# A Report on a
# Ploughing Trial at St Aubin's Bay

**Department of the Environment**

**- July 2017 -**

# Summary

1 - A ploughing trial has been undertaken following a methodology presented to the Department by Mr Tony Legg in November 2016. The trial was required to test basic practicalities behind some predictions made in the proposal concerning the evolution of furrow topography. It was also undertaken to gauge practical and logistical requirements for ploughing on the beach.

2 - A furrow depth of 50 cm as specified in the proposal could not be achieved despite using a powerful tractor and deep plough. A depth of only 36 cm could be achieved following three passes of the plough. It took one hour to plough a total of 621 metres to this depth. The speed of ploughing was much slower than the 7 km/hr predicted in the proposal. This has implications on the practicality, equipment needed, feasibility (time when working between tides) and cost of ploughing to the specifications given in the proposal.

3 - Eight days of observation and time lapse photography following the ploughing showed a rapid infilling of the furrows to a few centimetres' depth and a more gradual levelling of the sand. The furrows had entirely gone by day eight. The topography of the area between the furrows was unaffected and no domed structures as were described in the proposal developed during the trial.

4 - Observation and photography could find no measureable effect on the distribution and movement of *Ulva* in the areas neighbouring the furrows.

5 - Based on the trial results, it is the Department's opinion that the outcomes listed in the proposal are unlikely to occur. This, in combination with concerns expressed regarding potential amenity disruption, environmental damage and taxpayer expense means that it is not recommended that further action is taken with regard to the full scale trial ploughing of St Aubin's Bay.

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# 1 - Introduction

On 21 November 2016, the Department of the Environment received a written presentation from Mr. Tony Legg (entitled 'A Proposal Scoping Draft and Technical Annex') which proposed the ploughing of a series of deep furrows running perpendicular to tide movement along the length of St Aubin's Bay. The proposal contained a methodology for the ploughing of the furrows and information he had gathered regarding the conservation status and biology of the native seagrass species *Zostera noltii*, which is growing in the bay. The conclusion of his proposal was that the creation of a series of deep furrows '*could not only go some way towards solving the* Ulva *issue but actually benefit the* Z. noltii *as well*'.

The proposal was discussed within the Departments of the Environment and Infrastructure. Several concerns were expressed which related to whether the suggested scheme would work, the feasibility of the proposal, the visual impact of the ploughing, public health and safety issues, cost to the taxpayer and the potential ecological damage to a species and habitat (*Z. noltii* beds) that are subject to local and international conservation measures.

Answers to these concerns were not readily available from the information provided in the proposal and the use of furrows for the control of *Ulva* has not been trialled and tested elsewhere. To assess whether the proposal was likely to have any merit it was decided that the States of Jersey should pay for a small scale trial which could test some of the expected outcomes. This involved undertaking the trial on a section of beach away from the sensitive areas of *Z. noltii* to firstly assess the robustness and longevity of the ploughed furrows and compare physical results with predictions made in the proposal.

The trial was undertaken in accordance with the specifications contained in the proposal and is assessed against his methodology and projected outcome.

## 1.1 - Methodology

The proposal provides an explicit methodology for the beach ploughing. It states that the ploughing requires 'single furrows 15m apart c. 50cm deep at 90 degrees to the shoreline from mid tide to mean low water neap (c 400m)'.

The proposal requires these furrows to be placed within an area where *Zostera noltii* was present. However, *Z. noltii* is internationally regarded as a key habitat and also subject to a Jersey Biodiversity Action Plan. Additionally the Department of the Environment had received verbal and written advice from three UK *Zostera* experts all of whom expressed concern that ploughing through *Z. noltii* areas would risk causing permanent damage to the plants. Similar concern was expressed by some of the Department's officers and by the Société Jersiaise. In light of this it was decided that the trial ploughing should not occur within the *Zostera noltii* but in an area to the west of La Haule slipway.

The proposal states that 'the process can be achieved by a small tractor (40 hp+) with a single "last furrow" plough'. The Department sought a tractor and plough which could achieve the stated 50 cm depth and was told, repeatedly, that the only equipment capable of reaching this depth would be a

more powerful tractor (160 hp) fitted with a deep ridging two blade plough which had been converted to a single furrow ridging plough. This plough is no longer used in the island and had to be obtained from storage. As this seemed to be the only means of achieving the 50 cm depth, this equipment and a professional tractor driver was hired.

### 1.2 - The Ploughing Trial

On 30 May 2017 the tractor and plough were driven to La Haule slipway where it was met by officers from the Department of the Environment and the Chair of the Marine Biology Section (Société Jersiaise).

Ploughing commenced at circa 16:37 and finished at circa 17:38. In this time two furrows were created which were 305 and 316 metres long and which started approximately 8.5 metres above chart datum (Mean High Water Neap) and terminated at 4.5 metres above chart datum (just above Mean Low Water Neap). The furrows were an average of 15.65 metres apart and were approximately 2.3 metres wide (80cm of this was the furrow, the rest was sediment splay).

The tractor and plough could not achieve the desired 50 cm depth, despite making three passes in each furrow. The first pass produced a depth of circa 27 cm with the depth having reached circa 36 cm after three passes. Officers took photographs during the trial and measurements were made of the furrows. The path of the furrows was tracked using a GPS unit and notes were made on the sediment properties and any fauna that was revealed by the ploughing.

Between the 30 May and 7 June the furrows were observed by a time lapse camera (mounted on a lamppost overlooking the site) which took an image every hour from before the ploughing to the 6 June. The site was also visited on the 30 and 31 May and the 5, 6 and 7 June by officers from the Department of the Environment. During these visits observations, measurements and photographs were taken.

### 1.3 - Monitoring Parameters

The proposal expects the ploughing to produce several outcomes and benefits for St Aubin's Bay. This includes supressing '*the development of* Ulva *spp. and augment the development of seagrass Zostera noltii in St Aubin's Bay by slightly changing the bottom benthic boundary by means of well-spaced drainage channels between mid-water and low mean water neaps.*'

The proposal states that the furrows will alter the topography and chemistry of the sediment in such a way that it will

- assist with the movement of *Ulva* down the shore
- suppress the development of new *Ulva* plants
- and enhance the density of the *Zostera noltii*.

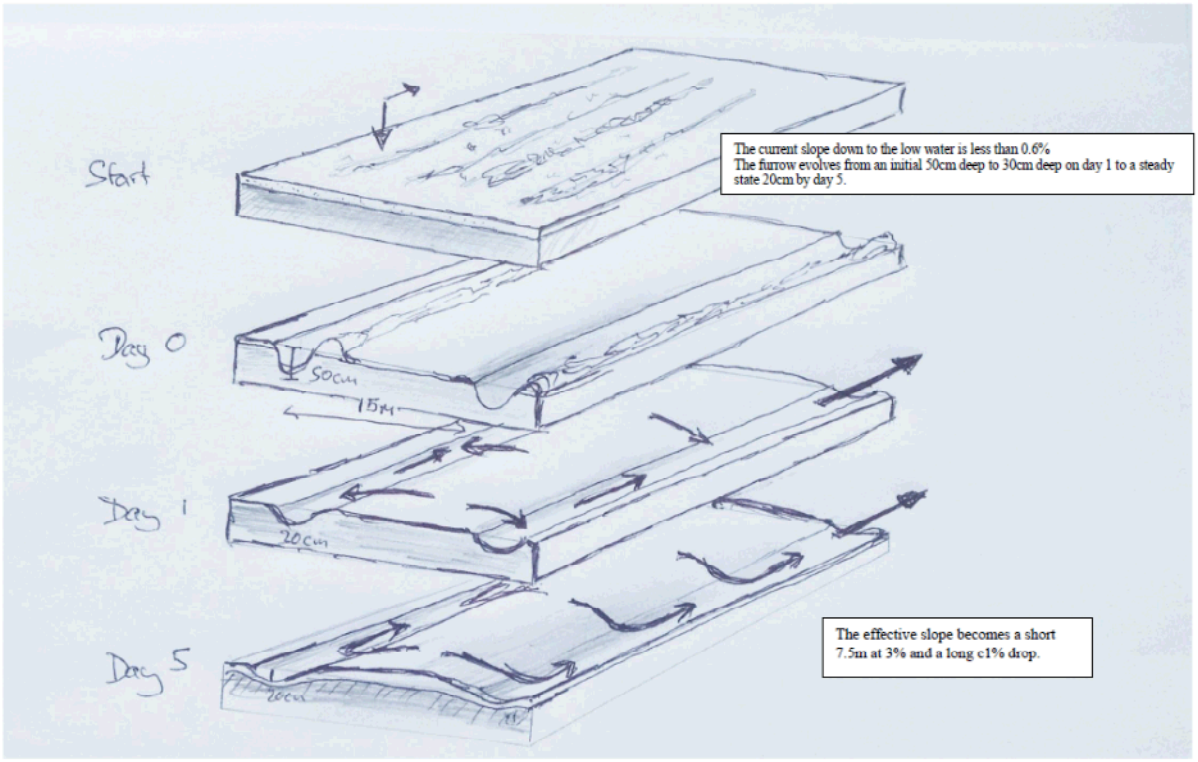
The proposal offers five core predictions which could have potentially been tested by a field trial. These are listed below.

<u>1 – Changes in Beach Profile</u>

One of the objectives of the trial ploughing was to measure any topographic change in the beach area associated with the furrows.

The proposal states that: '*The increased water velocity on the dropping tide and pulse effect of wave action maintains the channels and increases a domed effect away from the channels and parallel to them… Over time (months) the structure should take on a degree of permanency with a corduroy effect of channels alternating with raised lines of higher density* Z. noltii*.'* It was expected that the furrows would *'evolve over a few days to be a series of compound curves that increase the drainage angles and resultant velocities.'*

A diagram in the proposal displays the expected development of the beach profile between the two furrows from a flat beach surface into a gently domed one.




2 – Movement of *Ulva* to the lower shore

The proposal suggests that the change in beach profile will change the local drainage pattern in such a way that it will assist with the movement of *Ulva* down the shore. For example: *'This dome… acts as a drainage and movement slope for* Ulva*…'*

3 – Chemical Change

The proposal states that: *'The creation of the ploughed furrows channels changes the oxidation profiles of the sand by making the anoxic boundary, which is more bound through interstitial sulphide results, descend.'*

The anoxic layer was found to be just below surface along the length of the furrows. However, it was not possible to observe any change in the height of this layer in the days after ploughing due to the rapid infilling of the furrows.

4 – Enhancement of Seagrass

The proposal states that the action of ploughing might serve to enhance the long-term health of the *Zostera noltii* in St Aubin's Bay.

The proposal states variously that ploughing *'creates a beneficial substrate for the* Zostera noltii*' that the 'reduction of the excess production of macroalgae and prevention of smothering of a protected species should enhance its [*Zostera noltii*] density' and that the overall effect could 'potentially increasing densities of* Z. noltii *to defined bed densities'.*

This idea has been strongly opposed by UK experts each of whom stated that physical disruption of *Zostera noltii* invariably leads to a decline in its health or its eradication. Because the trial ploughing did not take place in areas of the beach inhabited by *Zostera noltii* this could not be tested.

5 – Logistics and Cost

The proposal provides an estimate of the time needed to undertake regular ploughing of the beach and also the expected cost to the taxpayer.

The proposal states: '*At 7 km/hr estimated plough speed this represents c 12 hrs ploughing time (80,000m). On spring tides the area is fully exposed from top to bottom for three hours. Four days for three hours would establish the initial furrows. This process can be repeated on each of the main summer spring tides. So hours would be 5 months x 12 hrs or 60 tractor hours per year. Given operational timings a realistic 100hrs per year should be adequate. The NAAC UK Contractor quote for mole ploughing is £35/hr but being sweater, etc that puts additional cleaning loads etc. A total estimate of £10,000 per annum is probably a significant overestimate.'*

The trial ploughing was able to establish what equipment is required to create the deep furrows (although not to the 50 cm depth specified) and the logistics associated with ploughing the beach. These observations can, however, be used to provide an accurate estimate of the likely time and expense required if the project were ever extend to a full development phase.

*The exact position of the two furrows on an aerial photo, as plotted using a GPS unit.*

# 2 - Results

The observations and measurements obtained from the ploughing trail are given in Appendix I. This section looks at those aspects of the trial results that may be related back to the predictions made in the original proposal document as submitted to the Department in November 2016 (see Section 1.3).

## 2.1 - Furrow Depth

Advice to the department from a professional farmer raised concerns about obtaining a furrow depth of 50 cm: *'We are just a bit concerned about the depth of 500mm that has been specified as a plough is really designed to work at half that depth usually and a maximum of 300mm in an unusually deep soil. So we wondered how critical the depth is to the trial*.'

A light-weight tractor and plough was eventually deemed inadequate to achieve the stated 'c50cm' furrow depth. Instead a heavy tractor (160 BHP) with an old deep ridging plough that was purposefully brought out of retirement had to be used. The normal two blade plough was converted to a single furrow ridging plough.

Even with a deep ridging plough a furrow depth of 50cm could not be achieved. The first pass produced a depth of 27cm and after three passes the depth was 36cm. Based on this, it was unlikely that the furrowing could be done to a depth of 50cm and that a heavy tractor is required, not a light one.
The trial indicates that '*a small tractor (40 hp+) with a single "last furrow" plough*' is inadequate to create furrows that are 50 cm deep.

## 2.2 – Beach Profile

The proposal predicted that the beach profile adjacent to the furrows would '*evolve over a few days to be a series of compound curves that increase the drainage angles and resultant velocities*.'

The evolution of the furrows was monitored by the use of a time lapse camera mounted on a lamppost situated on the sea wall directly in front of the ploughed area. This was started before ploughing took place and took a single image every hour between 30 May and 6 June. Monitoring was also achieved through site visits made by Department officers and Gareth Jeffreys (Société Jersiaise) at low water on the days following the ploughing trial. The final visit was made on 7 June.

On the afternoon of 31 May (24 hours after the ploughing) observations were as follows:

"1. At the top of the furrow where there was a steeper gradient, the mounds either side of the channel had almost completely dissipated and the channel itself was close to returning to the level of the surrounding beach (*circa* 3cm depth);

2. Where the gradient decreased and became relatively constant down to the low water mark the mounds remained intact in a relatively uniform state;

3. The mounds themselves were very compact, free draining and structurally quite sturdy (easily supporting my weight when walking on them as evidenced by the footprints on the photos);

4. In contrast to this, the sand filling the channel is saturated with water and very loose. Due to the high levels of interstitial water between the loose grains, the amount of sand required to refill the channel is (most likely significantly) less than the volume of sand removed from it. As a consequence, the depth of the lower gradient channels only ranged from between *circa* 3 cm to 10 cm in depth against the surrounding beach level, while the height of the mounds remained at 10 cm to 15 cm.

5. Where there is water pooling lower down the beach the channels to not drain this, they are simply filled with water to the height of the surrounding water level.

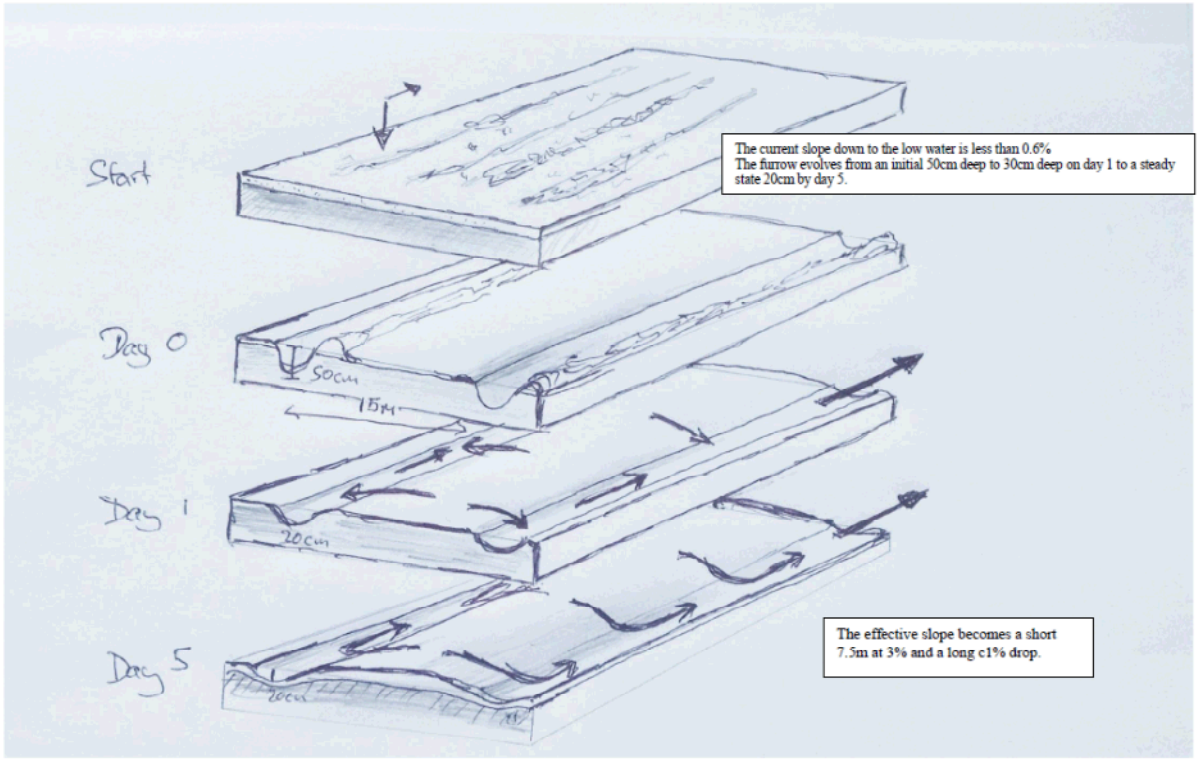
6. If a blockage occurs in a channel the water being forced around the blockage creates a wider area of erosion; and

7. There is still a lot of *Ulva* amassing in the channels."

In the days that followed the furrows continued to infill and the side mounds levelled off until by 6 June (following stormy weather) the beach had become level. On 7 June the furrows could not be seen at all.

Photographs taken during visits and by the time lapse camera footage document a rapid infilling of the furrow and a more gradual levelling off of the side mounds. Beyond this, there was no discernible effect on the beach topography, including in the area between the two furrows. The 'compound curves' which were predicted to 'evolve over a few days' were not observed.

Page 23 of the proposal contains a diagram which predicted the evolution of the furrows over a five day period. The illustration (which is for furrows within an area of *Zostera noltii*) suggests that by Day 5 the beach will have developed a domed feature and that the furrows will be 20 cm deep.




*A diagram from the proposal predicting the evolution of the beach for five days after ploughing.*

The trial suggests that ploughing the beach creates temporary furrows that have no effect on the topography of adjacent areas. The furrows proved to be unstable and infilled rapidly with loose, water saturated sand. The side mounds levelled off over a few days.

Ploughing took place in an area of compact sand, rather than in an area with *Zostera noltii*, where the sediment is more stable. It is the Department's opinion that if 'compound curves' cannot form in an area of compact (but non-cemented) sediment, then they are even less likely to occur in an area where the sediment has been stabilised by *Zostera*. Also such domes would need to form in the 15 metre gap between furrows and yet the trial furrows demonstrated no influence at all on areas of sediment immediately adjacent to the furrows.

Furrows placed within the *Zostera* area will suffer from the same instability issue as was seen in the trial area and are liable to be rapidly infilled with water saturated sand. The furrows are equally as unlikely to influence the adjacent sediment which, if bound by *Zostera*, will be more stable than in the trial area.

The trial produced no observable change in the beach profile between the two furrows. Based on this the creation of semi-permanent furrows or a 'corduroy effect' of ridges and furrows, as predicted in the proposal, is unlikely to occur.

### 2.3 - Movement of *Ulva*

The proposal predicted that the evolution of 'compound curves' (see 2.1 above) will 'act as a drainage and movement slope for *Ulva*'.

The compound curves did not develop and no movement of *Ulva* was seen along and down the furrow towards the low water. The sand surrounding the furrow at the high water mark was seen to dry for approximately five metres either side of the furrow. This was confined to the upper 10 metre furrow length with the furrow section lower than this remaining saturated. A layer of loose green seaweed remained on the beach throughout the observation period.

### 2.4 - Time and Effort

Three passes were needed to achieve a 36cm depth along two furrow with a total length of 621m. This took an hour to achieve via continuous ploughing.

The proposal states the total length of furrows needed across St Aubin's Bay is 80,000 metres (80 km) and that this would require 12 hours ploughing time. The trial suggests that the ploughing will take considerably longer than this, perhaps as much as 129 hours. Given that ploughing will, according to the proposal, need to take place on spring tides for three hours a day, to achieve one ploughing cycle could require up to 43 consecutive spring tides across a single calendar month.

Two such cycles per month are outlined as necessary in the proposal. At £35/hr (a base figure suggested in the proposal), each ploughing cycle will cost around £4,500 (i.e. £9,000 per calendar month or £45,000 per annum / season). This compares unfavourably with the '*estimate of £10,000 per annum*' in the proposal.

The trial suggests that the 'tractor operation and budget' section of the proposal will need to be completely revised as at present the time required and cost are liable to be far greater than anticipated. To proceed without this revision risks not being able to achieve the desire ploughing in the time allocated and/or much greater expense to the taxpayer than originally predicted.

### 2.5 - Other Observations

Departmental officers have raised concerns that some of the statistics and information presented in the proposal may be incorrect or at odds with the Department's own datasets. For example, the proposal states that the area to be ploughed is 'c350 hectares' whereas the ploughed area that is indicated on an aerial image in the proposal actually covers an area of 180 Ha. The proposal also says that the furrows will occupy '2% cover of the entire area' whereas a departmental calculation gives a figure of 8.8%.

These issues are not dealt with directly in this report but if the trial is to move into a full operational stage then clarification will need to be sought for some of the figures provided and raw datasets requested for some of the research evidence cited.

# Appendix I - Trial Results

**Background**

The ploughing trial was designed to look at the physical and logistical aspects of the proposal proposition. Its primary objectives were:

- To quantify the machinery and effort needed to create the furrows to establish the practicality

- To observe the topographic evolution of the furrows against the predictions provided in the proposal.

- To observe any changes in the distribution, abundance and movement of Ulva deposits associated with the furrows.

The trial was not designed to measure any chemical changes in the sediment and nor was it designed to test the notion that ploughing across *Zostera noltii* areas will lead to an enhancement of its density.

**Statistics and Measurements**

Start Time: 16:37
Finish time: 17:38

**Furrow Dimensions**

Furrow 1 (northernmost): 305 metres
Furrow 2: 316 metres
Distance between furrows: 15.65 metres (average of 5 measurements)

Width of tractor tyres: 2.3 metres
Furrow width at top: 0.8 metres
Depth of furrow: 0.36m after three passes by the tractor.
Width to outer edge of sand splay: 1.8 metres
Height of sand splay: between 0.19 and 0.36 metres
Width of each splay: 0.5 metres

**Profile (using heights from a LIDAR survey)**

Height of start of furrow = approx. 8.5m above chart datum (high water, neap tides)
Height of end of furrow = approx. 4.5m above chart datum (low water, neap tides)

**Sediment Properties**

Measured from upper end of furrow, the first 20 metres consists of coarse poorly sorted gravelly sand with a significant quantity of broken shell debris. The next 10 metres has fine to medium moderately sorted sand matrix with lenses of poorly sorted gravelly sand. At circa 30 metres this moves into well sorted fine sand that remains consistent to the end of the furrows.

Anoxic black sand starts around 14 metres (furrow 1) and 34 metres (furrow 2) and continues to the end of the furrows although in furrow 1 there is a patch of less anoxic sand between 55 and 95 metres. The anoxia begins between 2 and 4 cm below the sand surface.

# Appendix II -A Selection of Time Lapse Camera Images


*Day One (just ploughed)*


*Day Two (24 hours)*


*Day Three (48 hours)*


*Day Eight*