Natural Capital Solutions

Valuation of carbon storage, sequestration and sea bass production in the Deben Estuary

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Background

The aim of the Suffolk Marine Pioneer, focused on the Suffolk Coast and Heaths AONB, is to produce a Natural Capital Plan that explores the ecosystem service production and value of the Deben Estuary. Natural Capital Solutions were commissioned to provide monetary valuations of carbon storage, sequestration and sea bass production, based on research that has been completed in relation to three main saltmarsh areas of the Deben Estuary: Loder's Cut & Kyson Point, Melton and Waldringfield marshes.

Methods and results

The most up to date and contextually appropriate production functions available in the scientific literature have been used to calculate the ecosystem service flows (i.e. the accrued benefits over a period of time) for carbon sequestration and sea bass production. The approach to valuing the flows of ecosystem services is based on ONS (2017) Principles of Natural Capital Accounting. The stored carbon, a stock of natural capital (a quantity of resource measurable at a fixed point of time), has been valued using standard techniques, but an asset value has not been calculated as this would normally be based on the accrued benefits over a particular time period.

Carbon storage

A monetary value was calculated for the carbon stored by the three marsh areas (saltmarsh and mudflat) in the Deben Estuary, Loder's Cut & Kyson Point, Melton and Waldringfield, before and after restoration, and for carbon estimates from 2D and 3D models (source: Slee et al. 2018). The carbon (C) estimates were converted into CO_2 to enable valuation. The price of CO_2 was derived from the Government's non-traded carbon prices (2019 low: £34, central: £67, high: £101) (BEIS 2017). The tonnes of CO_2 at each site were multiplied by the price per tonne of CO_2 (Table 1). The Government prices include both traded and non-traded carbon values. We use the non-traded carbon price because it is a better reflection of the 'real' value of carbon sequestration if it were to be exchanged, than market prices. Using the latter reflects the current institutional set up of carbon markets, rather than the true value of stored carbon or carbon sequestration.

Carbon will be released from the marsh habitats as they erode or are lost (as a result of coastal erosion, sea level rise or land reclamation). The rate of loss for the Deben Estuary is estimated at 1% extent per year (based on historic losses). Here, the stored carbon that will be lost in the future during this process is estimated. The estimate of carbon lost, and the value of the carbon lost was calculated for 5, 10 and 50-year time horizons (Table 2). The lost carbon was valued using the Government's central non-traded carbon price (£67).

Table 1. The total carbon and carbon stored per hectare at the marsh sites (saltmarsh and mudflat) of the Deben Estuary, for estimates of carbon derived from 2- and 3-D models. The restored marsh figures include the potential storage of carbon from this new area, and that from restoring the existing original area using sediment infill to raise eroded areas to the height of the rest of the salt marsh.

Deben Estuary site	Area (ha)	Total carbon stored (t)	Total CO_2 stored (t)	Value of CO_2 store (£ 2019)			tCO_2 ha^{-1}	Value ha^{-1} (£ 2019)		
				Low	Mid	High		Low	Mid	High
2D model estimates Original marsh										
Loder's Cut & Kyson Point	15.4	336.8	1,235.0	41,991	82,747	124,739	80.2	2,726	5,373	8,100
Melton	13.95	282.2	1,034.6	35,177	69,320	104,497	74.2	2,522	4,969	7,491
Waldringfield	8.81	239.8	879.4	29,899	58,918	88,817	99.8	3,394	6,688	10,081
Restored marsh										
Loder's Cut & Kyson Point	15.4	419.3	1,537.5	52,277	103,015	155,292	99.8	3,395	6,689	10,084
Melton	13.95	479.7	1,758.9	59,804	117,849	177,652	126.1	4,287	8,448	12,735
Waldringfield	8.81	303.2	1,111.7	37,798	74,484	112,281	126.1	4,290	8,455	12,745
3D models estimates Original marsh										
Loder's Cut & Kyson Point	15.4	336.8	1,235.0	41,991	82,747	124,739	80.2	2,726	5,373	8,100
Melton	13.95	282.2	1,034.6	35,177	69,320	104,497	74.2	2,522	4,969	7,491
Waldringfield	8.81	239.8	879.4	29,899	58,918	88,817	99.8	3,394	6,688	10,081
Restored marsh										
Loder's Cut & Kyson Point	15.4	6,832.3	25,051.9	851,765	1,678,478	2,530,243	1,626.8	55,309	108,992	164,302
Melton	13.95	13,261.0	48,623.8	1,653,210	3,257,796	4,911,005	3,485.6	118,510	233,534	352,043
Waldringfield	8.81	3,838.3	14,073.9	478,512	942,950	1,421,462	1,597.5	54,315	107,032	161,346

Table 2. The value of the carbon lost through the erosion of the existing marsh areas (saltmarsh and mudflat) in the Deben Estuary (estimated at a decline of 1% $year^{-1}$) at years 5, 10 and 50. Valuations were based on the central non-traded carbon price for 2019 (£67).

Deben Estuary site	Year 5			Year 10			Year 50		
	Area lost (ha)	tCo_2	£ 2019	Area lost (ha)	tCo_2	£ 2019	Area lost (ha)	tCo_2	£ 2019
Loder's Cut & Kyson Point	0.8	61.8	4,137	1.5	123.5	8,275	7.7	617.5	41,374
Melton	0.7	51.7	3,466	1.4	103.5	6,932	7.0	517.3	34,660
Waldringfield	0.4	44.0	2,946	0.9	87.9	5,892	4.4	440.0	29,459

Carbon sequestration

Data that demonstrate the ability of the saltmarsh in the Deben Estuary to sequester carbon were not available. In order to derive a biophysical value for this ecosystem service, it was necessary to find other studies that had measured carbon sequestration of saltmarsh in similar locations. The carbon sequestration rates for UK saltmarsh vary between 2.35 and 8.04 $tCo_2ha^{-1}yr^{-1}$ (Chmura et al. 2003, Adams et al. 2012, Beaumont et al. 2014). The rate of sequestration will depend on which coast the saltmarsh is located and the specific conditions that exist there, for example, whether the coast is eroding or accreting. Table 3 shows the rates of carbon sequestration that are available in the scientific literature derived from empirically based field studies and models. Most of the estimates at specific locations in the UK, rather than the average rate across the UK, are those for restored saltmarsh. There were no available rates for natural saltmarshes at scales smaller than the UK. Burden et al. (2019) demonstrated that saltmarsh carbon sequestration occurs at a rapid rate during the first 20 years following restoration, where it slows to a steady state. This suggests that using sequestration rates from restored sites during this initial phase of carbon accumulation could mean overestimating carbon sequestration in natural saltmarshes.

Given the variability in the data available, the most sensible approach was to use the sequestration rates from studies that would be the most geographically similar to the Deben Estuary (east coast), to use an average rate across the time period that it takes for a restored marsh to accumulate as much carbon as a existing natural saltmarsh (in the absence of rates for natural saltmarsh), and to ensure it is a rate within the range expected for UK saltmarsh. Therefore, the rate of 2.85 $tCo_2ha^{-1}yr^{-1}$ was used from the Burden et al. (2019) study of restored saltmarsh on the Essex coast. It is important to remember that these are estimates of sequestration rates. Depending on whether there is coastal erosion or accretion means that the rate used could be over or under estimated.

Table 3. UK saltmarsh carbon sequestration rates from the scientific literature.

Study	$tCO_2\ ha^{-1}\ yr^{-1}$
Burden et al. (2019) **Average across 100 years for a restored saltmarsh in Essex**	**2.85**
Burden et al. (2013) Rate for a restored saltmarsh in Essex	3.37
da Silva (2012) Rate for a restored saltmarsh in Somerset	2.23
Alonso et al. (2012) Humber Estuary	0.59
Chmura et al. (2003) General rate for UK saltmarsh	2.1

To calculate the physical flow of this ecosystem service (tonnes of carbon per year), the sequestration rate was multiplied by the area of original and restored (original saltmarsh + restored area) saltmarsh in each of the Deben Estuary sites. The annual monetary flow of this service was then estimated by multiplying this value by the central non-traded carbon price (£67), as above. The present value (PV) of the ability of the marsh to sequester carbon into the future was calculated over 10 and 50 year periods, using the discount rates suggested in HM Treasury (2018), and the formula within ONS (2016). We used the predicted carbon prices for the next 50 years to account for the change in value over these time horizons (Table 4).

Table 4. Annual monetary and Present Values (PV over 10 and 50 years) of carbon sequestration of the original and restored saltmarsh habitat at the Deben Estuary sites. Valuations were based on the central non-traded carbon price for 2019 (£67).

Deben Estuary sites		Saltmarsh area (ha)	tCO_2 ha yr^{-1}	£ 2019	PV 10	PV 50
Loder's Cut & Kyson Point	Original	4.09	11.7	781.0	7,845	44,874
	Restored	8.14	23.2	1,554	15,613	89,309
Melton	Original	2.58	7.4	492.7	4,949	28,307
	Restored	12.27	35.0	2,343	23,535	134,621
Waldringfield	Original	4.65	13.3	888.0	8,919	51,018
	Restored	7.76	22.1	1,482	14,884	85,139

Sea bass production

Although the number of bass per tide is available for the Deben Estuary in Slee et al. (2018), it is not possible to estimate the survival rate of bass to a length of 36 cm, at which point they are legal to capture commercially in the UK. The production function is based on quantitative estimates of the abundance of juvenile bass up to two years old calculated in

Fonseca (2009) for the Blackwater Estuary, Essex. Lower, upper and mean survival rates (Table 5) to 36cm in length in kg per hectare were taken from Fonseca (2009). The economic contribution of the bass to the local inshore fishery after five years (the age at which the bass are likely to reach the legal length for harvesting) was then estimated in units of £ per hectare of saltmarsh also from Fonseca (2009), and used subsequently by Luisetti et al. (2011) and da Silva (2012). We used the average wholesale price from Fonseca (2009) adjusted to 2019 prices (£7.13, using the latest Government GDP deflators at market prices), so Table 5 shows the newly calculated value per hectare for the lower, upper and mean survival rates. These values were multiplied by the area (ha) of the original and restored (original + restored area) saltmarsh at each of the sites (Table 6). The present value (PV) of sea bass production into the future was calculated over 10 and 50 year periods, using the discount rates suggested in HM Treasury (2018), and the formula within ONS (2016). The price per ha was assumed constant in this calculation, due to the absence of data on how it has or may change in the future.

These estimates are based on a number of assumptions that are both ecological and economic. First of all the abundance of bass per hectare was estimated in the Blackwater Estuary, and we are assuming by transferring the values that the abundance and survival rates in the Deben Estuary will be similar. The Fonseca (2009) study was also rather short term to derive a robust estimate of fish biological production, so there is a good degree of uncertainty around the estimates used. Further ecological assumptions, taken from those listed in Luisetti et al. (2011) are that water volume, fish distribution, habitat quality, catchability, the total yield of bass from a number of different cohorts in any one year equals one cohort over the whole of its life span, the ecological carrying capacity and resilience of the estuary, the biological and physical processes determining supply of 0 to 3 group bass to the saltmarshes over time, the natural and fishing mortality rate, and the migration of 3 and 4 group bass away from the local market is constant. There is also an assumption that the price at local market is constant, when it can actually be quite volatile and influenced by the market for farmed bass (Fonseca 2009, Luisetti et al. 2011). These estimates should, therefore, be seen as an indication of the value of bass production, but not in any way an accurate estimate of value of bass in the Deben Estuary.

Table 5. Survival parameter estimates and value of bass (£ per hectare) contributing to inshore fishery after five years

Survival parameter estimates	Lower	Mean	Upper
Total weight (kg) of juvenile bass per hectare surviving to 36 cm after 5 (or 4) years	0.28	1.65	6.78
Value per ha at average wholesale price (£7.13 2019)	2.00	11.77	48.34

Table 6. The value of sea bass production in the original and restored saltmarsh nursery habitat at the Deben Estuary sites for lower, mean and upper survival estimates, with present value estimated at 10 and 50 years.

Deben Estuary sites		Saltmarsh area (ha)	Value of sea bass (£ 2019)			PV 10	PV 50
			Lower	Mean	Upper		
Loder's Cut & Kyson Point	Original	4.09	8.2	48.1	197.7	449	1,229
	Restored	8.14	16.3	95.8	393.5	893	2445
Melton	Original	2.58	5.2	30.4	124.7	283	775
	Restored	12.27	24.5	144.4	593.1	1,346	3,686
Waldringfield	Original	4.65	9.3	54.7	224.8	510	1,397
	Restored	7.76	15.5	91.3	375.1	851	2,331

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