Remote sensing of boat abandonment using Google EarthTM

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Research Article

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Abstract

Abandoned boats represent a pervasive and growing problem in the coastal zone that have received little regulatory or scientific attention. In this study, we show how Google Earth™ can be employed to remotely identify abandoned boats and provide information on their size, age and condition. Based on specified criteria for abandonment, a survey of southern England (1700 km in length) reveals the presence of 266 boats that are mainly located in the intertidal zones of estuaries and inlets and that are often contained within clusters. Boat length ranged from 2.6 to 60 m (median = 10.5 m) and since 2004 abandonment has been increasing at a rate of about eight per year. The majority of boats appear to be of timber construction and exhibit evidence of damage and water-sediment ingress. The environmental impacts are likely to be most significant where boats are clustered in protected mudflats.

1. Introduction

An abandoned boat is a vessel of any size (e.g., pleasure boat, fishing boat, cargo ship) that has been given up by the legal owner without the intention of reclamation at a later date. Boats are abandoned for a multitude of reasons, but it often comes down to costs. With a life span of around 30-45 years depending on the construction material, boats eventually come to their “end of use” and need to be restored or disposed of safely and sustainably (European Commission, 2017). However, both options are expensive, with the largest boat recycler in the UK, located in Portsmouth, quoting around £100 per foot of hull length for dismantling and material recovery (Practical Boat Owner, 2020). To avoid these costs, owners may remove any means of identification before the boat is left at its mooring, set adrift, sunk or concealed. These practices are often considered to be less “conspicuous” and more “acceptable” at locations where abandoned boats already exist (Turner and Rees, 2016).

It appears to be illegal to abandon a boat in the UK but legislation is unclear and difficult to enforce. The Thames Conservancy Act (1932) refers to removing or destroying “sunk or stranded” vessels at a cost to the owner, and more recently, Environment Agency press releases mention removing “unregistered” boats when they obstruct waterways, damage the environment (principally through oil spillage) or have a significant impact on the aesthetics of the area (Environment Agency, 2017; 2018; 2019; 2020). Coupled with the costs mentioned above, there is, therefore, little incentive to safely dispose of end-of-life or unwanted boats and the problem is predicted to increase (Summerscales et al., 2016; Turner and Rees, 2016).

The Hydrographic Office houses a database on ship wreck locations around the UK derived from insurance claims and boats flagged as a navigation problem (Admiralty Maritime Data Solutions, 2020). However, because abandoned boats are unreported, they are generally excluded. To this end, we present a novel means of remotely and safely identifying and characterising abandoned boats in the coastal zone through the use of Google Earth™ (GE). Specifically, we focus on the south coast of England and systematically examine the scale and locations of the problem and how abandonment has been evolving

over the past two decades in order to identify any environments at risk and assist in any remediation measures or decision-making.

GE was introduced in 2005 as a powerful, interactive platform that superimposes satellite images, aerial photography and GIS data onto a three-dimensional globe. The original imagery has a resolution of 15 m but this is being progressively replaced with improved imagery that allows spatial detail down to 30 cm or less to be observed (Boardman, 2016). Because GE is freely available, easy to use, compatible with other systems and data resources and has a twenty-year timeline range, it is a popular tool in both education and research (Mather et al., 2015; Malarvizhi et al., 2016). GE Earth has been particularly useful in physical and human geography, geology and geomorphology and specific applications here include the mapping, monitoring and management of urban characteristics (San Emeterio and Mering, 2020), river networks (Akawwi, 2013), wetlands (Hoffmann and Winde, 2010), glacial landforms (Darvill et al., 2014), desert dunes (Goudie, 2011), coastal dunes (Turner et al., 2021), droughts (Khan and Gilani, 2021) and shorelines (Warnasuriya et al., 2018).

2. Methods

Abandoned boats were identified between Rye, East Sussex, and Land's End, Cornwall (and including the Isle of Wight), a stretch of coastline of about 1700 km in length and encompassing fourteen unitary authorities (Figure 1). The coast comprises cliff-backed rocky shores, sandy beaches (often backed by cliffs or dunes) and shingle ridges interspersed with rias, estuaries and tidal inlets where ports, harbours and various industries are often located. The entire coastline, including estuaries and inlets up to their tidal limits, was surveyed with GE Pro at an eye altitude of about 200 m and across the range of dates for which suitable imagery was available (between 1999 to 2004 and 2020, and up to fifteen different dates). Where abandoned boats were suspected, eye altitude was decreased to between 50 and 100 m. Here, the approximate spatial resolution, estimated from the smallest objects or details that could be observed, ranged from about 0.3 to 2 m. Where available, imagery from Google Street View, an additional feature of GE Earth that provides interactive panoramas from positions along public streets, was inspected to gain further details about specific boats.

Boats were defined as being abandoned if being they had been in precisely (or approximately) the same position for a period of at least five years and/or met one or more of the following criteria:

- partially or completely sunk
- taking on water
- lack of human activity on-board (e.g., tarps and gear not moved and no evidence of renovation)
- plant growth or rust on the deck
- damage with no attempt to fix (e.g., collapsed wheelhouse, holes in the deck)
- inadequate mooring
- evidence of attempts to conceal (e.g., hidden under trees, located away from public access).

The construction material of each abandoned boat was noted if evident, and the ruler tool and time series imagery in GE Pro were used to determine length to the nearest 0.1 m and date of abandonment, respectively. The latter was defined as the year of first appearance of the boat if successive years of imagery were available or the middle year if annual imagery was absent (i.e. temporal resolution was more irregular).

In many cases, identification of abandoned boats was straightforward in that a vessel would remain at a specific location and undergo decay. Boats could first appear on imagery at a particular date or be present throughout the whole time series recorded. In other cases, identification and characterisation was more complex, as exemplified by the GE imagery of the intertidal zone of Hooe Lake, Plymouth, captured on four dates and that illustrates the evolution in the number and condition of several boats (Figure 2). Thus, boats A and B, of 20.4 m and 9.8 m in length, respectively, are evident on the earliest imagery (December 2002). Boat A remains in the same position throughout the time series to May 2020, but has begun to list by August 2016 and exhibits considerable damage, including by fire, in the most recent image. In contrast, boat B has shifted its precise location, either because of tidal currents or intervention during the mooring or abandonment of other boats and structures, but is nevertheless classed as abandoned. Boats C and D, of lengths of 20.7 m and 17.8 m, respectively, appear in imagery dated April 2007, and while the latter is clearly abandoned and decaying, the former remains moored and appears to have undergone recent modification. Subsequent visits to the location revealed that the boat is undergoing restoration on an intermittent basis and is, not, therefore, classified as abandoned. Boats E (32.0 m) and F (8.0 m) appeared between 2007 and 2010 and in 2016, respectively, and while the former is in poor condition and taking in water, the latter appears to be securely moored and in relatively good condition. Since boat F had been at the same location for only four years, the principal criterion for abandonment was not, therefore, met.

The condition of each abandoned boat in the most recent imagery was categorised as follows:

Intact: Reasonable condition with minor cosmetic damage.

Damaged: Notable cosmetic or physical damage but no evidence of significant sediment or water ingress.

Partially submerged: Partly below water or buried in sediment, often with notable damage.

Broken down: Completely (or almost completely) submerged and/or major damage to the whole structure.

Examples of each category are illustrated in Figure 3.

3. Results And Discussion

3.1. Spatial distribution of abandoned boats

The full data set for the study can be found in the Supplementary Data. Overall, 266 abandoned boats were identified along the southern coast of England from GE Pro imagery, with the vast majority overlooked by the existing Wrecks Areas UK EEZ database (Admiralty Maritime Data Solutions, 2020). This figure is equivalent to an average of one abandoned boat for every 6.4 km of shoreline. However, the geographical distribution of the boats, shown in Figure 1, reveals a high degree of spatial variation. Specifically, the majority of boats ($n = 257$) were encountered on or in the intertidal mudflats and saltmarshes of estuaries and tidal inlets, with just nine boats found above the high water line of (mainly) shingle beaches. This distribution results in significant fractions of abandoned boats being located within protected sites, including 60.4% in Ramsar Wetlands of International Importance and 68.7% in Sites of Special Scientific Interest (SSSI). Presumably, the relatively high density of boats in mudflats and saltmarshes reflects limited public accessibility (especially where the shoreline is industrialised) and ready concealment (and in particular amongst saltmarsh vegetation), as well as the ability of fine, accreting sediment to immobilise large structures.

Many of the boats on intertidal flats were also encountered in distinct clusters of up to twelve boats (with clusters defined as at least two boats within 100 m of each other). The majority of clusters were encountered in the sheltered intertidal flats of estuaries and embayments around Portsmouth, Southampton, Poole and Plymouth (Figure 1). In some cases, clusters appeared to develop over a period through mooring aggregation, and as exemplified in Figure 4. Here, boats abandoned before 1999 in the Itchen Estuary (and illustrated in 2004) were subsequently used for the illegal mooring and abandonment of newer vessels, which in turn were used to moor and abandon further vessels. Over time, a dense cluster has developed (and illustrated in 2016) that is in clear view of housing and businesses and close to one of the main roads into the city centre of Southampton.

Scattered clustering occurs when there is a growth of abandoned boats at a particular locality that are not moored together. This type of clustering is evident in Hooe Lake, Plymouth (Figure 2), and at Lytchett Bay in Poole Harbour (Figure 5) and has been reported in studies of the east coast of England (Turner and Rees, 2016) and Pacific and Caribbean territories of the US (Lord-Boring, et al., 2004). Such locations are perceived to be “convenient” and “acceptable” because they evade any punishment or other repercussions; consequently, they attract successive abandonments by the same or different people over a period of time. These locations often attract the dumping of other structures that may or may not be related to boating activities (and as exemplified in Figure 5).

Event clustering is the sudden, mass abandonment of multiple boats at the same time resulting from an incident. Mass abandonment has been reported in US territories because of extreme weather events (Lord-Boring et al., 2004) but this is unlikely in the UK. More important here might be closures of boating facilities or the withdrawal or replacement of a particular type of vessel. As an example, a cluster of abandoned boats observed in Forton Lake, Portsmouth Harbour (Figure 6), was attributed to an event that pre-dated GE imagery. Specifically, multiple boats were left when a boatyard closed down in 1959, with additional boats being abandoned within the cluster since (Karmy, 2009).

3.2. Characteristics of boats and dates of abandonment

The size distribution of the abandoned boats identified in the present study is shown in Figure 7. Length ranged from 2.6 m to 60 m, with mean and median values of 13.4 m and 10.5 m, respectively, and frequency exhibited a reduction with increasing length. Regarding boat condition, and according to our criteria, 191 were broken down, 43 were damaged, 31 were partly submerged and two were intact. Amongst the abandoned boats, 95 could be defined in terms of their material of construction. Thus, based on colour, texture, panelling and decay, and, where available, imagery generated by Google Street View, 90 were identified as being of timber construction and five were identified as being of steel construction.

Local databases and historical accounts of shipwrecks and other underwater structures mention a few of the larger foreshore boats identified in the present study with abandonment dating back to 1945 (Langley and Small, 1988; The SHIPS Project, 2021). However, and despite GE imagery dating back to 1999 in some areas, the earliest date of recording across the entire region surveyed was 2004. The year of abandonment since this date is shown in terms of cumulative frequency in Figure 8 and reveals a steady increase in the number of boats that averages 8.4 per year and a relationship between cumulative frequency and year of abandonment that is defined by linear regression with statistical significance. Note that this figure is not offset by boat recovery as none of the abandoned vessels identified were removed from their locations during the time period surveyed.

3.3. Environmental impacts of boat abandonment

GE provides a convenient and novel means of remotely assessing the scale and evolution of a pervasive problem that has thus far received very little systematic or scientific attention. The findings of this study reveal that boats are most commonly abandoned in the intertidal zone of estuaries and inlets and, for a number of reasons, abandonment is often observed in distinct clusters. Along the south coast of England, abandonment frequently occurs in areas that are protected and is increasing at a rate of about eight boats per year.

Remote monitoring of abandoned boats, will not, however, provide information on the significance of the problem, and in the UK intervention from the Environmental Agency will only take place if there is an immediate or visible navigation or pollution threat. The latter is generally restricted to leaking oil (Turner and Rees, 2016), with impacts associated with human safety, habitat loss and access to the shoreline not generally considered. A longer term pollution risk to the environment that is also overlooked by the authorities is the gradual loss of antifouling hull paint particles into intertidal sediments. On older boats, these paints may contain substances based on mercury, lead and tributyltin that have been restricted or banned for decades (Rees et al., 2014; Lagerström et al., 2017). Empirical evidence in the literature suggests that antifouling paint particles based on various contemporary and historical formulations are toxic to many marine plants and animals at environmentally realistic concentrations (Soroldoni, et al., 2018; 2020; Muller-Karanassos et al., 2019). In this regard, some of the areas surveyed in the present study would appear to be at particular risk. For instance, Lytchett Bay (Figure 6) is both an SSSI and a Ramsar Site and had the highest concentration of abandoned boats across southern England (27 on about 1 km² of mudflats). According to the Dorset Wildlife Trust (2021), the area is crucial for wading

birds, fish, invertebrates and amphibians and is also a destination for migrant birds which rely on invertebrates inhabiting the mud for food.

To conclude, the approach described in the present study serves as a useful means of determining the scale and evolution of the problem of boat abandonment in the coastal zone. Although the precise environmental impacts of abandoned boats will require in situ monitoring, remote sensing can help to identify sensitive or remote areas at risk and regions where abandonment is rapidly increasing in order to assist with any decision- and policy-making and guide intervention strategies.

Declarations

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Ethical approval

Not applicable

Consent to participate

Not applicable

Author contribution MP: methodology, formal analysis, investigation, resources, data curation, writing—original. AT: conceptualization, methodology, formal analysis, investigation, writing —original draft, writing—review and editing, visualization, supervision, and project administration.

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Figures

Figure 1

The area surveyed along the south coast of England from Rye to Land's End and the location of boats abandoned in estuaries (and inlets) and on beaches.

Figure 2

GE imagery of a region of Hooe Lake, Plymouth (50°21'22"N, 4°06'28"W), where boat abandonment has been increasing over the past twenty years. Dates are shown as month/year and boats labelled in each image are described in the text.

Figure 3

(a) A broken down boat in Tipner Lake, Portsmouth (50°49'38.29"N, 1°05'18.86"W), (b) an abandoned boat, hull facing upwards, in reasonable condition (intact) and with the hull facing upwards on the Exe Estuary (50°40'53.81"N, 3°28'03.65"W), (c) a damaged but floating boat on the Itchen Estuary (50°55'08.46"N, 1°23'05.17"W), and (d) a partially submerged and concealed boat in a creek off Southampton Water (50°53'39.19"N, 1°25'35.00"W).

Figure 4

Evolution of a cluster of abandoned boats on the Itchen Estuary ($50^{\circ}54'57''\text{N}$, $1^{\circ}22'55''\text{W}$) between (a) 2004 and (b) 2016.

Figure 5

A cluster of abandoned boats (A to E) in Lytchett Bay ($50^{\circ}43'53''\text{N}$, $2^{\circ}02'10''\text{W}$). Note the presence of an additional, rectangular structure (F) that has been dumped at the location.

Figure 6

Clustering of abandoned boats in Forton Lake, Portsmouth Harbour ($50^{\circ}48'11''\text{N}$, $1^{\circ}07'57''\text{W}$). Most boats, including those partly submerged in the sediment, were abandoned following the closure of a boatyard in 1959, but boat A appeared in 2015.

Figure 7

Size distribution of the abandoned boats identified along the south coast of England.

Figure 8

Cumulative frequency distribution of date of boat abandonment along the south coast of England. The regression (solid line) is defined by the parameters annotated.

Supplementary Files

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- [PayneandTurnersupportinginformation.xlsx](#)