Ki(n Doherty

From:	John P Kelly (Galway) <John.Kelly@tobin.ie>
Sent:	Tuesday 10 December 2019 12:41
To:	Kieran Doherty
Subject:	GHE CMR Additional Intertidal reference area : more detailed map and statement of targets, methods, indicators, etc, PA0033
Attachments:	Response 10XII BOC + Fig20(1) and 14(1).docx; GHE CMR Figures 20(1) Draft & 14(1) Draft.pdf

Kieran.

Following receipt of your email of 3/12/19 relating to the reference site map and proposed studies, attached please find information for your approval that deals with:

1. Map showing the details of the reference sites.
   Why they were selected and the areal extent of each as shown in Figure draft 20(1)

and

2. The objectives of the planned monitoring surveys, the methods to be used for each and what the monitoring plan intends to show including sampling sites and dates of surveys.

Also attached is a draft of Figure 14(1) which will be the revised Didemnum Management Control Area (1) to correspond with 1. above.

Please note that the attached information will be included in the response to the ten points previously raised by ABP that will be submitted to you once we have your reply to this email.

Thank you,
John

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__2017__ National Standards Authority of Ireland Award Winner

Reference Areas 2 and 3 are within the intertidal management area as noted at paragraph 1, p.58 of the CMR as submitted April 2019.

Objectives associated with the proposed sampling design.

Target 1.

1. **The control of the invasive, non-native tunicate species *Didemnum* in Mweeloon Bay.**

The target of this element of the compensation plan is to control the population of the non-native invasive tunicate *Didemnum* which is present on oyster trestles and bags at the site.

Method

An annual control regime for the species is proposed as part of the compensatory measures. The control regime includes regularly turning the bags to increase "drying out" periods and the use of acetic acid that kills the tunicate. These methods have been shown be an effective method to control *Didemnum.*

Indicator

The Abundance and Distribution Range method (ADR) developed by Olenin *et al.* (2007) and used recently by Cottier-Cook *et al.* (2019) in a survey of *Didemnum* in Loch Creran, Scotland is the indicator that will be used to measure the relative effectiveness of the control regime at Mweeloon. Use of the ADR tool will readily and quickly show the effectiveness of the control regime.

In addition, a photographic survey will be carried out to visually document the population and distribution of *Didemnum* before the control practice commences and on an annual basis post-commencement.

It is proposed to carry out this *Didemnum* control regime throughout the entire reference site (including the additional area presented in this document, see Figure 14(1) plus the additional area 1) where trestles are present and is not restricted to a single area. This is to ensure that, if populations are left in close proximity to the fallow site, they cannot re-infest the fallow area.

Threshold

The threshold for this objective of the compensatory plan is to reduce the percentage cover of *Didemnum* in Mweeloon Bay to within *ca* 20% of what it is at the start of the CMP to within 5 years of its commencement.

Details regarding the map showing the marine areas where *Didemnum* control and intertidal monitoring post-cessation of oyster farming will be carried out (see attached Figure 20).

The area in the eastern part of Mweeloon Bay is where the highest concentration of oyster farming is located and this is also the area where *Didemnum* occurs. Its presence in this area was established during the overall survey of the marine habitat that was carried out for the Compensation Plan and it was shown in the CMR as the area where *Didemnum* would be controlled (see attached Figure 14(1)). The eastern and northern parts of Mweeloon Bay were not covered as part of the baseline survey for the CMR and for this reason, they were not considered for either *Didemnum* control area or as a monitoring site post-cessation of oyster farming.

The area where *Didemnum* will be controlled has been extended eastwards to the southeastern shoreline of that part of Mweeloon Bay (see Figure 20(1)).

The main aims of the marine element of the compensation plan include:

1. The control of the invasive, non-native tunicate, *Didemnum vexillum*
2. The removal in some areas of oyster trestles and
3. The impact of intensive agriculture practices on intertidal ecology.

For these reasons, this is the area that was selected as the location where these control activities and monitoring studies should be carried out. As there are no aquaculture activities within Mweeloon Lagoon, that area could not be used for either of the first two purposes.

This area of Mweeloon Bay formed part of the entire study of Mweeloon Bay and Lagoon and parts of Lackanaloy Lagoon that was studied as part of the Compensation Plan report and this initial data set will be used as a backdrop to the proposed *Didemnum* control and intertidal monitoring plan.

Furthermore, there is intensive agriculture carried on in the fields directly to the South of this marine reference site (see Reference Site 1 in Figure 20(1)). This is the additional area of the reference site to show comparison between Reference Area 1 where intensive aquaculture will continue and is adjacent to an area where intensive agriculture will continue and Reference Area 2 where aquaculture will cease and also is adjacent to where intensive agriculture will continue.

Reference Area 3 is the location where aquaculture will cease but is adjacent to where agriculture will be organically managed.

What this aspect of the Compensation Plan will demonstrate.

This will show how successful the control of *Didemnum* at the Mweeloon site will be over time.

Target 2. The removal of oyster trestles and cessation of tractor movements from the reference area.

The second target of the marine aspect of the compensation plan is the permanent fallowing of sites in Mweeloon Bay that are currently used for culturing oysters including the elimination of tractor traffic to and from the fallow site.

The effects of mollusc aquaculture on marine ecology has received some focus of research not only in Ireland (Forde *et al.*, 2015 *inter alia*) but also further afield (see for reviews see McKindsey *et al.*, 2011; Gallardi, 2014). Forde *et al.* (2015) investigated the potential impact of oyster trestle cultivation activities on intertidal soft sediment habitats and infaunal communities at six sites located within four designated Natura 2000 sites distributed around the north-west, west and south coasts of Ireland. Specifically, the study investigated changes in sediment characteristics and associated infaunal communities 1) underneath trestles and 2) along access routes.

Results showed that sediment characteristics, and the associated infaunal community structure and diversity indicators across the sites was highly variable, with increases in species abundance and diversity attributed to faecal/pseudofaecal material produced by the oysters acting as a source of additional food for the infaunal taxa. The variability across sites prevented the detection of the general effects of cultivation activity on sediment characteristic and faunal community structure. To overcome variability, the Water Framework Directive (WFD) Ecological Quality Ratio (EQR) Infaunal Quality Index (IQI) indicator was used to assess impacts on the Ecological Status (ES) of the infaunal communities.

This study showed that activities along access routes had a significant negative impact on ES. The negative impact on ES was attributed to heavy vehicle traffic and the compaction of the sediments. This study highlighted the IQI EQR indicator as a tool for the management of aquaculture activity and as a potential tool for assessing the conservation status of designated habitats in Natura 2000 sites.

Method

Within the Mweeloon marine reference site, four areas will be selected and these are as follows:

1. At the trestles of an active aquaculture site (Map 20(1), Reference Area 1) and adjacent to an area of intensive agriculture including the access route to and from it,

2. At an aquaculture site that will be fallowed and adjacent to an area of intensive agriculture (Map 20(1), Reference Area 2),

3. At an aquaculture site that will be fallowed and adjacent to an area of "organic" agriculture (Map 20(1), Reference Area 2) and

4. At a location on the tractor access route to the active aquaculture site (Reference Area 1).

Within each of these including the access routes, 10 stations will be selected. At each station two core samples will be taken, one core for faunal analysis and one core for sediment granulometry and organic carbon analysis. At each station, REDOX depth will be at the assessed visually using a transparent, plastic core. Summaries of the faunal and sediment analyses are presented below. Sampling will be carried out as listed below:

1. Before the trestles are removed;
2. 1 week post removal;
3. 1 month post removal;
4. 6 months post removal;
5. 1 year post removal and
6. Once a year for 5 years post removal.

The temporal changes at the fallowed sites will be compared to temporal changes at a nearby trestle oyster site where cultivation activity will be continue *i.e.* an active production site and at the access route. All sites to be investigated will be selected to ensure that they are comparable in terms of shore tidal height and sediment type.

Samples for quantitative faunal analysis will be sieved on a 1mm mesh sieve, preserved, sorted and identified to species level where possible.

The faunal samples will be processed in a systematic way to ensure that no samples are omitted. A daily inventory of what samples have been sorted/identified/counted will be maintained. The samples will be sorted as follows:

- Conspicuous fauna will be placed in an illuminated shallow white tray and sorted first by eye to remove large specimens and then sorted using a stereo microscope at 6 to 10 times magnification.

- Following the removal of larger specimens, the samples will be placed into Petri dishes, approximately one half teaspoon at a time and sorted using a binocular microscope at x25 magnification.
- The fauna will be maintained in stabilised 70% industrial methylated spirit (IMS) following retrieval and identified to species level where practical using a binocular microscope, a compound microscope and all relevant taxonomic keys. AQUAFACT has an extensive library of taxonomic publications (including BEQUALM/NMBAQC guides).
- Species nomenclature will be classified in accordance with Howson & Picton (1997).
- After identification and enumeration, specimens will be separated and stored to species where possible.
- All containers will be clearly labelled on the outside stating site, date, sample code, replicate number and name of individual who analysed the sample.
- A permanent internal label bearing the same information will also be included with all containers.
- Specimens will be stored in stabilised Industrial Methylated Spirits (IMS) in containers with adequate seals and labelled accordingly.
- Residual detritus will be kept in a separate container for each sample, labelled inside and outside. Sample residue will be preserved in alcohol in containers with adequate seals and labelled accordingly.

All faunal abundance data will be recorded in an Excel spreadsheet.

The following description outlines the methodology for granulometric analyses.

1. Approximately 25g of dried sediment is weighed out and placed in a labelled 1L glass beaker to which 100 ml of a 6 percent hydrogen peroxide solution is then added. This is allowed to stand overnight in a fume hood.

2. The beaker is placed on a hot plate and heated gently. Small quantities of hydrogen peroxide are added to the beaker until there is no further reaction. This peroxide treatment removes any organic material from the sediment which can interfere with grain size determination.

3. The beaker is then emptied of sediment and rinsed into a. 63µm sieve. This is then washed with distilled water to remove any residual hydrogen peroxide. The sample retained on the sieve is then carefully washed back into the glass beaker up to a volume of approximately 250ml of distilled water.

4. 10ml of sodium hexametaphosphate solution is added to the beaker and this solution is stirred for ten minutes and then allowed to stand overnight. This treatment helps to dissociate the clay particles from one another.
5. The beaker with the sediment and sodium hexametaphosphate solution is washed and rinsed into a 63µm sieve. The retained sample is carefully washed from the sieve into a labelled aluminium tray and placed in an oven for drying at 100ºC for 24 hours.
6. When dry this sediment is sieved through a series of graduated sieves ranging from 4 mm down to 63µm for 10 minutes using an automated column shaker. The fraction of sediment retained in each of the different sized sieves is weighed and recorded.
7. The silt/clay fraction is determined by subtracting all weighed fractions from the initial starting weight of sediment as the less than 63µm fraction was lost during the various washing stages.
8. The particle size (PSA) data will be processed using GRADISTAT (Blott and Pye, 2001) software to derive sediment type classification and sediment particle parameters including (ø) particle graphic mean values (Mz) and sediment distribution modality. All sediment samples will be classified using Folk and Ward (1957). Mz is a parameter used to describe the mean particle size of a distribution and is analogous to the graphic mean employed with the normal distribution in conventional statistics (Forde *et al.*, 2012); consequently, the Mz parameter can be used with confidence where sediments exhibit unimodal distributions. If the particle size distribution of the sediments samples are unimodal (or approximately unimodal), Mz values will be used to track change in average particle size over time.

Indicators

It is intended that the experimental design, methodologies and indicators used in the Forde *et al.* (2015) study will be used to track change over time at the Mweeloon site following the removal of the trestles and cessation of tractor traffic. Specifically, univariate and multivariate statistical analyses (PRIMER, PERMANOVA) will be used to assess changes in sediment characteristics, faunal diversity measures and IQI ES.

Univariate statistics will include the following:

1. Species richness which is a measure of the total number of species present for a given number of individuals.
2. Evenness which is a measure of how evenly the individuals are distributed among different species.

3. The Shannon-Wiener index incorporates both species richness and the evenness component of diversity (Shannon & Weaver, 1949).
4. The diversity index is then converted to effective numbers of species to reflect 'true diversities' (Hill, 1973; Jost, 2006) that can then be compared across communities (MacArthur, 1965; Jost, 2006).
5. Effective Species Number (ENS). The ENS is equivalent to the number of equally abundant species that would be needed in each sample to give the same value of a diversity index, *i.e.* Shannon-Weiner Diversity index. The ENS behaves as one would intuitively expect when diversity is doubled or halved, while other standard indices of diversity do not (Jost, 2006). If the ENS of one community is twice that of another then it can be said that that community is twice as diverse as the other.
6. Multivariate statistical analyses will be used to investigate change in community structure.

Other indicators will include the level of reduction of organic carbon in the sediments and the increase in median particle size (Mz) at the fallow site in comparison to the actively farmed site.

The full suite of analysed data will provide a comprehensive and robust data set on which to base conclusions from the results of the statistical analyses. It will also allow comparisons in "*ante et post*" conditions at the fallow site, the active production site and the access route.

Thresholds

Based on the results of Forde *et al.*, (2016), it is predicted that as there will less organic matter in the sediment post-fallowing, numbers of individuals of suspension and deposit feeding taxa such as *Macomangulus* and *Polycirrus* (that were recorded in the reference area of Mweeloon as part of the intertidal survey for the CMP report) will decrease. The threshold for densities of these taxa is set at a reduction of 20% of the previously recorded densities 5 years post-removal.

Amphipoda are known to be sensitive to increased organic carbon loadings and densities in taxa such as *Bathyporeia* (that has also been recorded at the site) are predicted to increase post-fallowing. The threshold for densities of these taxa is set at an increase of 20% of the previously recorded densities 5 years post-removal.

Nematoda and Oligochaeta are known to be tolerant to increases in organic loadings and a threshold for densities of these taxa is set at a reduction of 20% of the previously recorded densities 5 years post-removal.

With regard to changes in numbers of individuals and numbers of species, it is predicted that post-removal of trestles, this should be reflected in the Effective Species Number (ENS). A threshold for a reduction of 20% for the ENS is set 5 years post-removal from the values recorded in the CMP.

Threshold values for a decrease in levels of organic carbon are set at a 10% reduction 5 years post removal while for median particle size, a threshold value of 10% increase is set for 5 years post-removal.

Regarding the access route, it is predicted that numbers of species and numbers of individuals will increase over time. A threshold for densities of taxa is set at an increase of 20% of the previously recorded densities 5 years post-removal.

What this aspect of the Compensation Plan will demonstrate.

The purpose of this target is to be able to demonstrate the effects of fallowing oyster production sites on intertidal benthic ecology. Given the number of sampling locations, the number of replicates and the temporal extent of the survey period, it is considered that this sampling strategy is adequately specific to:

1. Establish a baseline of the intertidal habitat and
2. Determine the success of this aspect of the compensatory measure.

Success of this aspect of the compensatory measures is defined as the stabilisation of the benthic fauna at the fallow sites (Reference Sites 2 and 3) and on the former access routes in comparison to what is present at the trestle and access route to Reference Site 1.

Target 3. Initiate an annual marine monitoring survey after commencement of "organic" farming practices including reduced stocking densities to record measurable changes in intertidal ecology due to these alterations in agricultural practices.

Methods

The same methods as outlined above will be applied to these surveys (see Target 2, Methods section). A much longer time scale (decadal) is required to demonstrate this and well may be masked by a stronger signal such as a rise sea temperature or an increase in storm activity.

Indicators

The same suite of indicators as listed above (see Target 2, Indicators) for the study on the fallowing of oyster culture sites will be used in the Objective 3 study.

Threshold

As is noted above in the Methods section for Target 3, a much longer time scale (decadal) is required to demonstrate this an as the response may be masked by a stronger signal, it is not possible to set a threshold level for this target.

What this aspect of the Compensation Plan will demonstrate.

One potential positive aspect of this section of the Compensation Plan is that it may demonstrate, over an extended time period, the reduction the spatial text of green algae (that are known to react positively to increased levels of organic enrichment) on the intertidal areas of where "organic" farming practices are implemented. The presence/absence and percentage cover of green algae such as *Ulva* (+ synonym *Enteromorpha*) will be documented as part of each annual survey.

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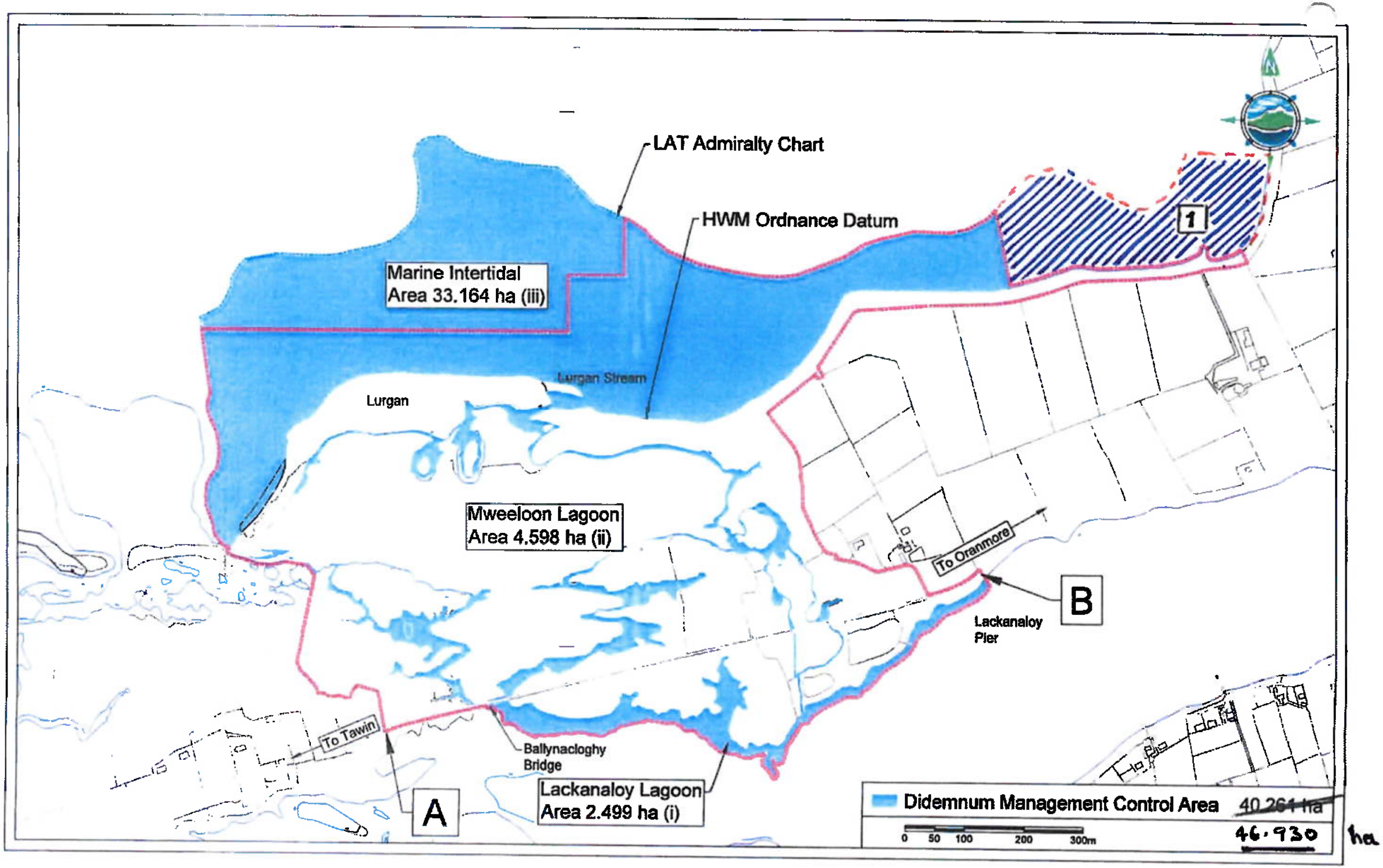

Fig. 14 Didemnum Management Control Area (1). [DRAFT]

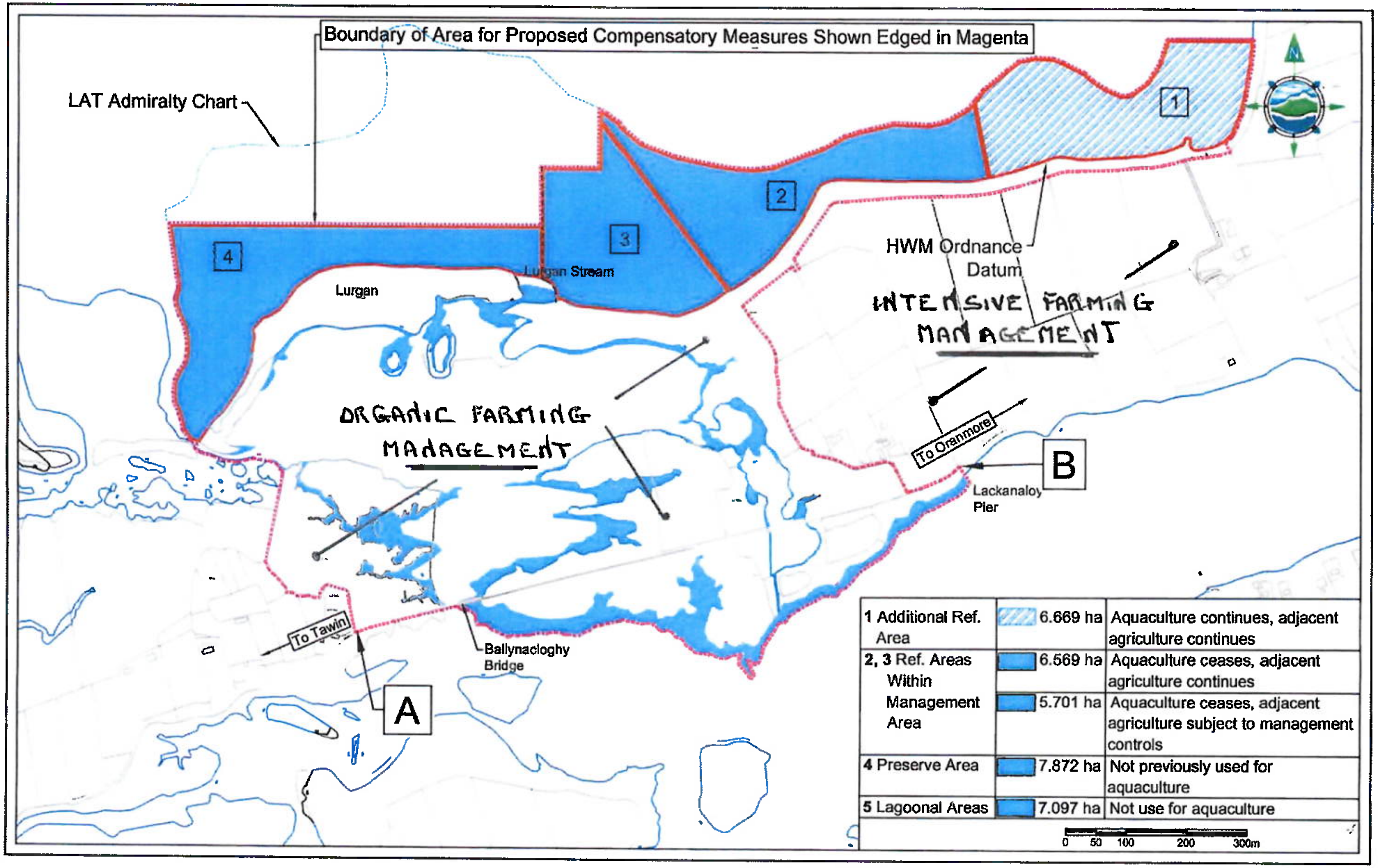

Fig. 20 Additional Intertidal Reference Area (1). [DRAFT]