Dr Rob Kirby

Career

As an expert coastal geomorphologist, Dr Rob Kirby has written more than 60 technical reports and research papers on the Severn Estuary (UK) and 15 papers on the Medway Estuary (UK), two eroding muddy coastal systems. He has been involved in every phase of Severn Tidal Power Barrage study of the modern era and supplied his 30-year scientific archive to facilitate progress with ongoing investigations.

According to the BBC, '*Over the past 40 years, Dr Rob Kirby's life has been consumed by the Severn Estuary*' (https://www.bbc.co.uk/news/uk-england-somerset-11567764). His extensive research reports and data details how the estuary's ecosystems have evolved over the years.

Following his PhD in Sedimentology, 'Cohesive sediment transport in the Medway Estuary', at London University, Dr Kirby's impressive career has included the following roles:

- Marine geologist at Institute of Institute of Geological Sciences, Edinburgh
- Principal Scientific Officer at Institute of Oceanographic Sciences, Taunton
- Adviser to Netherlands Government, Associated British Ports at Hull, Immingham and Port Talbot, to BP and Forth Ports Authority at Grangemouth and to Port of London Authority at Tilbury on mud surveying and dredging problems, especially the use of in situ density measuring devices to monitor the channels as an alternative to conventional echo sounder surveys.
- Independent Consultant at Ravensrodd Consultants Ltd. in the fields of marine sedimentology, dredging, oceanography, sedimentation engineering, coastal engineering and environmental research
- Inventor of new technology related to coastal geomorphology and sedimentology systems. Associated international businesses.
- Visiting research fellow and Advisor and Expert Witness to local governments and international corporations.
- Recipient of Lifetime Achievement Award as "Distinguished Diplomate in Navigation Engineering" (Dist. D. NE) of the Academy of Coastal, Ocean, Port & Navigation Engineers of the American Society of Civil Engineers (Washington DC) for innovation, starting 1965, in Sediment Management Systems for the international port and shipping industry. Recipient of Thomas Telford "Telford Premier Award" of the Institution of Civil Engineers for Outstanding Paper of the Year in respect of Kirby & Retière (2009) Comparing ecosystem response of Rance & Cardiff-Weston tidal power barrages published in Maritime Engineering.

A copy of his full CV and research / report summary is available here:
https://www.icopmas.ir/files_site/files/r_48_220723103232.pdf

Recognised as an expert in his field, Dr Kirby has over 30 years' experience of researching the Severn Estuary, its marine sedimentology and coastal geomorphology.

Dr Kirby retired over ten years ago. However, his body of research speaks for itself.

Dr Kirby's expert view on the unfeasibility of creating salt marsh in Kingston Seymour

In 2011, following an announcement by the Environment Agency of its proposal to create a salt marsh in Kingston Seymour to mitigate for habitat loss in Europe (in line with the EU Habitats Directive), the Kingston Seymour Landowners' Action Group sought expert opinion from Dr Rob Kirby, a Coastal Geomorphologist and renowned expert in sedimentology in the Severn Estuary.

On 28 March 2012, Dr Kirby presented evidence to the Kingston Seymour Landowners' Group challenging the advisability of setting back the seawall defences in Kingston Seymour for salt marsh habitat. The meeting minutes highlight Dr Kirby's views that intertidal land in the Severn Estuary is soon eroded away requiring seawall defences and that, crucially, any new habitat created would be short lived:

> **'Basically, his contention is that any area of inter tidal land created would sooner or later be eroded away, thus needing another "bite of the cherry" or a return to the current system of providing protective armour to the raised defences.**
>
> **The published strategy would thus fail completely to fulfil its claimed sustainability benefits**.'

> **'Dr. Kirby explained that the technical work on this aspect of the Habitats Directive was led by marine biologists rather than coastal geomorphologists who would have understood that any habitat benefits would be only short lived.**'

Presentation of Kirby findings to the Environment Agency

Kingston Seymour Parish Council Minutes

A meeting of the Landowner's Group was attended on 28th March.

The meeting was addressed by Dr.Rob Kirby an eminent coastal and marine scientist who presented evidence challenging the advisability of the proposed setback strategy which has been suggested for the shoreline both North and South of the Congresbury Yeo pill.

Basically, his contention is that any area of inter tidal land created would sooner or later be eroded away, thus needing another "bite of the cherry" or a return to the current system of providing protective armour to the raised defences.

The published strategy would thus fail completely to fulfil its claimed sustainability benefits.

A /lively/ discussion queried why those responsible for the strategy had not come up with the same conclusions as Dr. Kirby.

It was suggested that this is because the setback strategy is basically a reaction to the EU Habitats Directive demand for inter tidal zone creation rather than the result of a technically sound and economically optimised engineering appraisal.

Dr.Kirby explained that the technical work on this aspect of the Habitats Directive was led by marine biologists rather than coastal geomorphologists who would have understood that any habitat benefits would be only short lived.

As they are similar in character, the same factors apply to other significant lengths of the Severn Estuary shoreline and a co-ordinated challenge to the strategy,backed up with robust scientific and engineering evidence was considered to have a good chance of success. The meeting felt that this should be pursued, with a particular need to get as many local politicians and organisations as possible on side.

Kirby Report to the action group

Implications of setting back sea defences at Kingston Seymour to create salt marsh habitat

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10th November 2011

NOTE: This is not a conventional technical report as there are no illustrations. North Somerset District Council has made an effort to obtain appropriate high level guidance in order that residents may reach an educated view on what are unfamiliar and complex scientific issues. This is a once-off complimentary piece of work provided by a foremost expert in this field whose knowledge is focused on the Severn.

1. Introduction

Evidently there is a plan to compulsorily purchase farm land in the Kingston Seymour region of the Severn Estuary coastline with a view to breaching the sea wall, setting back the defences and allowing the site to revert to salt marsh habitat. The viability of the scheme is evaluated in the context of the behaviour of fine cohesive sediment in the estuary. Two issues are addressed. The first is the philosophical principal underpinning the scheme (2, below) the second its practical viability (3, below).

2. Sediment Budget and Circulation

The Severn is a high turbidity (hyper-concentrated) estuary. Arising from its high and variable tidal range, the currents are also both strong and variable. It is a muddy system due to erosion of the rock types it drains through. In the 1970s and 80s our former Institute of Oceanographic Sciences (now Southampton Oceanographic Centre) undertook very large scale and expensive investigations of the turbid zone of the estuary between The Shoots (above Avonmouth and now site of the Second Severn Crossing) and Watchet. In total, 24 shipboard measurement campaigns were undertaken involving 210 standard stations at all tidal stages (Kirby, 1986). As a result of these studies, the behaviour of fine cohesive sediment in the estuary is better understood/documented than in any other estuary in the world. For purposes of this inquiry, it is only necessary to quote the variability of the fine sediment load between highest springs and lowest neaps in calm weather. On spring tides the quantity of fine cohesive sediment in the zone in question is more than 30 million tonnes (how much more is unknown as the calibration range of our measuring instruments was at times exceeded). A fortnight later this falls to 2 million tonnes. Thus, over this short period 28+ million tonnes settles out of the water body onto the bed where it temporarily forms deep layers of "fluid mud" (hyper-concentrated suspensions). These layers are distributed principally in deep water channels (The Shoots, King Road, Bristol and Newport Deeps) but also form thinner layers on tidal mud flats.

This "cycling" of mud on a semi-diurnal (flood-ebb) and semi-lunar (spring-neap) basis leads to the siltation rate of harbours (Barry, Cardiff, Newport, Sharpness, Avonmouth, Watchet, etc.) being exceptionally high. For example, the entrances to Avonmouth haves a mud dredging need of 1.5-2 million tonnes/year, whilst "in-dock" dredging at Royal Portbury and Royal Edward reaches similar quantities. At Watchet the siltation rate over the lip closing of the inner marina is 40-60 tonnes/day.

Reduced to simplest terms, as energy levels decline towards neaps, there is, fortnightly, a huge suspended fine sediment burden "looking for a home". Man interferes with such a system at his peril.

Turning to a further related issue, the fine cohesive sediment budget of the estuary is finally well documented (started 1843). By "budget" we mean the regular gains and losses to the system leading to comprehension of where mud "comes from" and "goes to". The mean annual input of mud from rivers lies in the region 0.6-0.75 million tonnes/year. Uncertainty

remains concerning the exchanges between the estuary and the Bristol Channel/Celtic Sea. Evidence suggesting a two-way exchange has been demonstrated and there is no definite proof of the net exchange. It must, however, be small.

It has recently been conclusively proven that the biggest contributor to the annual budget is foreshore to subtidal exchange. ("Subtidal" is the part of the estuary permanently covered by the tide). The entire mud flat zone extending seawards to the westerly limit of Bridgwater Bay is losing mud at the mean rate of 5 million tonnes/year. This is a robust number, being extrapolated from the installation drawing of the "Y&P" sewer pipe off Cardiff in 1890, plus other similar structures, compared to today. These cross the entire foreshore and formerly discharged below low water mark (DECC, 2010).

It is a misconception that estuaries discharge sediment to the sea (except for exceptional examples such as the Mississippi, Amazon, Yangtze and Yellow Rivers, etc). The fresh annual increments of mud from the Severn's rivers and coastline are exchanged via the mobile mud population. They end up being deposited as neap tide fluid muds, which subsequently dewater to a firm mud deposit at Bridgwater Bay, Cardiff Roads, Newport Deep and, at times, Avonmouth and Bristol Deep.

The above outline of the quantities of mud mobile in the turbidity maximum (the muddy zone between the clear water rivers and the clear water sea), coupled with quantification of the sources and identification of sinks (above), clearly indicate that the main fine cohesive sediment "problem" in the estuary is foreshore to subtidal transfer. Consequently, it is axiomatic that one should never seek to manage the estuary by setting-back defences and broadening this vulnerable zone. This merely exacerbates the worst fine sediment problem in the estuary. Instead, one should seek methods to "recharge" the tidal mud flats and consequently bolster coast defences. (In erosion-dominant systems, as here, such set-back attempts merely "buy time").

It is also essential to appreciate the environmental consequences of such action. Sea level and tidal range are increasing, thus currents become incrementally stronger and carry ever more mud. The water body is already perpetually dark on account of the high solids load, so preventing any photosynthesis, but rising turbidity also reduces the dissolved oxygen concentration of the water body. Were the water to become completely devoid of oxygen (anoxic), even temporarily (as it does at times in summer in the Inner Severn), the consequences for organisms with oxygen-based respiration systems would be fatal. As far as the bed is concerned, subtidal mud patches formed by mud being retained in the estuary (as opposed to mud discharged seawards) are barren, as are intertidal sandbanks. Subtidal sand deposits verge on barrenness. Broadening eroding muddy foreshores (by set-back) results in the subtidal muddy apron offshore from it also spreading, smothering such few organisms as might otherwise live there. Arising from the severity of suspension-induced environmental suppression, the fish fauna of the Severn lacks any bed-feeding species. The shorebird fauna lacks any diving birds. The carrying capacity for birds of the upper mudshores is only one third that of a "normal" mudshore elsewhere in our latitudes. Moreover and disconcertingly, the avian (bird) fauna of the Severn has collapsed by two thirds in the last 40 years due to climate change.

We need to appreciate that THE ENVIRONMENT comes as one big chunk. We should not embark on management strategies which offer only temporary benefit on the foreshore whilst directly inducing environmental damage below low water where the eye can't see. This would be analogous to an American claiming extreme environmental responsibility whilst cheerfully living a lifestyle which corporately contributes 24% of world CO_2 emissions.

All fundamentalisms are undesirable. Environmental fundamentalism, as proposed here, merely adds another to the pile. There are no "one size fits all" solutions. Methods which seem to work along open coasts such as East Anglia are wholly inappropriate to semi-enclosed and turbid water bodies such as the Severn Estuary.

3. Would this proposed set-back work?

A few general points need to be set out. First, citizens have a right to joined-up government. So, at a time when the UK population is predicted to rise shortly from 62 million to 72 million, it is reasonable to pose the question "is it wise to regularly and on a large scale give up food-producing land in the manner envisaged here?" Furthermore, has Defra made public the scope of its ambitions in this sphere? The entire Somerset Levels as far inland as Glastonbury is a reclaimed fresh and salt water marsh. Possibly Defra's interest stretches to this area and elsewhere? One can be certain that the Dutch won't follow this path.

Creating new salt marshes has a long history in the UK (110-120 years), although their purpose has changed in the last decade or so. In the late 19th Century a new hybrid, the highly invasive salt marsh plant species Spartina anglica, began being deliberately planted out as an inexpensive means of coast protection (Roper 1918 & 1919). During 1928-9 the then Somerset River Authority successfully planted this marsh grass as an inexpensive means of coast protection for the area fronting the coast at Stert Flats. The grass spread along the coast and offshore, attracting an incremental 3.0m mud deposit which protected the coast. It is now in a retreating cycle with the marsh being eroded and not able to be regenerated a second time. An undesirable side effect of Spartina in appropriate circumstances (hot dry summers) is its highly invasive nature. In suitable years it has seeded, spread and germinated naturally along the Somerset coast, for example encroaching onto the sand beach between Brean and Burnham-on-Sea. In another example, at Southport, Lancs., Spartina has prograded from the Ribble Estuary and invaded the recreational tourist beach at the resort. It is highly undesirable for a sand beach to be converted into a muddy salt marsh. At Southport and at similar sites it is classified as a "noxious weed" and can, with permission, be sprayed and destroyed using herbicides. This illustrates one concern with salt marsh creation.

The pebble ridge at Porlock Bay has breached naturally and the low-lying, backing arable land has been allowed to revert to salt marsh which is now regarded as a new habitat and the marsh has no coast protection function. However, it is "successful" and, importantly, there is no implication that this change has detrimentally affected the subtidal zone of the estuary, because the site lies seaward of the mud flats and turbidity maximum. (These lie in the inner estuary, for example at Kingston Seymour). Hence, broadening the intertidal zone here has no implication for continued mud flat loss and smothering of subtidal habitats.

The purpose of the above outline for Porlock and Stert, even the contrasted purposes of inducing a salt marsh, is to show that creating such marshes is neither universally "good" nor universally "bad". Instead, it must be clear that unthinking "one size fits all" solutions should not be embarked upon uncritically. So, what of prospects for Kingston Seymour?

Many such schemes envisage creating not just salt marsh but also tidal mud flat. The implications for these two are quite different. Allowing the backshore area to revert to salt marsh, as at Stert Flats and Porlock Bay, would "work", though its damaging consequences for the subtidal environment are outlined above. Aside from the issue of Spartina being a highly invasive species in certain circumstances, another issue to consider, especially for nutrient-enriched waters, as here, is the risk of blooming of the intertidal macroscopic alga Enteramorpha. This may develop prolifically and become stranded within the set-back area. When it rots it creates a pungent odour, one of the gasses generated being hydrogen sulphide (the "bad egg" smell). In 2010 a horse died from hydrogen sulphide poisoning whilst being exercised on a French beach in a zone where large rafted and stranded algae accumulations were rotting nearby. This rider was presumably unharmed. This is not considered a likely prospect at Kingston Seymour as horses are not able to traverse the soft substrate beneath a salt marsh, though it does flag issues which need to be considered.

If creating a salt marsh would "work", as explained above, what then are the prospects for creating sustainable bare tidal mud flat areas in this set-back zone?

What is "a given" for the Severn Estuary is that if one builds a small enclosure (eg. an intertidal pond or tidal flat) it immediately silts up. The siltation rate/dredging need quoted for Avonmouth and Watchet is not necessarily what might be anticipated along the shallow coastline on grounds that dense turbid suspensions have a preference for deep water channels. On the other hand, we do have good anecdotal and quantitative evidence for siltation of small enclosures along the coast. The Victorians "discovered" coastal recreation, though in the Severn were frustrated by the distance the tide went out. They responded in true Victorian fashion by "bringing the water to the people" and building permanent estuary water bathing ponds along the coast at Burnham, Weston-super-Mare, Clevedon and Portishead. These have been notorious for the rate at which they silt up. There is also a small cooling water pond at Oldbury nuclear power station which has never had access to more than 10% of its capacity - the remainder being silted up. Avonmouth docks formerly had "settling ponds" in an attempt to prevent "ambient" (turbid) water getting into the impounded dock systems where the mud settled out. This further emphasises the general muddiness of the water.

Separately from this anecdotal evidence, we have the results of a 1 year experiment at a nearby tidal flat (Stert Flats and Hinkley Point) (Wimpey Environmental, 1993). Here wind data for Rhoose airport, as a surrogate for wave data on Stert Flats, was co-analysed with data from two long term (continuous reading) siltmeter deployments. The siltmeters were mounted near the bed on the Hinkley Point Cooling Water Intake Dolphin. On windy days suspended sediment concentrations routinely reached 10,000+mg/l. The mud was eroded off Stert Flats (Kirby & Kirby, 2008). This is exceptionally high. It would have the physical appearance of Brown Windsor soup. Where deposited, it would cause an extremely high siltation rate.

Were the defences at Kingston Seymour to be breached and set-back, as envisaged by Defra, exactly the same conditions would be encountered in any ponds and new tidal flats as at Stert Flats. Siltation rates, as in these numerous other examples, would inevitably be high. During windy spells from our predominant southwesterly direction the water surface slope against the coast would be raised (called wave set-up) and strong littoral (coastal boundary) currents would be created. Very strong mud-laden flows would be swept along the sea defence, entering the planned breach at Kingston Seymour. A strong eddy rotating with a vertical axis (a whirlpool) would be set up inside the breach, which would draw mud into its axis, where it would be deposited creating a shoal. Rapid siltation rates would also occur on high spring tides. As has been outlined above, small enclosures in the Severn have a well-established history of silting up quickly.

Note: Siltation would continue until the enclosure is full, whilst net erosion of the fronting bare tidal mud flats would continue. Tidal flats are highly susceptible to wave attack, but the salt marshes are sheltered. In due course rising sea level and increased storminess would break down the remains of the breached defence and erosion would propagate inshore. Thus, deposition and erosion are not contradictory. It is merely a question of "buying time".

It is fair to reflect on how much time for any pond or tidal flat would be bought by this set-back? A quote from what must remain an anonymous government conservationist ref. a similar plan elsewhere: "If it lasts for 5 years that's all we can expect!" The inevitable implication which residents must draw is that in the world of environmental fundamentalism "worms are more important than people". Is it reasonable for land which has been continuously farmed for millennia to be sacrificed to the sea for such a short term "benefit" to such a small segment of the wider community - and the worms? We would end up with a salt marsh bought at a high price in terms of enhanced sub-aqueous environmental degradation.

4. Conclusions

It is unambiguously shown that setting-back defences in a semi-enclosed turbid water body like the Severn exacerbates destruction of the subtidal fauna and flora. This would be the inevitable long term consequence of widening the muddy foreshore at Kingston Seymour. Much of the subtidal zone of the Severn is already barren or nearly so, but expansion of stable mud patches at various sites arising from foreshore-subtidal transfer of mud is enhancing this destruction. We know of no book or law which places a higher value on intertidal compared with subtidal faunas or floras.

Arising largely from tidal flat losses and accelerating due to stronger currents (which are a consequence of sea level rise), the water body is already inhospitable to most living organisms. The margins of subtidal mud patches are spreading. These lack any life (are abiotic) and their outward spread is smothering other marginally habitable substrates. As an alternative to set-back, were the eroding mud flats to be recharged with mud and regenerated, the ongoing damaging deterioration of habitats, especially intertidal ones, would be reversed. Applying a mixture of large stones with their matrix "glued" together by mud outside the sea defence, then seeding salt marsh plants to bind its surface has never been tried. It may work, and it may cost a comparable amount to the proposed set-back. The fact that this "good thing" is currently "challenging to engineer" should not be a good reason for a "bad thing" (set-back) to be substituted for it.

Examples of "new" salt marshes fronting the coast at Stert Flats (1928 to present) and at Porlock Bay reveal that a salt marsh could be created behind the present defences at Kingston Seymour (if the inevitable collateral damage to subtidal environments is accepted). However, local residents must be informed of the scale of Defra's long term intensions (Somerset Levels, etc?), the issue of management of the invasive plant Spartina must be addressed, together with the possible consequences of Enteramorpha blooming and decay, plus possible hydrogen sulphide gas production and dispersal in hot dry summers.

Separately, it is conclusively shown that creation of small enclosures, for example an intertidal pond or bare tidal flat, within the set-back area can never be a sustainable option. The lifespan of all such schemes is inevitably limited. Attempts at their provision would be doomed to failure. Using local examples it is made clear how there is now such thing as a "one size fits all" solution.

Residents may be alarmed to discover from SMP documents that the UK government has allowed itself to be legally bound by EU legislation to provide "compensatory" habitat to replace that lost because man-made sea defences prevent the natural processes of change to the shoreline occurring. UK government representatives have allowed this draconian obligation to arise without any appreciation that in the muddy Severn this can only happen at the expense of other estuarine habitats. This seems to be a case of "the blind leading the blind" and is disconcerting.

5. References

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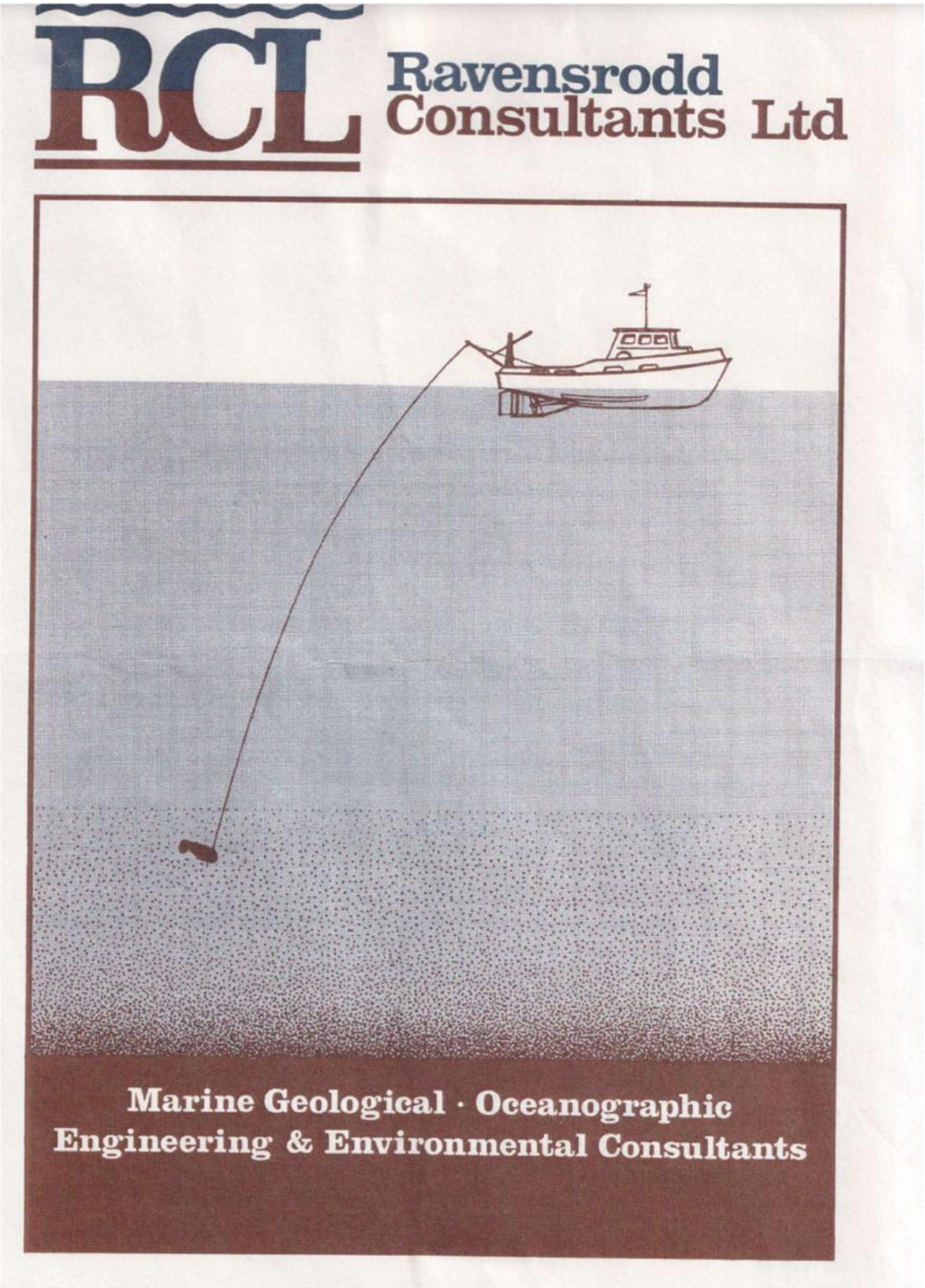

In his research article entitled '**Distribution, transport and exchanges of fine sediment, with tidal power implications: Severn Estuary'** Dr Kirby further expands on the problems of fine

sediment movements in the hypertidal, high turbidity environment of the Severn Estuary and the erosional effects of the intertidal zone and on salt marsh. Highlights from his research include the following:

- **The Severn Estuary's 'inter-tidal zone is mainly mudflats, the universal erosional trend of which is now proven.'**
- **'The fronting inter-tidal zone is highly susceptible to erosion. In places a narrow salt marsh ribbon survives, but this is almost always marked along its seaward edge by an erosional cliff**.'
- **'Much of the salt marsh at Stert Flats is "engineered", being planted out as a cheap coast protection measure by the then Somerset River Authority in 1928–29. This was initially successful, accreting and reaching its maximum seaward and along-coast extent in the 1960s (Ranwell, 1964), since which time it has reverted to an erosional trend and retreated laterally.'**
- **'**Tidal mudflats in the Severn have particular attributes, such that their long term erosional nature is proven by exposure of the ancient deposits, from occurrence at the tidal flat surface on the Welsh coast of formerly buried sewer pipes, and from repeat theodolite surveys 20 y apart on the English coast. An important attribute of the tidal mud flats of the main estuary is that they have low and concave cross-sectional profile. Such profiles are "challenging" on both engineering and environmental grounds, in that they imply larger waves reach close to high water, coupled with offering restricted feeding opportunities for birds.'
- **'In the Severn salt marshes have a limited areal extent, being limited to a narrow, mostly contracting fringe. In contrast, the fronting bare mud flats are especially wide (up to 3 km) and especially vulnerable to effects of sea level rise, being a net erosional zone with a low and concave profile and an elevation which rises up-estuary. This replicates geomorphology of other eroding muddy estuaries, for example, the Medway. The recently published CHaMP predicted rapid inter-tidal "habitat" loss due to sea level rise (10–20% in 100 y) without, it seems, including a component for vertical erosion, which is proceeding 3–5× more rapidly**.'
- **'**Clearly, the Severn is a "high turbidity phase behavioural system". It is dominated by its high turbidity and the large scale cycling of fine sediment between water body and bed on daily and fortnightly tidal intervals. ..... On stormy days surficial internal turbulence in the water body inhibits the process of settlement, which is usually initiated at shallow depth. Similarly, large scale erosion of tidal flats is induced (Severn Tidal Power Group, 1993, Kirby and Kirby, 2008). The largest amounts of fluid mud on neaps, including formation in Bridgwater Bay, occurs after equinoctial spring tides coincident with gales.'
- **'The foreshore is narrowing and lowering, barren sub-tidal mud patches are expanding and smothering other almost barren substrates. Tidal range and storminess are increasing, nominally raising the mobile fine sediment load. Each has an engineering and environmental impact.'**

Further Kirby research papers

Marine Pollution Bulletin, Volume 61, Issues 1-3, Pages 21-36

Distribution, transport and exchanges of fine sediment, with tidal power implications: Severn Estuary, UK - ScienceDirect

https://doi.org/10.1016/j.marpolbul.2009.12.011

Dr Rob Kirby

Marine Pollution Bulletin, Volume 61, Issues 1-3, Pages 21-36

Distribution, transport and exchanges of fine sediment, with tidal power implications: Severn Estuary, UK - ScienceDirect

https://doi.org/10.1016/j.marpolbul.2009.12.011

Abstract

The Severn, a hypertidal, high turbidity estuary, has a bed largely stripped of unconsolidated sediment. **Its inter-tidal zone is mainly mudflats, the universal erosional trend of which is now proven. These are a source for sub-tidal mud accumulations in Newport Deep, much of Bridgwater Bay, less so in Bristol Deep and Cardiff Roads**. The main estuary turbidity maximum is dominated by its exceptional turbidity and the cycling of this on two tidal timescales. It is the means to exchange fines between sources and sinks. It shows discontinuities in three planes – lutoclines, suspended sediment fronts and slug flow. Much of the estuary is verging on or actually barren. It has been designated under EU legislation for its fine sediment-induced naturally-depauperate nature. This is invalid as it is complicated by large scale ecosystem collapse due to climate change. Building a Cardiff-Weston barrage would induce a large rise in faunal abundance and biodiversity.

1. Introduction

The Severn is a hypertidal (mean tidal range >6.0 m) estuary with a highest astronomical tide of 14.7 m, a mean spring range of 12.3 m and a mean neap range of 6.5 m. This paper gives an overview of the fine sediment "regime" of the estuary. The word "regime" is taken here to mean all the exchanges, on all timescales between all the bed and suspended "phases" of the fine cohesive sediment population in the Severn Estuary and Inner Bristol Channel, in the case of the latter, specifically Bridgwater Bay (Fig. 1). In other words, "how the system works".