Swansea Bay & Gower Native Oyster Survey 2019

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Authorship and Contributions*: Listed in order of preceding page using PCI (percentage-contribution–indicated) approach to author sequencing. Where section contributions are numerically equal then Authors are placed in alphabetical order by surname. No differentiation is made between primary or contributory authorship;

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RECORD OF STUDY DEVELOPMENT

Version	Date	Reason for Change	Primary Author(s)
WD1.0	19 July 2019	Working Draft – Version 1.0 –	APW
FD1.0	28 July 2019	Final Draft – Version 1.0 –	APW
FR1.0	7 August 2019	Final Report – Version 1.0 –	APW

Figure 1. Oyster dredge haul of cobbles, dead shell and live native oysters at Porthcawl

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1. Introduction

1.1 Background

The native oyster Ostrea edulis was once the basis of an important shellfish industry in South Wales; records date commercial fisheries at Mumbles and Oystermouth stretching back to Roman times. By the late 19th century the local oyster fishery employed many hundreds of people, supported 200 vessels together landing over 9 million oysters, many of which were transported to the London markets and beyond to the continent. This pressure on the beds, combine with poor water quality from heavy industry and disease resulted in the demise of the population by the 1920s.

Mumbles Oyster Company Ltd. have recently demonstrated the potential for the restoration of native oyster beds by relaying 40,000 adult oysters on historic beds at Mumbles. These oysters were shown to thrive and begin to reproduce exporting larvae to the surrounding waters (Syvret et al, 2015; Syvret & Woolmer, 2015).

Since the reintroduction of a breeding population of oysters at Mumbles there have been reports of new recruitment around Swansea Bay and along the Gower coast, e.g. a number of live whelks have been landed with young native oysters attached.

The Swansea Bay FLAG has recognised the need to establish an up-to-date baseline of the wild native oyster population in Swansea Bay and along the Gower coast in order that the current status of native oysters and be established. Such information underpins appropriate management of this once important commercial species and this information can inform the potential for future fisheries.

The Swansea Bay FLAG are supportive of the continued restoration of this commercially and ecologically important species and the oyster bed habitats that they cr eate and this survey will inform future efforts and the outcomes of past work.

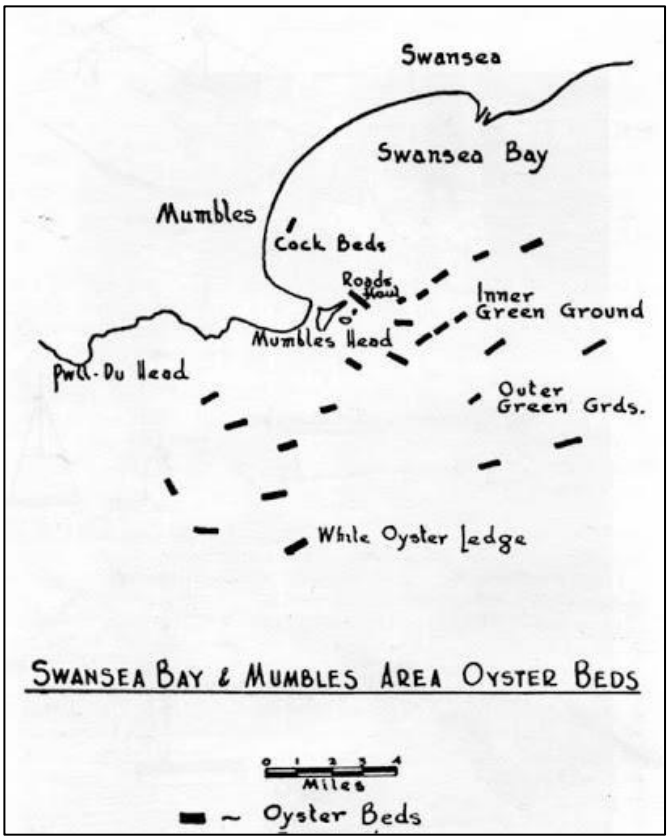

Figure 4. Locations of historic oyster beds in Swansea Bay and Gower (Wright, 1923)

2. Methodology

This survey was undertaken using an adaptation of the protocol employed by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) for shellfish (described in Walker, 2007; Walker, 2008). This protocol is currently employed in other native oyster fisheries such as the Solent and was similarly used to carry out previous oyster surveys in Swansea Bay (Palmer, 2013) and in Milford Haven (Pell, 2011). The survey was carried out over a 3-day period in July 2019, onboard Swansea-based vessel Sea Venture with the assistance of skipper Barry Thomas. The number of survey sites was determined to encompass the greatest areas of the Bay practicable within the constraints of time, cost, tidal and weather conditions.

2.1 Survey planning

The survey drew upon previous oyster bed mapping work which attempted to locate the historic oyster production areas (Woolmer, 2011).

The location of historic oyster beds was informed by reference to a series of pre-war reports produced by Ministry of Agriculture and Fisheries and South Wales Sea Fisheries District Committee (F.S. Wright, 1923; 1932). Copies of the original survey field notebooks from the Cefas archive were also referred to. These notes recorded the locations of dredge tows carried out between 1922 and 1932. Using the bearings from landmarks recorded at the time, we were able to plot the locations of these tows and infer from sketch maps the approximate location of the oyster beds. The location of the original tows were themselves informed by the local knowledge of the remaining oyster fishermen at that time (the reports indicate that these men would have been working in the fishery in the late 19th Century).

Additional information on the current and recent distribution of native oysters in the survey area was provided by local fishermen and skipper Thomas. This local knowledge, based on recent oyster fishing activity and from observations of bycatch, provided up to date information on the distribution of live oysters.

Four oyster bed areas were identified in the Swansea Bay area: White Oyster Ledge, Mumbles including the Mumbles Oyster Company restoration area, Green Grounds (east of the fairway), and beds at Porthcawl off Ogmore close to Tusker rock. Further areas identified for investigation included south of the Helwick Bank and in deeper water offshore of Port Eynon (Figure 6)

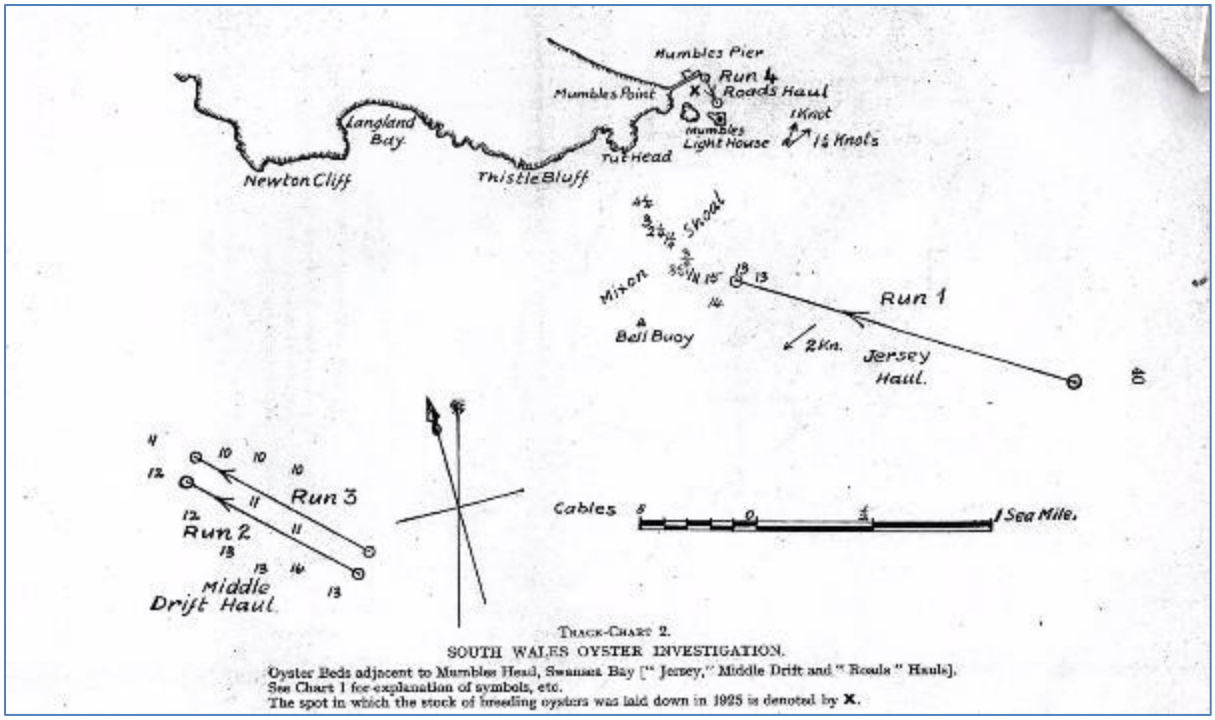

Figure 5. Example of sketch maps from 1932 used in survey planning (Wright, 1932)

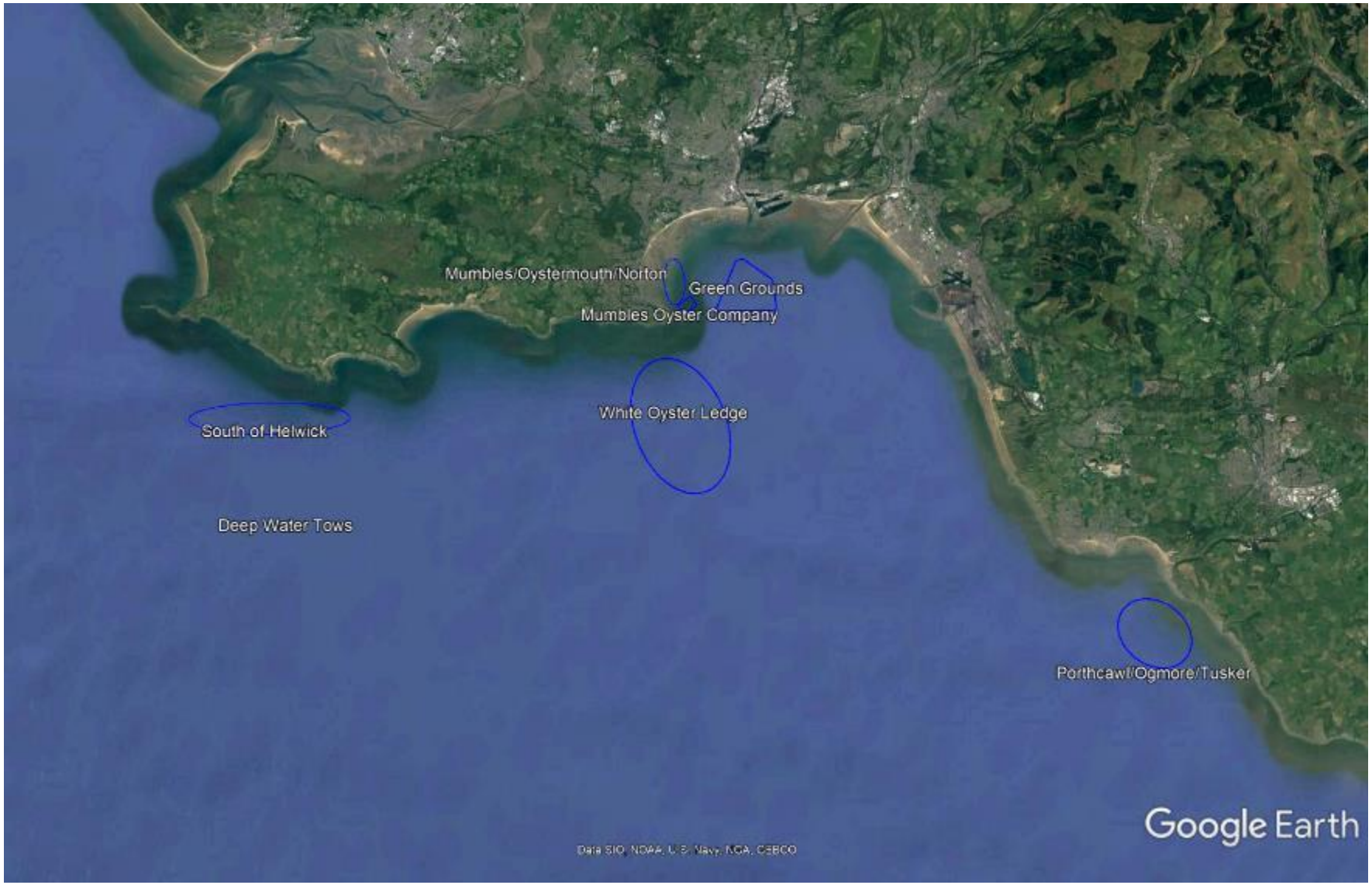

Figure 6. Areas of historic native oyster beds and fisheries identified to be the focus of the current survey

2.2 Survey Methods

The survey was carried out over 23-25th July 2019, onboard Swansea-based vessel Sea Venture using a rock dredge. This is a non-standard oyster dredge better suited to the hard ground encountered around Swansea. A bladed oyster dredge was available but although suitable for the Mumbles beds was not considered so for other sites, so in order to ensure the survey results were consistent and comparable the rock dredge was used.

A series of tows were carried out within the target areas of historic beds. The number was dictated by sea and weather conditions on the day.

Tow duration was standardised to 10 minutes on the bottom and commenced when the trawl winch stopped. The tow duration was timed using an electronic stopwatch. The towing speed for each site was ~2.5 – 5 knots and the direction of the tow was determined by the skipper depending on tidal and wind conditions. Latitude and longitude coordinates were recorded by vessel/handheld GPS for the start and finish of each tow.

2.3 Sample Processing and Enumeration

A dredge survey log was produced for this survey to record all relevant information at sea (see Appendix 1). Key data recorded:

- Site Name (corresponding of historical oyster bed or charted seabed feature)
- Dredge Station Number (a unique record number)
- Date
- Dredge Tow Start and Finish Position and Time (provides accurate positional information for mapping and enables the calculation of dredge tow length)
- Vessel Speed
- Seabed Types (key habitat information based on material retained in the oyster dredge)
- Native Oyster Features (includes presence of live oysters, spat, shell cultch types and pest species)
- Native Oyster Sizes
- Notes (contextual observations and information was recorded)

Length data for *O. edulis* at each site was summarised into length groups as defined by Cefas (Vanstaen, 2010).

- Large - ≥ 65 mm
- Medium - 50-64 mm: oysters that should reach landing size within the next two seasons.
- Small - 35-49 mm: oysters that are unlikely to attain landing size within next two seasons.
- Spat - < 35 mm: oysters that were spawned within the last 18 months.

Trawl fullness was determined by recording the total volume of dredged material and a photograph was taken for contextual information. All live oysters were removed and counted. The largest linear dimension of each oyster was measured to the nearest one millimetre using Vernier callipers. After counting and measuring, all oysters were returned to their collection area.

Dredged material volumes were recorded using an abundance percentage, as a proportion of the total haul (Cooper and Boyd, 2002; Walker 2008), including rock and shell material. The total amount of suitable oyster settlement substrata ('cultch') available (shell material and rock) was recorded as a percentage of dredge material, to assess the availability of suitable habitat for *O. edulis*. The presence of absence of oyster 'clocks' (shells with both valves still connected together) was recorded to determine if there had been any recent mortality within a site.

Oyster pest species slipper limpets (*Crepidula fornicata*) and common starfish (*Asterias rubens*) were recorded using the ACFOR scale in the dredge as were conspicuous species.

The A.C.F.O.R. scale is as follows:

A – Species observed is "Abundant" in the dredge.

C – Species observed is "Common" in the dredge.

F – Species observed is "Frequent" in the dredge.

O – Species observed is "Occasional" in the dredge

R – Species observed is "Rare" in the dredge

Shell and rock material were examined for evidence of *O. edulis* recruitment by recording any spat.

Note: Individual weights were not recorded as originally intended due to practical considerations on the vessel and as the oysters were returned to their sampling site they could not be processed on land.

2.4 Analysis

All data recorded in field logs was transposed to Excel spreadsheets.

A series of Length/Frequency histograms of shell length were produced to provide population size structure information:

- All survey stations
- All survey stations excluding Mumble Oyster Company restoration site (to avoid skewing population outputs)

Density calculations were not undertaken due to insufficient sample sizes and unknown dredge efficiency (see discussion).

2.4.1 GIS Analysis

A GIS analysis produced relative abundance maps of the sample areas and location maps for sample sites.

6.1.1.1 Recruitment Determination

Further GIS analysis was undertaken in order to determine areas of recent recruitment subsequent to the introduction of 40,000 broodstock at Mumbles in 2013-4 by the Mumbles Oyster Company.

The rationale for determining a recent recruit was based upon the native oyster's tendency to develop more massive shells as they age. Shell length and width growth tends to slow as they age but shell depth or thickness increases. Using shell depth as a determining metric may provide a useful proxy for age in a mixed population. A shell depth of 30 mm was used as the upper limit for "recent recruit". This was based upon the authors experience growing native oysters in aquaculture. An oyster with a shell depth of less than 30 mm is likely to be less that 5-6 years old which corresponds to the start of the restoration efforts.

A series of thematic maps were produced presenting areas of broodstock oysters (source) and areas where recruitment has occurred in the last 5-6 years (sinks).

3. Results & Discussion

The survey was carried out between 23-25th July 2019. A total of 40 dredge tows were worked over the three days and over 130 nautical miles steamed. Locations of sample sites are presented in Figure 8Figure 10Figure 12

3.1 Swansea Bay (Mumbles, Green Grounds and Fairway Tows)

The Swansea Bay tows include Mumbles between Norton, Oystermouth and the Lighthouse, and the Green Ground and Fairway tows (Figure 8).

Key statistics:

- **Mean shell length: 87 mm**
- **Mean shell width: 94 mm**
- **Mean shell depth: 38 mm**
- **Number of oysters sampled: 28 > 65mm individuals**
- **Number of recent recruits: 2**

Habitat description:

The Mumbles, Oystermouth and Norton tows were characterised by mixed sediments and cobbles with varying amounts of old oyster shell material. The Green Grounds and Fairway tows were harder ground with larger cobbles.

Old oyster shell was present in most samples other than on the hard ground sites.

Pest species:

Slipper limpets *Crepidula fornicata* were present in low numbers in 2 of the tows but were abundant at one tow off Norton. This was a shallow tow close to the low water mark suggesting that these could have been aggregated there by wave action.

Common starfish *Asterias rubens* were rare and present in 3 of the 13 tows in these areas.

Figure 7. Dredge haul off Norton with high abundance of slipper limpets

Figure 8. Locations of the Swansea Bay survey tows worked in the current survey

3.2 Gower Coast and White Oyster Ledge

The Gower coast tows include sites off the Mixon, Oxwich, Port Eynon and in deeper water south of the Helwick Bank. The White Oyster Ledge tows were worked at locations around the large cobble reef (Figure 10).

Key statistics:

- **Mean shell length: 104 mm**
- **Mean shell width: 100 mm**
- **Mean shell depth: 35 mm**
- **Number of oysters sampled: 8 > 65mm individuals**
- **Number of recent recruits: 4**
- **No oysters were recorded along the Gower coast or around Helwick Bank**

Habitat description:

The Mixon, Oxwich, and Port Eynon tows were characterised by soft sediments with no oysters or shell material. The Helwick and offshore tows were firm sediment grounds with some cobble. The White Oyster Ledge tows were characterised by cobbles and the dredge behaviour suggested that the ground was predominantly boulder and cobble (Figure 9).

Old oyster shell was present in the Helwick tows and in the majority of the tows around the White Oyster Ledge.

Pest species:

Slipper limpets *Crepidula fornicata* were present in low numbers in 2 of the tows but were abundant at one tow off Norton. This was a shallow tow close to the low water mark suggesting that these could have been aggregated there by wave action.

Common starfish *Asterias rubens* were present in 3 of the 13 tows in these areas in low numbers.

Figure 9. A typical dredge haul from White Oyster Ledge.

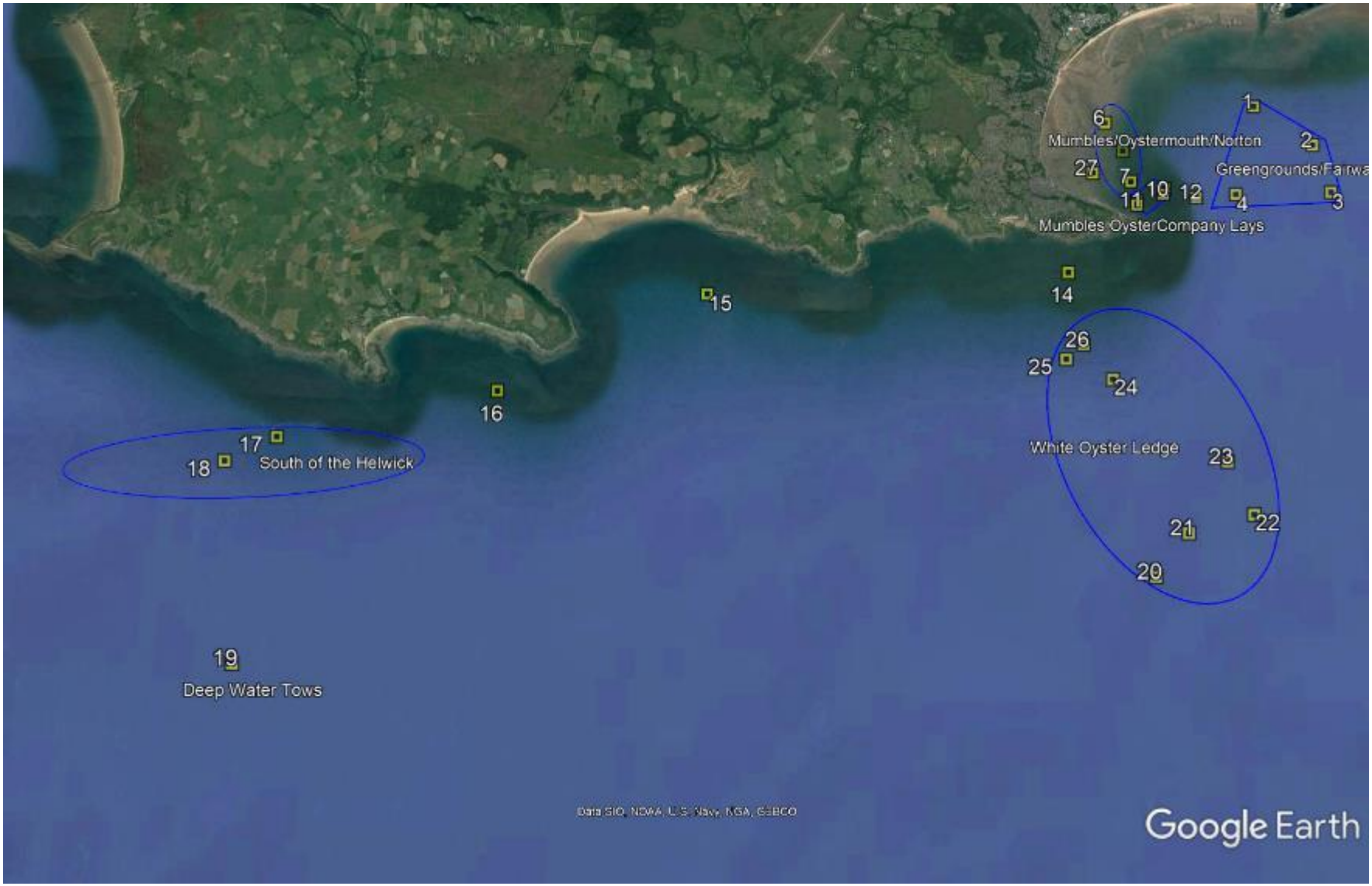

Figure 10. Locations of the Gower Coast and White Oyster Ledge tows worked in the current survey

3.3 Porthcawl, Ogmore and Tusker

The Porthcawl tows were focused on the historic oyster beds east of Tusker Rock off the coast between Porthcawl and Ogmore (Figure 12Figure 10).

Key statistics:

- **Mean shell length: 95 mm**
- **Mean shell width: 100 mm**
- **Mean shell depth: 30 mm**
- **Number of oysters sampled: 13 > 65mm individuals**
- **Number of recent recruits: 21**

Habitat description:

With the exception of 2 tows to the south of the reef all tows were characterised by the presence of cobbles. The dredge behaviour indicated that the reef was hard ground of boulders and cobbles (Figure 11).

Old oyster shell was present in the majority of the tows but similar to elsewhere on similar ground not abundant.

Pest species:

Slipper limpets *Crepidula fornicata* were found in only 1 of the tows and only as a single individual.

Common starfish *Asterias rubens* were present in 3 of the 10 tows in these areas in low numbers.

Figure 11. A typical dredge haul from the Porthcawl tows.

Figure 12. Locations of the Porthcawl/Ogmore/Tusker tows worked in the current survey

3.4 Population size structure

Key statistics and characteristics:

- A total of 74 native oyster were recorded in 40 tow stations
- All individuals can be classified as “adult” or mature oysters
- All individuals, based upon size, were estimated to be 4 or more years old
- 47 older broodstock oysters were characterised by their massive shells (shell depth >30 mm)
- 27 recent recruits (shell depth <30 mm) were reported
- No spat or new recruits were observed.

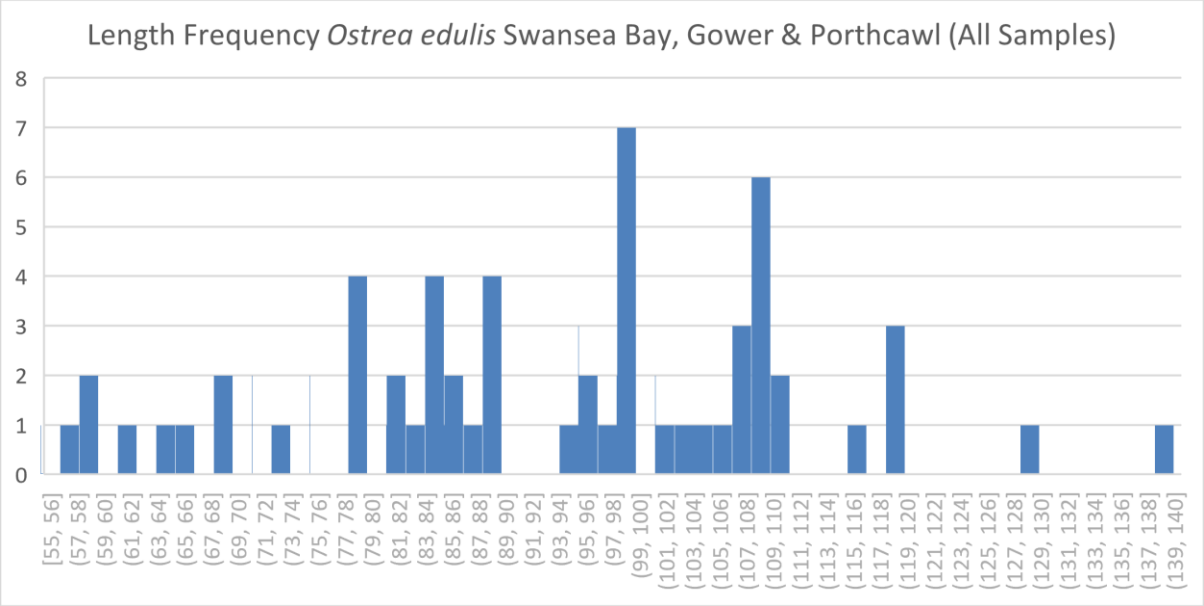

Figure 13. Length Frequency Histogram of all oysters sampled in the survey

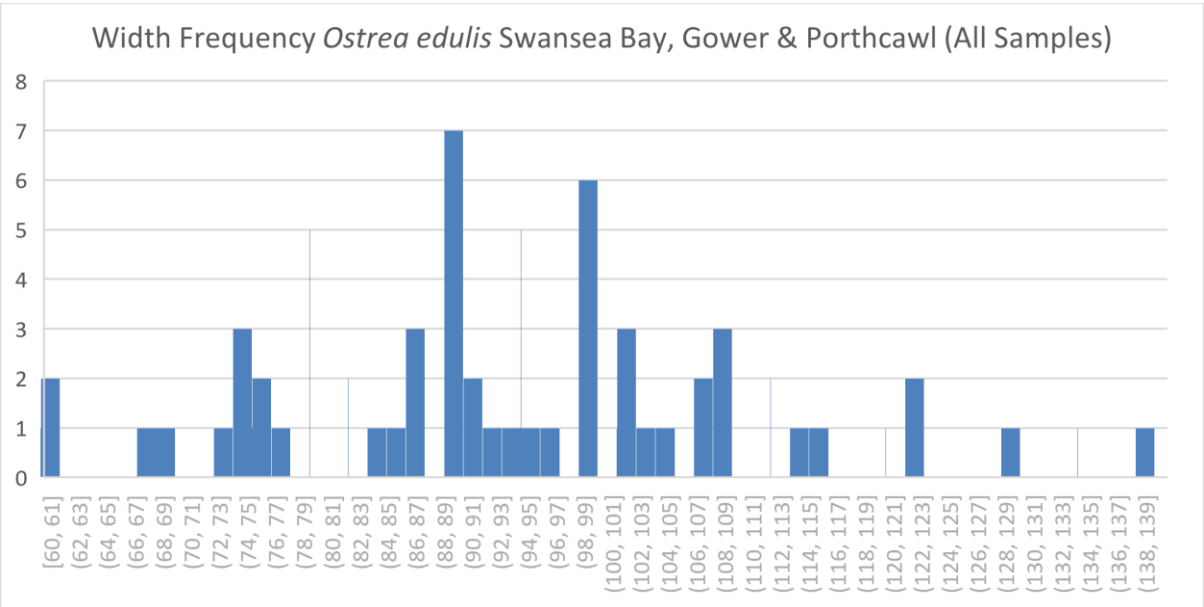

Figure 14. Width Frequency Histogram of all oysters sampled in the survey

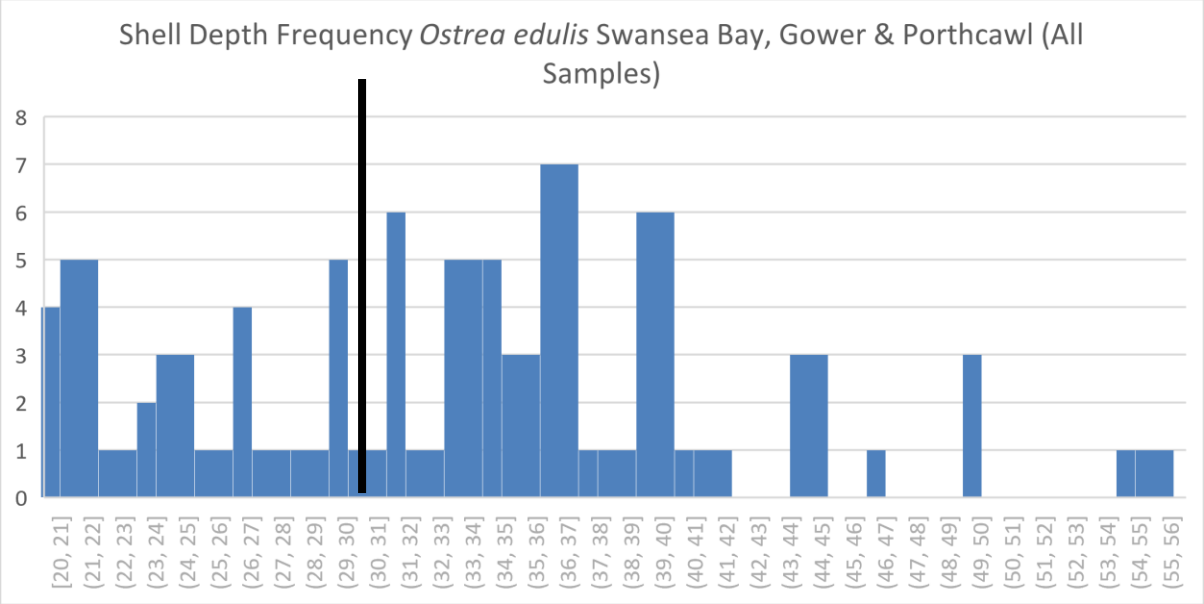

Figure 15. Shell depth frequency histogram of all oysters sampled in the survey (Black line indicating cut off between recent recruits and older oysters)

3.5 Spatial distribution of size classes

Spatial analysis using GIS software highlighted an interesting difference in demographics within the wider Swansea Bay population. Figure 16 shows the distribution of larger size classes of native oyster broodstock with high density hotspot on the Mumbles Oyster Company's restoration site. Figure 17 shows the distribution of recent recruits, those individuals that lack a massive shell and measure < 30 mm thick. These younger individuals were found around the Bay but with a hotspot at Porthcawl.

The design and scope of the current survey did not enable more time to be spent at these sites to carry out further sampling and collect more data to shed light on this emerging pattern but it is possible that it may represent a source and sink process. Figure 18 shows the relative abundance of recent recruits and broodstock oysters with the locations and directions of the tidal ebb and flood tidal currents that influence the Bay. The tidal currents and gyre present a potential 2-way pathway between sites.

Native oyster larvae are brooded within the oyster after fertilization and are released into the water column when they are well developed veliger larvae. These larvae spend between 7 and 14 days in the water column where they feed and develop further whilst using swimming behaviour to maintain at preferred depths. The combination of tidal currents and larval behaviour acts to transport larvae from natal sites to other suitable settlement sites on other beds and can act to retain larvae within estuarine systems. Native oyster larvae have been shown to respond to chemical ques to preferentially settle amongst other oysters and delay settlement until suitable substrata or ques are present.

The Mumbles Oyster Company broodstock site of 40,000 large oysters was established in 2013/4 and sampling at that time reported spawning taking place in at least 10% of the oysters the following summer (Syvret et al, 2015). A single broodstock oyster can produce over 1 million larvae, this spawning would have produced at least 4 billion.

The distribution of the higher density broodstock, necessary for successful spawning, at Mumbles and the higher relative number of appropriately aged new recruits at Porthcawl hints at a possible source and sink interaction between sites. It also suggests that the restoration actions at Mumbles may be having a positive outcome.

Molecular techniques comparing the DNA from recruits and broodstock oysters would be necessary to investigate this further.

Figure 16. The distribution and abundance of broodstock oysters (shell depth >31 mm). Note potential source site at Mumbles

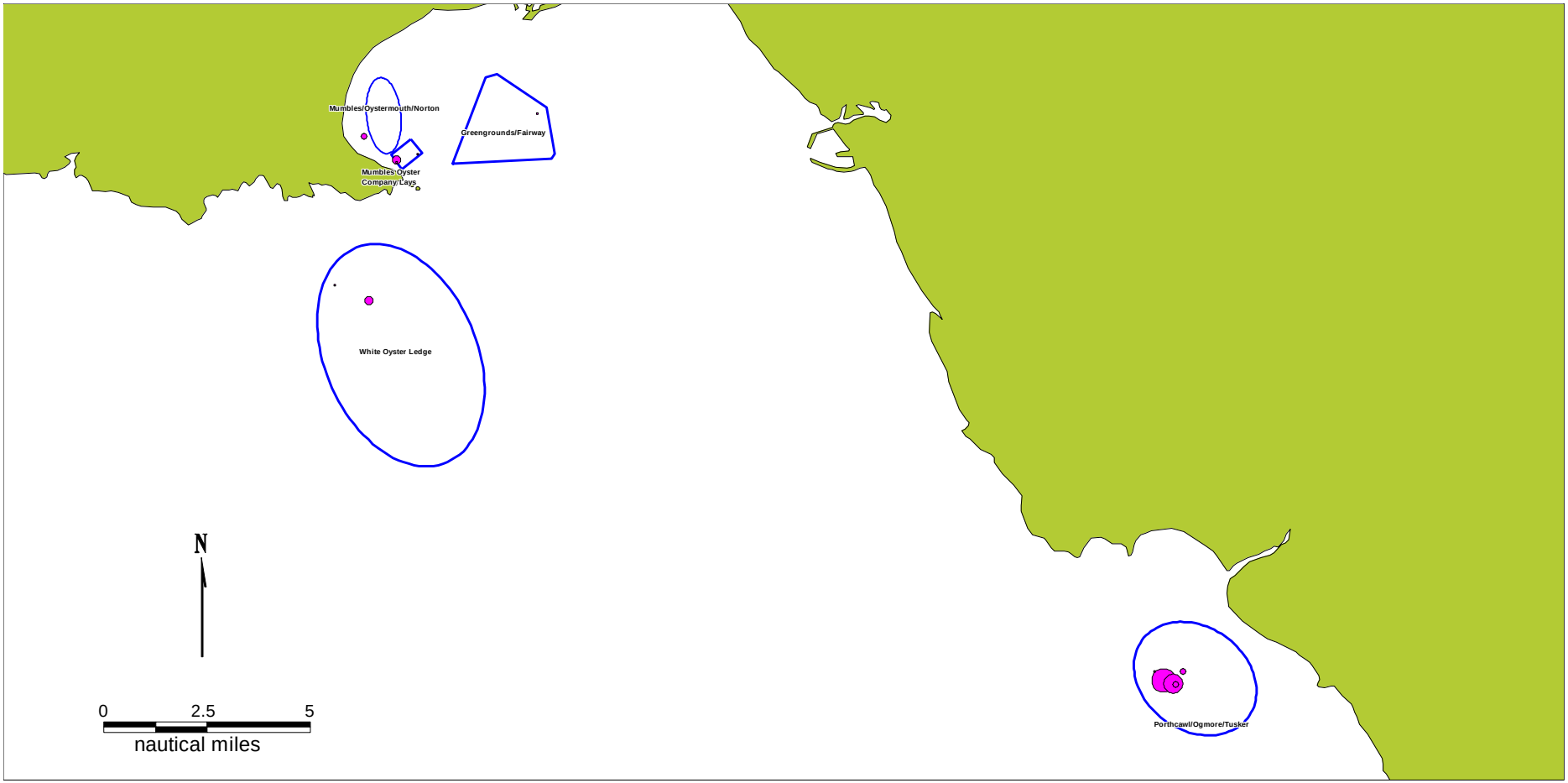

Figure 17. The distribution and abundance of oyster recruits (shell depth <30 mm). Note potential sink site at Porthcawl.

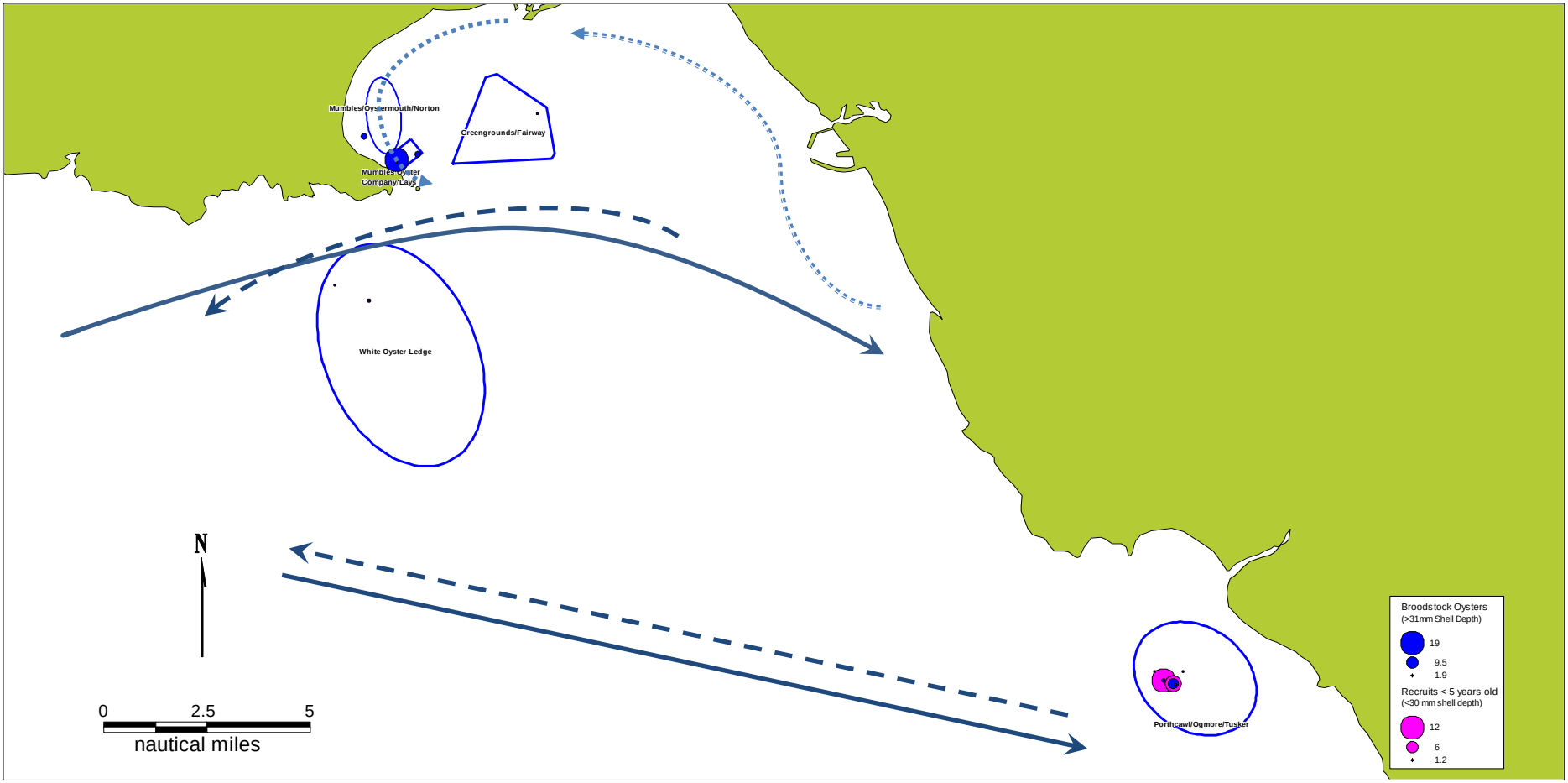

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Figure 18. The distribution and abundance of broodstock oysters and recent recruits with tidal regime in Swansea Bay. Arrows show approximate tidal gyre and directions linking sites. Solid arrows = flood tide, hatched arrows = ebb tide, dotted arrows = residual flow and gyre.

3.6 Notes on habitat and dredge efficiency

Native oysters collected on this survey, outside of the Mumble Oyster Company site, were commonly associated with cobble and hard ground habitats. Although native oysters have a well-documented plasticity in habitat preference, being found on a variety of grounds from estuarine muddy sediments to bedrock, the highest densities being associated with cobble reefs is considered unusual in a UK context.

The OSPAR definition of an oyster bed habitat suggests a preference for more sheltered, shelly sediments "on shallow mostly sheltered sediments" and "there may be considerable quantities of dead oyster shell". This is a good approximation of the habitats at Mumbles and on the Mumbles Oyster Company site and of other native oyster beds in the UK.

Native oysters will settle on any hard surface but are generally considered to preferentially settle on shell cultch material. Limited amounts of shell material were collected by the dredge at the majority of sites. The only oyster shell recovered was very old weathered shell of doubtful quality as a settlement substrate. Examination of recent recruits did not provide any information on settlement surface with no shell fragments apparent around the hinge area where settlement occurs.

The higher density sites at White Oyster Ledge and East of Tuskar Rock at Porthcawl are more accurately described as boulder and cobble reefs. These reefs are characteristic of outer Swansea Bay which is formed a series of higher banks and reefs marking the southerly limit reached by Welsh ice during the Last Glacial period. The cobble reefs such as the Green Grounds are areas of glacial till left behind by the retreat of the ice.

This survey employed a rock dredge in order to better deal with these rocky substrata rather than a bladed oyster dredge used more widely. The dredge did sample oysters from these hard ground habitats but its efficiently is unknown. Sampling this type of ground in a quantitative manner is difficult and under-sampling undoubtable occurred. A standard oyster dredge working on an easier worked shelly substratum may have an efficiency of 15% and the current dredge is likely to be less than that.

The lack of small recruits and of fresh shell cultch, such as mussel shell, which were expected in the samples indicates that these were not successfully sampled by this dredge. In the absence of small oyster recruits, mussel shell is almost certainly present in the Bay and would be expected in a sample. The absence of fresh shell cultch impacted the assessment of spat recruitment. No spat were found in samples but limited shell cultch confounded these observations.

The vessel skipper Barry Thomas, an experienced fisherman, suggested the use of sprung toothed dredges in future which are designed to flip shellfish off the bottom rather and scoop them up as on a bladed dredge. This would be a consideration for future survey work.

The author believes that the White Oyster Ledge and Tuskar rock reef both warrant further investigation either with divers or with video cameras to gain a better understanding of native oyster densities and their relationship with the habitat. It may be the case that native oysters are settling directly on these rocks or upon the calcareous epifauna such as tube worms that cover them. The spaces and interstices between boulders and cobbles may provide secure refuge for native oysters in these tide swept locations.

4. Conclusions

- A native oyster population remains present in Swansea Bay and at Porthcawl
- The population is characterised by large individuals > 100 mm shell length with massive shells which indicates ages of 10 years +
- There is evidence of recent recruitment in last 5-6 years based on shell morphology, with a hotspot at Porthcawl
- No small recruits and no spat were observed (possibly due to the dredge design used and the absence of shell cultch in samples)
- The native oyster relaid by Mumbles Oyster Company in 2013/14 are still surviving with low mortality rates
- Spatial analysis of survey data revealed a potential link between recent recruits at Porthcawl and the Mumble Oyster Company broodstock oysters relaid at Mumbles which warrants further research
- The habitat where most oysters present is considered unusual not being “typical” oyster grounds. This is of interest to ecologists and fisheries managers alike and warrants further research

Figure 19. View from the stern of Sea Venture sampling off Mumbles

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