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## Port dumping and participation in England: Developing an ecosystem approach through local ecological knowledge

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### 1. Introduction

Globally, disposal from dredging continues to increase in this era of the blue capitalocene; a marine era dominated by capital and humans (Anbleyth-Evans, 2018b). Demand for larger ports and shipping is resulting in persistent changes to ecosystems (de Jonge et al., 2014), altering benthic community structure and reducing species richness and biodiversity (Ware et al., 2010; Bolam et al., 2016). From the expansion of the Panama Canal (Meek, 1923), to the beginning of the Nicaraguan Canal (Goffman, 1968), to the decrease of the seabed of the River Scheldt, and the construction of multiple ports in India, Australia (Goffman, 1968), China, Malaysia, and beyond (Manap and Voulvovs, 2015), anthropogenic ecological change continues without local communities enjoying parity of participation in an environmentally just form. Many ports and harbours around the world, including Britain's, are situated at river mouths, meaning that ports must conduct dredging to ensure that approach channels are sufficiently deep for vessels, and the amount of dredged material has increased over time, due to increasing draughts (Sys et al., 2008).

While off-shore dumping might seem insignificant from land, the ecological impacts are significant to local communities, while dumping decision-making are based on national demands for economic growth (Mansfield, 2004; Pinkerton and Davis, 2015). Realising environmental justice requires using an ecosystem approach to inform governance by integrating local and expert knowledge (Agyeman, 2005). The case studies from Southern England presented here demonstrate

a broader international significance: the value of marine local ecological knowledge (LEK), that is the knowledge of non-scientists working in ecosystems, who experience an evolving influence from science, technology, and governance (Anbleyth-Evans, 2018b).

Local democratic decision-making on ecological-process impacts can include local expertise in participation and development while improving overall understanding. Participation can lead to adaptive co-management, with LEK detecting changes through monitoring (Armitage et al., 2009). However, integrating LEK into governmental monitoring and equalising power structures remains challenging, as different forms of evidence are not treated equally (Anbleyth-Evans and Lacy, 2019). Indeed, there is a need for the democratisation of the process, which would include how different value systems couch different forms of evidence.

Marine LEK can play an enhanced role in ecological monitoring, filling gaps that scientists cannot reach (Wilson and Kleban, 1992; Pauly, 1995; Johannes et al., 2008). LEK's participation in marine governance is not adequately acknowledged, with increased knowledge-sharing between fishers and scientists influencing scientific research, and with feedbacks returning to coastal communities (Anbleyth-Evans, 2018a). In this way, marine LEK can inform the ecological norms of civil society, and a better-informed society may have a greater appetite for stronger sustainability solutions (Eagle et al., 2018). LEK can be linked to impact assessment on other cultural services, which it can preserve by identifying ecological risks. It shows why certain forms of evidence are validated while others are not, un-

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derlining why a major shift in political governance is needed in order to realise the parity of participation that is possible through decentralisation of marine governance.

Here, we use a case-study approach, utilising two locales in Southern England to examine the ways that marine LEK was marshalled in order to improve local governance of areas affected by dumping of dredged sediments from nearby ports. Our objective was to (a) demonstrate the value of marine stakeholders' LEK in port development and dumping and provide a participatory mechanism for its inclusion, and (b) indicates how LEK can spotlight environmental injustice.

**2. Literature review**

Our literature review is based on the literature explored in Anbleyth-Evans (2018b). All standard marine journals were explored; key words, including 'marine governance', 'contamination', 'pollution', and 'biodiversity', were searched online and in library collections.

**2.1. Marine governance and port disposal**

Sediment dumping decreases benthic biodiversity through sediment resuspension and sedimentation (Balchand and Rasheed, 2000), resulting in reduced benthic biodiversity and lowered ecological resilience (Bolam et al., 2016). Recycling this material reduces potential impacts to marine environments and ecosystems. Furthermore, there are powerful economic arguments for ports to minimise sea disposal (Murray, 2008). While the policy of the Department for Environment, Fisheries and Rural Affairs (DEFRA) in the UK has officially been to follow the EU Waste Framework Directive, the Centre for Environment, Fisheries and Aquaculture Sciences (CEFAS) states that such schemes are 'practically, environmentally, and financially prohibitive' (Cefas, 2005), effectively making marine dumping the *de facto* favoured policy.

English marine governance related with offshore sediment dumping from ports is defined by the Marine and Coastal Access Act 2009 (MCAA) and the Environmental Impact Assessment (EIA) Regulations 2017, with the Marine Management Organisation (MMO) being the final decision-maker. The MCAA makes all works from below Mean High Water Springs (MHWS) up to the tidal limit licensable by the MMO (Lonsdale et al., 2017), and the MMO is not legally obliged to answer to the public (Appleby and Jones, 2012). The process sees the

MMO ask for statutory advice from CEFAS, the Environment Agency, and Natural England, and the Inshore Fisheries and Conservation Authorities (IFCAs), who all answer to DEFRA (Fig. 1). The MMO also asks for advice from Trinity House and the Maritime and Coastguard Agency for navigation concerns. Once the MMO has taken the advice, it will make a decision, which is to give a license, unless there is a concern under the Conservation of Habitats and Species Regulations (2018) that a significant impact could occur to a Marine Protected Area, a Special Protected Area, or a Marine Conservation Zone (MCZ), under the Marine Strategy Framework Directive 2008, following an appropriate assessment. It is worth mentioning that when there is a significantly strong economic case, the MMO can use Imperative Reasons of Overriding Public Interest to push through development, even if there is an ecological impact, through compensation or mitigation offsets.

The MMO also allows the general public to submit comments, and advertises its public comment periods in two local papers for two weeks. There is no legal requirement that they listen to these comments. The MMO must, however, respond to clients seeking to pay for marine licences. In the case of dumping at sea, this is primarily commercial ports, and the second case reported in this paper features the Royal Navy. The MMO has co-decision-making obligations, but lacks a framework for considering local community stakeholder concerns or marine LEK.

UK's EIA regulations state that public participation is intrinsic to the process, but they lack clear guidance for integrating community or marine LEK (Lonsdale et al., 2017). Regulators often interpret LEK as non-scientific knowledge, and the use of such knowledge in monitoring activities is virtually non-existent (Wynne, 2012). For example, while the Convention on Biodiversity showed that 63% of indicators could involve community 'citizen scientists' (Danielsen et al., 2014), there is only superficial implementation and a failure to integrate citizen science into 'mainstream' scientific research (Cigliano et al., 2015). This, despite monitoring being acknowledged as important in producing new knowledge for the scientific community, and producing social norms and informing society (de Jonge et al., 2012).

**2.2. Marine governance, participation, and LEK**

LEK derives from the continuous experience of non-scientists recording and working in ecosystems (Anbleyth-Evans, 2018b),

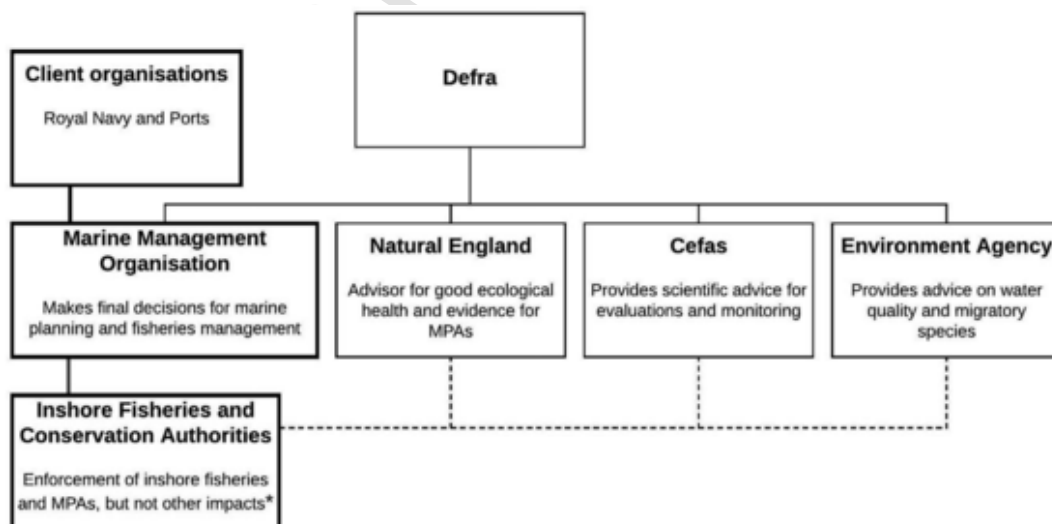


Fig. 1. Institutional structure related with current marine governance in England (in bold). Defra is the parent agency for all bodies, with Natural England, CEFAS, and the Environment Agency, and as sister agencies to the MMO. In addition to Defra, the MMO also serves their client organisations – primarily the Royal Navy and ports in the case of dredging and dumping. IFCAs are subordinate to the MMO, but often consult with other agencies to fulfil their conservation mission. \*IFCAs have semi-democratic processes for developing conservation bylaws.

such as fishers, farmers, and harvesters; it involves intergenerational transmission and might involve interaction with experts. LEK comprehensions of ecological processes are continually evolving alongside scientific research, technology, the market, and governance. Unlike traditional/indigenous ecological knowledge, it does not rely on cultural transmission within stateless or 'Fourth World' nations (Patel and Kymlicka, 2000). As such, LEK can provide a means of incorporating local ecological understandings into management decisions of those local places where the non-scientists are observing ecosystems. Furthermore, since there are cultural benefits from landscape, heritage, and identity (Tengberg et al., 2012), LEK can aid in marine governance by effectuating a number of these, including sense of belonging, sense of place protection, educational/research opportunities, aesthetic inspiration, and tourism (Urquhart and Acott, 2014; van Putten et al., 2018).

The shared values of communities utilising their LEK can provide context to their deployment, such as emotional attachments to place and its preservation (Manzo and Perkins, 2006). Additionally, attachments to and conservation motivations for animals, ecosystems, and landscapes that are held publicly (Tengberg et al., 2012; Hausmann et al., 2016) can both inform LEK and be a means to justify its use in public participation in environmental impact assessment. In England, however, locally held conservation motivations for marine ecosystems must contend with the centrally governed, technocratic MMO, creating several structural challenges to incorporating LEK into marine governance. Using marine LEK can improve public participation in local decision-making and capture complementary knowledge that can inform scientific evaluations and monitoring. These case studies of dumping show how marine LEK provides evidence to complement science-based management. The case studies lead to a discussion of how a mechanism for its reception and evaluation might evolve.

### 2.3. Integrating marine community LEK

This research provides evidences that marine governance currently positions LEK as less significant, considering it anecdotal and thus scientifically invalid. This paper also highlights LEK's value in illuminating the processes that cause ecological debilitation, which can lead to further research to help improve marine governance. Natural science has historically perceived traditional, indigenous knowledge and LEK as inaccurate. Nevertheless, natural science tends strongly to reductionism or atomism, and has not typically allowed for more holistic conclusions to emerge. Given the general perception of LEK's positioning beneath scientific knowledge in the knowledge hierarchy, this paper utilizes the lens of critical realism to triangulate between disciplines, allowing for the explanation of how different elements, such as socio-economics, can influence overall knowledge. Such a lens can show how different evaluations of the environment are influenced by the perceived commercial importance of development, in comparison to the framing of the problem by the marine LEK of divers and fishers (Sayer, 1984). An alternative to these dichotomies of accuracy-perception is that "the differences between fishers and scientists ... point to different spatial languages and understandings of fish populations, not just a lack of information on the part of fishers" (St. Martin, 2001, 129). This difference flows from the different labour-processes of scientists vs. non-scientists in assessing fish and habitat populations, not to mention the different spatial and temporal scales, data collection instruments and methods, and data evaluation methods used and valued by each group.

The scientific integration of LEK may be diluted when placed unequally in a hierarchy of power with information stemming from the natural sciences, and the resulting diluted hybridisation of knowledge could invalidate all the systems involved (Jacobs and Mulvihill, 1995). Due to this risk, we should aim for 'co-evolution', allowing all systems to grow both independently and simultaneously. With validation cen-

tral to the scientific paradigm, resource managers have a problem when attempting to integrate LEK, as they are reluctant to use data when they cannot assess its reliability and error margins. Thus, it is important to use mixed methods from the social and natural sciences when evaluating instances that seek to incorporate LEK and natural sciences.

Acceptance of the potential of community LEK by the government, beyond potential negative perspectives of 'NIMBYism', is an important first step. In 2009, exploring NIMBYism, Devine Wright identified how place attachment can lead to individual and collective protective action of place through positive emotional connections (Manzo and Perkins, 2006), but did not consider how such connections encourage the measurement of ecological impacts of activities, such as dumping, through LEK nor its benefits for conservation. Following the position of Devine Wright, this paper shows that the communities have something valuable to add regarding local ecological conservation. Indeed, we hypothesise here that if these groups are considered through a democratic emancipatory mechanism, such as interviews and focus groups, an approach satisfying both the natural and social sciences can be created. Actors' values can be offered up front, related to claims of accuracy, and offered the opportunity for further discussion. To demonstrate its potential, the lead author sought scientific support after marine LEK was deemed invalid by government and scientific journals.

## 3. Materials and methods

### 3.1. Case studies

We present a pair of case studies to explain the uses of marine LEK and community participation in decision-making, since the case-study approach permits the comparison of a number of instances of a particular phenomenon in order to help explain it (Hardwick, 2009). These cases focus on the use of marine LEK to address sediment dumping in two communities in Southern England, Harwich and Rame Head, and are based on interviews and focus groups, conducted from 2015 to 2017. Harwich is a town in the county of Essex (Fig. 2) that has a large container port and ferry terminal, and has a vibrant fishing community, if little tourism. The fishing community and its interest in the marine environment are a small minority in comparison to those working in and around the port. Maintenance dredging in the port of Port of Harwich sees up to 1 million tons per year of sediment from the harbour and approach channel, which is dumped at sea. In 2014, the Port applied to change its dumping site, citing money saving opportunities, but the proposed site coincided with regionally rare rocky reef and boulder habitat complexes. These had the best lobster, crab, and flatfish habitat in the area, and the local Harwich Fishermen's Association objected to potential impact from dumping. Cautionary statutory advice from IFCA and CEFAS advisors was ignored; the MMO did consent to a series of trial dumps and eventually approved the new site (MMO, 2017). The most important evidence for approval came from the EIA consultant working for the port, who ruled the ecological impacts negligible (Wallingford, 2017). The case has seen a contestation between marine LEK, supported secondarily by science, and port consultants. For example, the fishers queried the port consultant's sampling regime, which did not include the centre of the dump site (Fig. 2).

The second case study is from the Rame Peninsula in Cornwall (Fig. 3), which includes Whitsand Bay, where people swim, dive, fish, sail, and walk, and the coastal villages of Kingsand, Millbrook, and Freathy. The dump site has received material from the Plymouth naval yards and commercial ports for several decades, but there are no records pinpointing its exact start (Widdows et al., 2007). In 1980, with diving equipment being more accessible, a group of local divers first began protesting the smothering of rocky reefs caused by sediment dispersal from the dump site. In 2013, momentum began to gather after the creation of the community group 'Stop Dumping at Whitsand Bay'. Whitsand Bay and the Rame Peninsula – designated an Area of Outstand-



Fig. 2. Harwich sediment disposal sites (orange: old, dark grey: new), port-consultant monitoring sites (red); potting monitoring locations (yellow), and port dredging sites (blue); and the proposed temporary conservation zone (green rectangle). Note that the port-consultant did not sample within the disposal site. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

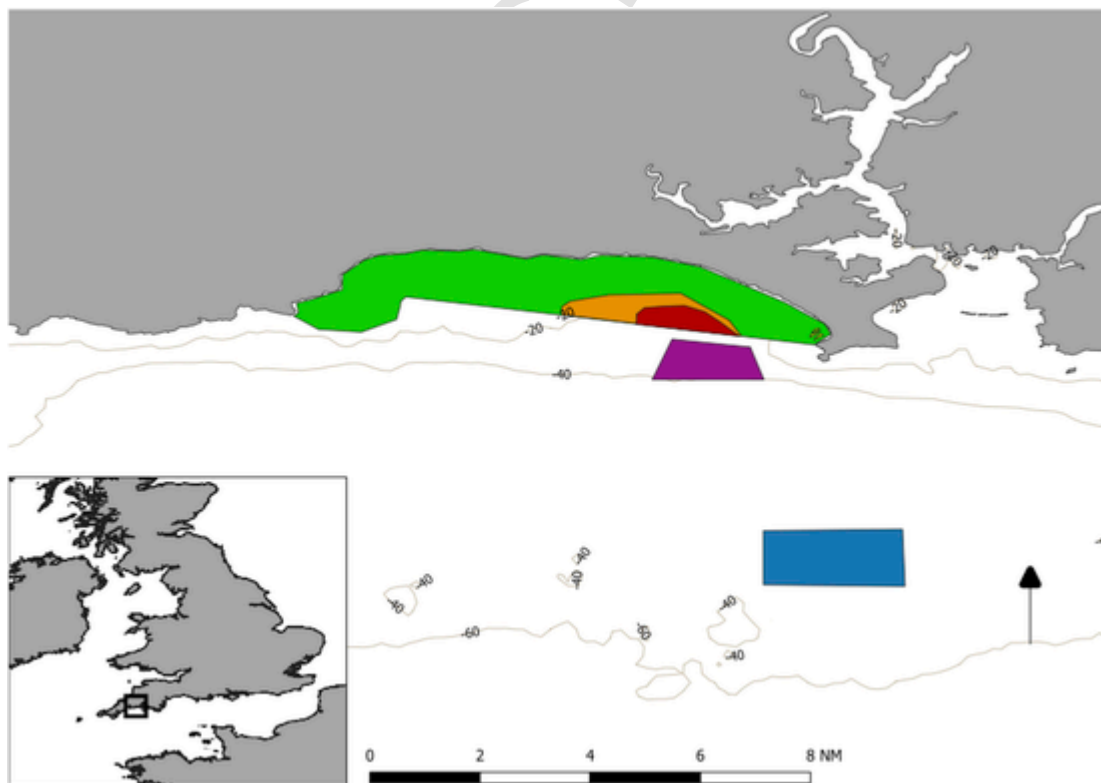


Fig. 3. The locations of Whitsand Bay in the Rame Peninsula, Cornwall UK, showing the old disposal site (purple), the new dump site (blue) to the south, the new (green) MCZ, the reefs identified as smothered by local divers (yellow), and the subtidal mud recorded by CEFAS (orange). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

ing Natural Beauty (AONB) in 1959 – enjoys marine and coastal stakeholders from the fisheries, conservation, arts, professional diving, and leisure sectors. Many have a deep interest in the continuing health of the marine environment and the culture deriving from it. This includes for some of the community, drawing from a separate Cornish (Kernowek) ethnic identity different to England, across the Tamar river (WillettAgyeman, 2005; Anbleyth-Evans, 2018a, 2018b; Anbleyth-Evans and Lacy, 2019; Appleby and Jones, 2012; Armitage et al., 2009; Balchand and Rasheed, 2000; Bolam et al., 2016; Cefas, 2005; Cigliano et al., 2015; Clarke and Braun, 2013; Danielsen et al., 2014; de Jonge et al., 2012, 2014; Eagle et al., 2018; Goffman, 1968; Haraway, 1988; Hardwick, 2009; Hausmann et al., 2016; Johannes et al., 2008; Lonsdale et al., 2017; Mangi et al., 2015; Mansfield, 2004; Manzo and Perkins, 2006; Miles and Huberman, 1994; Murray, 2008; Patel and Kymlicka, 2000; Pauly, 1995; Pinkerton and Davis, 2015, QGIS Development Team, 2018, SAS Institute Inc, 2011; Sarewitz, 2004; Schindler et al., 2016; Shiva, 2006; Sterman, 2002; Sys et al., 2008; Tengberg et al., 2012; Touraine, 1981; Urquhart and Acott, 2014; van Putten et al., 2018; Ware et al., 2010; Wildows et al., 2007; Wilson and Kleban, 1992; Wynne, 2012; Zambra-Alvarez et al., 2016; MMO, 2017; MMO and Natural England, 2015; Wallingford, 2017 and Tredinnick-Rowe, 2016). This included the first author, who is from the area and supported the new social movement. It is worth mentioning reflexively that the first author took part in the LEK assembly with the community by supporting the co-production of the evidence. Although this evidence was ignored by management agencies, through collaboration with natural scientists, this marine LEK information can serve as a basis to translate the concept of marine democracy and participation to a wider audience and highlight the differences of knowledge production. Ethical approval for conducting these case studies was granted in 2014 as part of doctoral research of the lead author (Anbleyth-Evans, 2018a,b).

### 3.2. Semi-structured interviewing

Semi-structured interviews (Miles and Huberman, 1994) were key to understanding the experiences of those excluded from participation and the extent that community LEK could enhance ecological health. This paper builds on research indicating that marine governance currently positions LEK as less significant, anecdotal, and not scientifically valid (Anbleyth-Evans, 2018a,b), while also highlighting LEK's value in illuminating the processes that cause ecological debilitation, which can lead to further research, thus improving marine management. Sampling using a snowballing interview technique led to forty semi-structured interviews in the areas of Harwich and Rame. Twenty semi-structured interviews from each case site were deemed sufficient to capture those interested community stakeholders not typically validated institutionally. It also included ten from each case site who participated in the Eastern and Southwest Marine Plan consultations, respectively. Interview data was analysed through an inductive approach to thematic analysis, supported by NVivo 10 (Clarke and Braun, 2013). The themes used during interviews to develop questions were: (A) Access to decision-making and participation, (B) Impact and pollution in the marine environment, (C) Scarcity and abundance, (D) Seabed characteristics, (E) Seabed habitats and biodiversity, and (F) Interaction with the scientific knowledge system. The identities of the interviewees were kept confidential; references in the text identify them by their local community and the order in which they were interviewed. The different stakeholders' values are contrasted in the stakeholder tables presented in each case study.

### 3.3. Participatory monitoring/participant observation

Participant observation of monitoring was conducted in order to elucidate community LEK in a manner more accessible to governance (Schindler et al., 2016). Participatory impact assessments were conducted to quantitatively evaluate the local effects of marine dumping. The fishers of Harwich made use of the lobster and crab pots they typically work with to observe the amount of sediment smothering of the habitat before and after dumping, a methodological framework referred to as self-sampling (Mangi et al., 2015). The amount of material collected in the area prior to being a dump site was recorded and compared with the various measures of the amount of the material collected following sediment dumping. In the Rame Peninsula dumping case, divers took georeferenced measurements of rocky reef smothering using rulers to measure the depths of sediment caused by dumping.

Participant observation relates to the observing and questioning of the activities of the group studied (Goffman, 1968). In both cases, observation focused on the process of fishing and its evaluation of fish stocks, as well as the MMO Marine Licencing and Planning teams. In the MMO, the process was observed in detail after working in the team. In Harwich, participant observation of fishing, specifically lobster potting, took place in the new dump site area. At Rame, scuba diving observation in the dumping area took place to better understand the smothering impacts to the reefs.

### 3.4. Participatory cartography/focus group

Participatory cartography took place during the focus groups to understand how marine LEK could contribute to marine governance. Focus group discussions occur with an informal group with a specific theme, with open feedback, such as used in Participatory Rural Assessment in fisheries (Fitriana and Stacey, 2012). Groups were divided into two and asked to draw the ecological impacts of dumping on a local map. Coloured pens were given out with a key to different habitat types and features for groups to identify and annotate (Zambra-Alvarez et al., 2016). It was important to encourage the quieter members to take part, so that more prominent members did not dominate. Mapping with the group was the most accessible way to elicit LEK in the first instance, before consolidating the maps using the open-source Geographic Information System program QGIS (QGIS Development Team, 2018). In Rame, local divers explained where they attempted to measure the reef smothering over time. These results coincided with the perception of others regarding material dispersal. This cartography was shared with the groups, who used the evidence as a community baseline in the campaigns to get the MMO to stop the dumping.

### 3.5. Statistical assessment

Standard statistical assessments were conducted on the sediment data collected using community LEK. After the original evidence was rejected by the MMO, the actors invited further quantitative analysis of the gathered data. The sediment weights collected using pots in Harwich were log-transformed to ensure normality, sediment collection data were collated as 'pre-dumping' and 'post-dumping', and t-tests were run to evaluate the differences in sediment accumulation. The annual sediment depth measurements from smothered reefs in Whitsand Bay (Rame Peninsula) were also log-transformed to ensure normality, and the evaluation examined sediment accumulation over time using linear regression. SAS Studio 3.4 (SAS Institute Inc, 2011) was used to conduct all statistical assessments.

## 4. Results

### 4.1. Harwich

The Port of Harwich stated that the costs of dredging had increased by over 100% over the prior five years due to changes to fuel prices, and costs were significantly affected by the long sailing distance to the previously existing disposal ground (MMO, 2016). Thus, the framing of the consultant's evidence could be seen in the light of creating an argument to save money. The semi-structured interviews show the perceptions of the various community stakeholders about fair decision making with the MMO and environmental justice in terms of impacts to the ecosystem and fishing grounds. The marine LEK produced by participatory monitoring showed how marine LEK can provide measurements of ecosystem changes via silt collection using lobster pots. The focus group utilized LEK to indicate a monitoring zone that would best capture the effects of dumping on the fishery grounds.

#### 4.1.1. Semi-structured interviews

In May 2016, the MMO unilaterally made the decision to conduct trial dumping (Fig. 2). This decision was taken over the objections from the local fishers' association, CEFAS, and the Eastern Inshore Fisheries and Conservation Authority (EIFCA), but was not ruled as significant under the Imperative Reasons Overriding Public Interest. Semi-structured interviews show how these fishers were led to believe that being given an opportunity to comment on the proposed trial dumping meant that they would be listened to. In the end, the fishers' criticisms were ignored in regard to the ecological impact on the fishery.

We objected to the proposal as it would put the mud on the lobster and crab grounds, smothering good flat fish habitats. The report doesn't show how the ecosystem, the species we fish for won't be impacted (Harwich 1).

Seven of the association's fishers reported how they were to be included in the decision-making process related with the dumping. Furthermore, they attested that they were also led to believe that they would take part in the scientific surveying of trial dumping, which did not happen.

The port told us that we were going to be involved in any testing, that we would be there to take part in any trials. But we haven't heard a word (Harwich, 2).

We told the port that we would be interested in being involved in the testing, before they started the dumping. We called them up, asked to meet about it, but it turned out to be a load of rubbish (Harwich, 3).

The monitoring locations sampled by the MMO consultant (HR Wallingford) did not include any sampling points within the dump site itself. One of the affected fishing skippers explained why the sampling should have included sampling in the dumping site:

The HR Wallingford report lists five sample points. All are one nautical mile away from the new dump site following a line NE to SW, approximately 0.5 miles apart. The greatest increase was the dump site itself. That is where they should have measured, as it is where we fish, and where the rocky reefs are (Harwich, 2).

Other fishers repeated this point in the focus group meeting. The fishers made clear they considered this to be environmentally unjust evidence production, based on the economic power of the port. Since fishers were aware of the lack of monitoring that would occur, they decided to evaluate the impacts using crab and lobster pots to examine the sediment accumulation before and after trial dumping (see Section 4.1.2, below).

The unilateral decision by the MMO to proceed with trial dumping also occurred despite warnings from CEFAS about *Sabellaria* biogenic reefs found in the fishing-ground-cum-dump-site.

We explained that the area to the west of and close to the disposal site is suitable for crab and lobster fishing. It is important to state

that as it is a crustacean habitat and a herring spawning ground, and that the dumping would change that. Also, I do consider there is a lack of appreciation of the potential impacts to *Sabellaria spinulosa*, which is abundant and their biogenic reefs are listed under Annex I of the Habitats Directive and are legally protected (CEFAS, 1).

Additionally, the Eastern Inshore Fisheries and Conservation Authority highlighted that shellfish, herring, and other fish spawning and nursery grounds should be considered.

We need to see evidence to show how fish spawning, nursery ground impacts and benthic habitats and species will not be impacted, through sedimentation, and on herring spawning. These impacts have not been addressed (EIFCA 1).

And the Kent and Essex Inshore Fisheries and Conservation Authority added:

The lobster and crab stocks present provide a viable non-quota species which local vessels rely upon. Were this area to be negatively impacted by the proposal then this could economically affect the local vessels as well as environmentally impact upon these grounds. A concern regarding the legitimacy of the application on the grounds of costs savings and a reduction in carbon footprint was also voiced. With this in mind, we ask that the views from the local fishing community are actively considered (KEIFCA 1).

Even the MMO coastal office recognised that the proposed disposal site is inhabited by commercially important species.

The area of Shipwash has been used by the fishing industry for many years, it is one of their more important fishing grounds. They fish there for sole and skate throughout the year. Bass and lobster are targeted and constitute a significant part of the income for fishermen from Harwich and Felixstowe (MMO 1).

A thorough reading of the consultant's report (Wallingford, 2017) fails to show how any of the ecological impacts described above by the fishers or the statutory advisors would be mitigated.

#### 4.1.2. Fisher LEK monitoring

In order to show the impacts of the trial dumping and to create contrasting evidence to that of the consultant's report, the fishers conducted sampling and monitoring to evaluate the fishing ground impacts. Since they had no access to scientific sediment-monitoring equipment, they decided to reutilize their crab pots to serve as sediment samplers and their fishing scales to weigh them.

We taped up some pots with gaffer tape and left them there before the dumping, and weighed how much silt we recovered. We then weighed how much it was in comparison after they dumped the port sediments. Strangely there was no life in them.

The fishers videoed the sampling approach prior to trial dumping and recorded less than 0.5 g of silt on average per pot in the potting sites. These sites were within the 800 m × 800 m dumping zone and lies at only 21–22m depth (purple area, Fig. 2). Fourteen days following the trial dumping, the fishers recovered an average of over 78 g of silt per pot in the same sampling sites. This increase in post-dumping sediment observed by fishers is strongly statistically significant ( $t = 19.11$ ,  $p < 0.0001$ , Fig. 4).

## 4.2. Focus group

The details of the smothering were sketched out through participatory cartography on maps during the focus group session with the Fisherman's Association. They were invited to suggest an area of protection from dumping impacts (green triangle, Fig. 2) that would function as a temporary MCZ, meaning baseline measures on habitats and species would be carried out before any further dumping were to continue.

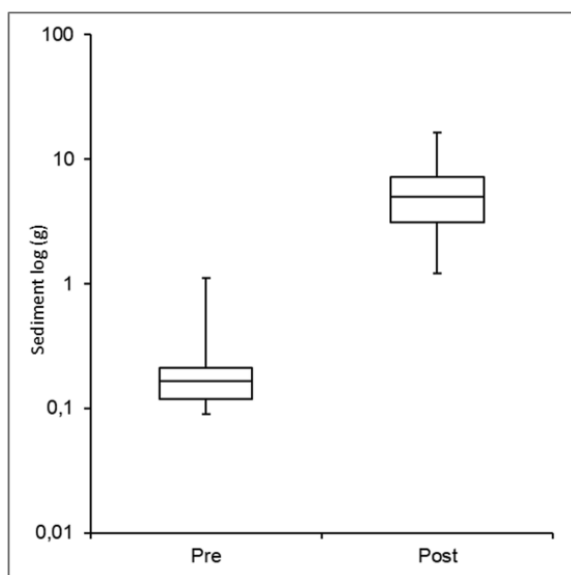


Fig. 4. Box plot evaluation of the amount of collected sediment by members of the Harwich Fishers Association in the months pre- and post-dumping. Note that the y-axis uses a log scale.

4.2.1. Competing values and interests

Table 2 compares the values, interests, and methods of recording and observation of the fishers, formal governmental advisors, the port, and its consultant. Both fishers and the commercial port are businesses that wish to maintain long term profit, but only the fishers are directly dependent on the future health of the ecosystems under threat from dumping. Only marine LEK considered livelihoods and ecological health to be both important in realising environmental justice. To the MMO, though, the business of the port was considered to be of primary importance, as it is a paying customer, generates more profit, and employs far more people than the local fishing industry. The designation of a new dumping area in this area was not declared under Imperative Reasons for Overriding Public Interest in 2016. As they were unable to migrate, seven fishers stated that they would be forced into retire-

Table 2 Stakeholders' interests, values, knowledge, method of recording and scale of interest in Rame.

Stakeholder	Interest/Goal	Values	Knowledge/epistemology	Method of recording	Scale of interest
Scuba Divers/Stop Dumping in Whitsand Bay Group	Good visibility for diving and healthy ecosystems in local area and globally	Preserve the local ecosystem. Tourism promotion.	Based on experience of observation and recording underwater	Photo recording and observation over time	Local to global
Fishers	Interest in maintaining local ecosystem for fisheries	Focus on maintaining long term profit through ecological health	Based on the amount of fish caught over time in the area and habitat sampling through gear	Chart plotter and records of where fish were caught	Local
Navy	Maintain and increase channel depth for vessels	Defence of the nation.	No knowledge and experience of ecosystems	None	National
Commercial Port	Maintain and increase channel depth for vessels	Expand profit through freight transport	No knowledge and experience of ecosystems	None	Local
MMO	Regulate the marine environment within existing parameters	Ensure decisions are made efficiently	Knowledge based on advice from scientific statutory consultees	No recording or experience	Local to national
Devon based marine scientists	Maintain good relations with governmental funders including Navy/MMO	Improve the environment in general	Desk based modelling dependent on data from L4 and E1 stations rather than Whitsand Bay	Modelling not based on sampling or experience	Local to global, seeking generalisability
CEFAS	Maintain the environment within specific institutional parameters	Maintain the environment according to existing legal parameters	Science based positivist or empirical approach	All possible methods available	Local to global
Natural England	Maintain the environment within specific institutional parameters	Maintain the environment according to existing legal parameters	Science based on positivist or empirical approach	All possible methods available	Local to national

ment if the rocky reef dump site were to be made permanent. In 2018, the MMO made the site a permanent dumping ground.

4.3. The Rame head south dump site case study and the MCZ

For decades, there has been significant social-movement efforts by the community of the Rame Peninsula to stop the Port of Plymouth from dumping at Rame Head. Various public campaigns to move the dumping went unheeded, until judicial review was enacted, and finally a Marine Conservation Zone (MCZ) was defined in the Bay. The quotes from the interviews highlight the ways in which community stakeholders perceived their interaction with the MMO and the role that marine LEK played in the decisions that led to halting the sediment dumping. The participatory monitoring explores how evidence that was complementary to LEK was elicited in response to marine LEK being repeatedly ignored by the government.

4.3.1. Semi-structured interviews

For many years, dredged material from the Port of Plymouth was dumped the area around Rame Head, as confirmed by an MMO representative.

We believe the site has been a disposal site for over a century. Thus, it seems suitable for it to continue to remain a disposal site into the future (MMO 2).

However, starting in 1980, letters from the community were continually sent to the government, explaining how the dumping was inappropriate, considering the diversity of the ecosystems and the valuation of their health to the community. The lack of apparent change in governmental response to suggestions from local stakeholders led to community members utilising their LEK to monitor the sediment dumping. The motivations for conservation came from the community response to questions of ethics, aesthetics, local history, attachment to place, spirituality, and natural conditions associated with the area:

Historically, the area has been a burial-at-sea area, so I find dumping on that personally offensive. Added to that, the Celtic Christian Church on the head is right next to the dumping area. And visually, the park is an area of outstanding natural beauty. You can't imagine them dumping in an AONB on land, so why at sea? There is no forum for discussion of it (Cawsand 1).



While the area had been a historical area for dumping, including decommissioned weapons following the World Wars, the port's growth and the simultaneous increase of material dumped over time came to the community's attention.

I remember a few years ago now, someone from what was then called MAFF, described the area around Rame Head as a sacrificial sea. They said it was a zone sacrificed for Plymouth to dump their rubbish and there was nothing we could do about it. (Cawsand 2).

This characterization of Whitsand Bay as a sacrificial area motivated the community to investigate, led by a retired police diver.

We've been diving on those reefs for thirty years and we've noticed the increased smothering of the reefs and the silt. There have been all sorts of things disposed of at that site.

Following conversations with local scientists from the Marine Biological Association in Plymouth, the community began recording observations of the smothering of reef habitats.

We had (Name anonymised) from the [Marine Biological Association] come and confirm the extent of the *Eunicella verrucosa* species and the extent it's been affected in Polhawn (Cawsand 3).

After posting letters and (later) emails for many years, the group finally started to think about developing alternative mechanisms to get their observations taken seriously, such as using rulers and secchi disks. Local monitoring efforts of sediment dumping were not limited to divers. A community member evaluated the timing and location of dumping vessels in Whitsand Bay:

So, I did some vessel monitoring. They'd issued a dredging and dumping notice to mariners, but they were dumping on the flood tide (the rising tide). They were not dumping it in the right area. In the court they recognised that 33 of 34 of the disposals were in the wrong area. They issued a small fine, but it could have been £40,000 per time and time in prison (Millbrook 1).

This shows the perceived environmental injustice of the process by the community, as the problem continued for many years without the MMO deploying scientists to investigate the knowledge claims.

In 2015, the case developed with designation of an MCZ in Whitsand Bay. Subsequent surveys undertaken in support of the MCZ identified an area of subtidal mud habitat north of the disposal site. The license was suspended, although CEFAS continued to deny that subtidal mud located in the MCZ had any relationship to the mud being dumped from Plymouth (MMO, 2015). Disposal activities recommenced in November 2015. The stop dumping group once again challenged the MMO, showing that they were in breach of both the Water Framework Directive and the Waste Framework Directive, and the dredger was once again dumping on the flood tide. Frustrated that the observations were not taken seriously, the community organised a crowd-funded legal challenge against due process. After this, the MMO asked to carry out a mediation session in early 2016. A stop dumping campaigner explained:

The judicial review was a very useful tool to keep the pressure on. We agreed to stay the JR as they agreed to move the site to Plymouth Deep. But I was speaking to the River Trust, the problem wouldn't be half as bad if you did the proper management. Under the waste framework directive, disposal is supposed to be the last resort (Cawsand 5).

The group eventually agreed to stay the judicial review under agreement that CEFAS would create a new dump site at Plymouth Deep, which effectively shifts dumping to a popular fishing ground elsewhere. For Rame Head, only after strong legal pressure evidencing the dumping on the flood tide were community observations considered. This series of actions is something outside of the budgetary possibilities of most coastal communities. A participatory alternative mechanism is explored in the discussion.

#### 4.3.2. Participatory monitoring/participant observation

For over thirty years, local divers attempted to regularly monitor the extent that the rocky reefs were being smothered over time by returning to the same areas and making annual measurements of the deposited silt, using a ruler. During these monitoring excursions, the diver would select sections of reef and gently work a ruler through the accumulated sediment, stopping when that end of the ruler encountered the rocky reef itself. Divers also measured turbidity from the surface using a secchi disk. They kept records from 1980 until 2015. The linear regression on the annual measurements indicated that sediment deposits on the reefs increased exponentially over time ( $F = 343.17$ ,  $p < 0.0001$ ; Fig. 5).

#### 4.3.3. Competing values and interests

Table 2 in the annex below shows the competing values between the Rame Peninsula community, the port, Naval port, marine governance and governmental scientists. The community take a more holistic cultural valuation of its local area and the importance of maintaining it in good ecological health, according to principles of environmental justice. Worth mentioning in this case is that, like marine managers, scientists supporting governmental evidence through modelling were also physically remote and not affected by dumping in their everyday lives.

### 5. Discussion - critical reflection on integrating marine community LEK

#### 5.1. LEK in harwich

The results from Harwich demonstrate the need for a mechanism to include marine LEK and to facilitate a discussion over the ethical claims of the community. In this case, the community's position concerning dumping was not accepted, and the new dump site was created on the rocky reefs that served as its fishing grounds, despite observations made by fishers that dumping had increased siltation (Fig. 4). This underlines how LEK was positioned as anecdotal, since the community used non-standard methods. However, the port consultant's scientific methods, failed to monitor the dumping zone itself, a site of rocky reefs (Fig. 2) and concluded that sedimentation was insignificant. Since the consultant did not monitor the dumping zone, the evidence from the report was not accepted as valid by the Harwich fishers. Further-

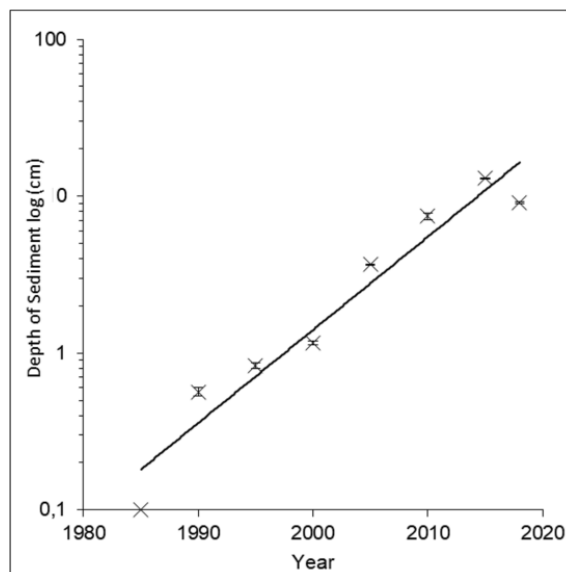


Fig. 5. Scatter Plot showing exponential increase of reef-smothering sediments, measured by divers in Whitsand Bay. Note that the y-axis uses a log scale.

more, this report did not discuss how dumping on the proposed site would influence the fishers' local livelihoods, their rights, or the biodiversity upon which they relied.

The failure to monitor the fishing grounds was compounded by a failure to address how to mitigate the ecological effects of dumping, impacts raised by various governmental advisors. CEFAS warned of the significance of *Sabellaria* biogenic reefs and highlighted the importance of the area west of the disposal site as suitable habitat for crab, lobster, and a commercial fishery. The Eastern Inshore Fisheries and Conservation Authority (EIFCA) highlighted that the report should identify shellfish and fish spawning and nursery grounds and also consider the impacts of sedimentation on herring spawning. Similarly, even the MMO coastal office's response detailed that the proposed disposal site was inhabited by commercially important shellfish species and demersal fish species. All these institutional warnings and recommendations about the ecology of the area correspond to the marine LEK held by fishers. Despite the presence of institutional knowledge and marine LEK, the consultants' report was silent on these aspects (Wallingford, 2017).

In February 2018, despite the various sources of evidence of negative effects from dumping, the site was made active, meaning that capital dredged material from channel deepening the ports of Harwich and nearby Felixstowe can be dumped at the site, further debilitating the existing ecosystem. There is no proposed MCZ, although a form of MCZ as a conservation mechanism was proposed by the fisher community group (Fig. 2). Political support is needed to move from current top-down power relations, with the MMO being led by client organisations, to local-scale systems where LEK feedback can be heard and its claims discussed. A mechanism can be created where the MMO head office allows input of LEK and environmental justice concerns, via social science methods, into marine planning (see Section 5.3).

### 5.2. LEK in Rame and Whitsand Bay

The dumping site in Whitsand Bay was eventually moved, and this case also demonstrates the need for a mechanism to better include the marine LEK into local decision-making. The results show the importance of LEK in describing environmental justice challenges (Table 1). While marine LEK was employed in Harwich, a major difference com-

pared to Rame Head was that in Harwich, it was unable to connect with broader community interests. Unlike Harwich, the Rame Peninsula community was in consensus across sectors of employment and interest groups, based on a shared sense of connection to place, supported by designation as an AONB and later an MCZ. The broader community considered the site's aesthetic and historical importance, which connect deeply with themes of cultural landscapes and cultural ecosystem services (Tengberg et al., 2012).

The protections in Whitsand Bay (Fig. 3) would not have been possible without LEK, specifically, the vessel observation made by community members that was complemented by impacts observed by divers of the dumped materials on the reefs. From these sources of evidence, the community could demonstrate that the dumping company violated its license conditions, and the community launched a legal challenge, the judicial review that stated that due process was not being followed. The case evolved with the designation of the area as an MCZ, with supporting evidence from Natural England. Subsequent surveys undertaken in the MCZ identified an area of subtidal mud habitat spreading from the disposal site north onto the circalittoral rock habitat (MMO and Natural England, 2015). The original modelling undertaken as governmental advice from Hull did not show this. The dumping license was suspended, although the MMO continued to deny that subtidal mud located in the MCZ had any relationship to the mud being dumped from Plymouth (MMO and Natural England, 2015), despite the strong locally collected evidence of sedimentation associated with the dump site (Fig. 5). Dumping recommenced in November 2015, and the MMO was again challenged legally, since the dumping was in breach of the Marine Strategy Framework Directive, and the dumping was influencing the health of the new MCZ.

On the MMO's side, the evidence coming from LEK was dismissed during interviews as anecdotal, due to perceptions that it was based on non-standard methods. In contrast, the decisions to continue dumping were based on a modelling program used by scientific advisors to the MMO that assumed that the dredger was depositing sediment in a predictable way, and that the tidal effects and the almanac were correct. Evidence from the vessel monitoring by the community showed that the dredger was not acting in the advised manner, and through human error dumped on the flood tide on the majority of occasions. Thus,

**Table 1**  
Stakeholders' interests, values, knowledge, and recording methods in Harwich.

Stakeholder	Interest/Goal	Values	Knowledge/epistemology	Method of recording/observation	Scale of interest	Power relations
Fishers	Maintain local ecosystem for fisheries	Focus on maintaining long-term profit through ecological health	Based on the amount of fish caught over time in the area and habitat sampling through gear	Chart plotter and records of where fish were caught local	local	Low, only when in union with other fishers/ academics/new social movements/sympathetic governance
Port of Harwich	Maintain channel depth for vessels, including channel expansion and deepening.	Focus on profit maintenance by saving money on dredger fuel	None	None	national	High, significant financial resources for lobbying/legal and scientific evidence team
Commercial Consultant	Maintain profit/enhancing client base	market growth	Scientific positivism	All scientific methods available	national	High, significant financial resources for scientific evidence team
MMO	Regulate the marine environment within existing parameters	Ensure efficient decision-making	Knowledge based on advice from scientific statutory consultees. Positivist approach to data	No recording or physical experience	national	High, final decision maker, no oversight from coastal communities
IFCA	Maintain health of fishery and local ecosystem	Ecological and social sustainability	Knowledge based on natural science and experience with local stakeholders including fishers	All possible methods available	Local to global	Medium, some oversight from coastal communities and fishers
CEFAS	Maintain the environment within specific existing institutional parameters	Maintain the environment according to existing legal parameters	Science based positivist or empirical approach	All possible methods available	Local to global	Medium oversight only from secretary of state but no decision-making

the importance of LEK is apparent from the communities' ongoing observations of siltation over the years in these areas was dismissed, while the modelling, which did not account for human error, was taken seriously. Furthermore, the ethical claims of environmental justice underpinning the argument against dumping at sea made by the community were not taken seriously on their own, given the dominant perception of the inadequacy of marine LEK by the MMO. Following the designation of the MCZ, the Rame dump site was moved to a new site to the south named Plymouth Deep. This process shows the value of integrating marine LEK into decision making, maintaining and even improving ecological health in the Rame area, and the importance of creating a space where claims of environmental justice can be heard.

### 5.3. Integrated lessons about marine LEK and participation in decision-making

The decision-making challenge of linking the different spatial scales of environmental processes to local participatory planning decisions is difficult, but it can be achievable if local community LEK is integrated (Anbleyth-Evans, 2018b). While not all environmental processes occur at a local scale, the local ecological impacts are typically considered to be of greater importance by those living within, connected directly and depending directly on ecosystems (Anbleyth-Evans, 2018b). This can move us closer to what Shiva (2006) calls Earth Democracy. Furthermore, the values and interests held by stakeholders need deeper consideration by decision makers when considering the environmental justice issues. Tables 1 and 2 compare the values and interests of community LEK holders in Harwich and Rame, among other stakeholders. They show that LEK and non-governmental advice is important by contrasting their worldviews, in terms of the importance of the local versus national environmental objectives. In each case, LEK and non-governmental advice were equally valid forms of knowledge production, with both influenced by how problem perception framed its investigation. However, there was no direct mechanism to communicate community LEK findings in a manner that could connect with and be evaluated alongside the findings of natural scientists. Despite the communities' original claims not being taken seriously, applying a statistical lens showed a robust impact over space (Fig. 4) and time (Fig. 5) associated with sediment measurements. Thus, data collected with LEK can also be verified—using the 'techno-scientific' framework (*sensu* Haraway, 1988). Independently of whether quantitative evidence is possible for communities to back up their observations, this paper shows LEK claims should be taken seriously, especially where environmental justice questions are raised. These are led by questions which do not focus on the scientific questions of, 'what is happening', but move from the social question of, 'what *should* be happening'.

The pre-existing institutional parameters and values limit local marine governance in the UK, with actors including the navy and ports, with interviews indicating that marine conservation is not a part of the Port's or Navy's training or job. To ensure community LEK can contribute, a legal mechanism is needed that could see power shared with coastal communities, where marine conservation is valued. The cases from Rame and Harwich show the democratic limitations of the current system. In Rame, the dump site went from being open access, with little legal support, to an MCZ, with strong legal protections, which Harwich is unlikely to see. While future MCZ designations are unlikely, as the Harwich case suggests, creating a temporary protection zone could provide the opportunity to develop supporting baseline data. The Rame case contrastingly to Harwich saw judicial review, with the legal evidence of malpractice by the dumper being developed through LEK. This effectively forced the MMO to negotiate with local stakeholders. The fishers in Harwich were unable to afford legal counsel, and the fate of the rocky reef habitat seems likely to be 'burial at sea', given that the MMO has formalised dumping at the site. A key reason for the fail-

ure at Harwich in contrast to Rame is the community relations: the composition of the Harwich community campaign consisted predominantly of fishers, a relatively small (numerically and economically) group within the port town community. In contrast Rame included a diverse range of people, including environmental NGOs and local council bodies. A wider social movement of diverse actors, connected to both the local to global scale, and wider appreciation of environmental justice, appear critical for effecting outcomes favourable to local governance by giving credence to LEK (Touraine, 1981).

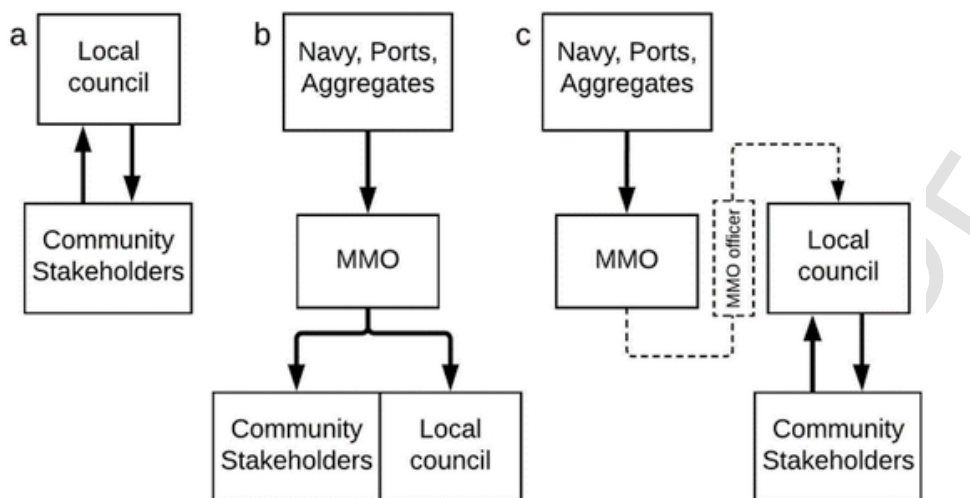
While the Environmental Impact Assessment Regulations 2017 were updated to include Environmental and Social Impact Assessment, how LEK could be incorporated into the ecosystem approach is not mentioned (Lonsdale et al., 2017). LEK knowledge claims are important, because they support community education and are significant in assessing environmental impacts, since those deploying it are motivated to protect ecosystems through their sense of connection to those places from which their ecological knowledge derives (Tengberg et al., 2012). Using the insights from Harwich and Rame, this paper recommends a framework for impact assessments upon tourism, employment, sense of place, aesthetics, education, and knowledge, with socio-economic impacts to the wider community under the current marine licensing regime, and valuing the role people play in enhancing ecosystems (van Putten et al., 2018).

LEK is useful for governance, as it can identify risk and changes to ecosystems that might not be apparent through mainstream scientific methods or government advisors (Anbleyth-Evans and Lacy, 2019). Nevertheless, there is only superficial praise for LEK and citizen science, without actual implementation, and a failure of its acceptance by 'mainstream' scientific research (Cigliano et al., 2015). While LEK data collection might not show the highest levels of mainstream scientific rigour, being the result of a different value and assessment system, it can identify patterns that scientists might not always think to evaluate, using innovative approaches. Indeed, while expert validation can be important, it is not always reliable (Anbleyth-Evans, J. (2018b). Additionally, modelling can occur without real world, local interaction, and implicit biases can drive outcomes (Sterman, 2002). Positivism can be reductive, leaving two opposing evidence bases valid whilst only measuring small parts of a collapsing system, without resolving the controversy (Sarewitz, 2004). Finally, affected communities should have the right to democratic participation where environmental justice questions arise, independently of whether experts are available. Thus, mechanisms where the moral claims and value systems can be taken into account are necessary for decision makers to realise marine environmental justice.

### 5.4. Integrating marine LEK into local decision-making in the UK

It is possible to re-evaluate the marine governance system in the UK to improve the inclusion of LEK into local marine decision-making, by looking at how governance systems over land contrast with those covering marine waters. While not necessarily including stakeholder LEK in decisions, in terrestrial ecosystems, planning decisions are realised through democratically elected local councils, with local populations being able to contribute as stakeholders (Fig. 6a). Contrastingly, current marine governance system in the UK is a strongly top-down, vertical structure, without any mechanism to consider LEK, local concerns or the ecosystems that they value (Fig. 6b).

As shown in Tables 1 and 2, the stakeholders interested in perpetuating the dumping do not share conservation goals with local communities for local ecological health. Meanwhile, the local communities lack a comparable financial and institutional capacity to those driving marine decision-making (Fig. 6b). Unequal or top-down power relations between the MMO, client organisations, and local communities are maintained in other areas of marine development, such as aggre-



**Fig. 6.** Current power relations contrasted. a) Reciprocal power relations between local councils and community stakeholders in terrestrial conservation. b) Top-down-only current power relations from the MMO client organisations (also including aggregate dredging industry and energy industry) to the MMO through financial power and from the MMO head office to communities, who lack a feedback mechanism. Training in social sciences approaches can support this. c) Possible relations restoring local reciprocal power relations to mediate MMO head office input via coastal offices.

gates, windfarms, and power stations, often through financial power or led by perceived economic benefit. While enforcement of large-scale regulations, such as the Habitats Directive, Marine Strategy Framework Directive, and Water Framework Directive, should be top-down, to ensure LEK participation in a democratic context, decision-making power should also flow up from the local neighbourhood, parish or municipal scale.

In one way to accomplish this in the UK marine context (moving from Fig. 6b to c), MMO officers involved in licensing, enforcement, monitoring, and community training can be embedded in county and parish councils as well as the central MMO. These marine officers can interact with regional policies or plan connecting activities with marine and river systems. Marine license decision-making can be democratically generated through activities such as participatory cartography and knowledge exchange workshops (Fig. 6c). In places with no protected areas, and where the community has applied for a conservation zone plan, it would be more democratic if decisions were accountable to the community's proposals. Further, if marine licensing officers were invited to work in local council offices – even part time – it would be easier for stakeholders to bridge knowledge systems through face-to-face dialogue (Anbleyth-Evans and Lacy, 2019). This would require the MCAA 2009 and EIA 2017 regulations be updated, an action that must come from Parliament.

This paper examined how marine LEK contributed to local decision-making around marine conservation in the face of sediment dumping. We have shown that the groups in these two cases used their LEK to enable a form of monitoring, that while originally ignored, were shown to be potentially valuable sources of environmental assessment. However, without supporting legal challenges and citizen science, non-techno-scientific knowledge production does not fit into any existing marine decision-making framework. It is only by bypassing the local decision-making framework entirely through processes such as judicial review or reframing the decision-making space around an MCZ that marine LEK can be incorporated. In order to democratize marine governance, decision-making systems should be modified to provide greater opportunities for LEK to be considered, as is done analogously in decision-making on land.

The advantage of LEK is that it can demonstrate insights through *ad hoc* methods outside of traditional marine governmental power rela-

tions. Social science methods, such as interviews, focus groups, and participatory cartography, are useful for decision makers to understand how to include LEK. It is important to emphasise that LEK users' moral and truth claims should be considered significant in local decision-making about environmental justice, regardless of whether they are supported by natural science. In the future, it may be possible to mix methods with natural sciences to develop quantitative approaches, guided by the epistemic insights of the community, elicited by social science methods. The feedback of conservation norms into the wider community is invaluable in itself, by increasing overall understanding (Anbleyth-Evans and Lacy, 2019).

## 6. Conclusions

Long-term monitoring using LEK functions at a local geographical scale where shared values of ecological health can emerge among users. Divers and fishers and other community members can provide detailed recorded observations over long time frames, which can be used to advance overall knowledge. After risk identification, conservation recourses, such as temporary MCZs, can be deployed to support the integration of the diverse types of LEK with other types of information. To realise the ecosystem approach, marine laws must alter decision-making over marine licensing to emerge from participatory planning, as is done on land. Such participatory planning can integrate LEK with a democratic local council, ensuring power can flow from the community. These local case studies on dumping demonstrate the importance of integrating LEK with scientific knowledge in decision making for improved accuracy and democratic processes. Integration of stakeholder LEK decision-making and monitoring can support the health of ecosystems and democratic processes, whilst remedying the excesses of blue economic growth.

## Uncited references

Joanie and Tredinnick-Rowe, 2016.

## Declaration of competing interest

The authors have no financial interests to declare. The authors did not work with other people or organisations that could inappropriately bias the work.

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