

Identifying critical habitat with archives: 275-year-old naturalist's notes provide high-resolution spatial evidence of long-term core habitat for a critically endangered shark

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1 **Abstract**

2 Historical sources can provide important data for modern-day threatened species conservation,
3 such as identifying formerly important habitat on which to focus recovery efforts. Here we
4 reveal unique written archival material from the 1740s that provides reliable first-hand
5 observations of the Critically Endangered angel shark *Squatina squatina*, extending modern
6 knowledge of this species in Welsh waters back by over half a century. These sources clearly
7 identify small-scale and spatially explicit locations areas of abundance (including of juveniles)
8 around specific reefs that align with more recent data, further strengthening evidence that these
9 areas are of long-term importance that should be prioritised for the global conservation of this
10 species, which has become extinct across much of its former range. These contemporary
11 sources also describe fisheries for angel shark and high desirability, economic value and export
12 trade of their meat, which could suggest that population declines of this intrinsically vulnerable
13 species commenced centuries before modern science detected this. These unique contemporary
14 observations highlight the value that historic material can provide in prioritising resource-
15 limited conservation efforts, as well as helping to reframe our temporal understanding of
16 elasmobranch fish declines.

17

18 **Key words:** historical ecology, conservation, fisheries, elasmobranch, nursery, marine
19 protected area

20 **Running head:** *Historic sources reveal core shark habitat*

21

22 **1. INTRODUCTION**

23 Restoring biodiversity is a major global policy target. However, this is constrained by the fact
24 that modern scientific research or monitoring often started long after declines commenced,
25 resulting in only a partial understanding of past distribution, suitable habitat, and abundance.
26 Historical data sources such as archives can reveal new spatially explicit information on the
27 former distribution and critical habitat of threatened marine species which can inform their
28 conservation, such as humpback whale feeding grounds, shark nursery areas, and turtle nesting
29 beaches (Reeves et al. 2004, McLenachan et al. 2006, 2012, Moore 2018, Thurstan et al. 2022).
30 Historical sources are also gaining broader acknowledgement for their ability to inform
31 ambitious species recovery initiatives like the IUCN Green List of Threatened Species (Grace
32 et al. 2019). As archival material or old texts can by their nature be unique, valuable or fragile,
33 they can be difficult to access, but this is changing with open-access digitisation of resources,
34 such as the Biodiversity Heritage Library (<https://www.biodiversitylibrary.org/>).

35 The angel shark (*Squatina squatina*, Squatinidae) is a medium-sized (ca. 2.44 m total length,
36 TL) shark, with a historic range across shallow seas of the northeast Atlantic. Formerly
37 common, its demersal nature, affinity for sedimentary habitat, and relatively large size make it
38 highly susceptible to a range of fishery gear types. Combined with intrinsic biological
39 vulnerabilities of slow growth and low productivity, this has resulted in widespread local
40 extirpations, and it is now considered Critically Endangered with extinction; it is now only
41 regularly observed in the Canary Islands, and occasionally in Wales and Ireland (Morey et al.,
42 2019).

43 In British waters the decline of *S. squatina* has been known for some time, based on 20th century
44 trawl surveys (Rogers and Ellis 2000). Within Welsh waters, two recent studies have compiled
45 data, including from historical sources, on angel sharks. Hiddink et al. (2019) collated 1860
46 records between 1970 and 2016, and from this estimated a 70% decline in abundance, with a
47 contraction in range to Cardigan Bay. These authors noted a concentration of records in the

48 area around three parallel shingle reefs or causeways (Welsh ‘sarn’, pl. ‘sarnau’) extending
49 northeast-southwest from the coast, across a distance of approximately 40 km from north-south
50 in the northern half of Cardigan Bay, particularly around the Cynfelyn Patches (also known as
51 Sarn Gynfelyn) (Figure 1). Hiddink et al. (2019) suggested these reefs may comprise essential
52 habitat which could be the focus of conservation efforts, such as spatial restrictions on net
53 fisheries to minimise unintended bycatch. The Angel Shark: Wales project gathered additional
54 unique records around the Welsh coast dating back to 1812, and similarly reported the highest
55 concentration in coastal waters of the northern half of Cardigan Bay (Figure 1)(Barker et al.
56 2020). This area included the central reef, Sarn-y-Bwch, which extends from the coast
57 approximately 13 km south-southwest of the town of Barmouth (Figure 1). Here we report on
58 how archive material significantly extends our understanding of angel shark in Welsh waters.

59

60 **2. MATERIALS & METHODS**

61 Lewis Morris (1701-1765) was a Welsh polymath whose life included surveying the entire
62 coast of Wales to produce detailed and accurate maps, and working as a customs officer in
63 Welsh ports, notably the north Wales settlements of Holyhead and Beaumaris (Jenkins, 1959).
64 Morris owned and annotated a copy of the second edition of *De Historia Piscium*, Francis
65 Willughby’s seminal ichthyological work of 1686, a digitised copy of which is available from
66 the National Library of Wales; it is thought Morris made these notes between 1740 and 1747
67 (Morris 1740-1747). In this, Morris provides numerous handwritten observations on fish and
68 fisheries around northern Wales which are often both spatially explicit and accurate based on
69 modern knowledge (Moore, in prep.). Morris also owned a ‘commonplace book’ (undated, but
70 text dates within range from 1736-1754) which included further observations of fish; we
71 examined this in the National Library of Wales. We also examined an original text of Morris’
72 published coastal maps of Wales (“*Plans, harbours and roads of St. George’s Channel...*”),

73 which included notes on ‘natural commodities’ at each location (Morris 1748) in Bangor
74 University Archives and Special Collections. Spellings in quotes are verbatim.

75 3. RESULTS

76 Within the section of *De Historia Piscium* dealing with elasmobranch fishes, digitised page
77 435 of Morris (1740-1747) presents an unmistakable image of an angel shark *Squatina*
78 *squatina*, the only species of this family to occur in British waters. In handwriting above this,
79 Morris notes: “*The monkfish or angelfish. In Wales called Maelgi. They are found in plenty*
80 *about Sarn y Bwch and in Barmouth Bay*”. On the same page, Morris also notes, sketches the
81 ventral surface of, and provides measurements for what is also clearly an angel shark “...which
82 I took A.D. 1739. It was 20 inches [51 cm] long” (Figure 2a). He goes on to note that angel
83 shark were sizeable (“...*generally of the size of a man*”), highly desirable as food (“...*delicious*
84 *eating, said to have 3 sorts of fish on it, a ray, a salmon, and a sturgeon*”), and caught either
85 in targeted or bycatch net fisheries (“*They take them in nets with meshes 10 inches [25 cm] or*
86 *a foot [30 cm] square.*”).

87 In his commonplace book, Morris then provides further additional detail on angel sharks
88 (Morris, undated, p. 5). Along with a reliable description (inc. “*It is rough on the back like the*
89 *common dogfish, & of ash colour. The belly is soft, white and tender. The eyes very small &*
90 *near its snout*”), he notes “*These fish breed in great plenty about Sarn y Bwch & Llwyn Gwryl*
91 *on the coast of Merionethshire [historic county name]*”. He then elaborates on utilisation, trade
92 and fisheries: “*The wings [pectoral fins] of it are exceeding tender, eating like a maiden ray*
93 *[rajid skate, typically thornback ray *Raja clavata*]. The tail like a dogfish, the main body like a*
94 *sturgeon, for which latter fish it is often sold in England by the Welsh fishermen who make*
95 *great gain of it. They are commonly about the bigness of a man, and are taken in nets whose*
96 *mashes [sic] are squares of 10 inches side & sometimes are found entangled in herring nets*”.

97 Morris (undated) also sketches and provides details of what is apparently the same juvenile
98 already mentioned (Figure 2b), but this time provides both ventral and dorsal views (Figure
99 2b) and a capture location: “*The fish by which I took this draught was taken in Holyhead, 1739*
100 *and was but a young one of 20 inches [51 cm] long i.e. 8 inch [20 cm] tail, 12 inch [30 cm]*
101 *body. 11 inch [28 cm] broad at the main wings”.*

102

103 Lastly, in *Plans and harbours*, under Cardigan Bay, Morris (1748, p. 11) has a subheading
104 entitled ‘*Of the monk-fish*’. The first sentence of this provides yet further location data: “*This*
105 *fish breeds in plenty about Sarn Gynfelyn and Sarn y Bwch; and is called by the natives*
106 *Maelgi.*”. He also reiterates his observation on fisheries and desirability: “*It is taken in nets*
107 *made of small ropes, with about ten inches mash [sic], and is reckoned a delicious dish.”*

108 4. DISCUSSION

109 These contemporary observations extend modern knowledge of the Critically Endangered
110 angel sharks in Wales by at least 64 years (cf. 1812 in Barker et al. 2020). Morris can be taken
111 as a reliable source for first-hand observations: his nautical charts of detailed bathymetry
112 demonstrate he had intimate knowledge of the coast, including the sarnau in Cardigan Bay
113 (Morris, 1748). His identifications can also be regarded as accurate based on his sketches and
114 descriptions; possible confusion with the teleost fish *Lophius piscatorius*, sometimes also
115 called ‘monkfish’, can be discounted, as he accurately sketched this species quite separately
116 from *S. squatina* (Morris, undated). His Welsh name for angel shark, maelgi, also aligns with
117 current usage (Barker et al., 2020).

118 The most important aspect of these sources for modern-day conservation is the high-resolution
119 spatial information they provide on core habitat. Collectively, Morris’ notes from nearly 300
120 years ago, and based on his knowledge of the entire Welsh coast, provide information on a

121 specific area of local abundance around two of the sarnau (Sarn-y-Bwch and the Cynfelyn
122 Patches/Sarn Gynfelyn) and two nearby coastal settlements (Barmouth and Llwyngwril, Figure
123 1). Combined with more recent records of Hiddink et al. (2019) and Barker et al. (2020), these
124 therefore significantly strengthen evidence that this relatively small area is of long-term
125 importance to this species.

126 These records also reveal new insights into the life history of angel shark in Welsh waters. The
127 individual Morris reported and accurately sketched from Holyhead would have been within its
128 first few years of life, given that the birth size is 20-30 cm TL (Morey et al. 2019). Morris
129 (undated) clearly knew this (“...*a young one*”). To our knowledge, this is the earliest record of
130 a young angel shark in Welsh waters and possibly much wider, or even of the species as a
131 whole. It also provides valuable rare supporting evidence that young occur in Welsh waters, as
132 only 4% of the records collected by the Angel Shark: Wales project were juveniles (Zoological
133 Society of London 2021).

134 Two of Morris’ observations from northern Cardigan Bay around the sarnau specifically
135 mention breeding (“*breeds in plenty*, “*breeds in great plenty*”; Morris undated, 1748). As
136 Morris was clearly familiar with what a young angel shark looked like, and the entire Welsh
137 coast, this could indicate a nursery area. If so, this is of direct conservation interest, because
138 northern Cardigan Bay was also where the underwater footage of a young angel shark – the
139 first of this species in Welsh waters - was recently captured and reported to media globally
140 (Davies 2021, Zoological Society of London 2021).

141 Collectively these data add further weight to the importance of inshore waters of northern
142 Cardigan Bay, and specifically the relatively small areas around the sarnau, as a global priority
143 for the conservation of this species of angel shark, given its disappearance from much of its
144 former range as a priority for conservation. Having evidence of long-term importance,

145 including as a possible nursery area, provides confidence in the focused targeting of resource-
146 limited conservation efforts, such as research and angler education. The spatially explicit nature
147 of the ‘hotspot’ and the highly threatened status of angel shark, would make this an ideal
148 candidate for an Important Shark Area, an initiative that aims to provide an easily accessible
149 overview of globally recognised, criteria-based selections to further conservation and
150 sustainable management (Moore & Fowler, 2022). In the context of severe declines elsewhere,
151 the reasons for the relative abundance and/or persistence of angel shark in this area are
152 unknown, but it may be that the shallow reef features may have provided a refuge from fisheries
153 interactions, especially the historic trawl fisheries that operated in Cardigan Bay (Moore,
154 unpublished data).

155 Morris’ notes also provide new insights on fisheries, utilisation and trade that significantly
156 extend our temporal understanding of the exploitation of this elasmobranch fish. Angel shark
157 was apparently highly desirable (“*delicious*”, “*exceeding tender*”) and commercially valuable
158 for export trade as counterfeit sturgeon meat (“*often sold in England by the Welsh fishermen*
159 *who make great gain of it*”). Combined with their relatively large body size this would have
160 made them a valuable catch, and Morris’ mention of large-mesh nets suggests they may have
161 been targeted or semi-targeted, in addition to their bycatch in herring nets. Angel sharks were
162 also being caught long before Morris’ time, in Dutch fisheries of the 1500s, and possibly in
163 Scottish fisheries in the 1600s (Bennema & Rijnsdorp 2015, Raye 2018). Combined with their
164 inherent biological vulnerability (e.g. low productivity) already noted, this could suggest that
165 fisheries-induced declines of angel shark commenced long before it was formally documented
166 by modern science around 250 years later (e.g. Rogers & Ellis 2000). This may help re-frame
167 the conventional narrative that declines in elasmobranch abundance are a phenomenon that
168 largely commenced in the 20th century (Brander 1981, Rogers & Ellis 2000, Ferretti et al.,
169 2010, Pacoureaux et al., 2021).

170

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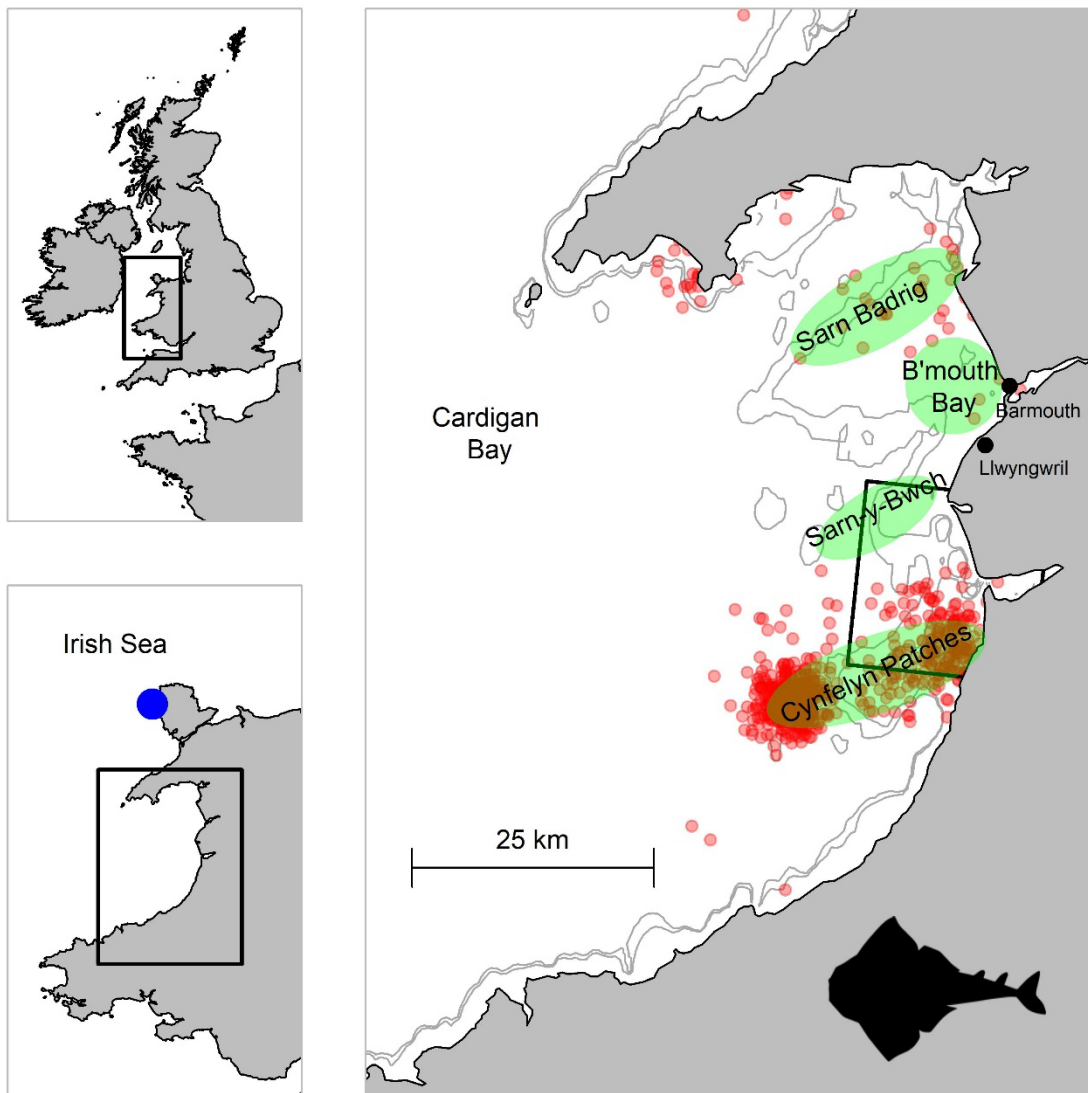
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232



234

235

236 Figure 1. Left (top): British Isles (inset: Wales); left (bottom): Wales (inset: Cardigan Bay).

237 Blue circle shows Holyhead, site of 1739 record of young angel shark *Squatina squatina* (see

238 Figure 2). Right (main image): map of northern Cardigan Bay showing shallow reef ('sarn')

239 features and isobaths (10 and 15 m). Green shading shows areas of angel shark breeding habitat

240 and/or abundance recorded by Lewis Morris in the mid-1700s around Sarn y Bwch, Sarn

241 Gynfelyn (Cynfelyn Patches), Barmouth Bay and Llwyngwril (see text). . Recent angel shark

242 records from 1970-2016 compiled by Hiddink et al., (2019) are shown in red, with density of

243 colour increasing with number of records. All records are jittered (normal distribution with SD
244 = 2000 m). Thick black lines surround the approximate area containing the highest density of
245 angel shark records, Wales-wide, compiled by Barker et al. (2020).

246 Figure 2. A (left) Sketch of ventral surface of young angel shark *Squatina squatina* extracted
247 from Morris (1740-1747) “which I took A.D. 1739. It was 20 inches [51 cm] long”. B) (centre
248 and right). Sketch apparently of the same individual, from Morris (undated) “...taken in
249 Holyhead, 1739, and was but a young one of 20 inches [51 cm]”.

