilborn (2006), this approach does not seem to provide a critical analysis of evidence. Although the value of data on historical distributions is widely recognized for improving our understanding the structure, function, and processes of ecosystems (Boshoff & Kerley 2010), historical population records for most species are fragmentary and of questionable quality if they exist at all (Balmford & Bond 2005; Bonebrake et al. 2010). In adition, the use of anecdotal data to establish the presence or geographic range of rare or ellusive species is inherently unreliable (McKelvey et al. 2008). Researchers should reexamine pre- and early scientific evidence through modern prisms. However, they must appreciate that the data may not be firm and that testimonies may not be reliable (Taylor 2013). I hope my review provides new insights into the rigorous process required to establish baselines aimed at informing the design and implementation conservation measures for critically endangered species.

Acknowledgments

I am very grateful to W.F. Keegan, Florida Museum of Natural History, for his encouragement and valuable suggestions, which improved very much the first draft of this paper. I also thank the 4 anonymous reviewers, who helped to correct some mistakes and improved the manuscript, and H. Marsh, handling editor, who also provided appreciable help.

Literature Cited

Adam, P. J. 2000. Monachus tropicalis. Mammalian Species **747:**1–9.

Adam, P. J., and G. G. Garcia. 2003. New information on the natural history, distribution, and skull size of the extinct West Indian monk seal, *Monachus tropicalis*. Marine Mammal Science **19:**297–317.

Allen, G. M. 1942. Extinct and vanishing mammals of the western hemisphere with the marine species of all the oceans. American Committee for International Wild Life Protection, Special Publication **11:**1–620.

Allen, J. A. 1880. History of North American pinnipeds. Government Printing Office, Washington, D.C.

Allen, J. A. 1887. The West Indian monk seal (*Monachus tropicalis* Gray). Bulletin American Museum of Natural History **2:**1–34.

Anonymous. 1722. Proceedings of the government and council of the bahamas 1722. Minutes of the Council. British Public Records Office CO 23/1, Section 3, p. 17.

Arredondo, O. 1996. Lista de especies extinguidas de vertebrados halladas en las provincias orientales de Cuba. Garciana **24–25:**1–2 (in Spanish).

Baisre, J. A. 2010. Setting a baseline for Caribbean fisheries. Journal of Island and Coastal Archaeology **5:**120–147.

Balmford, A., and W. Bond. 2005. Trends in the state of nature and their implications for human well-being. Ecology Letters **8:**1218–1234.

Berta, A. 1995. Fossil carnivores from the leisey shell pits. Bulletin of the Florida Museum of Natural History **37:**463–499.

Bjorndal, K. A., and J. B. C. Jackson. 2003. Roles of sea turtles in marine ecosystems: Reconstructing the past. Pages 259–273 in P. L. Lutz, J. A. Musick, and J. Wyneken, editors. The biology of sea turtles. Volume II. CRC Press, Boca Raton, Florida.

Bolster, W. F. 2006. Opportunities in marine environmental history. Environmental History **11:**1–31.

Bonebrake, T. C., J. Christensen, C. L. Boggs, and P. R. Ehrlich 2010. Population decline assessment, historical baselines, and conservation. Conservation Letters **3:**371–378.

Boshoff, A. F., G. H. Kerley. 2010. Historical mammal distribution data: How reliable are written records? South African Journal of Science **106:**26–33.

Bruce, P. H. 1782. Memoirs of peter henry bruce. T. Payne and Son, London.

Carlton, J. T., J. B. Geller, M. L. Reaka-Kudla, and E. A. Norse. 1999. Historical extinctions in the sea. Annual Review of Ecology and Systematics **30:**525–538.

Catesby, M. 1731. The natural history of Carolina, Florida and the Bahamas Islands. Volume I. Available from http://digital.library.wisc.edu/1711.dl/DLDecArts.CateNatHisV1 (accessed April 2013).

Catesby, M. 1754. The natural history of Carolina, Florida and the Bahamas Islands. Containing the figures of birds, beasts, fishes, serpents, insects and plants. Volume II. Available from http://digital.library.wisc.edu/1711.dl/DLDecArts CateNatHisV2 (accessed April 2013).

Cumbaa, S. L. 1980. Aboriginal use of marine mammals in the southeastern United States. South-eastern Archaeological Conference Bulletin **17:**6–10.

Dampier, W. 1699. A new voyage around the World. 4th edition corrected. James Knapton, London.

Dampier, W. 1700. Voyages and descriptions. Volume II. 2nd edition. James Knapton, London.

Daneri, G. A., and L. J. M. De Santis. 2002. Ejemplar de la especie extinta *Monachus tropicalis* (Carnivora, Phocidae) en el museo de la Plata (Argentina). Mastozoología Neotropical **9:**59–63 (in Spanish).

Darwin, C. 1859. On the origin of species. John Murray, London.

Debrot, A. O. 2000. A review of records of the extinct West Indian monk seal, *Monachus tropicalis* (Carnivora: Phocidae), for the Netherland Antilles. Marine Mammal Science **16:**834–837.

Flather, C. H., and C. H. Sieg. 2007. Species rarity: definition, causes, and classification. Pages. 40–66 in G. R. Martin and R. Molina, editors. Conservation of rare or little-known species: biological, social, and economic considerations. Island Press, Washington, D.C.

Fontaneda, H. E. 1575. Memoirs of Hernando Escalante de Fontaneda respecting Florida, written in Spain, about the year 1575.

Gaumer, G. F. 1917. Monografía de los mamíferos de Yucatán. Departamento de Talleres Gráficos de la Secretaria de Fomento (in Spanish), Mexico City, Mexico.

Götz, C. M., and T. N. Sierra Sosa. 2011. La arqueofauna de Xcambó, Yucatán, México. Antipoda. Revista de Antropología y Arqueología **13**:119–145 (in Spanish).

Harrison, S., J. H. Viers, J. H. Thorne, and J. B. Grace. 2008. Favourable environments and the persistence of naturally rare species. Conservation Letters **1:**65–74.

Hays, G. C. 2004. God news for sea turtles. Trends in Ecology & Evolution **19:**349–351.

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

IUCN (International Union for Conservation of Nature). 1996. Monachus tropicalis. Seal Specialist Group, IUCN, Gland, Switzerland.

Jackson, J. B. C. 1997. Reefs since Columbus. Coral Reefs **16S:**23–32.

Jackson, J. B. C. 2001. What was natural in the coastal oceans? Proceedings National Academy of Science **98:**5411–5418.

Jackson, J. B. C., et al. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science **293:**629–638.

Jennings, S. 2007. Reporting and advising on the effects of fishing. Fish and Fisheries **8:**269–276.

Jennings, S., M. J. Kaiser, and J. D. Reynolds. 2001. Marine fisheries ecology. Blackwell Publishing, Oxford, United Kingdom.

Kenyon, K. W. 1977. Caribbean monk seal extinct. Journal of Mammalogy **58:**97–98.

Kerr, R., and F. A. S. Edin. 1811. General history and collection of voyages and travels, arranged in systematic order: forming a complete history of the origin and progress of navigation, discovery, and commerce, by sea and land, from the earliest ages to the present time. Volume III. William Blackwood, Edinburgh.

King, J. E. 1956. The monk seals (Genus *Monachus*). Bulletin of the British Museum (Natural History) Zoology **3:**201–256.

LeBoeuf, B. J., K. W. Kenyon, and B. Villa-Ramirez. 1986. The Caribbean monk seal *Monachus tropicalis* is extinct. Marine Mammal Science **2:**70–72.

McClenachan, L., J. B. C. Jackson, and M. J. H. Newman. 2006. Conservation implications of historic sea turtle nesting beach loss. Frontiers in Ecology and Environment **4:**290–296.

McClenachan, L., and A. B. Cooper. 2008. Extinction rate, historical population structure and ecological role of the Caribbean monk seal. Proceedings of the Royal Society B **275:**1351–1358.

McKelvey, K. S., K. B. Aubry, and M. K. Schwartz. 2008. Using anecdotal occurrence data for rare or elusive species: the illusion of reality and a call for evidentiary standards. BioScience **58:**549–555.

Milanich, J. T. 1971. The Depford phase: an archaeological reconstruction. PhD dissertation. University of Florida, Gainesville.

NMFS (National Marine Fisheries Service). 2008. Endangered Species Act 5-year review for the Caribbean monk seal (*Monachus*

tropicalis). National Marine Fisheries Service Southeast Regional Office, St. Petersburg, Florida.

Nesbitt, C. R. 1836. On the Bahamas fisheries. Journal of the Bahamas Society for the Diffusion of Knowledge **1836:**126–136.

Newson, L. A., and E. S. Wing. 2004. On land and sea. Native American uses of biological resources in the West Indies. The University of Alabama Press, Tuscaloosa.

Pandolfi, J. M., et al. 2003. Global trajectories of the long-term decline of coral reef ecosystems. Science **301:**955–958.

Parra, A. 1787. Descripción de diferentes piezas de historia natural. Imprenta de la Capitanía General. Edición Facsimilar, Editorial Academia, 1989 (in Spanish), La Habana, Cuba.

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

Poey, F. 1851. Memorias sobre la historia natural de la Isla de Cuba. Tomo I. Imprenta de Bareina, La Habana, Cuba (in Spanish).

Pregill, G. K., D. W. Steadman, and D. R. Watters. 1994. Late Quaternary vertebrate faunas of the Lesser Antilles: historical components of Caribbean biogeography. Bulletin of Carnegie Museum of Natural History **30:**1–51.

Rabinowitz, D., S. Cairns, and T. Dillon. 1986. Seven forms of rarity and their frequency in the flora of the British Isles. Pages 182–204 in M. E. Soulé, editor. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts.

Raun, G. G. 1964. West Indian seal remains from two historic sites in Texas. Bulletin of the Texas Archaeological Society **35**: 189–192.

Ray, C. E. 1961. The monk seal in Florida. Journal of Mammalogy **42:**113.

Rice, D. W. 1973. Caribbean monk seal (*Monachus tropicalis*). Pages 98–112 in Proceedings of a working meeting of seal specialists on threatened and depleted seals of the world. International Union for Conservation of Nature, Morges, Switzerland.

Richards, W. J., and J. A. Bohnsack. 1990. The Caribbean Sea: a large marine ecosystem in crisis. Pages 44–53 in K. Sherman, L. M. Alexander, and B. D. Gold, editors. Large marine ecosystems: patterns, processes, and yields. American Association for the Advancement of Science, Washington, D.C.

Roberts, W. 1763. An account of the first discovery, and natural history of Florida. Reprinted 1976. University of Florida Press, Gainesville.

Sergeant, D. E., G. Nichols, and D. Campbell. 1980. Expedition of the R/V *Regina Maris* to search for Caribbean monk seals in the southeast Bahamas Islands, April 13–26, 1980. Newsletter of the League for the Conservation of the Monk Seal **5:**75–82.

Sloane, H. 1707. A voyage to the islands Madera, Barbados, Nieves, S. Christophers and Jamaica. Volume I. Printed for the author, London. Available from http://archive.org/details/mobot31753000820123 (accessed April 2013).

Sloane, H. 1725. A voyage to the islands Madera, Barbados, Nieves, S. Christophers and Jamaica, Vol. II, 1–499. Printed for the author, London. Available from http://archive.org/details/mobot31753000820115 (accessed April 2013).

Taylor, J. E., III. 2013. Knowing the black box: methodological challenges in marine environmental history. Environmental History **18**: 60–75.

Timm, R. M., R. M. Salazar, and T. Peterson. 1997. Historical distribution of the extinct tropical seal, *Monachus tropicalis* (Carnivora: Phocidae). Conservation Biology **11:**549–551.

Van Sittert, L. 2005. The other seven tenths. Environmental History **10:**118–121.

Vento Franco, G. 2001. La verdad sobre la foca de Las Antillas. 1861. Revista de Espeleología y Arqueología **1–4:**57–59 (in Spanish).

Ward, H. L. 1887. Notes on the life history of *Monachus tropicalis*, the West Indian seal. The American Naturalist **21:**257–264.

Wing, E. S. 1992. West Indian monk seal: *Monachus tropicalis*. Pages 35–40 in S. R. Humphrey, editor. Rare and endangered biota of Florida mammals. University Press, Gainesville, Florida.

Wing, E. S. 2001. Native American use of animals in the Caribbean. Pages 481–518 in C. A. Woods, and F. E. Sergile, editors. Biogeography of the West Indies: patterns and perspectives. 2nd edition. CRC Press, Boca Raton, Florida.

Wing, E. S., and L. J. Loucks. 1984. Grenada site faunal analysis. Pages 259–345 in J. W. Griffin et al., editors, Archaeology and history of the Grenada, site. Excavations at the Grenada site. Florida Division of Archives, History and Records Management, Tallahassee.