Thinking with Tides: Engaging with Embodied Technical Processes within the Tidal Ranges of the Thames Estuary

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Abstract

The following paper reports on findings from doctoral research in Arts and Computational Technology. The research is about tidal environments. More specifically, it engages with the tidal ranges of the Thames Estuary and explores what thinking with tides might signify. In the face of uncertain futures—sea-level rise, increase in flooding, pollution—and through art practice, it reflects on how combining different ways of knowing the Thames Estuary could reintroduce questions of locality, situatedness and diversity to make the estuary differently available. The paper is divided into four sections. The first section summarises the kind of tidal processes that unfold in the estuary. The second section introduces the methodology, Practising in the Wild, and explains how Embodied Technical Processes (ETP) are necessary to engage with the estuary. The third section presents an inventory of different technical objects that are used to think with the estuary and its tides. Finally, in the last section, two art projects—by composer John Eacott and art collective YoHa—are discussed. Both projects were situated within the tidal ranges of the Thames and applied ETP. It concludes with reflections on future studies that this research is currently developing.

Keywords

Embodied Technical Processes, Thames Estuary, intertidal zone, tides, technical objects, art practice.

DOI

10.69564/ISEA2023-60-full-Gnecchi-Thinking-with-Tides

Figure 1. Rowing during the ebbing tides along the intertidal zone, Leigh-On-Sea ©Emma Jaay.

Introduction – A More-Than-Human-Soup

Tides are always on the move. They have their own spatial and temporal growth. They vary from place to place. Every tidal environment sounds, smells, looks, and feels different. As you read these words, tides are changing the way life unfolds, intersecting with organisms, ecologies, cultures, wavering space, time, and materiality. Their openness, their complexity, their diversity, makes tidal environments both knowable and unknowable, predictable and unpredictable.

This paper reports some of the findings and methods, developed along the tidal ranges of the Thames Estuary. The Thames Estuary can be seen as a complex more than human soup of colonial histories, empires, trade, language, cosmic forces, the Anthropocene.[1, 2, 3] It is challenging, more so impossible, to create a totalising narrative of this stretch of mud and water. Thus, what this research can offer, are different ways of knowing the estuary.

The estuary has multiple facets, which include material, ecological, and cultural roots, but it is also the plumbing of a global city like London.[4] It is both wild and industrial. Over the 20th century, the estuary has been deepened, widened, diverted, drained, channelised, filled in and built over, and dammed. It is an emblem of the Anthropocene that has been colonised, commoditised, artificially engineered, bombed, trashed, and recently is being rewilded. Yet the estuary exists before and beyond its codification as a place for trade, empire, consumption. A port is a space built for human use, representing distribution, labor, marine routes, networks, but an estuary, in the most basic geological sense, is about sediments, algae, silt, bodies, species, salt marshes. Thus, the estuary cannot be defined solely by natural characteristics, nor is it merely a product of human use and imagination.[5] It is a transitional space, with different temporalities and flows that oscillate between the river Thames and the North Sea, sea and land, fresh and salt water. But most importantly, a space dictacted by its tides.

To engage, explore, and know the estuary, this doctoral research proposes to learn how to think with the more-than-human: the forces of waters, the winds, the ever-changing seabed, as well as many other beings like boats, buoys, tide charts, algae, barnacles.

Aims and Objectives

The purpose of this paper is to introduce the methodology of this doctoral research named 'Practising in the Wild'. Practising in the Wild is imbued with Embodied Technical Processes (ETP). Processes that are tied to different ways of knowing the estuary, both embodied and technical, experiential and scientific. They aim to establish an active engagement with the estuary, combining different ways of knowing—embodied, technical, situated, local to name a few—and provide methods for artistic and design practices that deal with tidal environments. Furthermore, it attempts to demonstrate the structural coupling that occurs between objects, bodies, tides, the atmosphere and avoid any hard distinctions between cultural, ecological, social, and technical ways of knowing the estuary. The paper then proposes an inventory of technical objects used to explore the Thames Estuary, such as boats, tide gauges, and tidal predictions. It then looks into two art interventions in the estuary that apply ETP, one by composer and sailor John Eacott and the other by art collective YoHa. However, before delving into the methodology, a summary of the kind of tidal processes that expand and retract in the estuary should be considered.

The Thames Estuary and its Tides

The Thames Estuary experiences two distinct tidal patterns, one from the North Sea and the other from the English Channel. Generally speaking, estuaries are composed of a stew of water and mud where freshwater and seawater meet. The infusion depends on various factors, such as the state of the river and sea at a given time and the repetitive stirring of its tides. This unfolds into spaces with no clear boundaries making estuaries both familiar and unfamiliar, where certainty is flawed by uncertainty, and constancy is affected by fluidity. Its tides result in monthly, seasonal, and yearly variations, which correspond to the complex 'pas de trois' between the sun, moon, and earth.[6, 7] The height and timing of tides are determined by various factors, including seabed topography, atmospheric pressure, wind patterns, and wave dynamics, to name a few. Despite efforts to predict tides accurately, their intricate dance defies their predictability, which makes them both predictable and unpredictable.

Some Basic Tidal Knowledge

The estuary's tidal processes interconnect land and sea, salt and fresh water, sewage and silt, wrecks and barnacles, creating a complex range of eco-social assemblages.[7] They have a significant impact on the estuary's morphology, co-creating and transforming a variety of ecosystems. The seabed in this liminal space is in a constant state of flux, with channels and banks shifting daily, monthly, and seasonally. There is no finality or fixed reality when it comes to the intertidal zone. For instance, as saltwater flows up the estuary with each incoming tide, fresh water from the river's catchment carries silt and other materials downstream. As the tides recede, coastal habitats, such as salt marshes, are formed. These low-lying habitats are characterised by deep, irregular creeks and soft, fine silt. They are home to a wide variety of wildlife, including sea molluscs, wildfowl, and a vital fish nursery.

Figure 2. Photo taken during fieldwork from the Belton Craft Club in Leigh on Sea, illustrating the two different tidal states. Left image shows the intertidal zone during low tide, while the right image during high tide.

Their cycle is known to be semidiurnal, which means tides rise and fall roughly twice in twenty-four hours, revealing two different environments within the intertidal zone (figure 2). The waters expand and retract. Their timings do not synchronise with the day-night cycle in any simple way.[7] During high tide the intertidal zone covers itself with water. During low tide vast ecologies of mud are revealed. The tidal range is larger than 4 meters. These kinds of tides are known as macro tides. In London Bridge, the tidal range can reach up to seven meters. Along the estuary, it varies between five and six meters. Moreover, the timings of high and low water occur at different moments between London Bridge and the estuary. At the estuary, high water precedes that of London Bridge by approximately one hour.

Tides also interplay with floods. The estuary has the highest proportion of its population within Zone 2 flood-plains.[8] Zone 2 flood areas represent the extent of an extreme flood event—the chance of flooding from rivers or the sea in 1000 years. More than half of the sites of ecological interest, nature heritage sites, areas of special protection, and wildlife trusts correspond to former landfills, sewage, and derelict wastelands, which lie within flood Zone 3 areas. Zone 3 represents the threshold for defining under-risk areas by sea level rise and coastal erosion. Approximately 1,200 hectares of habitats, such as mudflats and salt marshes, could be lost due to flooding.[9]

Tidal flooding can have significant destructive impacts when a combination of spring tide, strong gale-force winds, and low atmospheric pressure coincide.[10] The consequences of such events can be exemplified by the 1953 storm surge that hit the Thames Estuary shores, causing the loss of roughly 300 lives and the displacement of 30,000 individuals from their homes. The East Coast of the UK was severely affected, and communities were left isolated. The floodwaters submerged 65,000 hectares of farmland and inundated 240,000 houses. As a result of this catastrophic event, extensive research was conducted on coastal defences, storm surges, and policies, leading to the implementation of weather forecasting, warning services, and a network of tide gauges across the UK. The Thames Estuary remains vulnerable to future storms and sea-level rise.

Flood risk management often involves constructing higher seawalls, dikes, barriers, levees, as well as quantifying, modelling, and datafying the environment. This can leave out forms of knowledge that are subjective, local, situated, and ecological.[11] Current discourse on environmental management asserts that traditional modernist or engineering approaches are becoming obsolete.[12, 13, 14] Thus, in the face of uncertain futures and environmental challenges, how to reintroduce questions of locality, situatedness, and diversity into the discourse of the estuary? Moreover, how could this reintroduction contribute to the discourses of designing, planning, managing and dwelling in tidal environments?

Methodology – Practising in the Wild

Practising in the Wild is driven by a strong sense of environmental responsibility and ecological urgency. It problematises and challenges forms of scientific reductionism, exploitation, and appropriation of tidal environments that often go unchallenged. It involves the creation of knowledge through hands-on practice, outdoor exploration, and ethnographic studies. It enables one to fall into the estuary's flows and to attune oneself to the rhythms and patterns of its tides.

This methodology combines local, situated, sensorial, embodied, and technical knowledge in the attempt to challenge purely discursive readings of the estuary. This can create an opportunity for people to engage in a dialogue that questions prevailing methods and enables a more nuanced understanding of the complexities of the estuary. When engaging in activities within the intertidal zone, seafarers learn how to think with the forces of the waters, winds, seabed, tide charts, tidal predictions, sonar baths. Their approach allows to establish a close relationship with technical objects and our own embodied experiences. In other words, Practising in the Wild is imbued with Embodied Technical Processes (ETP). Processes that combine both technical and embodied ways of knowing and thinking with the estuary.

Embodied Technical Processes

Thinking through ETP allows us to comprehend the structural coupling of humans in collaboration with different bodies. Embodied, here, focuses on building knowledge about the estuary through bodily experiences. The body acts as an instrument to know, bypassing rational thoughts through bodily senses and feelings.[15] It provides a sensorial understanding of the estuary, opening the potential for affective transmission; from the body to environment and environment to body.[16] For instance, experienced seafarers can feel the wind changing through the hair of their skin—an embodied response to a changing environment.

Technical refers to the knowledge one develops in collaboration with tools, objects, instruments, devices. For instance, when planning a journey and before starting to navigate, knowing the tide's height and timings is necessary when seafaring the estuary. This information can be obtained from a nautical almanac, an app or a tide website that predicts the times and heights of high and low water daily. Alternatively, a tidal curve specific to each port can be used to manually calculate the tidal range at any given time. The tidal curve is a wave graph that can be found in the nautical almanac (see figure 4).

When sailing with experienced seafarers, one can gain further insight about ETP. People often discuss the relationships between the wind, water, boats, tools, devices. For instance, nowadays, many seafarers use GPS or radar tracking equipment, check tide charts and weather forecasts before heading out, and combine these different readings with their personal experiences to sail the estuary. It involves a balance between their knowledge and the use of technical objects, blurring the boundaries between humans, objects, and the estuary.

The acquisition of knowledge within the Thames Estuary, thus, relies on both technical and embodied cognitive processes. In other words, a thorough understanding of tidal environments is contingent on technology, experience, and embodiment.

The following section introduces an inventory of technical objects that are used to explore and think with the Thames Estuary. The aim is to understand the nature of the kind of knowledge that these objects embody and how in turn, they help us to build different ways of knowing the estuary.

Inventory of Technical Objects

Figure 3. One of the many wrecks that one can encounter when exploring the intertidal zone.

When walking along the Thames Estuary, one can notice the proliferation of technical objects along its shores and shoal waters. From tide gauges to wrecks, from jetties to cargo ships, the Thames Estuary is populated with technical beings. They act as mediators between the estuary’s ever-changing rhythms and patterns and us. Some encapsulate the estuary and its tides inside fibre-optic cables, informing us of the highs and lows of the waters, while others enable us to actively explore the estuary. Their different cultures embody different ways of knowing, allowing us to think with this soup of mud, water, salt marshes, pollution, sewage.

Boats

Within the context of seafaring, boats can offer thought-provoking insights into the ways people engage with the estuary. They are tied to the movement of the body in space, and the forces of the waters, winds, and seabed, creating constant feedback between the estuary and the body. They become a lens for a dynamic and sensorial experience of the estuary. For instance, sailing necessitates a unique set of skills and knowledge that are not typically required on land. They allow us to become amphibious. The movement of a sailboat is dependent on various factors, such as the boat's features, the forces of the waters and winds, and how they interact with each other. In other words, the movement is influenced by a complex interplay of external forces and internal intentions that dictate directionality and affect local action. Seafarers navigate by "feeling" their way towards their destination, continually adjusting their movements based on the flow of waves, wind, current, stars, and adjusting their boats.[17] The knowledge gained through seafaring is often implicit and intuitive, making it challenging to articulate or communicate with others. While discursive readings can provide a foundation, it is only through experience that one can gradually gain the skills required for exploing the shallow waters of the estuary.

Tillers The analysis of the potential of a seemingly mundane object, such as a boat's tiller, can provide valuable insight into the fundamental nature of seafaring.[18] By feeling the tiller, a seafarer can directly sense the impact of environmental factors on the boat and perceive fluctuations in the wind and water. According to Thomas Gladwin (1964), Micronesian sailors are constantly aware of "motion, sound, the feel of the wind, wave patterns, stars, etc." throughout their voyage. They utilise past embodied experiences to make adjustments, such as slightly changing the positioning of the tiller or instructing the crew to adjust the sails.[19] The tiller thus serves as an extension of the body, allowing the seafarer to seamlessly flow with the currents and manage the boat’s movements. Additionally, the tiller plays a crucial role in regulating and organising the rest of the boat, further highlighting its significance in the context of seafaring.

Data Sytsems

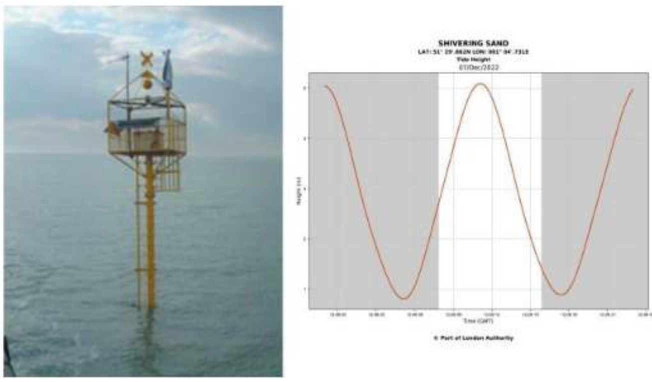

Figure 4. On the left side the tide gauge that is in Shivering Sand [https://www.resinextrad.com/en/tide-gauge-platform-for-the-thames-navigation/], and on the right, a tidal curve that reads the height of the waters at a given time in a specific location. The tidal curve is used as a real-time translation of the data recorded from the tide gauge [https://tidepredictions.pla.co.uk/].

Data systems are seen to provide a continuous stream of data on the Thames Estuary, including real-time tidal information, prediction tables, tidal currents, and charts. These systems play a significant role in various activities within the Thames Estuary. They are critical in monitoring sea level rise, flood risk management, navigational safety, and sea-based commercial logistics.[20] A whole technological infrastructure is situated upon the estuary, composed of tide gauges, ISO maps, tidal predictions, tidal apps, to name a few. These technologies function as an extension of our memory, enabling us to keep track of and compute tidal processes, to observe and analyse their cycles. They aid people in delineating the ranges, currents, and future states of the estuary.

Tide Gauges embody knowledge about the ranges of the tides. They are an important invention in the field of oceanographic measurement, first created by civil engineer Henry Palmer in 1831 for the London Dock Company. These devices were designed to automatically record water levels in a specific location, utilising a float that sat on top of the water in a tube and a pen that recorded the variations through a wave graph on paper attached to a rotating drum. With the advent of self-recording tide gauges, tidal measurements were transformed from a daily sequence to a continuous process over time, mediated by machines rather than human observation. [21] In other words, the introduction of tide gauges revolutionised the way in which tidal data was collected, enabling autonomous recording and representation of tides around the clock. Prior to their invention, the tidal range was measured using graduated scales and staff, which lacked the same level of accuracy and precision as tide gauges. Over time, numerous tide gauges were developed, each uniquely designed to suit its location and varying in mechanism and design.[22, 23]

Tide gauges are still today an essential part of the technological infrastructure of the Thames Estuary. They are spaces that are generally situated on piers, jetties, or buoys. They are equipped with digital sensors, acoustic-sounding tubes, data storage devices, and transmitting equipment. Tides are then captured approximately every six minutes and squeezed into a half-inch wide-sounding tube that measures the distance between the gauge and the water's surface, transforming the flows into indices, numbers, data for people to monitor, analyse, or simply check the range of the waters in real-time.

Furthermore, tide gauges provide essential data for predicting tides and monitoring port operations. Knowing the precise tide time and range is fundamental to life in the estuary. Scientists use this information to research ocean currents and climate change, engineers use it to design coastal infrastructure and simulations. They are used for flood risk management, environmental control, and commercial logistics. In the past, tide gauges were used to serve military and colonising purposes to control the empire. The flow of the empire required "as its lubricant a science of the sea, essential for any overseas expansion or military campaign."[24] Today, they remain vital for shipping and naval operations, with significant ports like Dover that rely on tidal knowledge.

Tidal Predictions William Thomson, popularly known as Lord Kelvin, was a renowned mathematician and engineer who made a significant contribution to tidal knowledge.[21] One of his key innovations was the introduction of harmonic analysis. This method effectively simplifies complex tidal motions into a series of distinct constituents, each of which corresponds to a different lunar or solar frequency.[21] Using this approach, Kelvin was able to develop the tide prediction machine, an ingenious device designed to accurately forecast tides in specific locations. The precise prediction of high and low water times was vital to the livelihoods of coastal communities and ports. As such, the accuracy of tide predictions increased propor- tionally with the number of constituents considered.

The operation of this machine was based on a simple harmonic motion characterised by appropriate speed, amplitude, and phase, which acts on a series of pulleys that represent the various tidal constituents. The spacing and diameters of these pulleys enable a flexible wire or metal tape to be threaded vertically from one pulley to the next. The summed motion is then transferred to a pen, which plots a timed trace on a moving chart at a reduced scale.[21] The machine is capable of handling up to ten tidal constituents, thereby enabling the simulation of the time and heights of tides as a sum of sinusoidal motions of several individual tidal constituents at any location and moment in time.[25]

Today tidal predictions are done on high-speed computers, which can compute more constituents and take seconds to calculate predictions. However, the techniques do not differ that much from the earlier methods.[26]

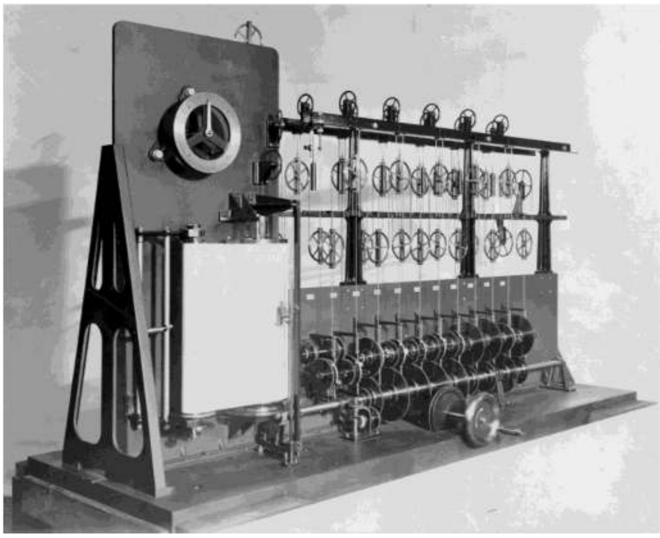

Figure 5. Lord Kelvin Predictor No.3 manufactured in 1881. Number of constituents 16.

Overall, the study of tides has been mostly the subject of scientific inquiry across various cultures, with disciplines such as mathematics and technological advancements contributing to a universal understanding of tidal environments, leaving out subjectivities. In the 20th century, the advent of digital computers paved the way for precise solutions to tidal equations across the entire ocean, incorporating critical factors like the seabed, land distribution, currents, and deformations of the Earth. [21] Advancements in marine instrumentation, tide gauges, and tidal predictions have further enabled calculations and observations of tides along coastlines worldwide. The integration of soundings, ISO maps/baths, bathymetry, predictions on nautical charts, and satellite altimeter data in the early 90s has resulted in the establishment of a Foucauldian-type formation of truth machines. Systems that systematically produce truths that hold validity within a particular discourse and provide answers to explicit questions that shape language and values regarding tidal environments.

This research proposes to triangulate knowledge refuting the idea of singular ways of knowing the estuary. In other words, tidal environments cannot only be understood by purely scientific methods.[27]

Art Projects and ETP

In this section, we will look into two distinct artworks, one by John Eacott and the other by YoHa. Both artists, in different ways, employ ETP to create their work, raising the question of how art practice can bring together different ways of knowing the estuary. John Eacott uses sensors to transform live tidal data into a musical performance. Art collective YoHa harnesses local, embodied and technical knowledge of the estuary to construct an anti-monument.

Flood Tide

Composer John Eacott created a unique sonification of the Thames Estuary in 2008. The composition was generated by using an Acoustic Doppler Current Profiler (ADCP) to read the speed of the flood tides in the Tidal Thames. During the performance, the ADCP was placed in the water to stream real-time data, which was then translated into an ever-changing musical score. An ensemble of orchestral instruments read live tidal stream data from computer screens, producing a musical experience that lasted approximately 6 hours, the duration of a complete flood tide. This performance seamlessly engages with the Thames, integrating music and data by combining cosmic forces, sensors, the tides, sound, musicians, and instruments.

In a group discussion analysed by the artist, insights were shared about the music, the data's importance, the performance's visual aspects, the experience of both performers and the audience, and the relevance and relation with the Thames.[28] The music is hypnotic, meditative, and slow. It is repetitive but varies. The performance raises awareness of the ever-changing rhythms and patterns of the tides and creates an unusual representation of the Thames tides. The experience is created through an interaction between the sensor, the tides, the musicians, and the spectators. The ADCP acts as a mediator between the tides and the music, combining an artistic and scientific approach with tides and allowing multiple narratives to emerge: tides as numbers, tides as flows, tides as sound, tides as experience, tides as structure, and tides as the gravitational pulls of heavenly forces. It acknowledges the complexities of the Thames.

Overall, the artwork provides an immersive experience that captures the intricacies and subtleties of the Thames through the sonification of the environment. Incorporating sound allows for a deeper connection with tidal environments, creating a multi-sensory experience that goes beyond rational thought.[16] However, I am curious how the music would change if this artwork were performed in different tidal environments. How does the data of the ADCP change and, in turn, vary the score from place to place? More so, how could the performance reflect the diversity of each place?

Graveyard of Lost Species

Figure 6. Low tide during the making of the installation ©YoHa.

The artwork, ' Graveyard of Lost Species,' by YoHa in collaboration with Critical Art Ensemble (2015), is an antimonument. It is composed of a wreck. The intertidal zone is home to many boats buried due to local activity. The wreck, which was once abandoned, forgotten, and let to fade, is transformed into a site of cultural production and served as a powerful reminder of the consequences of capitalism on the environment. It aims to raise awareness of environmental degradation and the loss of biodiversity along the estuary. The artwork is designed to fade and perish over time, highlighting the urgent need for ecological conservation and preservation.

The process involved the transportation of the wreck from the estuary mudflats to the shore. This was a challenging experience for those who participated since they had to deal with the unpredictability of the estuary. It required people with local, technical and embodied knowledge of the ever-changing rhythms and patterns of the estuary, allowing them to build a sense of place.[29]

This artwork is a significant contribution to exploring locality, embodiment, and materiality. It employs the idea of 'making, thinking, and being with', which involves collaborating with local materials, bodies, objects, and especially tides and mud. Furthermore, the project helps to show how people situate themselves within the estuary, engaging with it in alternative ways and providing valuable insights into participatory forms of making. An approach that this doctoral research aims to form.

Conclusion & Next Steps

One of the objectives of this doctoral research is to create various methods for artistic and design practices that engage with tidal environments and reintroduce discussions around locality, situatedness and diversity within this stretch of mud and water. The paper introduces a methodology inspired by people who work at sea, such as seafarers, fishers, sailors. By merging embodied, subjective, computational, and technical ways of knowing the estuary, this approach attempts to serve as the foundation for a more holistic understanding. In other words, it proposes to triangulate knowledge, promoting diverse perspectives to defy any rigid distinctions about the estuary.

The methodology proposed in the paper includes an inventory of technical objects that are necessary when engaging and exploring tidal environments. These objects allow us to think with the estuary and, more broadly, with the more-than-human world. While the paper provides a list of technical objects, it acknowledges that it is incomplete. Other objects, such as buoys, anchors, and ropes, in different ways, should also be considered to enrich the current state of the inventory.

Finally, it looks into two artworks that propose, in different ways, situated interventions within the Thames. They help to understand the importance of ETP further. Adjacent to this paper, future studies are currently being developed: (1) interviews with artists, seafarers, and river workers, (2) personal field notes, images, experiences, the development of a sort of 'cahier de voyage' (3) enriching the inventory (4) and finally the making and development of in-situ installations.

References

1 Sarah Whatmore, "Materialist Returns: Practising Cultural Geography in and for a More-than-Human World", *Cultural Geographies* 13, no. 4, 1 October 2006, p.600–609, https://doi.org/10.1191/1474474006cgj377oa.

2 Donna J. Haraway, *When species meet,* Vol. 3, U of Minnesota Press, 2013.

3 Rosi Braidotti, *The Posthuman,* Polity, 2013.

4 Graham Harwood, *Wasted Museums by YoHa,* The Exchange, Erith, November 9, 2022, Introduction to Exhibiton.

5 Robert Van de Noort, *North Sea Archaelogies: A maritime Biography, 10,000 BC-AD 1500,* Oxford University Press, 2011.

6 James Greig McCully, *Beyond the moon: A conversational common sense guide to understanding the tides,* World Scientific, 2006.

7 Jones Owain, "Lunar-Solar Rhythmpatterns: Towards the Material Cultures of Tides", *Environment and Planning A* 43, no. 10, 2011, 2285–2303, https://doi.org/10.1068/a4468.

8 Jane L. Fielding, "Inequalities in Exposure and Awareness of Flood Risk in England and Wales", *Disasters* 36, no. 3, 2012, 477–94, https://doi.org/10.1111/j.1467-7717.2011.01270.x.

9 HM Government, "UK Climate Change - Risk Assessment 2017", *Open Government Licence*, 2017.

10 David Pugh, Philip Woodworth, *Sea-level science: understanding tides, surges, tsunamis and mean sea-level changes,* Cambridge University Press, 2014.

11 Catherine D'ignazio, Lauren F. Klein, *Data feminism,* MIT press, 2020.

12 Britta Restemeyer, Margo van den Brink, Johan Woltjer, "Resilience Unpacked – Framing of “Uncertainty” and “Adaptability” in Long-Term Flood Risk Management Strategies for London and Rotterdam", *European Planning Studies* 26, n.8, 3 August 2018, 1559–79, https://doi.org/10.1080/09654313.2018.1490393.

13 Yarina Lizzie, "Your Sea Wall Won't Save You", *Places Journal*, 27 March 2018, https://doi.org/10.22269/180327.

14 David Chandler, "Forum 2: The Migrant Climate: Resilience, Adaptation and the Ontopolitics of Mobility in the Anthropocene", *Mobilities* 14, no. 3, 4 May 2019, 381–87, https://doi.org/10.1080/17450101.2019.1609194.

15 Michael Polanyi, *The Tacit Dimension,* Peter Smith, 1983.

16 Jones Owain, Louisa Fairclough, "Sounding Grief: The Severn Estuary as an Emotional Soundscape", *Emotion, Space and Society* 20, 1 August 2016, 98–110, https://doi.org/10.1016/j.emospa.2016.06.001.

17 Tim Ingold, *The perception of the environment: essays on livelihood, dwelling and skill,* Routledge, 2000.

18 B. Wattchow, A feeling for water: The body and the paddle, *Journeys*, *4*(2), 1999, 26-32.

19 T. Gladwin, *Culture and Logical Process in Explorations in Cultural Anthropology,* New York, McGraw-Hill, 1964, 167-177.

20 Addina Inayatillah, Ivan D.Haigh, James H.Brand, Katy Francis, Alex Mortley, Matthew Durrant, Laura Fantuzzi, Elizabeth Palmer, Callum Miller, Peter Hogarth, "Digitising Historic Sea Level Records in the Thames Estuary, UK", 2021.

21 David Edgar Cartwright, *Tides: a scientific history,* Cambridge University Press, 2000.

22 Wolfgang Matthäus, "On the history of recording tide gauges", *Proceedings of the Royal Society of Edinburgh, Section B: Biological Sciences* 73, 1972, 26-34.

23 Philip L. Woodworth, "Advances in the Observation and Understanding of Changes in Sea Level and Tides", *Annals of the New York Academy of Sciences* 1516, no. 1, 2022, 48–75, https://doi.org/10.1111/nyas.14851.

24 Michael S. Reidy, *Tides of History: Ocean Science and Her Majesty's Navy,* Chicago, US, University of Chicago Press, 2008.

25 Philip L. Woodworth, "An Inventory of Tide Prediction Machines", Monograph, National Oceanography Centre, 2016. https://eprints.soton.ac.uk/394662/.

26 Bruce B. Parker, *Tidal Analysis and Prediction,* NOAA, NOS Center for Operational Oceanographic Products and Services, 2007. https://doi.org/10.25607/OBP-191.

27 Graham Harwood, "Wrecked on the Intertidal Zone (2015)", YoHa Art Collective Website, last accessed December 6, 2022, http://yoha.co.uk/wrecked

28 John Eacott, "Flood Tide: Sonification as Musical Performance—an Audience Perspective", *AI & SOCIETY* 27, no. 2, 1 May 2012, 189–95, https://doi.org/10.1007/s00146-011-0338-2.

29 Brian Wattchow, Mike Brown, *A pedagogy of place: Outdoor education for a changing world,* Monash University Publishing, 2011.