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Lunar – solar rhythmpatterns: towards the material cultures of tides

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Abstract. The movements of the oceans, and the liminal margins of sea, land, and fresh water have profound implications for human/nonhuman life. Those movements and margins are rhythmically affected by tides which are thus a key means by which the forceful materiality of water is animated. Where salt water meets land and river mouths, ceaseless, varying, daily, monthly, and seasonal rhythms of sea level rise and fall occur. Complex patterns and rhythms of intertidal areas, currents, mixing of salt and fresh water, erosion, transportation, and deposition, and many impacts on human systems are created. Due to location, orientation, and sea/land topography, coastal areas around the world are subject to microtides, mesotides, or macrotides (4 m and higher). Particularly in the case of the last, the rhythms of the tides extend out into a range of intersecting ecosocial assemblages. This paper discusses tides and their rhythms, sets them in debates about temporality/nature, and introduces the idea of rhythmpattern which is timespace animated. It also considers dissonance and consonance within and between tidal rhythmpatterns and their overwriting by development.

Introduction

This paper is about relational, temporal – material performances of the world in ecosocial[1] formations. It seeks to consider this in the case of (sea) tides. It seeks to move towards a multifaceted view of tides (drawing upon technical, material, economic, historical, and cultural accounts) as a means of investigating their temporal – material implications in what are being called the 'rhythmpatterns of timespace'.

Tides are powerful processes which routinely/rhythmically shift millions of tons of water and material suspended therein at high speeds. They are a key way in which water-as-actant is animated. These mobile masses exert immense hydraulic forces which shape the spaces they operate within and the life/materiality they encounter in and around them. For example, tides ceaselessly resculpt coastal and estuarine features such as spits, channels, beaches, and sandbanks over millennia but at much faster timescales too. A spring tide in association with a storm can reshape sandbanks and channels in an intertidal zone in the space of a few hours.

In social terms, coastal defences, drainage systems, sea and land transport, industry (power generation), and other materialised practices such as fishing, coastal agriculture, sailing, coast-based tourism, walking, and birdwatching can be given form and rhythm by tides. Elsewhere I have discussed how senses/practices of tidal places and landscapes are portrayed in literature and art (Jones, 2010). Here I seek to focus on what I am calling tidal material culture/geography.

I have three aims. Firstly, to bring tidal processes into new academic foci. Tides have received attention from the natural sciences (see Cartwright, 2000), and from

[1] I use 'ecosocial' to register relational formations between nature and culture. Eco(logical) is put first as it frames the social in terms of generating and regulating the liveable biosphere, and habitats and bodies. The social can intervene creatively or destructively in formations but as yet does not have full life-making/regulating powers. 'Ecosocial' represents relational processes but these are *not* considered symmetrical.

society in terms of those who live and work with them, but they have received far less attention in the social sciences and, within that, human geography approaches to place and landscape, and considerations of temporality, process, and relationality.

Secondly, I use tides to discuss approaches to time and space in the context of relational approaches, reconsiderations of agency, and how we read ecosocial formations. Two main points are explored. One is about the agencies of processes and flows. Despite a great effort to deanthropocise ideas of agency, the tendency has been to extend agency from human actants to other discreet object or organism actants. There is a need to consider the agencies of relational processes and the material flows they consist of and/or generate. These are the profound planet/life-making agencies. Second I consider temporality, focusing on (nature) rhythms, and, building on those, rhythmpatterns. This is timespace (May and Thrift, 2001) enacted. There has been a focus on how space is produced and patterned (Harrison et al, 2004), but patterns are only snapshots of a fixed moment of space/place. They will always be on the move, and often be so rhythmically. Rhythm is to time what pattern is to space, and they need to be considered together. We live within rich temporal ecologies (combining forms of time) and these are expressed in the ongoing rhythmpatterns of animated timespace. Tidal processes offer fertile grounds on which to explore such ideas as they are so obviously temporal and spatial at once.

Thirdly, I consider tidal processes as a key form of watery agency which drives intersecting rhythmpatterns within the (material) ecosocial in many ways. These relationships are shapers of local topographies, ecologies, cultures, and economies. These vary greatly in differing tidal landscapes, and have changed historically. In the light of thinking about the flourishings—or otherwise—of social–ecological relations, I consider tidal formations not only in terms of ecosocial and temporality—how tidal rhythms generate ecosocial rhythmpatterns and provide ecosystem services—but also in terms of dissonant relations between and within tidal material cultures, and the ways in which tidal timespace can be overwritten by development.

Dealing with other forms of temporality is important in thinking about 'ecological planning' (Murdoch, 2005) and *ecological governance*. As Woods (2008, page 262) argues:

> "Temporal factors are of paramount importance because the degree to which society and nature operate in consonance or dissonance profoundly influences the health of the natural environment, the structure of the social system and, hence, the prospects of sustainable development."

These aims notwithstanding, I am keen that the world (in terms of tidal process) is considered in and of itself, and not just as a means to theory. This work draws upon two main information sources. Firstly, many years of engagement with the Severn Estuary (southwest England) which has the second highest tidal range in the world, witnessing it as a home landscape, photographing it, and studying its history, ecology, culture, and land-use/environmental governance. Secondly, I draw upon other studies/depictions of significant tidal landscapes and their hinterlands in the UK and beyond: including ecological summaries, planning documents, local histories/topographies, and literary accounts.

The agencies of the oceans and their tides

Satellite images taken from centrally above the Pacific ocean are startling because the whole 'earth' appears blue, with just a few fringes of land peeping over the circular horizon. Seven tenths of the earth's surface is ocean, and this majority element is restlessly mobile. The movements of the planet's salt waters form complex rhythmpatterns which, with their temperature patterns, inhabiting life, and exchanges with atmosphere, land, ice floes, and rivers/forests (Deakin, 2007) are some of the most forceful and creative processes on the planet.

These ocean rhythmpatterns are in turn expressions of the interplay of many profound forces, particularly the rotation and tilt of the earth and the relational movements of the heavenly bodies. As the earth rotates in relation to, and orbits, the sun, and the moon orbits the earth in a 'tidally locked' synchronous rotation, complex patterns of gravitational variation occur. It is chiefly the pull of the much closer moon, in varying concert with the sun, and many other factors (some outlined below), which creates the tides. In turn, the rhythms of the tides are folded into a range of ecosocial systems. All life feels this rhythm (Watson, 1973) and it is within such relational *processes* which pulse through the planet, oceans, bodies, and systems of joined-up bodies – materialities, that agency is to be found. As Barad (2007, page 141) states,

> "the primary ontological units are not 'things' but phenomena—dynamic topological/ reconfigurations/[...] entanglements/relationalities/(re)articulations of the world."

Tides cause strong currents and the sea level to rise and fall daily. Thus they rhythmically scramble two of the most fundamental divisions of physical space on earth—between salt water and land, and salt and fresh water. Margins where mixing and exchange occur are often fertile. The liminal margins of the mobile oceans, their intertidal areas (varying from vast to small), and spaces of brackish water (mixture of salt and fresh water) in estuaries and river mouths, and the immediate hinterlands of these areas, have been, and remain, critical zones for human and nonhuman life. When the moon was much younger and closer to the earth, tidal processes would have been much greater and more violent. The turbulent, repeating cycles of inundating, mixing, draining, and drying along coastal margins, the stirring of sand, silt, and mud and the organic matter therein, and the mixing of fresh and salt water, might well have been critical to the evolution of life itself (Kopel, 2007; Luick, 2008).

So tides are, as Clancy (1968, page xi) puts it, "the pulse of the earth", and a key way in which water is animated to agency. Ancient philosophers/geographers such as Strabo and Ptolemy wrestled with questions of tides and littoral margins (Bunbury, 1879; Romm, 1992) as they were so important practically for seaborne trade and conquest, and also such mysterious phenomena, given that gravity was not understood.

More recent studies have considered interactions between water, landscape, and engineering (Cosgrove and Petts, 1990), but Dalby (2007) has nevertheless asserted that water and wider ecosocial relations are underconsidered in human geography and related subjects, and has called for the development of what he calls "blue theory":

> "social scientists, and certainly many geographers, are guilty of a form of 'terrestrocentrism' a focus on the land rather than an understanding of ourselves as part of a biosphere dominated by oceans and atmosphere" (page 113).

Tides are just one of a vast number of natural spatiotemporal processes which trace through materialised social space and time. Other key forms are night and day, the seasons, weather cycles, and sun cycles. We live within *burgeoning temporal ecologies* which we often misread, or just ignore completely!

A (very) basic anatomy of tides

The sun and moon exert 'tractive' force on the oceans, drawing the waters towards their ever-moving 'sublunar' and 'subsolar' points. As a result of this in combination with other forces there is a basic tidal rhythm—a continuing cycle of *low water*; *the flood* (tide rising); *high water; turn of the tide*; *the ebb* (tide falling); *low water*; and *turn of the tide* again. At the turn of the tide there is sometimes a brief period of *slack* or *dead water*. The precise heights and timings of high and low tide are determined by the gravitational forces working in concert with a whole host of other factors, including atmospheric pressure, prevailing wind direction, wave dynamics, bathymetry, seabed topography, and coastal location, form, and orientation. Each of the oceans (Carson, 1961), their regions, and even lesser bodies of water, have their own distinct tidal rhythmpatterns. The timings and heights of high and low water migrate along coastlines, and so it is the case that all tidally affected places (such as seaports) will have unique rhythms of high and low water levels and times.

Variously, around the world's coasts, the all-important sea level continually rises and falls to make either microtidal coasts (under 2 m range); mesotidal coasts (2–4 metres); or macrotidal coasts (4 m and higher) (Haslett, 2008). Tidal areas can be 'diurnal' (tides rise and fall roughly once every 24 hours: eg, Gulf of Mexico); 'semidiurnal' (tide rises and falls roughly twice in 24 hours: eg, Atlantic coasts of Europe and North America); or 'mixed', where the rhythm is more syncopated, as in one low tide followed by two higher tides (eg, west coast of Canada and the United States).

There is, in general, a monthly rhythm of increasing and decreasing tidal range driven chiefly by the moon's pull which is either exacerbated by the sun's pull (at full/new moon) to make high *spring* tides, or suppressed by it (quarter/gibbous moon) to make low *neap* tides. There is also a seasonal (yearly) rhythm within these monthly rhythms. The very highest tides, *perigee spring tides*, occur at the equinoxes and are caused by the relative closeness of moon to earth.

Importantly, spring tides not only mark when the water level rises highest, but also when it recedes to its lowest at the other end of the cycle. In other words, spring tides consist of the largest range between high and low water, whereas neap tides have the smallest range between less extreme high and low water levels, and varying intertidal areas are consequently exposed/inundated.

Tides do not simply mean a constantly rising and falling sea level; they result in complex geographies of the sea. For example, regular tidal currents, tide races (when rising/falling waters are forced to flow through narrow channels between land formations), standing waves, and large tidal whirlpools occur along macrotidal coasts. Raban (2002) offers a rich description of local geographies of the sea and tidal margins on the northeast Pacific, where such tidal features are known to indigenous peoples in the same way that terrestrial landscape features are known to land dwellers.

Atmospheric pressures, wind directions, and wind speeds can either exaggerate or dampen tidal range and change the precise times of high or low water. Storm tides, sometimes responsible for devastating floods (as in Eastern England and Holland in 1953), occur when high winds and low pressure combine with a high tide in such a way to pile water up against coastal areas. Although generally predictable due to the good understanding of the gravitational relationship between earth, moon, and sun, in local detail, tides are dauntingly complex to understand and predict precisely. McCully (2006) states that,

> "unique tidal patterns often arise simply because there are so many constituents involved, and occasionally they will combine in a unique way, so that several of them will reinforce each other to produce an unexpected pattern, or a surprising high (or low) water level" (page 257).

In thinking about tidal rhythms in terms of temporal ecology and rhythmpattern it is important to note that *times of high and low water do not synchronise with the day–night cycle in any simple way.* "Because the earth rotates in relationship to the moon once every 24.8 hours, high tides occur on average every 12.4 hours" (Young, 1988, page 27). Thus the timings of high and low water slowly migrate across the 24-hour grid. The other monthly cycle of peaks (spring tides) and lows (neap tides) is 14.8 days. Thus tide times and day night times form a moiré pattern as they slide by each other. Figure 1 shows a week's tide times for the Port of Bristol (UK) set against the 24-hour grid.

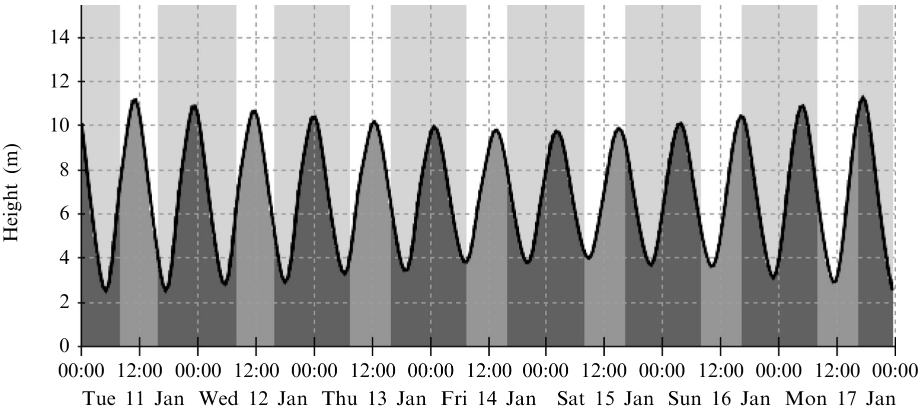

Figure 1. [In colour online.] A week's tide timetable for Port of Bristol (January 2011). Crown Copyright.

Time, ecological time, and rhythmpatterns

A focus on time in geography and social theory emerged in response to concerns about the separation of time and space and the relative neglect of time (Adam, 1994; 1998; Gell, 1992; Latour, 1997; May and Thrift, 2001; Parkes and Thrift, 1980). Interests in the ecologies and spatial – temporal fluidities of life, place, and landscape (Massey, 2005; Thrift, 1999) have developed which respond to Lefebvre's demand to think "time and space *differently* and to think them *together*" (Elden, 2004, page ix, emphasis in original), and not as abstract(ed) a priori grids to be filled out by life, but as only articulated in and through materialised and lived ongoing (relational) processes. Temporality has a great richness to it, with aspects of rhythm, tempo, and duration to consider, and how these trace through assemblages and bodies and affective life (human and nonhuman).

Within some of these approaches the temporal registers of nature have appeared only fleetingly. For example, May and Thrift's (2001) collection is overwhelmingly focused on aspects of social time. Elsewhere the temporalities of nature have come into focus (Macnaghten and Urry, 1998); for understanding environmental change (Driver and Chapman, 1996), environmental hazards (Adam, 1998), and nature conservation (Adams, 1996). Adam (1998) develops the notion of 'timescapes' in which she looks at the 'multiple rhythmicities of nature' within landscapes. In particular, Adam considers the rhythms/durations of nature primarily in regard to understanding environmental hazards and their governance (importantly) focusing on the temporal dimensions of such issues as bovine spongiform encephalopathy (BSE), and nuclear power generation and waste storage, and how these interact in problematic ways with the prevailing knowledges and practices of clock, industrial, and political time. As Wood (2008) asserts, addressing deeply ingrained, taken-for-granted assumptions about time, nature, and the environment is critical in developing understanding of nature – society relations, place, and space.

Here I look beyond hazard and risk to consider other naturally derived temporal ecologies. To talk of natural rhythms is not to separate out nature – culture into discrete sets, it is to point to the sources of pulses that enter any system of temporal ecology. Some clearly stem from pre/beyond-the-social, insofar as processes such as planetary rotation and orbit, and the gravitational rhythms stemming from these, are pre/beyond-the-social in terms of inception, scale, and physical influence. "Nature is [not] the polarized opposite of culture but [its] underlying condition" (Grosz, 2005, page 6).

This goes for the temporal signatures of nature—be they tides, seasons, day–night, body clocks, and so forth.

This is, in part, about the animation and *enchantment* (Bennett, 2001) of the materiality of landscape through natural, watery, timespace rhythmpatterns.

> "Water produces endless variation in systems of patterning, a design feature that perhaps explains its estuarine magnetism. The living waterscape is the public space in which people converge, dream, reflect, open up to the world around them, experience flow, move between the conscious and the unconscious, tune into the living aesthetics of water, which influence not just our biology but our psychology" (Clarke, 2010, page 122).

Tidal timespaces should be considered through Latour's (1997) approach which rejects both objective and social constructivist notions of time (and space) and instead focuses on the material, relational, and processual. Drawing on Whitehead and Leibniz, Latour (1997, page 174) argues that space and time are "the consequences of the ways in which bodies relate to each other. Instead of a single space–time, we will generate as many spaces and times as there are types of relations." Thus the position emerges that ecosocial processes are not only, as actor network theory (Callon and Law, 1995; Latour, 1993) suggests, the outcome of "a multiplicity of differing agents [...] human and non-human, technological and textual, organic and (geo)physical, which hold each other in position" (Whatmore, 1999, page 28), but also the outcomes of interconnecting time characteristics (duration, tempo, rhythm) of those entities/processes which will combine in relational hybrid rhythmpatterns of timed–spaced practices.

Macnaghten and Urry (1998) raise the notion of glacial time (long-term cycles of nature such as ice ages and plate tectonics). This they equate to Macy's (1993) notion of ecological time and here they hurry past an important set of distinctions. There is a vast multiplicity of nature times of which glacial and ecological are but two (broad) forms. Ecological time and other forms of nature times, such as diurnal and tidal sequences, need to be differentiated and analysed in order to grasp the complexity of temporal ecologies on this 'blue planet'. Tidally animated waters present endless repetitive/novel sets of relational processes resulting from the ceaseless gravitational interactions of the heavenly bodies which, in turn, are multiplied by earthly variations.

Grosz (2004; 2005) sees time as a neglected yet vital element in rethinking culture, and this in part comes from nature "in terms of dynamic forces, fields of transformation and upheaval, rather than as a static fixity, passive, worked over, transformed [...] by culture" (Grosz, 2005, page 7). Nature brings activity, unpredictability, and unruliness into culture. Tides fit into this debate interestingly insofar as they are both predictable and unpredictable, temporally open and changing, but also repeating rhythmically in ways which culture builds material arrangements around.

Towards rhythmpattern

There is a growing interest in the nature–culture 'patterning' of ground (Harrison et al, 2004) where all manner of things make formations—sites, landscapes, cities, places. People, nonhumans, materials, processes (cultural, political, economic, ecological), and more besides are brought and/or thrown together, and settle out into enduring, but always contingent and shifting, formations. Both the social and the natural are on the move in ceaseless migrations, cross-pollinating between formations to pattern space.

Such patterning will be taking place within a range of durations, tempos, and rhythms. So these patterns are (nonsymmetrically) kaleidoscopic over time. Timespaces animated are rhythmpatterns in action, and many of the beats in such rhythms stem from natural planetary system cycles which bodies, ecologies, economies, and cultures 'dance' with(in):

"the rhythmic structure of social time emerges not only from the interweaving and mutual responsiveness of human movements, but also from the way these movements resonate to the cycles of the non-human environment. Traditionally, people had to *fall in* with rhythms of their environment: with the winds, the tides, the needs of domestic animals, the alternations of day and night, of the seasons, and so on, in accordance with what the environment afforded for the conduct of their daily tasks" (Ingold, 2000, pages 325 – 326).

Complex moiré patterns, and dissonance or consonance, can occur between intersecting rhythms. Considering these temporal ecologies is a key part of reconnecting nature – culture. Massey's (2005) notion of places as events allows room for physical processes such as planetary movements and glacial rebound to become part of place-in-process. Thus, seemingly settled (even ancient) landscapes have to be seen as literally on the move. Massey does refer to tides and points to the fact that land masses show small degrees of tidal rise and fall. These, though, are only perceptible through the use of highly sensitive scientific instruments. The tides that wash our shores are not only visible, but also dramatic, impactful, even threatening processes that occur on a daily and hourly basis.

Evans and Jones (2008) suggest that we need to take up Lefebvre's challenge to conduct 'rhythmanalysis' of space. Lefebvre (2004) contends that spaces (such as cities) have multiple types of temporal patterns and rhythms (linear, sequential, cyclical), and this is key to understanding the pulse(s) of life within them.

Geographies of tidal material cultures

Around the world there are rich geographies of tidal material cultures; firstly, in the ways that tides vary as physical processes; and, secondly, in the ways they intersect with the ecosocial. This is very evident in the three areas with the highest tides in the world: the Bay of Fundy, Canada; the Severn Estuary, UK; and the Penzhinskaya Estuary, Russia (Barker, 2008). The Penzhinskaya Estuary is in a remote location and the estuarine landscape is almost entirely unmodified from its natural state. It is fringed with only a scattering of subsistence communities who interact with the tides for fishing and resource extraction. In contrast to this, some 3000 000 people live in large urban conurbations and smaller settlements around the Severn Estuary. Its shores are the site of large-scale civil infrastructure, such as nuclear power stations, international seaports, and large road bridges. Its landscape is highly modified, with 80% of its coastline being lined with sea defences to hold back the very highest tides. The Bay of Fundy, which has the highest tides of all, is in a rural location. Here the tidal landscape is a focus of tourism and a local fishing industry, and it has also been highly modified in some areas to prevent inland flooding. In these and many other coastal areas, tides gear with the ecosocial to create rhythmpatterns articulated in and through rich material ecologies.

Lefebvre considers tides as one form of cyclical, natural rhythm, making the point that cities on Mediterranean coasts (which are generally microtidal) might have fundamentally differing temporal/rhythmic signatures from cities on the Atlantic coast which have a macrotidal range.

"We shall [...] begin by indicating briefly certain contrasts between Mediterranean and oceanic towns. These are governed by the cosmic rhythms of tides—lunar rhythms! With regards to Mediterranean towns, they lie alongside a sea with (almost) no tides; so the cyclical time of the sun takes on a predominant importance there. Lunar towns of the oceans? Solar towns of the Mediterranean? Why not?" (Lefebvre, 2004, page 91)

But this fascinating idea is left there. Koppel (2007) fleshes it out to some extent when he describes the very different characteristic material harbour-side arrangements of Mediterranean and Atlantic seaports, and the resulting senses and practices of place.

Bays and funnel-shaped estuaries have some of the highest tides in the world because the surge of rising water is confined into increasingly narrow channels. This is particularly important in the UK. The Nature Conservancy Council (NCC, 1991) identified 155 estuaries around the UK and calculated that, "the 9320 km of estuarine shoreline makes up 48% of the longest estimate of the entire coast" (17 820 km) (page 10). These estuaries are highly dynamic natural and social systems and can contain vast intertidal areas (eg, Morecambe Bay, 61 506.22 ha; The Wash, 10 7761.28 ha). They are often linked to large conurbations through industry and transport histories. In the UK "18,186,000 people live in large towns and cities adjacent to estuaries" (NCC, 1991, page 10). Both urban and rural coastal hinterlands will have related rhythms tracing through them in a number of processes and material arrangements, such as transport, water management (drainage, flood defence), recreation, industrial and domestic waste discharges, and ecology management.

Tides thus create hybrid timescapes with nonhuman rhythms folding into social rhythms of economy and culture. This local temporal patterning can in turn contribute to local distinctiveness (Clifford and King, 1993) and 'ecologies of place' (Thrift, 1999). The idea of intersecting rhythms, including economic cycles, day and night, weather, tides, animal life cycles, creating distinctive senses of place and work, is illustrated by Young (1988), who, in seeking a vivid example of interlinkages between "natural rhythms and human timetables", turns to a tidal landscape, the Bristol Channel, which forms the western seaway leading into the Severn Estuary.

> "It is dawn at an English West Country fishing port on a summer morning. Norman Widdicombe, the skipper of the Mary Jane, has been woken by an alarm clock which is reset each night to a different time" (page 262).

Young goes on to describe the complex calculations this commercial fisherman makes to plan his trip, listing the natural and social rhythms which complexly gear together—tide times; weather patterns; the daily and seasonal habits of fish stocks and their responses to the tidal currents; day and night; fish trade prices; the weekly rhythm of the commercial fish markets; the family and working-life patterns of his crew. Thus emerges the possibility of people being embedded in ecological senses of time and *rhythmic 'practices of place'* as well as 'senses of place'.

Forms of study are needed which can respond to various kinds of temporal ecologies. Possible exemplars can be found in some recent work. Oliver (2002; 2010) has considered the dynamic interactions between water, river – tide dynamics, navigation, and material culture in the Thames river. Lorimer (2010), in reflecting upon a 'tidal self-experiment' conducted within the daily routines of landscape practice alongside a tidal estuary, considers the value of thinking temporal – spatial ecology.

> "living space – times cannot be bracketed off to the specific habitat of the tidal island at the river mouth, since co-existent ecological relationships emerge from a trans-local milieu and have followed patterns and rhythms ceaselessly, in timeworn fashion [...]. Figured thus, a different order of persons and powers in the world does become palpable, taking place through fields of variations, relations, sensations and affects: life felt on the pulse, in the turning of seasons, in mass movements of water and air, in depths, and surfaces, inhalations and exhalations, in the quickening and slackening of energies, in the pacing and duration of encounters, in the texture of moods and casts of light, in washes that are bio-chemical and tidal, and currents that twine the personal and impersonal, the substantial and immaterial, the perpetual and occasional, the territorial and transitory" (2010, page 73).

At Avonmouth Docks (Severn Estuary, UK) the difference between high and low water at the equinoxal spring tides is around 14.5 m. The sea will rise up the height of three double-decker buses in the space of six hours and then recede again. A huge volume of fast-flowing, turbulent, brackish, sediment-laden water presses up the estuary. It fills up this vast space to the very brim of its sea defences and forces water back up the normally draining rivers through both urban and rural landscapes.

Tidal rise and fall happens every day, but at higher tides (about 90 days a year) this surge of water culminates in the famous Severn Bore (a notable natural spectacle and tourist attraction). This is created as the increasingly confined advancing tide picks up enough speed and height to become a surfable tidal wave which washes up the lower reaches of the River Severn. Once high tide is reached the restless, flotsam-rich water stands for 30 minutes or so as much as 4 m above much of the surrounding (protected) land and would wash far inland if unrestricted. Then the tide turns and the sea itself recedes to leave a draining estuary. Six or so hours later (depending precisely where you are) hardly any water at all might be visible: just a deep, indistinct perspective of sand, mud banks, and draining channels.

The estuary is 557 km^2, with around 18% of this being intertidal (100 km^2). The tides and intertidal areas are a fundamental and unifying feature of this area's landscape character. They are extraordinary visual spectacles in themselves and the intertidal areas and margins are home to a rich combination of internationally important natural and culture heritage.

The estuary forms the sea division between southwest England and southeast Wales and the coastal edge of eleven local authority areas (unitary boundaries). The tidal dynamics bring many ecosystem services, but make the integrated management of the estuary highly complex. The Severn Estuary Partnership (SEP) (a coalition formed of local authority interests seeking to strategically manage this dynamic landscape) states,

> "Britain's longest river brings vast quantities of water into the Severn Estuary. Europe's biggest tide takes masses of water back up into the mainland. The mighty Severn influences the ways we live in many ways—and deserves all the attention we can give it!" (SEP, 2005, page 2).

The fast tidal currents allow large volumes of material to be carried in suspension—"in excess of 30 million tonnes of fine silt is in suspension on a typical spring tide" (SEP, 2001, page 57). This silt is a defining characteristic of the estuary (and other tidal spaces). It forms the mud banks and shifting channels, forms habitats, and impacts on port management, on aggregate extraction, and on tourist beaches, as of course does the rise and fall of the water level itself. Indeed, it could be argued that tidal estuaries are time–space geographies of mud! This often makes them disregarded and abused spaces in terms of public awareness and use.

The estuary space is a constantly fluxing rhythmpattern with daily, monthly, seasonal, and longer beats. The topography never settles as channels and sandbanks shift. The light and visible space (between sky, water, mud banks, and near and far shores) at differing states of weather/daylight/tide is extraordinarily liminal (and thus of fascination to poets, artists, and others who choose to engage with this landscape).

All manner of ecosocial material arrangements are adapted to the tidal waters and their rhythms, so the rhythmpattern of the tidal estuary has multiple registers. For example, the force of the tide, and the amount of fresh water draining into the estuary through a number of large rivers, means that the salinity of the estuary's brackish waters will vary markedly in time and space, and this has implications for estuarine ecology, fish habits, and fishing.

At high tide the ports are busy with departing and arriving ships, swing bridges are activated in city road networks to allow ship passage, (perhaps creating a traffic jam if high tide coincides with the rush hour). Seaside resorts will be transformed as a high tide pushes holidaymakers off the beaches and into shops, cafes, and hotels. Other work and recreational routines also respond to the high tide. Thus it is a moment of multiple, interrelating, practical, symbolic, and unifying significance within the landscape. This is so for the daily times of high tide and also for the seasonal highs. It must be added that in some ways the significance of tidal time has been diminished through technological mediation and other changes. This is returned to below.

Tidal ecosystem services and their protection

Tides provide a number of ecosystem services. These include creating wildlife habitats, fishing opportunities, particularly good (saltmarsh) pastures for livestock farming, tourist beaches, navigational services, pollution dissipation, sources of water/energy for power generation, and deposits of fine aggregates which can be exploited.

Recent research into the history of London in relation to the tidal Thames sketches out such intersecting tidal services.

> "The Thames was more than a commercial artery. [...] It was also a complex hydrological system supporting a wide variety of ecosystems within and adjacent to the main channel of the river. The tidal nature of the river enhanced its value as a trade route [...] but human intervention had influenced the flow and the height of the tides through embankment, reclamation, bridging and dredging. The natural resources of the river and the marshland bordering the tidal Thames and its estuary—[...] fisheries, wildfowl and reedbeds—were of value to Londoners, and were subject to repeated attempts at regulation [...]. The power of the tidal Thames and its tributaries were harnessed to operate mills" (Galloway, 2010, page xi).

While this account focuses on the importance of the river and tides to London's development, little mention is made of the complex temporal patterning this gave to local economy and practices of everyday life. One only has to consider the relationship between London's domestic and industrial waste discharge systems and the tides to begin to see the city itself as a vast materialised rhythmpattern with the time of the tides dictating its rhythms. Prior to the pioneering engineering efforts of the 19th century, London and the tidal Thames river were grossly polluted by domestic (and other) waste simply draining into the river and then being swirled up or down river/estuary depending on the tide. The stench and the health risks are the stuff of legend. In the 19th century a radical, tide-dependent solution was devised and built. This entailed creating a network of large interceptor drains north and south of the river which carried waste downstream to two holding reservoirs which were then discharged as the tide was turning to ebb—thus carrying the waste away from the city and out into the North Sea. [An account of this development can be found at The Crossness Engines Trust (2010)].

Estuarine and intertidal mud and sand flats are often home to very rich biodiversity of crustacea, the presence and habits of which are entirely tide dependent. In turn, these areas attract large populations of wading birds and there are distinctive tide-related rhythmpatterns to their yearly and daily habits. For example the Severn Estuary,

> "regularly supports over 20,000 birds, with over 100,000 recorded in the winter season of 1994–95. [...] The mudflats and sand flats provide an undisturbed refuge for the wading birds and wildfowl that flock to the estuary and the billions of invertebrate species living in the mud provide a rich source of food. At high tide the saltmarsh becomes roosting areas for the birds, while some species feed on seeds of saltmarsh plants" (ASERA, 2010).

The habits of the birds are practised in time with the tides as the mudflats are repeatedly exposed and inundated. These rhythmpatterns then extend out into social systems, such as those who work in relation to nature conservation, and those who practise birdwatching and walking as a recreation and who time their activities to high and low tides and the movements of the birds.

Thus the ecosystem services that tides bring are multiple, and range between provisioning, regulating, supporting, and cultural services. These can be in tension with each other as tides are put to very different uses, and/or the tides that bring benefits also bring risk to economic/social systems and space, particularly in the form of flooding and temporal disruption to systems. Thus there is a tension between managing and restraining tidal flow to protect from flooding and temporal disruption, and leaving tidal flow in place to deliver its services. This is illustrated by very expensive civil engineering projects which seek to protect areas from flooding while retaining tidal flow.

The spectacular piece of engineering that is the Thames Flood Barrier (opened 1984, cost £534 million) is an example of a high-tech closable/openable flood barrier placed at a strategic point on the estuary to reduce tidal surge risk to a large metropolitan area, while still allowing (normal) tidal rise and fall to occur as it is vital in many social and environmental regards.

A similar arrangement has been devised in Holland. Bijker (2005) describes the scientific, political, technical, and ecosocial controversies of defending the state of Holland, half of which is below sea level, from the risk of flooding at high tide. The story focuses on the developments after 1953, when devastating floods were caused by a storm tide. A whole raft of political and technical solutions were put in place under what was called the "Delta Plan". The cornerstone of this was dealing with the "Oosterschelde opening". This was an 8 km-wide channel which allowed tidal waters to flow far inland—a 20–40 m deep channel "with 1.1 *billion* cubic metres of water moving in and out at each tide, four times a day" (page 519, emphasis in original).

One major challenge for all Dutch sea defences is building a solid foundation for any kind of structure on the soft deposits of sand and silt that tides create. Traditional dykes were built on 'mattresses' of woven willow sunk into the substrate. A number of solutions were proposed for the Oosterschelde opening, including a permanent barrier. But controversy quickly developed because any plan to simply dam the gap would have eradicated inland tidal flow, thus affecting landscape and ecology. Bijker reports that controversies over the costs and design of the project were central to Dutch national politics in the 1970s. The final outcome was an extremely costly and innovative design, which put a storm-surge barrier across the gap, formed of a series of sluices built upon a high-tech equivalent of the traditional willow mattress. (The tide-deposited sand and silt were 'vacuumed' off the seabed and high-tech synthetic mattresses were put in place as foundations for the series of vast concrete structures which housed the sluices.) As with the London Thames barrier, this would be closed when there was the risk of flooding from exceptional high tides, but left open to normal tidal ebb and flow. So the tide's rhythms and environmental services were preserved, while the risk from tidal flooding at the very highest tides was reduced.

Rhythmpattern consonance and dissonance

Consonance between social (economic) and tidal rhythms occurs in the first instance because the social systems have to follow the timing of the tides to benefit from the ecosystem service they provide. An obvious example is shipping movements which take place at high tide. Even very advanced international logistics can have very precise timings tuned to high tides, as in the transportation of the wings of the Airbus A380 passenger aeroplane, which are produced in Broughton, UK, then shipped to Toulouse by river barge then sea (Edemariam, 2006).

Dissonance within tidal rhythmpatterns can occur in two main ways: firstly, between natural and social rhythms; and, secondly, between conflicting uses of tidal ecosystem services which share the same landscape. As already mentioned, Galloway's (2010) account of the tidal Thames discusses how the river and its tidal processes and spaces (such as salt marshes) not only brought a wide range of benefits to the city which were vital to its development, but also that the power of the river and its tides "could [...] be felt destructively, through storm flooding and tidal surges" (page xii). Thus there has been a constant negotiation within and between differing demands of exploitation, regulation and engineering of the tidal river. Such complex patterns of intersecting processes/uses, risks, and negotiations can be seen in strategic attempts to manage the Severn and other estuaries.

The Severn Estuary Strategy produced by the partnership (SEP, 2001) shows fourteen maps of processes/land/water uses: 1. Environment Agency Local Environment Action Plans; 2. major developments proposed in development plans; 3. coastal processes and topography; 4. coastal defences; 5. tourist attractions and recreational areas; 6. ports and harbour authorities and other areas of interest; 7. major sewage discharges and planned improvements; 8. major industrial discharges; 9. estuary water quality and statutory monitoring sites; 10. major atmospheric discharges and nuclear licensed site discharges regulated by EA; 11. licensed dredging sites; 12. fisheries and angling; 13. landscape; 14. designated conservation areas and scheduled ancient monuments.

These act as a useful summary of the range of uses of the estuary by society. All of them will have their own particular tidal dynamics, rhythms, and space. The maps represent a series of overlaying points, spaces, flows, boundaries, and juxtapositions. The tides will render these dynamic and interactive in a number of ways. The mixing of significant domestic and industrial discharges into a dynamic water landscape which is ecologically rich and used for transport and for recreation has obvious challenges. Discharges are, as far as possible, strategically placed and *timed* to use the transportive, dispersive services of tides. The active nuclear power stations discharge low-level polluted radioactive water into the estuary when the tide is ebbing, thus initially carrying it out into the Atlantic and away from urban areas. However, as Wheeler (1979, page 6) points out in relation to pollution in the tidal Thames, the great complexity of estuaries in part stems from the fact that "unlike a freshwater river [...] the same water flows back and forth [in the estuary] for days and even weeks, before it reaches the sea."

Many coastal areas in the UK and beyond that have been developed for agriculture, industry, and housing are below sea level at high tide: for example, 90% of the city of Hull (UK). Such areas have networks of defensive technologies, including sea walls, drainage channels, sluices, and pumps, all of which take their material form in response to the tides and which operate in synchronisation with them. Tides are linked to flooding in ways which speak to polyrhythmic intersections of differing socio-environmental processes in urban spaces [which can be scored as complex rhythms (Evans and Jones, 2008)]. Periods of high rainfall obviously engorge water courses and put both urban and rural drainage systems to the test. The timing of high rainfall events in relationship to tides can be critical with regard to flood risk. In a tidal river system such as the Severn, the flow of storm-water downstream can be impeded and even reversed if it happens to coincide with incoming tides. In the city of Gloucester (as in many other cities with tidal coast/river frontage) the storm-drain outflows are set at levels *below* the high-water mark. They have outfall covers which allow water to flow out but which are closed by external water pressure as the tide rises above them, thus preventing tidal waters washing up into drainage systems. This means, of course, that no water can flow out of the drains while the tide is high. The serious flooding in the City of Gloucester in 2007 would have been even more severe if the peak of the rainfall event and its discharge had coincided with a high tide. In effect, the normal draining of urban stormwater systems, articulated through networks of channels, pipes, and sluices, can be halted at high tide, and thus the watery material geographies of such cities run to a complex (risky) rhythm, largely unnoticed apart from by the engineers and managers in charge of city drainage and flood defence.

Dissonance occurs when differing uses of the tidal services come into rhythmpattern conflict. The extent of the danger of dissonance between the timings of immigrant economic labour and tide times was starkly exposed when sixteen Chinese immigrant workers were tragically drowned by a rising tide at Morecambe Bay (UK) in 2004 as they were gathering cockles.

The smoothing out of tidal rhythmpatterns

One of the apparent hallmarks of modernity has been the growing hegemony of social/clock time at the expense of natural time which is seen to retreat in the face of "instantaneous time" (Macnaghten and Urry, 1998), the 20th century as the century of speed (Conrad, 1998), and "the 24-hour society" (Kreitzman, 1999). Modern engineering of time is seen to mark the 'triumph' of culture over nature (as in the manipulation of plant and animal life to fit industrial capitalist time frames (Adam, 1998). Macnaghten and Urry (1998, page 137) suggest that "nature [...] has become subject to [...] calculations; it is planned, monitored, subdivided, and so on". And,

> "as Lefebvre suggests, with modernity lived time experienced in and through nature gradually disappears. It is no longer visible and is replaced by measuring instruments, clocks, which are separate from both natural and social space" (pages 141–142).

However, many 'other' nonhuman temporalities still trace through everyday life (Foster and Kreitzman, 2004) and the "timescapes of modernity" (Adam, 1998). Harvey (1996, page 210) observes that

> "to say that time and space are social constructs does not deny their ultimate embeddedness in the material world. [...] Night and day, the seasons, lifecycles in the animal and plant world, and the biological processes [of the body] are typical encounters with various kinds of temporality."

Tides and other temporalities of water/oceans merit a place on this list. As already discussed, more likely than eradication is temporal conflict between social times (capitalist, industrial) and natural times, and a disregard of other temporalities. Given the liveliness and intractability of the nonhuman world, this eradication, confinement, and/or regulation of natural time are highly partial and often violent.

The temporalities of tides fit into this debate in an interesting way. There are many examples where tidal rhythms have been eradicated from locations by modernity: for example, by reclaiming intertidal areas for development, or impounding bays and ports to create permanent high water. In some settings people *have* become disconnected from this pulse of planetary life as societies have modernised, urbanised, and specialised.

But tides themselves cannot be stopped any more than we can stop the moon revolving round the earth or drain the oceans dry. But the effects of tides, their rhythms and spatial ranges, and the tidal cultures they generate, can, to some extent, be adjusted or even smoothed out by material adjustments to the landscape and technological interventions. This then does speak to ideas of social/industrial time smoothing over, and becoming removed from, natural temporalities.

Barker (2008) feels that in the case of the Severn Estuary the population who live in settlements around its shore have (with a few exceptions) become distanced from tidal rhythms as work practices have changed, and as engineering has, to some extent at least, restricted and controlled the movements of tidal waters. There are many small and larger cuts by which the ancient rhythmpattern of the estuary as an ecosocial formation has been reduced.

The ports and harbours around the Severn Estuary have been important for local, regional, national, and international seaborne trade since early history. All these would have had to deal with tidal rise and fall and the strong tidal currents associated with them, imposing a lunar rhythm on when ships could dock and set sail, load and unload, and thus on the life and trade associated with them. Tide clocks—clocks which told the state of the tide for a particular harbour—were common. To counter the in-some-way awkward rhythm this placed on commerce, and the stress placed on boats by having to settle on mud at low tide, the major ports around the Severn Estuary became floating harbours (permanent high-water ports regulated by complex networks of lock gates and sluices) in the 19th century.

In the case of Bristol the high tidal range was long seen as a cause of decline in this major port. The idea of a 'floating harbour' was first muted in the 1700s. After forty years of planning and dispute about how to turn the junction of the tidal rivers (Avon and Frome) into a high-water dock, locks were put in place and, in 1809, the largest dock of impounded water in the world was opened. However simply blocking the rivers to make a high-water port would have suppressed the tidal range which carried the ships between the port and the open sea some 8 miles downstream, and also provided other services. The solution was to impound a section of the river for the port, by placing locks at the upper and lower end, and to cut a by-pass channel for the river itself which thus remained tidal. However, the rhythms of the city and its watery geographies were profoundly changed by the loss of the tidal rise and fall in the port.

Other forms of transport have changed peoples' material–temporal relationships to tides. Until the late 19th and 20th centuries the only immediate routes from Wales to southwest England were via the lowest bridging point on the Severn at Gloucester, or ferries which crossed the estuary further downstream, that were developed commercially in the 17th and 18th centuries. One of these ferries became part of Brunel's Great Western Railway network, with a line to the shore and ferry head, a hotel constructed to accommodate passengers waiting for a tide-dependent ferry, and then the line continuing on again on the far shore. From 1877 onwards the Severn Railway Tunnel provided an alternative to the ferries (but did not kill them off) and travellers swapped the wait, the drama, and views of the ferry crossing for the darkness and the clatter of the brick-lined tunnel, which, of course paid no heed to tidal times. The ferries persisted well into the 20th century, carrying cars and passengers until two vast Severn road bridges were opened in 1966 and 1996.

Making intertidal areas dry land

Something like 80% of the 200 km coastline of the Severn Estuary is protected by sea defences. Prior to these, the highest tides would have crept far inland, particularly into the low-lying marshy wetland areas, making them very different landscapes in terms of ecologies, economies, and rhythms to what they are today. The basic topographic tidal rhythmpatterns of the landscape would have been much more expansive. In other UK estuaries large areas of intertidal land have been reclaimed. For example, since the 18th century those of the Tees Estuary (UK) have been reduced from approximately 3000 to 500 ha in a series of land reclamations for agricultural and built development (figure 2).

Making intertidal areas permanent high water

The rhythms and ecologies of tides can also be smoothed out by making intertidal areas permanent high water. A very prominent and controversial example of this was the creation of Cardiff Bay. This entailed closing the mouth of the Taff Estuary—which

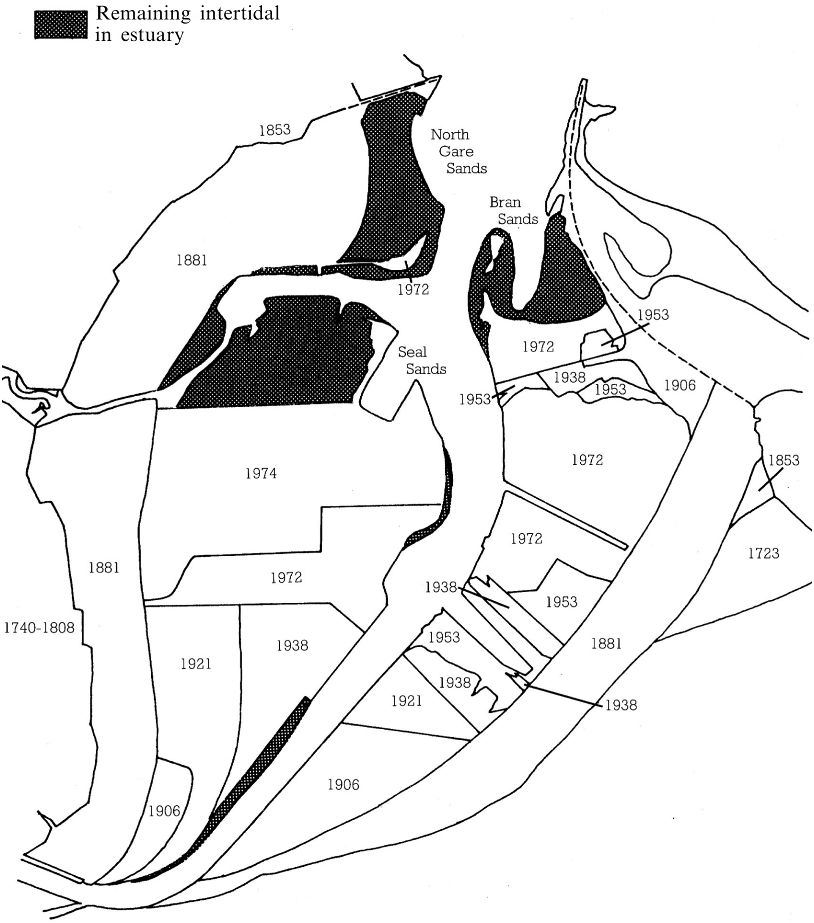

Figure 2. Land reclamation in the Tees Estuary (UK), 1723 – 1974 (NCC, 1991, page 368).

opened onto the wider Severn Estuary—with a fixed barrage which ponds the water of the Taff river into a permanent high-water lake on the western edge of the city. This was done for the sake of 'urban regeneration', as the extensive mud flats revealed at low tide were seen as problematic to the area's image. Adverts placed by the Urban Development Corporation to promote the idea, labelled the tidal estuary as "dormant space" and the projected 'docklands'-style lake and development as "vibrant space". However, the Taff Estuary was a Site of Special Scientific Interest because of the birdlife it was habitat to; thus the building of the barrage was opposed by a comprehensive alliance of local and national nature conservation bodies. Also the estuary had a distinctive cultural ecology of place with small industrial units and a community of boat keepers, fishermen, walkers, all of whom would have had relationships with the tidal river mouth. This wider ecology with its tidal signatures of mud and high and low water was at the heart of the Cardiff Bay controversy.

> "the [Taff] barrage was presented as cleansing as well as revalorising an unproductive landscape. Moreover, since wetlands are a physical barrier to progress, removing them becomes the epitome of progress. [...] Fully consistent with the hegemonic environmental imaginary, and regularly repeated in justification of the barrage, was that having 'vast areas of mud flats dominate the landscape for up to fourteen hours every day... severely limit(s) the potential use of the waterfront in the area [...]'

Integrating Cardiff with the rhythms of capital accumulation and urban consumption evidently clashed with the spectacularly tidal rhythms of the estuarine environment" (Cowel and Thomas, 2002, pages 1250 – 1251).

Koppel (2007) tells how five of the rivers that drain into the Bay of Fundy, Canada, were barraged in the 1950s – 1970s in order to prevent the highest tides washing upstream and causing flooding. The tidal reaches of the Rance River, in Brittany, France, have also been turned into permanent high water (with limited tidal rise and fall) for the purposes of tidal power generation. The ecology and the physical processes of scouring and silting of all these areas have been profoundly changed and the life of these landscapes diminished. This transformation is now a possibility for the Severn Estuary itself with a long-running government feasibility study into a range of tidal power barrage schemes slowly drawing to a conclusion.

More broadly, although development is perhaps inevitable, the more controversial eradications of tidal areas through either reclamation or permanent inundation, particularly in schemes such as the proposed Severn barrage, seem to me to create a form of necrosis in the landscape. Society repeatedly underestimates the extent to which ecosystem services and the very fabric of the liveable biosphere rest upon the dynamic interacting processes of geomorphology and ecology which are all too often stripped away, reduced, distorted, and/or frozen by development. Welland (2009) discusses the earth as an active system of erosion, transportation, and deposition acting over a range of timescales and to multiple rhythms, with tides, rivers, and sea currents playing their full part as arteries/flows carrying material. He suggests that, globally, something like a third of the river-borne sediment flowing to the oceans each year, (which over millennia sustains geological and geomorphological processes) is now prevented from doing so by dams and other forms of engineering.

Conclusions

All materiality is fluid in the end; even if some materials flow at slow speeds and run through rhythms that beat over millennia rather than years, days, or seconds. And all flows are complex in that they intersect with other flows and create multiple speeds, durations, and rhythms within relational processes. We live in rich temporal ecologies of ecosocial formations which enact rhythmpatterns of timespace.

The *looseness* of the materiality of water means that its flows are dynamic, forceful, and obvious. Because of this, water performs (in) ceaseless processes of flows and cycles and its material fluidities are of immediate and profound practical concerns to bodies, landscapes, and more besides. Tides are one key way in which the loose materiality of water is animated within the blue dynamism of planet 'earth'—driven as they are by planetary gravitational forces and folding those into local processes. If we are to take the agencies and the liveliness of nonhumans and nonhuman processes seriously in the construction of the 'social', then surely we must pay heed to such processes as the habits/rhythms of water and the oceans. They are shapers of life on earth at macro, meso, and micro scales and bring form to complex tidal rhythmpatterns of timespaces to be found at the ocean's margins.

I have attempted to locate tides in approaches to geographies of timespace and geographies of nature – culture and offer just some glimpses of the materialised rhythmpatterns that tides create in 'social' systems. These complex, largely lunar-driven rhythms, fold distinctive, polyrhythmic, natural temporality into more ubiquitous diurnal patterns and into the social and economic patterns and rhythms of cities, industries, agriculture, recreation, transport networks, and so on. How the rhythms of the tides interlink different processes of society in consonant or dissonant ways has also been considered. I have discussed how tidal processes can be smoothed out through various means.

Tides are vivid examples of how natural processes can not only create patterned ground but rhythmic time—rhythmpattern. Grappling with how this occurs is important for understanding how the social is never simply the social in terms of networks and spaces, *but also in terms of ecologies of time*—the hybrid mixtures of rhythms and tempos and durations where nonhuman elements play active parts.

Recognising this is important in checking the assumption that we can micro and/or macro engineer time and space to whatever we feel suits culture and political economy at any given (no doubt crisis and injustice-ridden) moment in history. Dealing with other forms of temporality is important in thinking about "ecological planning" (Murdoch, 2005) and *ecological governance*, and that means, somehow, bringing natural processes into political systems.

Latour and Weibel (2005) have stated that

> "The more we look into ecological controversies, the more important it becomes to consider an ecosystem as a sort of assembly without walls, inside which many types of 'speakers' are allowed to 'have a voice'. Not because we want to imitate the usual parliamentary settings, but, on the contrary, because it's obvious that the traditional site of politics have moved towards the centre of gravity of ecology. Ecology is not about a naturalisation of politics—as if one wanted to 'treat humans like plants and animals', it's about the recognition of the immense complexity involved for any entity—human or nonhuman—to have a voice, to take a stand, to be counted, to be represented, to be connected with others. From the beginning of modern science to the contemporary engineering of rivers, landscape and agriculture, it's clear that the number of speech instruments and apparatus has immensely increased. Without these many mediations, no representation would be possible. If we have to live from now on in the assemblies of nature, we had better be aware of the procedures that make them nurturing or deadly, liveable or tyrannical" (Latour and Weibel, 2005, pages 458–459).

Here I have sought to bring tidal processes and their associated material cultures/geographies and the rhythmpatterns thereof to a wider audience within human geography, I hope that this is a small step in helping to increase their visibility and thus their (political) representation.

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