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2013, Renewable and Sustainable Energy Reviews

Citation Excerpt :

The energy of tidal currents is an important factor in determining the sediment dynamics within a marine system. This is of particular significance to estuaries such as the Severn, which are characterized by high levels of suspended sediment [51]. The reduced current flows upstream of tidal barrages are likely to cause an overall increase in seabed deposition rates as fine sediments settle out of the water column [46].

Show abstract

- A review of the potential water quality impacts of tidal renewable energy systems

2012, Renewable and Sustainable Energy Reviews

Show abstract

- A review of sediment dynamics in the Severn Estuary: Influence of flocculation

2010, Marine Pollution Bulletin

Citation Excerpt :

The highest SPM loads occur on the English side, separated from clearer water on the Welsh side by a relatively sharp change in concentration. The front runs roughly along the middle of the estuary and is independent of the salinity distribution, being persistent on spring and neap tides, and during both flood and ebb (Kirby, 2010). Mobile suspensions are dense layers of moving mud.

Show abstract

- Physical properties and processes in the Bristol Channel and Severn Estuary

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Salt Marsh Issues – Spartina Anglica and Enteromorpha

Introduction

Dr Rob Kirby's report entitled '*Implications of setting back sea defences at Kingston Seymour to create salt marsh habitat. Report for North Somerset Council on Kingston Seymour'*, (Kirby, 2011, 7pp) outlined the significant challenges that would impact on any potential salt marsh habitat creation and concluded that **'it is conclusively shown that creation of small enclosures, for example an intertidal pond or bare tidal flat, within the setback area can never be a sustainable option. The lifespan of all such schemes is inevitably limited. Attempts at such provision would be doomed to failure.'**

Two of Dr Kirby's significant concerns relating to the creation of a new artificial salt marsh in Kingston Seymour was that it may give rise to a highly invasive salt marsh plant Spartina Anglica which has spread along the South West coast and on to beaches and is considered a noxious weed. There is also a risk of intertidal macroscopic Enteramorpha which can grow prolifically and would be stranded, while giving off hydrogen sulphide, a noxious gas which has killed a horse, wild boar and humans in Brittany, France.

This paper outlines relevant research on *Spartina anglica* and *Enteramorpha* in salt marsh environments.

This research shows that Enteramorpha, in particular, thrives in an intertidal environment where effluent from livestock and from a human sewage system can be washed into streams and rivers which creates algae. Kingston Seymour's livestock agriculture along the foreshore and inland and the Wessex Water Treatment Centre with its outlet pipes into the Severn Estuary could therefore create similar environmental conditions for the creation of Enteramorpha.

Spartina Anglica

Spartina anglica is a vigorous perennial grass that grows profusely in the lower intertidal zone of coastal and estuarine areas from its seeds and clonal growth. Due to its hybrid nature, it tends to dominate salt marshes where introduced. According to the *England Nature Research Report <u>Number 527</u> - Spartina anglica: a review of its status, dynamics and management* published in 2004, the common cord-grass *Spartina anglica* colonisation has been world-wide, accidental and controversial. In particular, the introduction of a non-native species has often been viewed as a threat to biological diversity in areas of intertidal mudflats.

> '***For some managers it is a threat to biodiversity especially for wintering birds that feed on invertebrate species of intertidal mudflats and other habitats displaced by S. anglica****; whereas for others, it is the product of evolution and therefore remains unmanaged. Despite this, S. anglica remains a controversial species both in the UK and around the world*' (Executive Summary).

Within this context, there has been a corresponding decline in native species of *Spartina Maritima* and *Spartina Alterniflora* in the UK, since the introduction of *Spartina anglica*.

The report notes that in the Bridgwater Bay, *Spartina anglica* spread profusely between 1954 and 1984 but then stabilised and appeared to die back. However, in Lindisfarne, Northumberland, it has been highly invasive and uncontrolled. Efforts to control or even eradicate *Spartina anglica* have been largely unsuccessful in the UK. Eradication often involves '*hand digging, herbicides, burning, biological control and rotoburying'* or a combination of methods, depending on available funding. Research on the impact on the wider environment is lacking.

> '*However, this review concludes that the* ***hydrodynamic regimes and the sediment conditions of the area are an essential factor to consider in order to make the most appropriate decision for managing S. anglica***.'

Sedimentation deposits and mudflats elevation are thought to increase with the presence of *Spartina anglica* on mudflats. However, the position is more complex. It often appears that sediment is deposited on the bare mud flats rather than on vegetation in some sites but there is sometimes accretion in the vegetation depending on tidal movements and conditions (p, 16). Natural dieback of *Spartina anglica* on salt marsh occurs after initial expansion, particularly along the south coast and in South Wales '*as the result of high mortality from diseases, or due to the presence of phytotoxins produced under anaerobic soil conditions created by poor drainage'* (p, 17). **Often this dieback, leads to greater problems such as an increase in Enteromorpha ssp. and Ulva Lactuca which adversely impact mudflat invertebrates which are the main source of food for estuary birds**, **and can lead to bird population collapse**:

> ‘***Following the dieback of Spartina, the mudflats seem to be more extensively covered in free living algal species such as Enteromorpha spp. and Ulva lactuca, possibly resulting from increased nutrients levels and even eutrophication. The presence of such species continues to make the mudflats unsuitable for invertebrates which birds feed upon and which may account for the early observations of bird numbers failing to increase within estuaries after Spartina died-back*** *(Goss-Custard & Moser, 1988). Later observations, however, seem to suggest that this may have represented a time-lag between reduction in Spartina and re-colonisation of the mudflats by invertebrate populations, as species such as black-tailed godwit (Limosa limosa) were found to recover significantly in areas such as Poole Harbour (Gray et al, 1997).’*

Spartina anglica **colonisation changes the sediment composition leading to a decline in invertebrate prey for birds and changes the environment:**

> *‘Changes in sediment composition following Spartina colonisation may result in a decline in the distribution of invertebrate prey for birds and fishes, and the tall dense structure of a Spartina sward reduces visibility for feeding species resulting in reduction of communication throughout feeding flocks and increased risk of predation (Millard & Evans, 1984).* ***Native intertidal vegetation may also be out-competed by the Spartina, notably Zostera species, the main food source of the light-bellied brent goose (Branta bernicla hrota) and wigeon (Anas penelope) i****n sites such as Lindisfarne NNR (Percival et al,1998) (p, 17).*

It is for this reason, that environmental managers are so keen to control the spread of *Spartina anglica* to protect wildfowl (p,17). **The spread of this non-native species destroys other important food sources for wildfowl or can lead to significant changes in wildfowl species composition visiting tidal mudflats.** Cattle grazing appears to be one way to reduce Spartina anglica roots (p, 18).

Spartina anglica plants are unsuitable food for invertebrates:

‘*C4 plants are relatively indigestible and therefore make an unattractive food source for wetland invertebrate species when alive*.’ (p, 18)

Doody in 1990 provided a summary of the impact of Spartina anglica on the environment, including salt marsh:

Advantages	**Disadvantages**
Prevents coastal erosion and stabilises mudflats	**Invades intertidal flats rich in invertebrates and feeding grounds for over-wintering waders and wildfowl**
Role in land reclamation and agricultural uses	**Decrease in diversity**
High productivity	**Replacement of richer communities**
Creation of grazing marsh	**<u>Promoting reclamation for agriculture that leads to the destruction of high-level salt marsh</u>.**

Value for research	

N.B. Bold and underlining is the current author's emphasis.

In terms of disadvantages, it is clear that the spread of *Spartina anglica* decreases biodiversity, replaces native species and adversely impacts the feeding areas of over-wintering waders and wildfowl. It can also destroy high-level salt marsh habitat.

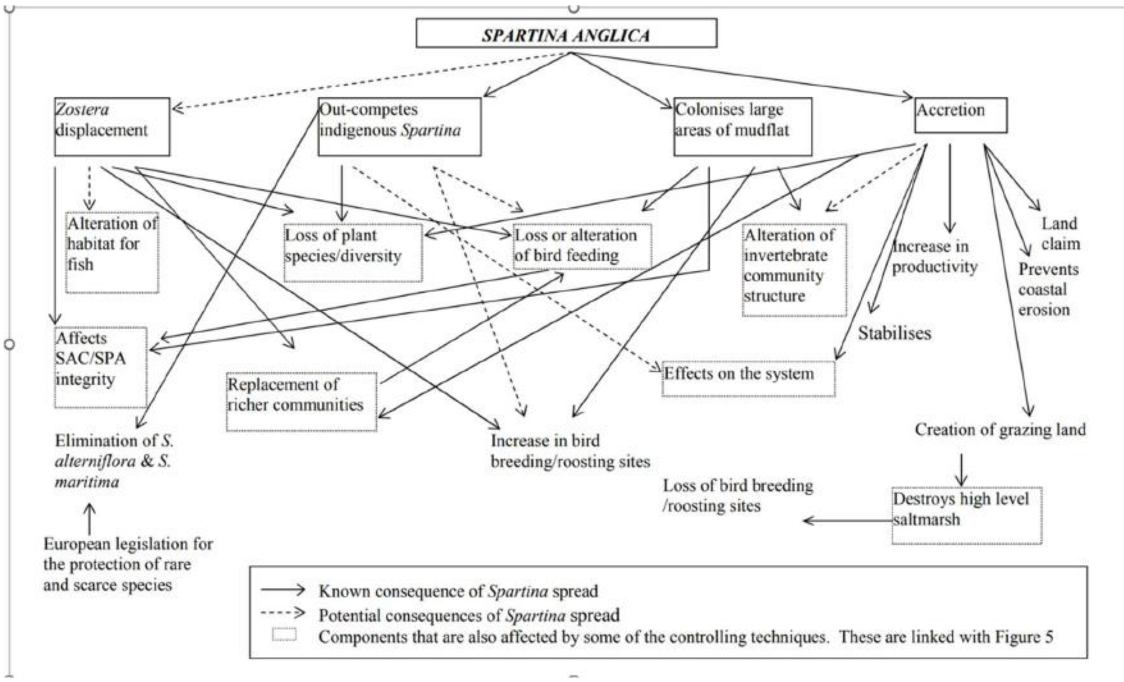
In New Zealand, legislation was introduced in the sixties to prohibit its planting due to its negative impact on bird habitat:

> '*In 1963, concern about the impacts of Spartina on New Zealand estuaries resulted in the introduction of legislation prohibiting further planting of Spartina. Areas of value for recreation and food collection, and as sanctuaries for resident and migratory birds, were thought to be at risk from the spread of Spartina. In particular, concerns were raised over the impacts of Spartina spread on the extensive tidal flats, Zostera beds and macro-algal beds bordering the existing saltmarsh, together with the impacts of accretion raising muddy land elevation and restricting navigation'* (Asher, 1990) (p, 24. 25).

In the UK, conservation agencies have been concerned about the spread of *Spartina anglica,* seen as leading to Dunlin reductions and loss of native seabed species used as feeding grounds for migratory and resident birds:

> '*Mudflats occupied by benthic invertebrates and eelgrass beds (Zostera sp.) have been displaced by S. anglica at a local scale. As these are often feeding grounds for migratory and resident birds, concern from conservation agencies has increased. Local indirect evidence has been given for dunlin although it has not been possible to directly attribute any decrease in the numbers of other birds to the expansion of S. anglica marshes*' (Gray et al, 1997) (p, 25)

There is no UK consensus on managing the spread of Spartina anglica due to the differing coastline and estuarine conditions around the UK. In some locations it proliferates and requires robust control and in other places it is subject to die back. **Spartina Anglica was introduced to Kingston Seymour in 1913 and to Bridgwater Bay on 1930** (Holland 1982) (p, 37) and then exported internationally.



Conclusions

***The non-native species Spartina anglica* can have serious consequences for wildlife conservation and biodiversity efforts through its dominance over other native species and its alteration of natural habitats. In particular, its reduction in feeding grounds for wildfowl and waders, its alteration in bird roost availability, its changes in habitats which leads to the loss of intertidal habitat, will negatively impact wildlife conservation and biodiversity. The table below provides further information on these impacts and costly control and mitigation measures that will be required.**

It is worth noting that some researchers consider that the erosional trend of the Severn Estuary will lead to net loss of *Spartina anglica* long-term:

> Dargie (1999) suggests the long-term trend in the Severn Estuary being a net loss of Spartina marsh in the outer parts of the estuary as a consequence of erosion; with Gwent and Gloucestershire as the only place in the Severn Estuary where S. anglica expansion could be occurring. Dargie cites a modest expansion in the middle and upper estuary and a conversion to other mixed communities on higher ground. As a general trend, Dargie (1999) suggested that, combined with other factors, the Severn Estuary saltmarsh is undergoing a transgression in response to sea level rise (p, 39).

Enteromorpha research

Enteramorpha when it dies and decomposes can suffocate oxygen levels in the sea or estuary and adversely impact flora, fauna, fish, shellfish and invertebrates. **On the estuary foreshore decomposing Enteromorpha macroalgae can produce high level of hydrogen sulphide which is a noxious gas and has been linked to paralysis, breathing issues, heart arrythmias**

and even heart attacks in humans and animals. Extracts from relevant research articles below outline some of the issues which may arise, unless strictly controlled.

Effects of the green macroalga *Enteromorpha intestinalis* on macrobenthic and seagrass assemblages in a shallow coastal estuary

S. P. Cummins[1,2,4,*], D. E. Roberts[1,3], K. D. Zimmerman[1]

Marine Ecology Progress Series, 266, 77-87 (20014) , doi:10.3354/meps266077

This research argues that a common symptom of eutrophication in temperate estuaries is the blooming of floating macroalgae, which aggregate over seagrasses and decompose. Experiments with *Enteromorpha intestinalis* were conducted in New South Wales (NSW) Australia. Over 3 months, decomposing *Enteromorpha intestinalis* in shallow habitats on the foreshore lead to:

> '*Dramatic declines in the biomass of seagrass and components of the infauna were detected in plots containing decomposing macroalgae. The results have implications for managing estuaries, since assemblages of seagrasses and macrobenthic organisms are considered to be important in nutrient-cycling and food-webs*.' (p, 77)

Enteromorpha in the media

There are several media articles which have highlighted the dangers of Enteromorpha, as outlined below.

How algae turns the tide toxic

[BBC NEWS | UK | How algae turns the tide toxic]

This BBC article highlights some of the main dangers of Enteromorpha:

- After heavy rain, nitrate based fertiliser from arable land and effluent from livestock and from the human sewage system can be washed into streams and rivers which creates algae. A lack of oxygen can kills prawns and plantlife and has a knock on effect on the fish and birds that feed on them.
- High tides can dump lots of alga on the foreshore where it dies then rots in the summer months. Hydrogen sulphide gas from rotting algae has killed horses in France
- Algae bloom has killed fish in Cornwall caused by microscopic form of plankton called *Karena mikimotoi*.

Horse dies, France faces reality of toxic beaches

[Horse dies, France faces reality of toxic beaches]

This 2009 article records how a horse died and a man was rendered unconscious due to hydrogen sulphide from rotting algae on the beach in Brittany France. It also mentions the death of a man and two dogs due to hydrogen sulphide gases. The article outlines how fertilisers and water treatment plants too close to the sea may contribute to this situation.

Seaweed suspected in French death

This BBC article from 2009 outlines how a driver removing seaweed from the beach in Brittany France, died after being overcome by fumes and crashing into a wall. It also describes how a horse died and its owner became unconscious due to the same noxious fumes.

BBC NEWS | World | Europe | Seaweed suspected in French death

Horse killed by lethal seaweed fumes

Horse killed by lethal seaweed fumes - Horse & Hound

This Horse and Hounds 2009 article records how a horse died from breathing in decomposing seaweed and suffered a fatal pulmonary oedema. Several locals were also treated in hospital, including a council worker who slipped into a coma after clearing the beach from seaweed. The beach was closed and people were warned to avoid beaches covered in seaweed.

Jersey monitors threat from toxic sea lettuce fumes

Jersey monitors threat from toxic sea lettuce fumes | Jersey | The Guardian

- This 2017 Guardian article records how a jogger suffered a heart attack and died due to rotting toxic sea lettuce fumes (a theory proposed by environmental experts).
- This article states that '**It tends to proliferate in warm, clear, calm, nitrate-rich waters. St Aubin's Bay is a perfect breeding ground because of its position– it is sheltered and sandy – and because it is rich in nitrates washed from farms in Jersey and northern France, and from the Bellozanne sewage treatment works.' – so sheltered positions, nitrates and sewage treatment works appear to be factors in creating conditions that promote Enteromorpha algae's toxic gases to humans and animals**.
- The rotten egg smells of hydrogen sulphide make it unpleasant for tourists and residents to be in the area

This research shows that Enteramorpha, in particular, thrives in an intertidal environment where effluent from livestock and from a human sewage system can be washed into streams and rivers which creates algae. Kingston Seymour's livestock agriculture along the foreshore and inland and the Wessex Water Treatment Centre with its outlet pipes into the Severn Estuary could therefore create similar environmental conditions for the creation of Enteramorpha

British tourists warned to avoid 'killer seaweed' in France blamed for death of teenage oyster farmer

British tourists warned to avoid 'killer seaweed' in France blamed for death of teenage oyster farmer | The Independent | The Independent

This 2017 Independent article records how British tourists had been warned to avoid 'killer seaweed' beaches in Brittany France following the death of a young oyster farmer. It describes that rotting algae gave off highly-poisonous gas previously linked to the death of a jogger, a horse and 36 wild boars in 2011.

Tourists heading to France warned to avoid toxic sea lettuce

Tourists heading to France warned to avoid toxic sea lettuce | Daily Mail Online

This Daily Mail 2019 article records how two men died of heart attacks, an Oyster farmer, 18 years old and a pensioner, aged 70 years old due to suspected hydrogen sulphide