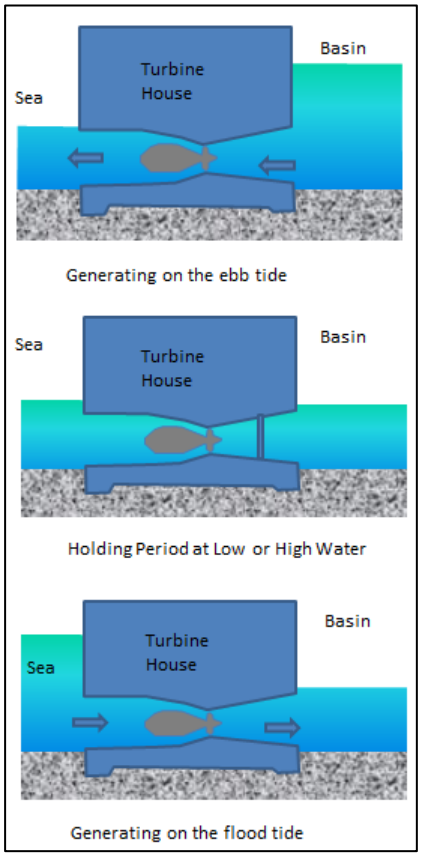
Tidal Lagoons in the Severn Estuary.
Devon and Severn IFCA Briefing Note (Number 1), August 2015

Summary

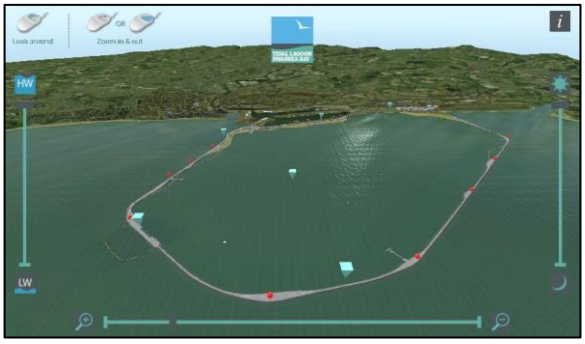
Devon and Severn Inshore Fisheries and Conservation Authority (D&S IFCA) supports, in principle, the aim of the UK Renewable Energy Strategy (2009) to de-carbonise the energy sector in order to tackle climate change and meet agreed reductions in greenhouse gases as set out in the Climate Change Act (2008). D&S IFCA acknowledges the growing body of evidence which suggests that climate change can and is altering fish distribution and behaviour, and therefore the fisheries that depend upon them.

However D&S IFCA has specific concerns regarding the placement of a series of tidal lagoons in the Severn Estuary, the English parts of which fall into the Authorities' district. This briefing note is intended to raise the key issues that concern D&S IFCA in terms of the possible effect tidal lagoons will have on the fish and fisheries (both commercial and recreational) and the habitats upon which these depend and the current trajectory of development of those lagoons. Highlighting these concerns at an early stage it is intended to help developers to understand the IFCAs position and to aid in the planning of any survey work which might in part directly address some of those concerns.

What is a Tidal Lagoon?



A tidal lagoon is a man-made enclosure created in a tidal area. The enclosure wall houses water turbines which are used to generate electricity. The lagoon is used to create a difference in the height of the tide (known as 'head') between the inside and outside of the enclosure. Once sufficient head has been created, sluice gates are opened and water flows through the turbines, generating electricity (Figure 1). The amount of electricity generated depends on many factors including the number of turbines, the size of the lagoon and amount of head generated (which is at least partly linked to the local tidal conditions). Some tidal lagoons may generate on the flood tide, the ebb tide or both.



a. **b.**

Figure 1. The structure of tidal lagoons including a) the turbines housed in the external walls showing how head is created in order to drive the turbines and b) an artists impression of a lagoon. Both taken from www.tidallagoonswanseabay.com

Where are the planned development sites?

At this moment in time Tidal Lagoon Power are currently actively developing the Tidal Lagoon Swansea Bay project (see useful links) but the company aims to "develop, construct and operate a fleet of tidal lagoons to meet up to 8% of UK electricity demand". A further three lagoons are currently being discussed for the Severn Estuary (Tidal Lagoon Cardiff, Tidal Lagoon Newport and Tidal Lagoon Bridgwater Bay). Although only the third site sits within the D&S IFCA district, the potential for the lagoons to impact physical and biological processes in the whole estuary, all three projects are of interest to the IFCA. Two additional lagoons are currently also in discussion, one in North Wales (Colwyn Bay) and one in West Cumbria. The exact details (size and location) are not available for most of the lagoons as they change as physical and economic factors affect their design. It is impossible to start to predict the scale of effects on environmental parameters until Tidal Lagoon Power finalises the approximate design of each lagoon and as such the IFCA would encourage that physical and economic modelling is completed as soon as possible so that baseline and monitoring work can be tailored appropriately. Additionally, the IFCA would encourage an ecosystem-approach to the development of Tidal Lagoons, requiring information on plans for all lagoons and plans for monitoring and mitigation at an estuary-wide scale from as early as possible in the process.

Comment 1: Tidal Lagoon Power must make every effort to provide specific details of the size and placement of lagoons as soon as possible in the process as estimating potential effects will be largely dependent on final design.

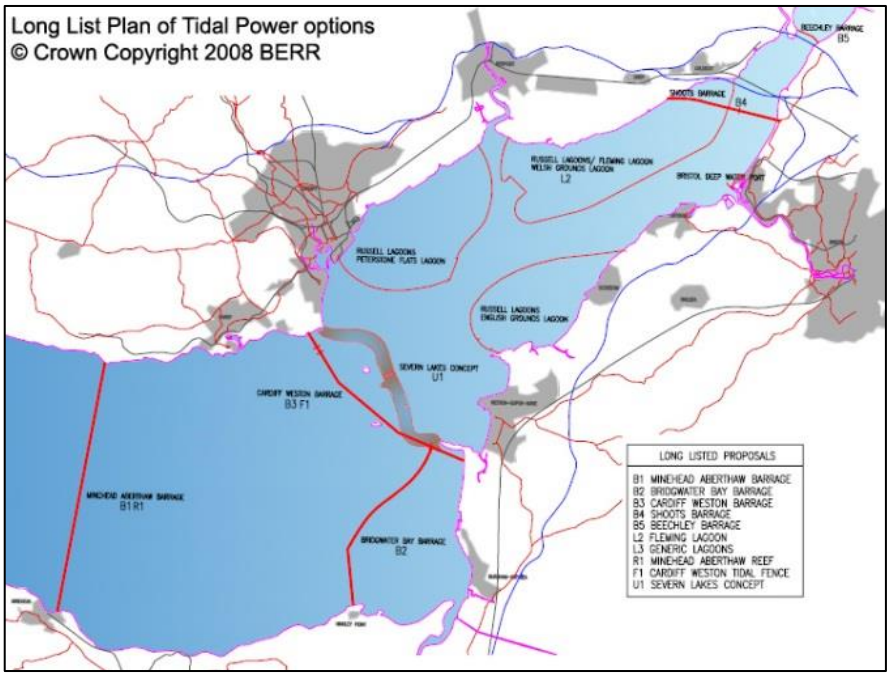


Figure 2. An indicative image of possible lagoon options described by DECC. Exact shape, placement and size of lagoons is still yet to be determined. Of particular relevance is the Bridgwater Bay lagoon, one iteration of which stretches from Brean Down to Minehead.

How might tidal lagoons affect fish?

Tidal Lagoons will potentially have far reaching environmental effects. Other agencies have interests in the migratory fish and birds of the Severn Estuary so the IFCA will only comment on impacts on sea fish and the habitats which support them. Potential impacts on fish could exist and change

through the construction, operational and decommissioning phases of a tidal lagoons life. Impacts can be largely split into those that are direct (fish strike through turbines, barrier to migration) and those which are indirect (change/ loss of habitat, water quality, tidal cycles). It should be noted that the indirect effects of tidal lagoons could have just as large effects as more direct impacts. A full list of possible effects identified by Tidal Lagoon Swansea Bay can be found in Appendix 1.

Direct effects - Turbines

Turbines can affect fish in a number of ways including direct strikes, abrasion, grinding, pressure change and shear stress. Injuries range from mucous and scale loss to damage to eyes, gills and swimbladders to spinal fractures and mortality depending on a large number of factors, including the shape and size of the fish, water velocity, turbine design and lagoon design Turnpenny & Horsfield Associates (2014). The direct effects of turbines on fish is one of the better studied aspects of Tidal Lagoons and advanced modelling techniques are now available and have been applied by TLP in the Environmental Statement for the Swansea Bay development. Using the Striker v4.0 model Turnpenny & Horsfield Associates (2014) found that Clupeids are the most sensitive to damage in turbines with injury rates of herring and shad being estimated (worst case scenario) at ~50%. That is not to say 50% of all herring in the vicinity of the lagoon will be injured, rather 50% of those entering a turbine. Gadoids (e.g. cod and whiting) have a predicted injury rate of 9%, bass 4.8% and flatfish 1.86%. By combining injury rate predictions with turbine encounter modelling estimates of overall mortality have been estimated.

Indirect effects - Habitat

Compared to the impact of turbines, potential effects of tidal lagoons on habitats and the fish populations they support is extremely poorly studied (Frid et al. 2012). Tidal Lagoon Power state on their website that Tidal Lagoons can 'promote biodiversity' but the IFCA urges caution in the interpretation of biodiversity, or the assumption that increasing overall species richness at a site is positive change. The uniqueness of the Severn Estuary is what has led to its protected status (Natural England and Countryside Council for Wales 2009) and it is not the diversity at a site level (known as alpha diversity) which makes the site important, rather how it fits into the wider ecology of Northern European (known as gamma diversity) (Magurran 2013). Although no final design has been put forward for the proposed Bridgwater Bay lagoon, one estimated scenario resulted in the loss that 5500ha of intertidal habitat would be lost (National Assembly for Wales 2010). Unlike the Swansea Bay project, many of the subsequent lagoons planned for the Severn Estuary fall close to or inside the Severn Estuary European Marine Site. The lagoons will therefore have to comply with the Habitats Directive which will almost inevitably require compensation measures for damage to the EMS (e.g. Sustainable Development Commission 2007, National Assembly for Wales 2010). However, the IFCA believes that although some knowledge exists in terms of recreating saltmarsh habitat, no such information is available in recreating tidal mudflats or other features of the SAC and SPA. Furthermore the extremely dynamic nature of the protected fish assemblage makes will make any efforts to compensate extremely difficult, even with extensive new survey data. The IFCA is particularly concerned about the implications for bass nursery areas given the current concerns for this species at a stock level (Ross 2015a). Although not designated the Severn Estuary and the estuaries of many of the smaller rivers and pills which feed into it are extremely important bass nursery areas (Colclough 2012, Ross 2015a).

Comment 2: Indirect impacts on fish populations through habitat change/ loss and changes to tidal cycles which could affect important nursery and feeding areas are likely to be as important as direct impacts of damage to fish caused by the turbines.

Fish baseline and monitoring data

The majority of our fisheries knowledge from the Severn Estuary comes from power station sampling, with a little more spatial resolution provided by Environment Agency Water Framework Transitional and Coastal waters monitoring (Colclough 2012). However the IFCA believes that insufficient data exists to sufficiently form a baseline for the Severn Estuary and extensive additional sampling is needed over a number of years in order to estimate natural variation and to be able to detect changes caused by the development of Tidal Lagoons. However the IFCA is concerned that in such a dynamic estuary even very intensive sampling may not truly capture the importance of the area for fish and fisheries and therefore caution must be applied in the interpretation of any survey data collected.

Which fisheries may be impacted?

The Severn Estuary is an extremely important area for recreational sea angling with boat and shore marks extending from the Somerset border, all the way up and along the South Gloucestershire coastline. Major ports for charter boats exist at Minehead, Watchet and Portishead with private boats also operating from these ports as well as Porlock, Burnham-on-Sea, Weston-Super-Mare and many of the smaller pills throughout the estuary.

Comment 3: The importance of recreational sea angling from boat and shore on BOTH sides of the estuary must be acknowledged and taken into account for lagoon developments on either side. Recreational sea angling has great socio-economic importance and this should not be downplayed or underestimated simply because it is hard to measure.

Other recreational fisheries exist, including traditional gill and trammel net fishing, herring fishing, shrimp netting, longlining and some potting. These fisheries are often small-scale and temporally sporadic, resulting in the exact levels being extremely hard to estimate (Ross 2015b) but in places they have socio-economic significance in terms of their heritage value and the connection of people to the estuary.

Comment 4: The lack of obvious, large-scale or industrial fisheries is NOT because of a lack of fish in the estuary; rather it is because of the macro-tidal conditions and the highly dynamic nature of fish utilisation of the Estuary. Fisheries in the Severn Estuary are often small-scale, seasonal and recreational in nature, making them hard to detect and quantify. The fishing intensity also shows inter-annual variation depending on the abundance of certain species. However netting, longlining and other methods employed often have importance from a heritage perspective and the extreme environment of the Severn has resulted in unique methods of fishing.

In addition the impacts of the Tidal Lagoons could be extremely far-ranging and D&S IFCA is concerned about the limited geographical range of TLPs initial plans for baseline data collection for Cardiff Bay and forthcoming lagoons. With the potential impacts on nursery areas for a variety of species and the importance of the Severn estuary for a variety of commercially important species such as herring, sole, cod, thornback ray, whiting, bass and many others, the potential links to commercial fisheries in the wider Bristol Channel must be considered. This would be consistent with

the proposed Ecosystem Approach the IFCA proposed earlier in this document. In particular the IFCA encourages a large-scale tagging exercise which should aim to look at the movement of commercially and recreationally important fish species between the Severn Estuary and Bristol Channel, as well as gaining more information on the nursery role of the Severn Estuary.

Comment 5: Tidal Lagoon Power must instigate an Ecosystem Approach to assessing impacts of these developments on fish and fisheries. Damage to nursery and adult grounds in the Severn Estuary may have impacts on fishing throughout the Bristol Channel and therefore scoping and EIA work must include these areas. D&S IFCA believes a wide-scale tagging programme is necessary to look at the movements of certain fish species between the Severn Estuary and Bristol Channel.

Have the impacts of tidal lagoons on fish and fisheries been studied?

Many of the aspects of tidal lagoons have not been well studied (Frid et al. 2012) and limited lessons will be learned from Swansea Bay that will be equally applicable to the unique environment of the Severn Estuary. Best practice principles developed in similar environments, such as the Bay of Fundy in Canada should be applied to developments in the UK (Acadia reference). The IFCA is concerned about comparisons with La Rance in France (e.g. Kirby 2006) due to the different nature of the estuaries and the lack of pre and post-monitoring at this site.

Additionally, much of the work for the Swansea Bay Tidal Lagoon has relied on modelling. Whilst D&S IFCA believes that the models are a useful approach for certain species, the lack of field data in the Severn Estuary to ground truth results means that it should be used as one tool in a suite of other methods. Certainly large scale tagging programmes will help to inform and guide model parameters and as such the IFCA once again call upon TLP to instigate this work as soon as reasonably possible.

Fish survey work should be co-ordinated to gain an overall baseline for the entire estuary, rather than discordant and geographically limited sampling for each lagoon. In addition TLP must recognise the potentially large sphere of influence for fish and fisheries and include this in any EIA. For example loss of nursery habitat in the Severn Estuary for important commercial species such as sole, bass, plaice and thornback rays.

Comment 6: Heed should be given to tidal research schemes relating to the Bay of Canada and best practice applied in the Severn Estuary wherever appropriate. Links between Tidal Lagoon Power and the Acadia research group are encouraged. TLP should be clear on the limited applicability of environmental research carried out at La Rance and TidalLagoon Swansea Bay on new developments in the Severn Estuary.

Comment 7: Tidal Lagoon Power must endeavour to commission new research wherever gaps in knowledge exist and factor in the time for this research to develop and produce answer into the timeframe of the development of sites in the Severn Estuary. Insufficient data exists on the fish and fisheries of the Severn Estuary in order to rely solely (or heavily) on modelling work, although D&S IFCA does see value in modelling in the broader scheme of work.

How will the IFCA engage in tidal lagoon issues?

The IFCA has been asked to sit on the Fish Expert Topic Group for Tidal Lagoon Cardiff Bay in order to input into the Evidence Plan Process and comment on various survey plans and proposals. The IFCA commends this type of expert review panel and acknowledges that Tidal Lagoon Power Cardiff Bay have responded positively to suggestions made by the group so far. Although the IFCA is not a 'discharging authority' it is vital that the IFCA is involved wherever possible to keep the focus on impacts on the fish and fisheries of importance to the Authorities stakeholders. However, the proposed development time-scale is daunting and with different lagoons being developed by different subsidiary arms of Tidal Lagoon Power (e.g. Tidal Lagoon Power Swansea Bay, Tidal Lagoon Power Cardiff etc) the potential for duplication of effort and over-stretching the IFCAs limited resources is great, so a co-ordinated approach is once again called for.

References

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The UK Renewable Energy Strategy (2009): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228866/7686.pdf

Turnpenny Horsfield Associates (2014) Tidal Lagoon Swansea Bay – Environmental Statement Volume 3, Appendix 9.4: Swansea Tidal Lagoon: STRIKER v4 Fish Turbine Passage Modelling.

Useful Links

The Climate Change Act 2008: http://www.legislation.gov.uk/ukpga/2008/27/contents

Tidal Lagoon Power: http://www.tidallagoonpower.com/

Tidal Lagoon Swansea Bay: http://www.tidallagoonswanseabay.com/

Tidal Lagoon Cardiff: http://www.tidallagooncardiff.com/

Tidal Lagoon Bridgwater Bay: http://www.tidallagoonpower.com/h/lagoons/bridgwater-bay/143/

RSPB comment: http://www.rspb.org.uk/community/getinvolved/wales/b/wales-blog/archive/2015/05/19/what-are-we-doing-about-tidal-lagoons-guest-blog-by-dr-sean-christian-rspb-cymru.aspx

Wildlife Trusts comment: http://www.wildlifetrusts.org/blog/joan/2015/03/02/more-tidal-lagoons-proposed-opportunity-or-threat

Appendix 1

Potential source	Potential impact	Potential effect
Construction phase		
Dredging, sand reclamation, formation and removal of temporary cofferdam.	Increases in suspended sediment and deposition.	I. Smother spawning grounds and benthic fauna. II. Impact on larval/juvenile fish. III. Injury and mortality. IV. Behavioural disturbance.
Piling, dredging, rock armour placement, increased vessel movements.	Increases in underwater noise and vibration.	I. Behavioural disturbance. II. Injury and mortality.
Construction lighting.	Increases in artificial light emissions.	I. Behavioural disturbance.
Construction of sea wall, temporary cofferdam and area for rock storage.	Habitat modification.	I. Loss/disturbance to spawning habitat. II. Loss/disturbance to foraging habitat. III. Gain of spawning habitat. IV. Gain of foraging habitat.
Dewatering of temporary cofferdam for turbine and sluice gate housing	Habitat loss due to dewatering of cofferdam.	I. Injury and mortality due to dewatering.
Dredging.	Entrainment from draghead.	I. Injury and mortality. II. Reduced fitness.
Operational phase		
Operation and presence of Tidal Lagoon.	Increases in suspended sediment and deposition.	I. Smother spawning grounds and benthic fauna. II. Impact on larval/juvenile fish. III. Injury and mortality. IV. Behavioural disturbance.
	Habitat fragmentation and isolation.	I. Delays to migration. II. Increased energetic costs. III. Fragmentation of migratory routes
	Habitat modification.	I. Loss/disturbance to spawning habitat. II. Loss/disturbance to foraging habitat. III. Gain of spawning habitat. IV. Gain of foraging habitat.
	Increased predation.	I. Injury and mortality. II. Reduced fitness.

Potential source	Potential impact	Potential effect
	Entrainment from draghead.	I. Injury and mortality. II. Reduced fitness.
Turbine operation.	Entrainment and injury from turbines.	I. Injury and mortality. II. Reduced fitness.
	Waterborne noise and vibration from the turbines.	I. Injury and mortality.
	Fluctuations in Lagoon water levels.	I. Behavioural disturbance. II. Injury and mortality.
Sluice operation.	Entrainment and injury from sluices	I. Injury and mortality. II. Reduced fitness.
Operational lighting.	Increases in light emissions.	I. Behavioural disturbance.
Changes in hydrological conditions and WWTW outfall.	Deterioration in water quality.	I. Behavioural disturbance. II. Increased mortality.
Insertion of power cables under River Neath.	Creation of EMFs.	I. Behavioural avoidance.
Recreational activities within the Tidal Lagoon.	Waterborne noise and vibration from recreational activities.	I. Behavioural disturbance.
Increase in recreational angling.	Increased pressure on fish populations as a result of recreational angling.	I. Increased mortality.
Decommissioning phase		
Removal of turbines and sluice gates.	Increases in suspended sediment and deposition.	I. Smother spawning grounds and benthic fauna. II. Impact on larval/juvenile fish. III. Injury and mortality. IV. Behavioural disturbance.
Removal of turbines and sluice gates and associated vessel movement.	Increases in underwater noise and vibration.	I. Behavioural disturbance. II. Injury and mortality.
Habitat modification.	Improved connectivity between the habitat within and outside the Lagoon.	I. Increased access to spawning grounds. II. Increased access to foraging grounds.
Cumulative		
Construction work associated with the Project occurring simultaneously to other Projects/activities.	Increases in suspended sediment and deposition.	I. Smother spawning grounds and benthic fauna. II. Impact on larval/juvenile fish. III. Injury and mortality. IV. Behavioural disturbance.
	Increases in underwater noise and vibration.	I. Behavioural disturbance. II. Injury and mortality.
	Habitat modification.	I. Loss/disturbance to spawning habitat. II. Loss/disturbance to foraging habitat. III. Gain of spawning habitat. IV. Gain of foraging habitat.
	Habitat fragmentation and isolation.	I. Delays to migration. II. Fragmentation of migratory routes.
	Increased predation.	I. Injury and mortality. II. Reduced fitness.
	Entrainment by turbines and water abstractions	I. Injury and mortality. II. Decreased fitness.