Does local marine conservation work? A case study of bait collection in the UK

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Bait collection – the harvesting of organisms for use as bait for sea angling – has been an integral part of coastal life for generations. There are an estimated one million UK anglers fishing in the sea and tens of millions worldwide, all of whom rely on bait for fishing, with the vast majority collecting bait from the wild. In recent years, bait collection has become a highly contentious issue, often polarising anglers, local communities and those managing marine coastal resources; it has even led to incidents of intimidation and violence. Marine ecosystems face increasing threats from human activities and it is now recognised that management of bait collection is a high priority in coastal marine protected areas. This article looks at our current research on this topic and discusses how successful local management has been in meeting its objectives. Locally driven approaches also have high relevance for a diverse range of human impacts on the coast, from recreational activities to fishing. As the marine conservationists' management toolbox is under ever-increasing financial pressure these types of schemes are likely to be increasingly used as they are often relatively cheap to implement and run.

Although some aquaculture companies have been able to carve a niche out of the bait market, the majority of bait organisms will be collected from the wild. Indeed many anglers prefer wild caught bait due to its greater 'wriggle ability', superior colour and smell – all essential in making your next big catch! A bait collector might be an occasional angler who needs to collect some bait for a weekend fishing trip or a match angler who is fishing several times per week and might collect a considerable quantity (several kilograms) and then store it. There are also commercial diggers who collect bait to sell to tackle shops or online, and often move around the country in organised groups.

In recent years bait collection has become a highly contentious issue. In the UK, ragworms (e.g. *Nereis virens*) and lugworms (e.g. *Arenicola marina*) (see Figure 1) are the two major groups collected, but many other species, such as soft-shelled shore crabs (*Carcinus maenas*), razor shells (*Ensis* spp.) and cat worms (*Nephtys* spp.),

Figure 1 ***Left*** *The king ragworm (*Nereis virens*), the most collected species in the UK.* ***Right*** *The lugworm (*Arenicola marina*). King ragworms are typically 10–50 cm long, and lugworms 5–20 cm long.*

Ragworms and lugworms – both polychaetes – are an ecologically important part of the marine benthic community

are also used, depending on season, personal preference and the species of fish to be caught. *N. virens* is the most commonly exploited species in the UK and is collected by manual turning of the sediment with a garden fork, usually to a depth of 30 cm. Experienced collectors can identify burrow entrances and then target-dig worms, but the more usual approach is to dig a trench and remove exposed worms. Some species such as the black lug (*A. defodiens*) live in burrows up to 1 m deep, and collecting these involves using a bait pump. A bait pump is a stainless steel tube with a plunger: the tube is inserted into the sediment and pulling the plunger removes a core of sand, which will (hopefully) include the worm. Bait dragging, which involves dragging rakes (30–40 cm long) behind a boat at high water, is another method for collecting *N. virens*. This method is unique to Poole Harbour on the south coast of the UK, due to the unusual conditions found there – the exceptionally soft sediment makes access difficult, and the double high water and small tidal range mean that it is only exposed for a short period of time.

Ecological impacts

The impacts of bait collection have received considerable attention over the last 30 years. Physical characteristics of the shore are altered, with the production of mounds and troughs being the most obvious result (Figure 2). These topographic changes redistribute organic material, which accumulates in the depressions, and there is a loss of the finer grained particles as they are resuspended in the water column. Not surprisingly, bait collection also results in significant changes in the size/age structure of exploited populations, but in a somewhat counterintuitive way. Dug sites have significantly higher densities of *N. virens* than unexploited sites, but individuals here are smaller. This is because although *N. virens* feeds on a wide range of other invertebrates it also has cannibalistic tendencies, and removal of the larger individuals from the sediment allows more of the smaller ones to survive.

By contrast, other long-lived, larger and less abundant invertebrate species suffer significant and long lasting reductions; these include cockles (*Cerastoderma edule*), burrowing sea urchins (*Echinocardium cordatum*) and other polychaetes (e.g. *Neoamphitrite figulus* and its associated scale worm, *Harmothoë glabra*). Our recent work has also shown that areas dug repeatedly have a different macrofaunal community structure at the hectare scale, as shown by the clear separation of points corresponding to 'dug' and 'undug' points in Figure 3 (*opposite*). For example, an increase in the abundance of *Hydrobia ulvae* is associated with undug areas on the mid shore, while increasing relative abundances of nematodes are associated with both dug and undug areas on the mid shore and dug areas on the low shore.

There is also some evidence that wading bird populations are disturbed by the presence of diggers on the shore and are affected indirectly by a reduction in prey densities. Bait collection can also adversely affect many shore users. Unfilled holes are a hazard, whilst moorings, jetties and boats can be damaged or undermined.

Conflict with coastal conservation?

European Marine Sites (EMS) were set up to manage marine and coastal resources in a sustainable way. They include internationally important marine sites designated under the EU *Habitats Directive* and *Birds Directive,* i.e. Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). SACs provide increased protection to a variety of wild animals, plants and habitats, as part of efforts to conserve global biodiversity,

Figure 2 *Intertidal sediment in Poole Harbour showing the topographic changes caused by bait collection.*

Bait collection produces mounds and troughs in which organic material collects

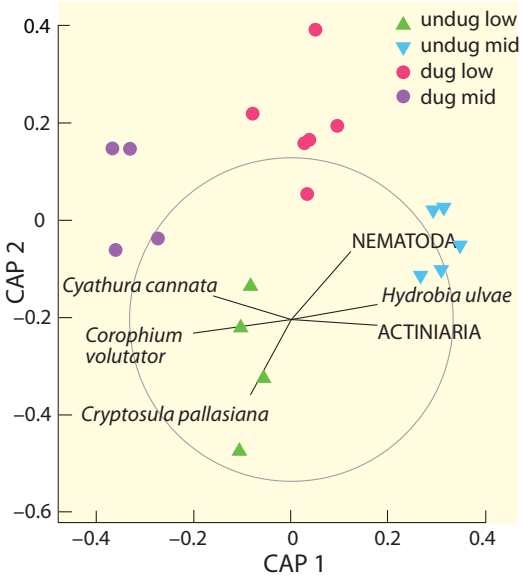

Figure 3 *CAP (Canonical Analysis for Principal Components) plot for square-root transformed macrofauna community data (abundance and diversity of all recorded species) from low and mid shore cores taken from Dell Quay. CAP is a way of finding axes through the multivariate cloud of data points (macrofaunal abundance data collected from sediment cores taken from the sites) that have the strongest correlation with variables, in this case, height on shore and presence/absence of digging. The axes are linear combinations of the orthonormal principal components axes. The community differs between dug and undug sites, but there are also differences between low and mid shore areas (shown by the groupings).*

A visually exploratory vector overlay of macrofaunal species (higher taxonomic levels in capitals) is overlaid (only vectors with length >0.4 are shown; the circle has radius = 1.0). The length and direction of each vector indicates the strength and sign, respectively, of the relationship between that variable and the axes.

The abundance and diversity of the various macrofauna living on the shoreline depend on the height of the site on the shore, and whether or not it has been dug

and SPAs have been identified as of international importance for the breeding, feeding, wintering or migration of rare and vulnerable species of birds found within the EU. However, as EMSs have been established in areas where many human activities were already occurring, the aim was not to exclude these activities, but to ensure that they are undertaken in ways that do not threaten the nature conservation interest,

In the Solent, extensive harbour and estuary systems that include soft sediment shores, combined with up to 60 000 active sea anglers, allows great scope for bait collection (and for stakeholder disputes that are hard to resolve). In fact, it is difficult to find an easily accessible area of mud supporting high numbers of the target species that is untouched. However, the Solent EMS (as well as many other areas around the UK) contains a number SACs and SPAs as well as Ramsar* sites, SSSIs and local nature reserves (cf. Figure 4 overleaf). Intertidal mud flats, sand flats and estuaries are key habitats for the SACs, and many sites are also SPAs as they are internationally important for overwintering wildfowl and wading birds; intertidal mud flats are highlighted in the EU Directives as being important habitats for feeding. More generally, those areas, features and species listed in *Annex 1* of the relevant directives are required to be conserved and protected.

In other countries, intertidal activities such as clam-digging have been banned or controlled. After extensive legal discussions and a number of public enquiries, bait collection in the UK remains a public right and so cannot be extinguished, but it can be regulated indirectly by a variety of local authority, public health, conservation, fisheries and harbour authority byelaws. This public right only extends to the collection for personal use as there is no legal right to take worms commercially, without the permission of the landowner.

Effective conservation management is integrally linked to well designed monitoring and evaluation systems. It must have clear objectives, community and scientific involvement from the beginning, and the schemes must be founded on up-to-date and locally based science, which performance can be set against. Unfortunately, many conservation schemes have serendipitous origins, taking advantage of politically expedient opportunities. Management of bait collection in the UK has been at a local level and this has resulted in the implementation of a range of site-specific management strategies that, in places like the Solent, can run concurrently and are in close proximity to each other. Their implementation has been a significant step forward, but any scheme must be evaluated in relation to how well it meets its primary objective. My research group based at the Institute of Marine Sciences of the University of Portsmouth has focussed on the efficacy of these management strategies as, to date, there has been no quantitative evaluation in the UK.

Management methods

Zonation

Marine Protected Areas (MPAs) are defined as areas in which certain uses are regulated to protect natural resources, biodiversity, or human livelihoods, and they have become a major focus of marine conservation. Their establishment, positioning and extent of coverage are currently hot topics of scientific and conservation debate as the UK grapples with establishing a coherent network of Marine Conservation Zones through the *Marine and Coastal Access Act* (2009). MPAs that use zonation – the exclusion of an activity from a site or for a particular period of time – are one of the most popular methods, gaining worldwide usage since the first marine reserves were established. Two sites in the Solent, which have

*Ramsar sites are wetlands of international importance, designated under the *Convention on Wetlands of International Importance, especially as Waterfowl Habitat*, signed at Ramsar in Iran in 1971.

An area such as the Solent may contain several different kinds of marine protected areas, perhaps with various serendipitous origins

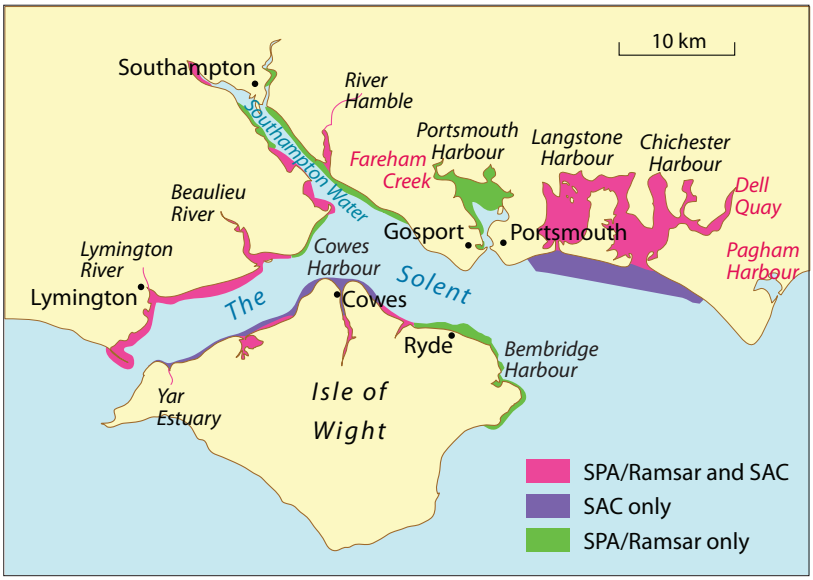

Figure 4 *Map of the Solent area with the names of the three study sites discussed in this article shown in red. (For explanations of SCAs, SPAs and Ramsar sites see p. 37.)*

spatial zonation at the core of their bait collection management, were used as case studies. These were Fareham Creek and Dell Quay (labelled in red in Figure 4). At Fareham Creek, a key collection area in Portsmouth Harbour, a Special Nature Conservation Order (SNCO) was established in 2003–4 to prevent commercial digging. The aim was to protect core parts of an intertidal area deemed unique to its SPA status using Natural Habitats regulations. At Dell Quay in Chichester Harbour (Figure 5), a byelaw prohibiting bait collection within 15 m of any mooring, or 6 m of any structure, was established by Chichester Harbour Conservancy Council with the aim of minimising damage and risk of injury to people.

Although data show that Dell Quay is a very popular site for bait collection (with up to 14 collectors present on one tide), very few diggers were observed within the protected zones (Figure 6); these observations were supported by mapping of the biotopes (areas of distinct habitat supporting specific communities of species), which showed that areas of dug sediment were nearly always located in unprotected areas (Figures 5 and 6).

At Dell Quay bait collectors respected the official exclusion zones

Figure 5 *Location of sediment areas of Dell Quay identified during the biotope survey as having been dug over for bait collection (red) along with the 15 m radius exclusion zones around moorings (purple circles) and 6 m exclusion zones adjacent to jetties/quays (yellow), established using the byelaw.*

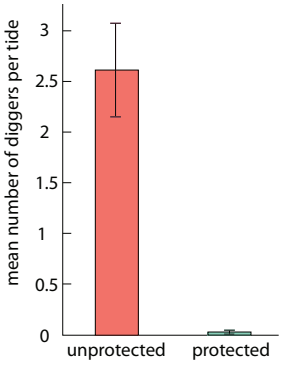

Figure 6 *Mean number of diggers per tide (± standard error of the mean) recorded on video within unprotected and protected areas (i.e. exclusion zones) at Dell Quay. Data are from two camera deployments (51 day and night tides in total), and show a statistically significant difference.*

Cameras are a cost-effective way of monitoring protected areas of shoreline

Figure 7 *Examples of deployment locations for CCTV cameras used at Pagham Harbour to record bait collection activity. Cameras run using leisure batteries or mains electricity.*

Fareham Creek was not as popular as Dell Quay, but still had significant levels of digging activity recorded inside and outside the area covered by the SNCO. This mirrors the patchy nature of areas which the biotope survey of the site showed were dug. It is theoretically possible that all digging within the SNCO area was for personal use only, but the CCTV video observations (Figure 6), history of the site and our own observations make this highly unlikely, suggesting a disregard for the relevant byelaw and, therefore, failure of the spatial zonation approach.

For our third case study we chose Pagham Harbour (Figure 4), a site located at the east end of the Solent, approximately 10 km from Chichester. This site is not within the Solent EMS, but is a local nature reserve and has SPA status. It was not possible to assess the effectiveness of the management methods as no diggers were observed from over 30 tidal cycles of recordings and only a very small amount of dug sediment was mapped during the biotope survey. Bait collection at this site is controlled by enacting National Nature Reserve byelaws through a combination of temporal and spatial zonation. Collection is restricted to two areas with alternate 6-month access to each to protect soft-sediment habitats and wading birds for the SPA status.

At Dell Quay, the regular and sustained 'unofficial' enforcement by officers of Chichester Harbour Conservancy is likely to contribute greatly to the success of the byelaw at this site, helped by the obvious nature of the protected structures (moorings, jetties etc.). This is in clear contrast to a lack of enforcement at Fareham Creek, combined with the difficulties of having merely a line on a map. In addition, even though the police and agencies were regularly contacted by the public to enforce the SNCO they have been unable to act on these reports due to the difficulties of separating commercial digging from personal use. In Pagham Harbour, rather than indicating a successful zonation system, the lack of activity is more likely to be because of the distance of the harbour from conurbations, and the distance from the car park to the digging areas.

Education

Education via stakeholder involvement is seen as a critical tool for the communication and promotion of conservation aims, because it stimulates support, and encourages a sense of ownership and buy-in to a conservation project. Understanding how people think about issues, their knowledge, beliefs, attitudes and values is crucial in the search for coastal management solutions. Education aimed at increasing awareness, reducing impacts and increasing sustainability, can be either active or passve: stakeholders can become involved through (say) workshops or focus groups, or may simply respond to signage or leaflets. In response to the commercial collection occurring at Fareham Creek a voluntary code of conduct was developed by stakeholders (conservation agencies, bait diggers and other local NGOs). The code, which is set out in a leaflet, includes ten points of which only five (cf. Table 1) relate directly to bait collection. The others cover general shore and countryside awareness and safety. The production of 42 000 leaflets distributed within the Solent region, and posters for information boards, were used to maximise exposure.

Table 1 *The key statements relating to reducing the impacts of bait collection, as set out in the Bait Collectors' Code*

- **Observe local byelaws; only dig in permitted areas**
- **Collect bait in a sustainable fashion**
  - Avoid damaging other animals, take only what is necessary
  - Do not take spawning worms
  - Store bait to minimise mortality
  - Return unused bait to similar areas
- **Back-fill holes, for safety and to maintin intertidal habitat**
- **Avoid disturbing wildlife (Including birds and marine mammals) and marine heritage**
- **Do not dig near moorings, slipways or sea walls**

Survey responses collected during visits to fishing tackle shops initially indicated that the Bait Collectors' Code seemed to be working well, with the majority of respondents having heard of it and saying that they follow the code. However, nearly all of the bait-specific points in the code are standard practice for most experienced diggers. For example, diggers routinely collect only what is needed, select larger worms, but avoid spawning ragworms as they do not remain intact on a hook. The fact that the code largely describes what people do already is likely to explain why the majority of the respondents said they follow the code.

Back-filling of holes has always been promoted as best environmental practice, but was also thought of as a way to turnover sediment with minimal effort. It was, therefore, a surprise to see the data show that 100% of observed diggers were disregarding this part of the code.

Our research therefore shows that the voluntary code has had little demonstrable positive impact on changing behaviour, as diggers were already doing many of those things recommended in the code, but were not persuaded to do anything new. These issues, combined with the code's influence being severely limited by the inability to reach all diggers, have meant this passive educational approach to management has not been successful. Education must also have 'teeth' to move stakeholders towards change.

Licences and quotas

As part of the management system for Pagham Harbour, approximately 18 permits to fish and collect bait were issued in the early 1990s. Although the permitting system has now been rescinded in this harbour, it is commonly used elsewhere, e.g. in the case of freshwater rod licences issued by the Environment Agency. Even bait collection on the east coast of the USA has a licensing programme, with approximately 1000 licensed diggers who can dig a range of invertebrates including clams and worms. Licences for bait collection in the UK have some support from the industry and from anglers. A licensing system has the benefit of being a method to rapidly assess the number of people performing an activity and also control who does it. However, numbers of licences do not accurately represent actual levels of bait-collecting activity on the shore. For example, CCTV recordings show that some diggers spend only a few minutes digging, but others are often present for over three hours. The frequency of visits is also dependent on need: a match angler may go a number of times a week, whilst an occasional angler may only go once every few months. In addition, it is not easy to assess scientifically what a sustainable level of digging might be for a particular vulnerable habitat. For these reasons, matching the number of issued licenses to the 'correct' level of activity would be impossible.

Often associated with licensing and permitting is the issuing of bag limits; Pagham Harbour also had a limit of 0.5 kg per visit as a condition of the licence. The variability in digging effort between sites, dates and individual diggers, and the fact that *N. virens* can be stored for several weeks using just a fridge, some coral sand and seawater, make any limit unrepresentative of the full spectrum of fishing. The question of what an appropriate bag limit mighe be also suffers similar problems to how many licences can be issued while still meeting the management objectives. The difficulties of enforcing licensing and bag limits, and of setting an appropriate price that is high enough to cover costs for strap-cashed public organisations but low enough to ensure uptake, not to mention that bait collection for personal use is a public right, currently all make these methods impractical in the UK.

Some golden rules for local management for conservation

Over the last few years, research on bait collection, including our own studies, has provided baseline data from which a number of general 'rules' can be applied to its management throughout the UK. However, it is also clear that many of these 'lessons' can be applied to local conservation strategies for a wide range of habitats and species that are under exploitation pressure. Here are some of the golden rules:

First, scientifically assess the problem

Plans to manage a resource must first scientifically assess the level of impact at the site. For example, Pagham Harbour has low levels of bait collection, so bag limits and a permit system, combined with temporal and spatial zonation, would be overkill. In other words, implementation of the correct level and extent of management must match the actual (not perceived) pressure at a site.

Build in evaluation

The *ad hoc* way local bait-collection management schemes have been established, and the fact that some were not evaluated until several years after they were set up, highlights a common problem of local conservation management. Any strategy must be established with scientific evaluation and assessment integrated from the start. A BACI (Before, After Control and Impact) or similar approach must be utilised. Although more costly in time and money, ultimately it will provide the data for evidence-based management.

Don't forget local geography!

The differences between the three geographically close sites used as our case studies confirm that any management must be site-specific and tailored to local needs – one size will not fit all. However, it is also important to have regional (or national) level management strategies to minimise displacement of diggers from one site to another, provide parity between regions and simplify the management process.

Consider legal aspects

As mentioned above, the public right to collect bait only extends to collection for personal use; there is no legal right to take worms commercially without the permission of the landowner. It is impossible to separate commercial from personal use in any meaningful way so any management methods must control both types, as the impacts are the same. Ideally, the legal status of the exploited resource (e.g. whether it comes under fisheries or habitat legislation) must be clearly understood before initiating the management process. If this is not the case, any management may be legally challenged, getting bogged down in the legal and public enquiry systems until resolved by case law. (Bait collection is a good example of where case law has not provided workable guidance for management.)

Enforce, or there's just a line on a map

Enforcement is critical to any conservation management (voluntary or backed by statute). Comparisons with Dell Quay and Fareham Creek, and the evaluation of the effectiveness of the Bait Collectors' Code, show that enforcement must mean deployment of people on the ground because signage, leaflets and other passive mechanisms are ineffective in reaching and educating all stakeholders and ensuring that the rules are adhered to.

The difficulty in policing a large number of inshore activities is exemplified by the Inshore Fisheries Conservation Agencies (IFCAs). As an example, the Southern IFCA's jurisdiction covers the Dorset, Hampshire and Isle of Wight coastline (~ 680 km), extending out to 6 nautical miles. However, financial constraints mean that management falls to just a few officers. Targeted approaches to 'hot spots' or areas of concern are used frequently, but it would still require substantial investment in direct observation, and considerable human resources, to monitor and gather appropriate levels of data.

A complementary approach would be to use CCTV (Figure 7) or even UAVs (Unmanned Aerial Vehicles). CCTV is now an everyday part of our lives and is integral to crime prevention and detection. The step-change in technology seen in recent years – analytic software with motion tracking, facial recognition for CCTV, and cheap, build-your-own smartphone-driven UAVs – would make possible cost-effective systems for monitoring and gathering evidence on many inshore activities, including bait collection. They could even be used for enforcement in areas which are difficult to access or remote; also covering activities such as bait collection which we know can often occur at any time of day or night. CCTV and UAVs that can do these sorts of jobs are technologically possible now, but there are a number of issues that would need to be resolved around the *Data Protection Act* (2008) and the *Regulatory Investigative Powers Act* (2000), not to mention authorisation by the Civil Aviation Authority for UAVs. The general public would need to accept this 'surveillance conservation' but might be reassured by the fact that the presence of CCTV and AUVs might reduce crime rates generally.

The future

There is an urgent need to stem the increasing threats to marine resources, notably overfishing, pollution and coastal development. There is also no shortage of regulatory requirements for on-going monitoring of key ecological indicators or of assessments of the condition of coastal resources (e.g. the *Marine Strategy Framework* and *Water Framework Directives*; the new EMS guidance on commercial fishing, and the up and coming MCZs). However, legal statutes have no effect without scientific monitoring on the ground. As our research on bait collection has shown, as long as the golden rules are followed, locally driven conservation methods, which are also relatively cheap, have the power to deliver effective management to help reduce the impacts of these threats now and for the future. Unfortunately, we need to remember that financial constraints on conservation science have never been greater, and the ability to do more with less can only be taken so far!

Further Reading

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