

## Tidal Power Barrage in the Severn Estuary: Environmental Consequences

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The government's Energy Review, set up in May 2005 under the chairmanship of Sir David King, the Government Chief Scientist, called for tidal power, in particular prospects for a barrage in the Severn Estuary, to be reconsidered urgently. This committee maintained that there were two dominating issues: "Could we afford it?" and "Were the environmental problems insurmountable?" This submission addresses this latter issue.

### **Present Regime**

I have worked in the Severn Estuary and Inner Bristol Channel since 1970 (36 years), at times very intensively, and have published over 60 scientific reports and papers on the system.

I am an expert in the behaviour of fine cohesive sediment in the natural environment, an issue with an overwhelming controlling influence on the ecosystems of the estuary. For 14 years I was employed as a government research scientist at our (as then was) Institute of Oceanographic Sciences (IOS) in Taunton, Somerset. Our research, via the strategic Cohesive Sediment Mobility Project, involved 24 shipboard marine research surveys undertaken between 1970 and 1984 mainly in the subtidal zone of the estuary. I have also acted as the Scientific Adviser to 3 phases of Severn Tidal Power investigations, partly overlapping with my employment at IOS. Substantially arising from the highly developed understanding of the subtidal fine grained sediment regime, investigations by Severn Tidal Power Group (STPG) mainly concentrated on the intertidal zone. Arising from my report of the IOS work, the three dimensional structure of the turbidity maximum of the estuary and its dynamics is better documented than that of any other estuary in the world.

*Kirby R 1986 Suspended fine cohesive sediment in the Severn Estuary and Inner Bristol Channel, UK, Report to ETSU No ETSU-STP-4042, 243pp.*

Since 1984 I have remained active in the Severn in a wide variety of consultative roles.

By way of a historical perspective on the environmental impact of a Cardiff-Weston tidal power barrage, the government conservation bodies have always taken an acutely antagonistic stance to barrage prospects. What has changed over the years is that their justification for resisting its construction has swung through 180°. Without exhaustive repetition, not embarked upon here, the initial official response was to stress the importance of the intertidal zone for shore birds, to point out the importance of the migratory fish fauna, and to stress the unimpaired nature of the water quality. The likes of Tony Cadwalladr, the former Director of what has now become CCW, and others maintained in written documents, not supplied here, that the existing Severn was a biological wonderland in which a barrage would reduce shore bird numbers by 62% (the exact area to become permanently subtidal within the basin). Fish would be unable to traverse dedicated fish passes provided or be damaged, often killed, by pressure fluctuations or turbine blade impacts. Similarly, these official bodies maintained that barrage closures for routine operation would inhibit fresh water flushing, permitting nutrient build up within the enclosed basin leading inevitably to plankton blooming and oxygen depletion of the water body. In summary, this well-argued stance can be termed the "Severn is Good and a barrage would render it Bad"

scenario.

There is no scientific rigour or validity in any of these arguments.

In 1997 an alternative scenario began to emerge. During negotiations for the establishment of a Special Area of Conservation in the Severn, the government conservation bodies - CCW, EN and JNCC - were progressively forced to face the reality of the actual ecology of rocky, sandy, and muddy bottoms, plus the water body and the status of each as ecosystems. There is such a huge amount of scientific evidence that the conclusions are unavoidable, robust and inevitable. These ecosystems are controlled/determined all the way from a regional estuary-wide scale, right down to the interstices of individual suspended flocs by the fine sediment regime. In particular, this is imprinted on the estuary via the controlling semi-diurnal and semi-lunar tidal timescales.

The reality is that the water body is rendered effectively barren by the high suspended load (evidence gathered in 52 separate whole system shipboard surveys). Sunlight, the essential prerequisite of photosynthesis, thus of primary production, is excluded from all but the top few centimetres of the water body and dissolved oxygen concentrations are reduced below optimal. Muddy subtidal substrates are extensive and expanding. Six lines of evidence not repeated here unambiguously confirm their perpetual barrenness.

Rocky substrates are also extensive, especially in the Outer Severn. They do exhibit small ephemeral communities of the reef-building worm Sabellaria alveolata. Unlike elsewhere, for example in the Bristol Channel to the west, these colonies are not just small and ephemeral, but have a negligible number of associated species. Sandy subtidal substrates are, similarly, predominantly barren or exhibit highly ephemeral faunas characterised by large numbers of short-lived juveniles, dwarfism and inability to reach reproductive maturity. Filter feeders are always absent (except Sabellaria). Importantly, the highly depauperate/barren Severn contains neither Red Book species (saltmarshes only) nor any organisms which typify highly stressed ecosystems. (Deserts etc. exhibit such organisms). The Severn only exhibits very small numbers of “pioneering” species found in more typical profuse estuarine communities elsewhere.

The body of data is so overwhelmingly huge and convincing that official conservation bodies have been forced to recognise and accept it. This is signally important on grounds that, after maybe 30 years of pressure, there is finally universal support for the scientific status of the estuary. This agreement is specified in documents, several of which conservation bodies have put their names to. The essence of these is outlined above and they are not further analysed here.

*English Nature/ The Bristol Port Company 1998 Severn Estuary/Môr Hafren pSAC. Agreed Scientific Statement, 38pp.*

The physics, chemistry and biology of the estuary compiled from a number of large, often formerly unpublished data sets, and providing the agreed scientific statement is underpinned in a more scientific treatment:

*Kirby R, Henderson PA & Warwick RM 2004 The Severn, UK: Why is the estuary different? Journal*

*of Marine Science & Environment. Proceedings of the Institute of Marine Engineering, Science and Technology, Part C, No C2, p3-18.*

The essence of this digest is the agreement finally emerging that the estuary is so severely stressed by its physical, in particular by its fine cohesive sediment regime, as to render it largely barren or able to support only locally-distributed, patchy, impoverished faunas and floras. The vertebrate fish fauna is unusual in so much as it completely lacks any benthic-feeding fish. The shorebird fauna is unusual in its paucity and its numerical domination by Dunlin, a bird especially small at adulthood (small prey species leads to predation by small shore birds). The Severn has a lower carrying capacity for shore birds than anywhere else in the UK, perhaps anywhere in the world. This impoverishment is a natural phenomenon and is NOT a manifestation of some all-pervasive contaminant.

The acceptance of this by the conservation bodies is recognised by other works commissioned specifically on their behalf. For example:

*Marine Biological Association 2003 (Langston WJ, Chesman BS, Burt GR, Hawkins SJ, Readman J & Worsfold P) Site Characterisation of South West European Marine Sites: Severn Estuary pSAC, SPA, 206pp.*

In its “Concluding Remarks: Severn pSAC” on the “Biological Status”, the report emphasises (p160) *“Generally, reports suggest that the Severn as a whole supports a relatively impoverished fauna and flora. High turbidity means that algal productivity is low, though organic carbon may be enriched and BOD high in fluid muds. These may disperse at spring tides to produce DO sags. In those areas frequently covered by turbid layers, colonisation by filter-feeders in particular, is likely to be sparse. Much of the sub-tidal Severn mud is impoverished and even some sandy areas may be impoverished because of extreme mobility of silts at spring tides”.*

In a 100% reversal of their earlier stance, the official conservation bodies now maintain that it is this very extreme natural ecosystem suppression which is remarkable and merits the Severn being submitted for consideration as a Special Area of Conservation, ie. what renders this environment an important end member of a suite of environments is this very absence of bio-diversity. Barrenness has become a virtue.

### **Consequences of a Barrage**

Bearing in mind that constructing a barrage would shift a hypertidal (hypertidal specified as spring and neap ranges >6.0m) into a macrotidal system (macrotidal ranges 4.0 - 6.0m), it is axiomatic that closure of the barrage would induce large scale reduction in tidal current strength and, as important, range of current variations. (Equally, a barrage would improve intertidal zone sheltering from wind waves). Sediment instability, the source of ecosystem suppression, would greatly reduce and an “explosion” of colonisation by a whole range of estuarine organisms currently excluded by the extremity of the regime, would not be preventable. This is outlined in a number of publications:

*Kirby R & Shaw TL 2005 Severn Barrage, UK - Environmental Reappraisal. Paper 13810 Proceedings of the Institution of Civil Engineers. Engineering Sustainability, 158, Issue ESI, p31-39.*

It is likely that the substrate of the remaining 38% of the intertidal zone and its cross-sectional shape will evolve to more than make up in quality of new habitat for foreshore losses. There is no reason to suppose that fish migration via fish passes will be impeded (viz. the Rance and Cardiff Bay Barrage experiences). Similarly, water quality could do no other than improve by a large amount. This would be accompanied by a massive scale invasion by presently excluded invertebrates.

This unavoidable massive “explosion” of colonisation is also evidently recognised and accepted by the conservation bodies. In Langston et al, 2003 may be seen the subscript, p160 *“It is interesting to note that, by reducing turbidity, a future Severn Barrage, if constructed, would theoretically increase primary productivity and the diversity of bottom fauna”*.

The conservation bodies still oppose the construction of a barrage, but now the earlier scenario is reversed. This is now “The Severn Estuary is Bad and a barrage would render it Good” scenario. Importantly, it is evidently recognised that constructing a barrage would be accompanied by a (large) increase in biodiversity at the site. It comes down to a matter of choice. Does our society prefer the example of biodiversity represented by virtual barrenness? , or the example admitted arising from construction? To stress a point: there is no longer any disagreement in regard to the science. There MIGHT be disagreement regarding the interpretation.

There can be few major civil engineering projects in the world whose construction would be so unavoidably and inevitably accompanied by a large rise in floral and faunal abundance, coupled with biodiversity. The Severn Barrage is that example.

For our society and for the Energy Review, the alternative needs to be posed: *Is it more important to preserve an example of a degraded/depauperate ecosystem, thus admitting no other “benefit” to our society, than to harness approaching 7% of the UK’s electricity need from non-fossil, non-nuclear sources with the accompanying protection in the enclosed basin from sea level rise, increased storminess, higher storm surge height and return frequency, plus have a greatly improved species abundance and biodiversity in the floral and faunal community?*

It is appreciated that the Environment Agency, plus government ministers, seem/have seemed until now universally opposed to the barrage on environmental grounds. What is not at all clear is whether they object on the now abandoned “Severn is Good and a barrage would render it Bad” scenario, or instead, on the latest “Severn is Bad and a barrage would render it Good” scenario.

It perhaps does need to be stressed, in case it is not obvious, that the conservation bodies’ view is that it is what makes the ecosystems of the Severn Estuary “Bad”, ie. impoverished, depauperate, barren, which makes it so very “Good”. In this scenario, the progressive trend towards ultimate barrenness (via mean turbidity rise, ongoing erosion of the foreshore, matched by smothering of the subtidal bed by mud encroachment - all evolving processes) will reach perfection when absolutely nothing lives in the Severn (as stated by conservation body officers). The system is not far off this situation today in many of its ecological attributes.

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