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An invisible trade in imperiled guitarfishes

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Ocean conservation is a priority, given global declines in marine biodiversity and climate change (Tittensor et al., 2019). The recent declaration of the first modern marine fish extinction (Java stingaree [*Urolophus javanicus*]) (Constance et al., 2023) highlights the need to secure remaining threatened species. Extinction risk in marine fishes is largely driven by overexploitation, yet harvest and trade are poorly understood or undocumented in many groups (Dulvy et al., 2003; McCauley et al., 2015). Characterization of the use of marine species for nontraditional purposes is especially limited and may contribute to global extinction risk. We considered an undescribed trade in a group of highly threatened species with an aim to inform research, management, and conservation.

INTRODUCTION TO CRYPTIDS AND TAXIDERMIED MYTHICAL CREATURES

Mysterious creatures have long fascinated the public (Dendle, 2006). Early Babylonian and Greek societies wrote about mermaids (Waugh, 1960), and accounts of basilisks date back to 79 AD (Krzyszczuk & Morta, 2023). Contemporary examples include the chupacabra in Latin America (Radford, 2011), bunyip in Australia (Edmonds, 2018), and windigo in North America (DeSanti, 2015). These creatures are collectively referred to as *cryptids*, animals whose existence is unsubstantiated. Cryptids take many forms, including anthropomorphic (human shaped), zoomorphic (resembling animals), hybrids (combining features from different animals), dragons (reptile or bird like), or undefined (variable or uncertain appearance) (Beconytė et al., 2014). Long-standing fascination with cryptids has inspired people to create taxidermied creatures fabricated using carcasses or parts from different animals (Dance, 1976). For example, taxidermists create the jackalope of North American folklore by combining the body of a rabbit with the antlers of a deer. Although taxidermied mythical creatures, such as the jackalope, may be created using relatively common species, others are made from rare or threatened species, which can have implications for conservation.

EARLY HISTORY OF MODIFIED BATOIDS

Batoids (skates and rays) have a long history of being cut, modified, and dried to produce mythical creatures (Gudger, 1934; Whitley, 1928). These manufactured creations have been regarded as pathways to the divine (Parish, 2019), as hoaxes, and as medical cures (Gesner, 1558). Globally, modified batoids have been colloquially referred to as Jenny Hanivers (Australia, Europe, United States); *garadiávolos*, *diablitos*, and *pez diablo* (Latin America); devil fish (United States, Europe); and *rayas chupacabras* (Guatemala) (Cano & Palomo-Muñoz, 2017; Whitley, 1928). This tradition likely originated in Europe, with the oldest known illustration appearing in Conrad Gesner's

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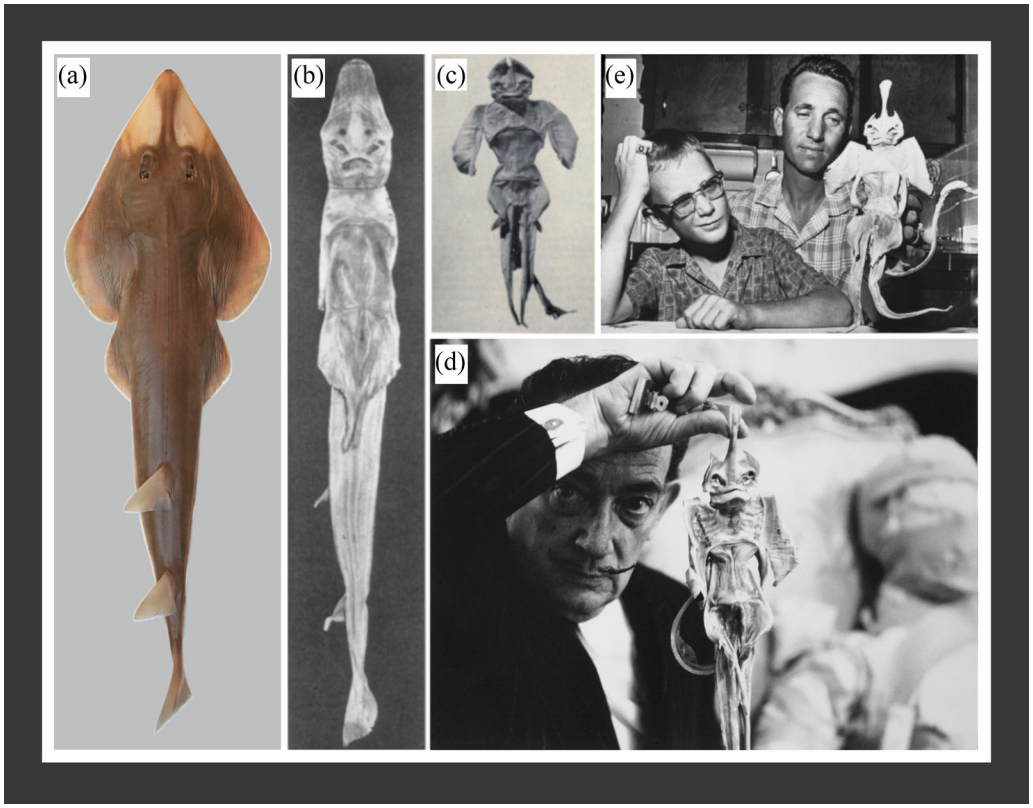

FIGURE 1 Guitarfish modification through history: (a) natural shape of a guitarfish (family Rhinobatidae) in dorsal view (photo by B.L.H.-B.), (b) ventral view of what appears to be the first documented modified guitarfish (photo from Gudger [1934]), (c) modified guitarfish purchased in Mexico as a devil fish in the early 1950s and accessioned at the Field Museum in Chicago, USA (photo from Polikoff [1953]), (d) world-renowned Spanish surrealist artist Salvador Dalí displaying a modified guitarfish (photo from Luc Fournol/Photo12), and (e) modified guitarfish photo featured by internationally renowned ichthyologist Carl Hubbs in his *Demons of the Deep* lecture in the 1960s (photo courtesy of UC San Diego Library).

Historiae animalium liber IIII in 1558. Gesner's illustration resembles a flying dragon, with the pectoral fins of a skate (order Rajiformes) bent upward to resemble wings. Other modified batoids resembling dragons and basilisks were drawn by the naturalist Ulisse Aldrovandi in *De Piscibus Libri V* in 1613 (Gudger, 1934). It is unclear whether Aldrovandi's illustrations were based on purposely modified specimens (Gudger, 1934; Whitley, 1928), on naturally deformed specimens (abnormalities have been recorded among skates [Luer & Wyffels, 2022]), or both. Regardless, nearly all early records (>150 years old) of modified batoids are skates (Gudger, 1934), the most diverse batoid group in European waters (Ebert & Dando, 2020).

FROM SKATES TO GUITARFISHES

Although skates represent the earliest creations of mythical creatures derived from batoids, modification of another batoid family, the guitarfishes (Rhinobatidae) (Figure 1a), emerged in the mid-20th century. The first documentation of a modified guitarfish (i.e., a guitarfish altered to resemble a mythical creature) is in Gudger (1934), where it is described as "the latest of Jenny Hanivers—1933 model." Created from a freckled guitarfish (*Pseudobatos lentiginosus*), it was more human-like than previous modified batoids (Figure 1b). Approximately 20 years later, a modified guitarfish labeled pez diablo (devil fish) was purchased from an antique store in Guadalajara, Mexico, and accessioned (FMNH 73390) at the Field Museum in Chicago (USA) (Polikoff, 1953) (Figure 1c). Guitarfishes may have been favored for modification because of their unique morphology, allowing for anthropomorphic representations. In contrast, the morphology of skates tended to lead to dragon-like creations (see Gudger, 1934).

Interest in guitarfishes modified to resemble mythical creatures increased globally from the 1950s to the early 2000s, capturing the attention of people from different countries, cultures, and fields of study. In the 1950s, the Spanish surrealist Salvador Dalí (Figure 1d) was photographed marveling at a modified guitarfish, and in 1968, American ichthyologist Carl Hubbs included a photo of a modified guitarfish in his *Demons of the Deep* lecture (Figure 1e). In 1974, Alfredo Garcia Garamendi's *Los Garadiávolos* featured a cover with illustrations of modified guitarfishes and spaceships. From 1968 to 2008, at least 2 dozen North American newspapers published stories about modified guitarfishes (Appendices S1-S3). In Indonesia, modified guitarfishes were woven into legends and inspired a superhero guitarfish figurine, *Anak Terkutuk Pariman* (Ray-Man, the Cursed Child) (Nurhamidah et al., 2020) (Appendix S1). Despite records from the early 1930s and increasing interest in modified guitarfishes since the 1950s, trade in modified

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guitarfishes has gone largely unnoticed; key publications on guitarfish trade (e.g., CITES, 2022; Jabado & Abercrombie, 2024; Sherman et al., 2023) fail to mention it.

IMPERILED GUITARFISHES

The shift from using skates to guitarfishes in creating mythical creatures poses a conservation concern. Guitarfishes are one of 5 families of rhino rays (order Rhinopristiformes), one of the most threatened vertebrate groups on the planet (Kyne et al., 2024). Guitarfishes comprise 3 genera: *Acroteriobatus* (10 spp.), *Pseudobatos* (9), and *Rhinobatos* (18) (Kyne et al., 2024). These rays are globally distributed across tropical, subtropical, and temperate waters (Last et al., 2016). Nearly two thirds of all guitarfish species (i.e., 65.7%) assessed by the International Union for Conservation of Nature (IUCN) are categorized as threatened (10 critically endangered, 5 endangered, 8 vulnerable) (IUCN, 2024; Kyne et al., 2024).

Occupying shallow coastal environments, guitarfishes are susceptible to interactions with fisheries, either as targeted species or bycatch (Moore, 2017). Guitarfishes are subject to minimal domestic regulations where they occur, and their harvest and trade are underreported and understudied (Sherman et al., 2023). These rays, in addition to being traded as mythical creatures, are primarily traded as an affordable protein source or a culinary delicacy (e.g., Bizzarro et al., 2009; Gonzalez-Pestana et al., 2024; Seidu et al., 2022). To a lesser extent, they are a component of the shark fin (Cardeñosa et al., 2020, 2024) and aquarium trades (Gurjão & Lotufo, 2018).

Guitarfishes were added to the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) Appendix II in February 2023. Accordingly, member governments are now required to demonstrate that guitarfish exports will not be detrimental to the survival of the species in the wild. The proposal to list guitarfishes on CITES outlined numerous forms of their use and trade, but it overlooked the modified guitarfish trade (CITES, 2022). Despite this, evidence of cross-border trade has been documented in modified guitarfishes (e.g., Dance, 1976), although the extent and scale of trade are highly uncertain.

UNIQUENESS OF MODIFIED GUITARFISHES

Modified guitarfishes come in various forms, with some no longer resembling a guitarfish. This presents identification issues and, therefore, enforcement issues for agencies tasked with managing domestic and international trade. Sixteen forms of modified guitarfishes were found that can be broadly grouped as devil shaped (e.g., Figure 2a–h) or alien shaped (e.g., Figure 2i–p) (Appendices S4 & S5). In devil shapes, the anterior end of the snout is typically cut, and the rostral cartilage is partially or completely removed to give the appearance of devil horns. In alien shapes, the rostral cartilage remains intact. In both forms, the gill arch is often partially (e.g., Figure 2b) or entirely (e.g., Figure 2f,g) removed to create a neck-like appearance and a more menacing facial expression wherein the nostrils of the guitarfish evoke eye-like structures. An hourglass body shape is often achieved by tying a string around the trunk of the guitarfish (e.g., Figure 2e). Finally, what look like legs are created with 2 parallel cuts along the vertebral column, with the vertebral column resembling a tail (e.g., Figure 2h,j).

DRIVERS OF TRADE AND USE OF MODIFIED GUITARFISHES

The drivers of modified guitarfish trade and use appear to be diverse. Despite limited documentation, available accounts highlight cultural, artistic, ornamental, medicinal, and economic drivers. The creation of taxidermied mythical creatures in itself is an artform, demonstrated through the variety of modified guitarfish documented here. These have been displayed as freaks of nature or simply for their curious forms (e.g., Appendix S3). Beyond artistic display, they have been documented entering the tourism curio market in Guatemala (Cano & Palomo-Muñoz, 2017) and elsewhere (Dance, 1976; Timmons & Bray, 1998). Alternative medicine is a significant driver of the exploitation and use of wildlife on a global scale (Alves et al., 2013), including modified guitarfishes. For example, in traditional Mexican medicine, powdered or boiled modified guitarfishes have been proposed as remedies for various conditions, including cancer, arthritis, and anemia (de la Rosa-Meza et al., 2013; Peralta, 1951; B.L.H.-B., personal observation).

Regardless of the final use or product, economic return appears to be a major driver of trade. The income from selling modified guitarfishes can be higher than the revenue from whole fresh guitarfishes. For example, in Mexico's largest fish market, a fresh whole guitarfish is valued at ~US$2 (B.L.H.-B., personal observation). In contrast, a modified guitarfish can sell for US$15–23 in medicinal markets. Even higher prices are seen in online marketplaces where they are sold as curios. Sale prices reach over US$50 in Mexico and are typically US$100–200 in the United States, Canada, and Europe, although they can reach US$500 (B.L.H.-B., personal observation). Examination of value and supply chains would be useful to fully understand the economic drivers of modified guitarfishes and how these compare with other products, such as meat and fins.

CONSERVATION IMPLICATIONS

The species-specific identities of modified guitarfishes are poorly documented. Given the conservation concerns for these imperiled marine fishes, the gaps in knowledge related to their trade, and the international regulations in place, it is imperative to identify and quantify the species commonly marketed as modified guitarfishes. Most modern modified batoids appear to be guitarfishes from the genera *Pseudobatos* or *Rhinobatos*. However, identifying modified guitarfishes based only on morphology is difficult. First, guitarfishes are similar in appearance, and some taxonomic issues remain unresolved (Kyne et al., 2024). Second, unique morphological characteristics are sometimes erased when guitarfishes are modified. Finally, the

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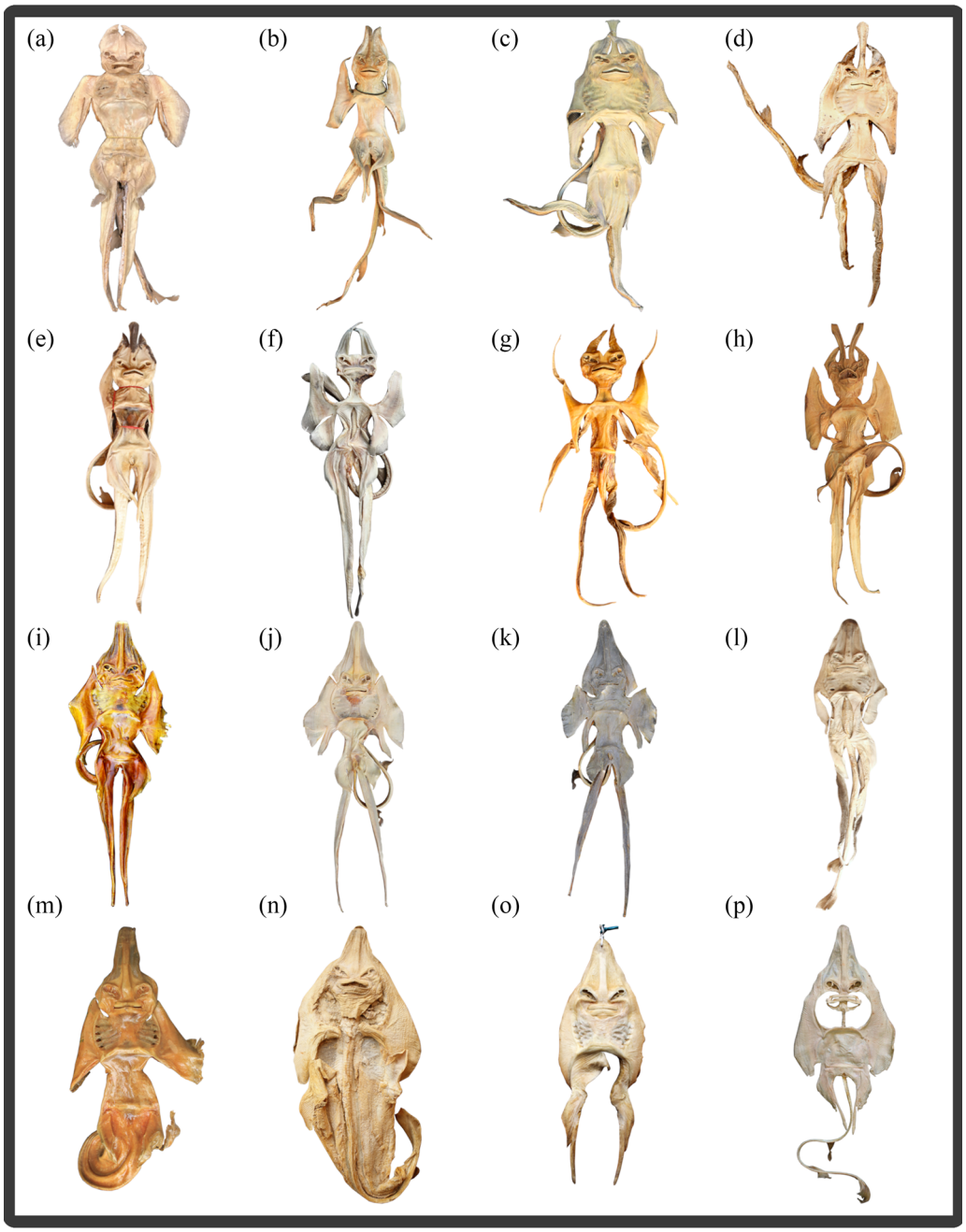

FIGURE 2 Variety in modified guitarfishes. Each artisan or fisher puts different amounts of creativity into producing mythical creatures, resulting in diverse variations. Although each is unique, modified guitarfishes are broadly shaped like anthropomorphic devils (a–h) or aliens (i–p) and traded as curiosities or for medicinal purposes (Appendix S4).

capture origins of modified guitarfishes could be unknown or unreliable. For these reasons, molecular techniques are likely the most effective approach for accurately identifying modified guitarfishes. Genetic identification from a small amount of tissue is minimally invasive and can be done at a low cost with routine methods (Phillips et al., 2009). These techniques have been successfully implemented in wildlife trade (e.g., identifying dried shark fins [Clarke et al., 2006] and ethnomedicinal ray products [Singh et al., 2020]) and can assist with identification for CITES enforcement purposes.

Although modified guitarfishes may be interesting curiosities, greater understanding and awareness of their trade is critical to assessing the full spectrum of guitarfish uses and threats. This can ultimately provide a stronger knowledge baseline to guide their conservation and management.

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