Impacts of bait collection on Welsh Marine Protected Areas

Report No: 862

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Crynodeb Gweithredol

Mae cynaeafu infertebratau a physgod i'w defnyddio fel abwyd pysgota yn arfer cyffredin. Mae casglu abwyd wedi cael sylw sylweddol dros y degawdau diwethaf gyda'r gweithgaredd hwn weithiau'n cael ei gydnabod fel rhywbeth sy'n achosi newidiadau hirdymor i gynefinoedd sensitif, fel gwastadeddau llaid a gwastadeddau tywod a morwellt, sy'n destun gwarchodaeth genedlaethol a rhyngwladol.

O fewn Ardaloedd Morol Gwarchodedig (MPA) Cymru mae nifer o weithgareddau casglu abwyd yn digwydd, gan gynnwys palu am abwyd, troi clogfeini a gosod llochesi crancod. Mae deall effeithiau gweithgareddau casglu abwyd ar gynefinoedd sensitif o fewn Ardaloedd Morol Gwarchodedig Cymru yn hanfodol i gynorthwyo i reoli'r gweithgareddau hyn mewn modd sy'n seiliedig ar dystiolaeth.

Comisiynwyd ABPmer gan Cyfoeth Naturiol Cymru (CNC) i roi asesiad o effeithiau gwahanol ddulliau casglu abwyd ar nodweddion dynodedig Ardaloedd Morol Gwarchodedig Cymru. Mae'r asesiad o'r effeithiau wedi targedu safleoedd penodol yng Nghymru a nodwyd gan CNC, gyda nodweddion a allai fod yn sensitif i weithgareddau casglu abwyd a lle mae casglu abwyd yn digwydd yn aml ar hyn o bryd. Er mwyn cyflawni hyn, cynlluniwyd cyfres o arolygon i ymchwilio i effeithiau technegau casglu abwyd ym mhob un o'r safleoedd a nodwyd. Bydd y dulliau a ddefnyddir yn helpu i lywio unrhyw asesiadau yn y dyfodol a allai fod angen eu gwneud ar gyfer safleoedd eraill lle mae gweithgareddau casglu abwyd tebyg yn digwydd. Yn ogystal, gellid sicrhau rheolaeth fwy effeithiol ar safle sydd wedi'i theilwra ar gyfer lleoliadau sy'n wynebu pwysau neu fygythiadau penodol ar nodweddion penodol y safle.

Mae'r adroddiad hwn yn crynhoi'r gwaith arolygu a wnaed yn ystod y prosiect a oedd yn cynnwys monitro rhynglanwol mewn sawl lleoliad yng Nghymru i asesu effeithiau amrywiol weithgareddau casglu abwyd:

- Troi clogfeini i'r gorllewin o'r Gogarth, Conwy a Phenmon-Biwmares, Ynys Môn
- Palu am abwyd ym Mae Angle, Sir Benfro, Pont-rhyd-y-bont a Phenmon-Biwmares, Ynys Môn
- Llochesi crancod ym Mhier Bangor, Gwynedd a Deganwy, Conwy

Defnyddiwyd amrywiaeth o dechnegau arolwg i asesu gwahaniaethau posibl yng nghyfansoddiad y gwaddod (lle bo hynny'n berthnasol), cyfansoddiad isffawna a megaffawna rhwng ardaloedd yr effeithiwyd arnynt (wedi'u cynaeafu) ac ardaloedd rheoli (heb eu cynaeafu).

Roedd troi clogfeini'n effeithio'n sylweddol ar gyfansoddiad cymunedol epiffawna rhwng top a gwaelod clogfeini wedi'u troi a heb eu troi yn hanesyddol i'r gorllewin o safleoedd Pen y Gogarth a Phenmon-Biwmares. Roedd y gwahaniaethau hyn hefyd yn amlwg ar lefel ehangach y safle rhwng yr ardaloedd rheoli a'r ardaloedd yr effeithiwyd arnynt. P'un a oedd clogfeini wedi'u troi ai peidio, canfuwyd bod mwy o amrywiaeth ffawna ar waelod clogfeini yn y ddau safle monitro. Roedd effeithiau hirdymor troi clogfeini yn amlwg mewn rhai cynulliadau ffawnol a gwelwyd hyn yn y ddau safle monitro.

Ymddengys bod troi clogfeini yn y gorffennol wedi effeithio ar dacsa symudol, fel molysgiaid. Mewn cyferbyniad, dangosai cregyn llong di-goes wytnwch a'r gallu i adfer yn gyflymach yn y ddau safle, yn enwedig ar ochrau uchaf y clogfeini. Roedd patrymau'r adferiad yn amrywio yn dibynnu ar y rhywogaeth a'r amodau amgylcheddol a oedd yn bresennol yn y ddau safle. Roedd y ddau safle yn dangos dwysedd cymedrol o ran troi clogfeini a lefel isel o weithgarwch troi clogfeini diweddar. Mae'n debyg bod diffyg aflonyddwch diweddar wedi hwyluso adferiad rhai cynulliadau ffawnaidd, yn enwedig y rhai ar yr arwynebau uchaf. Fodd bynnag, ni welwyd adferiad llwyr mewn cymunedau dan glogfeini yn y naill safle neu'r llall.

Ym Mae Angle, gwelwyd aflonyddwch ffisegol uniongyrchol ar gynefin gan weithgareddau palu am abwyd ar y safle gyda nifer o bobl wedi'u gweld yn palu am abwyd yn ystod yr arolwg yn yr ardal yr effeithiwyd arni, yn defnyddio technegau palu tyllau a sugno i gasglu. Er gwaethaf hyn, nid oedd unrhyw wahaniaethau ystadegol arwyddocaol rhwng y cymunedau ffawna mewn ardaloedd rheoli (heb eu palu) ac ardaloedd yr effeithiwyd arnynt (wedi'u palu) ym Mae Angle. Gwelwyd gostyngiadau ystadegol arwyddocaol mewn dwysedd morwellt rhwng yr ardaloedd rheoli a'r ardaloedd yr effeithiwyd arnynt, gyda 78% ar gyfartaledd wedi'i orchuddio o'i gymharu â 54% yn yr ardaloedd rheoli a'r ardaloedd yr effeithiwyd arnynt, yn y drefn honno. Mae rhywfaint o dystiolaeth o golli ffracsiynau silt mân o fewn ardaloedd yr effeithiwyd arnynt ym Mae Angle. Fodd bynnag, er gwaethaf y gwahaniaethau a welwyd yng nghyfansoddiad y gwaddod nid oedd llawer iawn o gydberthynas, a dim perthynas arwyddocaol, rhwng data cyfansoddiad ffawna a maint gronynnau yn yr ardaloedd yr effeithiwyd arnynt na'r ardaloedd rheoli.

Nid yw'n ymddangos bod palu am abwyd wedi newid cyfansoddiad y gwaddod ym Mhenmon-Biwmares. Fodd bynnag, dangosai cymunedau benthig arwyddion o aflonyddwch o ystyried y nifer uchel o rywogaethau sy'n goddef aflonyddwch yn yr ardal yr effeithiwyd arni o'i gymharu â'r ardal reoli. Roedd arwyddion o weithgareddau palu am abwyd yn amlwg o fewn yr ardal yr effeithiwyd arni, sy'n awgrymu ymhellach fod yr ardal yn cael ei tharfu'n rheolaidd. Roedd cymharu data hanesyddol yn awgrymu newidiadau hirdymor yn strwythur y gymuned, ond mae'n parhau i fod yn ansicr a ellir priodoli'r newidiadau hyn yn uniongyrchol i balu am abwyd oherwydd na ellir cymharu dulliau arolygu yn uniongyrchol.

Ym Mhont-rhyd-y-bont, roedd diffyg safle rheoli addas a gwahaniaethau yng nghyfansoddiad y gwaddod rhwng ardaloedd rheoli ac ardaloedd yr effeithiwyd arnynt yn gosod heriau ar gyfer asesu effeithiau palu am abwyd. Fodd bynnag, dangosodd yr ardal yr effeithiwyd arni arwyddion o aflonyddwch, gyda nifer fawr o rywogaethau gwydn sy'n goddef aflonyddwch, sy'n awgrymu o bosibl ryw lefel o effaith yn sgil gweithgareddau palu am abwyd.

Ymddengys mai effaith fach iawn mae darparu llochesi crancod artiffisial wedi ei gael ar safleoedd monitro Pier Deganwy a Bangor. Ym Mhier Bangor, ymddengys nad yw'r defnydd o deiars fel llochesi crancod wedi effeithio ar gyfansoddiad y gwaddod na'r cymunedau benthig. Roedd y gymuned niferus o facroffawna yn cynnwys tacsa a oedd yn goddef aflonyddwch yn bennaf ac roeddent yn debyg rhwng ardaloedd yr effeithiwyd arnynt a'r ardaloedd rheoli.

Yn Neganwy, roedd cyfansoddiad y gwaddod rhwng yr ardaloedd rheoli a'r ardaloedd effaith yn sefydlog ac yn unffurf, heb unrhyw wahaniaethau sylweddol yn strwythur y gwaddod islaw'r ffosydd. Roedd y nifer sylweddol uwch o facroffawna a'r cyfoeth

rhywogaethau yn yr ardal reoli, o'i gymharu â'r ardal effaith (yn union o dan y ffosydd), yn tynnu sylw at y tarfu ffisegol a achosir gan ffosydd. Er gwaethaf hyn, dim ond effeithiau lleol yng nghyffiniau'r ffosydd a welwyd. Nid oedd effeithiau ehangach ar y safle i'w gweld, gan fod y cymunedau benthig yn yr ardaloedd rheoli ac ardaloedd yr effeithiwyd arnynt wedi'u dosbarthu'n bennaf fel rhai sy'n goddef aflonyddwch ac i'w gweld yn wydn i fathau eraill o aflonyddwch ar y safle hwn.

Ar y cyfan, mae'r astudiaeth yn rhoi mewnwelediadau gwerthfawr i effeithiau gwahanol ddulliau o gasglu abwyd o fewn Ardaloedd Morol Gwarchodedig Cymru. Gwelwyd effeithiau nodedig yn sgil troi clogfeini a phalu am abwyd, tra bod llochesi crancod yn ymddangos i achosi ychydig iawn o aflonyddwch. Efallai y bydd adferiad isffawnaidd yn bosibl os bydd casglu abwyd yn cael ei leihau dros amser. Dylai asesiadau yn y dyfodol sicrhau methodolegau cyson, atgynhyrchu samplau addas a monitro am gyfnod hirach ar gyfer cymharu cywir a gwell dealltwriaeth o newidiadau ecolegol hirdymor. Trwy fynd i'r afael â'r ystyriaethau hyn ac adolygu dwyster casglu abwyd yn barhaus, gall astudiaethau gynnig mewnwelediadau cadarn i effeithiau casglu abwyd a chyfrannu at strategaethau rheoli effeithiol.

Executive summary

The harvesting of invertebrates and fish for use as angling bait is a widespread practice. Bait collection has received considerable attention over the last few decades with this activity sometimes recognised to cause long-term changes to sensitive habitats, such as mudflats and sandflats and seagrass, which are subject to national and international protection.

Within Welsh Marine Protected Areas (MPAs) there are numerous bait collection activities occurring, including bait digging, boulder turning and the laying of crab shelters. Understanding the impacts of bait collection activities on sensitive habitats within Welsh MPAs is essential to support evidence-based management of these activities.

ABPmer was commissioned by Natural Resources Wales (NRW) to provide an assessment of the impacts of various bait collection methods on designated features of Welsh MPAs. The assessment of impacts has been targeted at particular sites in Wales identified by NRW, where features potentially sensitive to bait collection activities have been experiencing frequent bait collection. To achieve this, a series of surveys were planned to investigate the impacts of bait collection techniques at each of the sites identified. Methods used will help inform any future assessments that might be required for other sites where similar bait collection activities are occurring. Additionally, more effective site-based management could be tailored toward locations with specific pressures or threats affecting specific site features.

This report summarises the survey work undertaken during the project which involved intertidal monitoring multiple locations in Wales to assess the impacts of various bait collection activities:

- Boulder turning west of Great Orme, Conwy and Penmon-Beaumaris, Anglesey
- Bait digging at Angle Bay, Pembrokeshire, Four Mile Bridge and Penmon-Beaumaris, Anglesey
- Crab shelters at Bangor Pier, Gwynedd and Deganwy, Conwy

A range of survey techniques were employed to assess potential differences in sediment composition (where applicable), infaunal and megafaunal composition between impact (harvested) and control (un-harvested) areas.

Boulder turning significantly affected epifaunal community composition between the top and bottom of historically turned and not turned boulders at the west of Great Orme and Penmon-Beaumaris sites. These differences were also evident at the wider site level between control and impact areas. Regardless of boulder turning, the diversity of fauna was found to be greater on the bottom of boulders at both monitoring sites. Long-term impacts of boulder turning were evident in some faunal assemblages and this was observed at both monitoring sites.

Mobile taxa, such as molluscs, appear to have been affected by historic boulder turning. In contrast, sessile barnacles showed resilience and faster recovery at both sites, particularly on the top sides of boulders. Recovery patterns varied depending on the species and environmental conditions present at both sites. Both sites exhibited moderate intensity of

boulder turning and a low presence of recent boulder turning. The lack of recent disturbance likely facilitated the recovery of certain faunal assemblages, particularly those on the top surfaces. However, complete recovery of underboulder communities was not observed at either site.

At Angle Bay, direct physical habitat disturbance from bait digging activities was observed at the site, with a number of bait diggers observed during the survey in the impact area using both hole digging and suction collection techniques. Despite this, there was no statistically significant differences between the faunal communities in control (undug) and impact (dug) areas at Angle Bay. Statistically significant decreases in seagrass density were observed between control and impact areas, with an average coverage of 78 % in comparison to 54 % in the control and impact area, respectively. There is some evidence of a loss of finer silt fractions within impact areas at Angle Bay. However, despite the observed differences in sediment composition there was very little correlation, and no significant relationship, between faunal composition and the particle size data in either the impact or control areas.

Bait digging does not appear to have altered sediment composition at Penmon-Beaumaris. However, benthic communities showed signs of disturbance given the high abundances of disturbance-tolerant species in the impact area compared to the control area. Signs of bait digging activities were evident within the impact area, which further suggest the area is regularly disturbed. Historical data comparisons suggested long-term changes in community structure, but it remains uncertain whether these changes are directly attributable to bait digging due to a lack of direct comparability between survey methods.

At Four Mile Bridge, the lack of a suitable control site and differences in sediment composition between control and impact areas posed challenges for assessing bait digging impacts. However, the impact area showed signs of disturbance, with high abundances of resilient, disturbance-tolerant species, which potentially suggests some level of impact from bait digging activities.

The provision of artificial crab shelters appears to have had minimal impact at the Deganwy and Bangor Pier monitoring sites. At Bangor Pier, the use of tyres as crab shelters appears to not have affected sediment composition or benthic communities. Macrofaunal community abundance consisted primarily of disturbance tolerant taxa and were similar between impact and control areas.

At Deganwy, the sediment composition between the control and impact areas was stable and uniform, with no substantial differences in sediment structure below the gutters. The significantly higher macrofaunal abundance and species richness in the control area, compared to the impact area (directly below the gutters), highlighted the physical disruption caused by gutters. Despite this, only localised impacts within the vicinity of the gutters were observed. Wider site impacts were not evident, as the benthic communities at the control and impact areas were primarily classified as disturbance-tolerant and appear to be resilient to other forms of disturbances at this site.

Overall, the study provides valuable insights into the impacts of different bait collection methods within Welsh MPAs. Notable impacts were observed for boulder turning and bait digging, while crab shelters appeared to cause minimal disturbance. Infaunal recovery may be possible if bait collection is minimised over time. Future assessments should ensure consistent methodologies, suitable sample replication and increased duration of monitoring for accurate comparisons and better understanding of long-term ecological changes. By

addressing these considerations and continuously reviewing bait collection intensity, studies can offer robust insights into the effects of bait collection and inform effective management strategies.

1 Introduction

The harvesting of invertebrates as a means of bait collection is widespread across many coastal regions globally (Wynberg & Branch 1991, Olive 1993, Sheehan *et al.,* 2008, 2010, Cole *et al.,* 2018). Within the United Kingdom (UK) and Wales, intertidally, the main fauna targeted for bait collection include worms, crabs, shellfish and sandeel, with the main methods of collection being bait digging/pumping, raking, boulder turning, provision of crab shelters, salting for razor clams and seine netting (Morris *et al.,* 2012).

Bait collection has received considerable attention over the last few decades with this activity sometimes recognised to cause long-term changes to sensitive habitats, such as mudflats and sandflats, muddy gravels and seagrass, which are subject to national and international protection. This is evidenced in numerous reports, such as Fowler (1999), Evans *et al.* (2015) and West *et al.* (2020). In this context it is recognised that bait collection activities may be affecting targeted/non-targeted fauna and other ecosystem components across Welsh shores.

Within Welsh Marine Protected Areas (MPAs) there are numerous bait collection activities occurring and are the focus of this study: bait digging, boulder turning and the laying of crab shelters. Bait digging is a common form of bait collection and simply involves the manual digging/turning of sediment with equipment (usually a fork) and targets various polychaetes. Boulder turning targets the collection of ‘peeler’ crabs (crabs in the process of moulting) which are a popular bait in the UK and are commonly collected beneath boulders in rocky areas. Provision of crab shelters is a harvesting technique to provide an artificial 'safe haven' to crabs to undergo the moulting process where they can be easily gathered. This technique mainly targets the green shore crab *Carcinus maenas* ‘peeler crabs’.

Understanding any impacts of bait collection activities on sensitive habitats within Welsh MPAs is essential to identify whether these activities require management. ABPmer was commissioned by Natural Resources Wales (NRW) to provide an assessment of the impacts of various bait collection methods on designated features of Welsh MPAs. This assessment of impacts has been targeted at particular sites in Wales identified by NRW, with features potentially sensitive to bait collection activities and as currently experiencing frequent bait collection. Methods used will help inform any future assessments for other sites where similar bait collection activities are occurring. Additionally, more effective site-based management can be tailored toward locations with specific pressures or threats affecting specific site features.

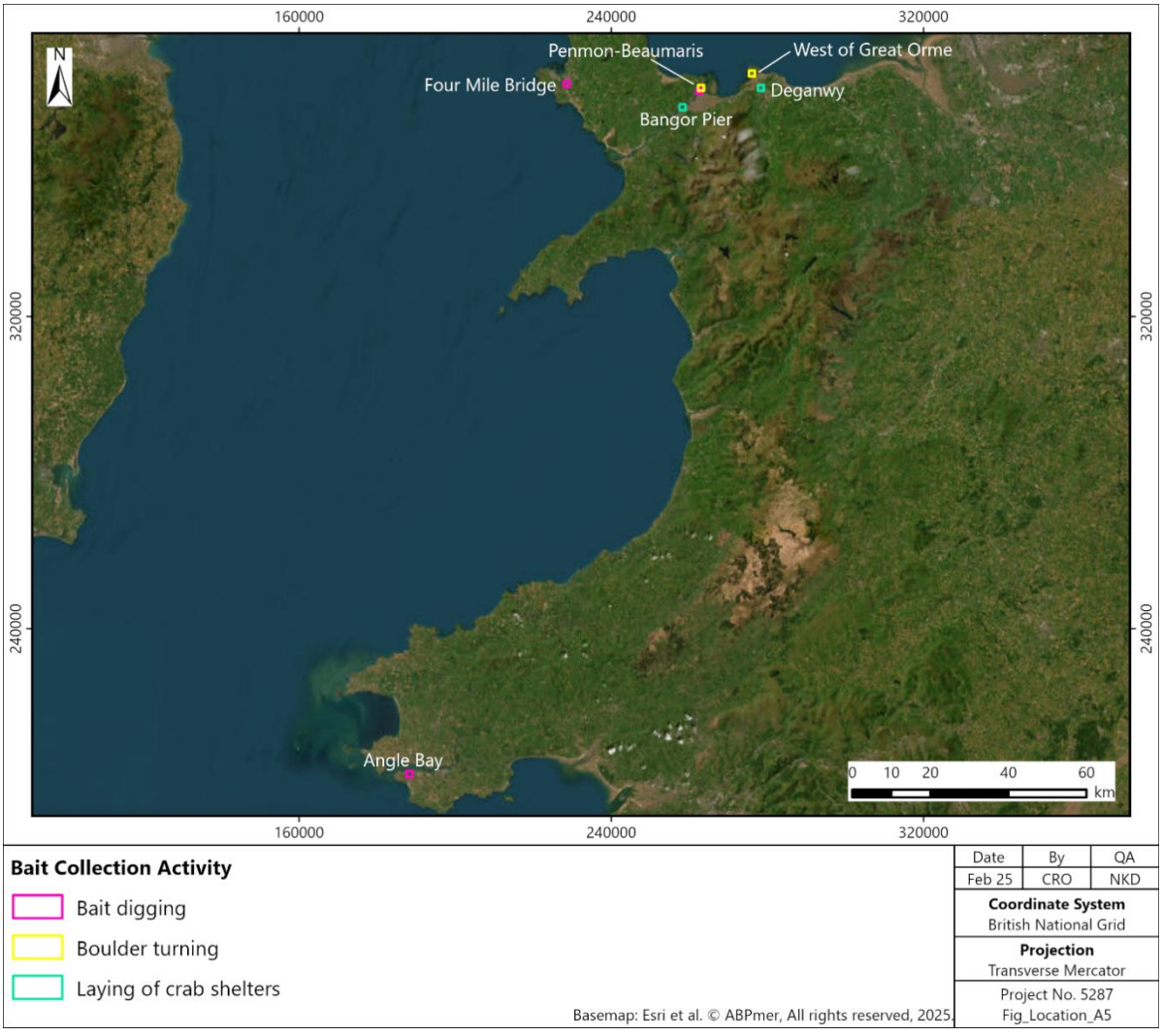
To support this work an evidence-based review of survey techniques that have previously been implemented to assess the impacts of various bait collection methods, was undertaken in Phase 1 of this project (West *et al.,* 2024). This was used to develop a sampling strategy for implementation in Phase 2.

The outputs of the Phase 1 review recommended that three survey strategies are implemented, one for each of the three bait collection techniques observed at specific sites across Wales. The sites identified for survey are presented in Table 1.

Table 1. Summary of survey sites to monitor bait collection activities.

Bait collection activity	Sites
Bait digging	• Four Mile Bridge, Anglesey • Penmon-Beaumaris, Anglesey • Angle Bay, Pembrokeshire
Boulder turning	• West of Great Orme, Conwy • Penmon-Beaumaris, Anglesey
Laying of crab shelters	• Bangor Pier, Gwynedd • Deganwy, Conwy

Figure 1. Location of survey sites selected to monitor bait collection activities.



The aim of Phase 2 was to complete a series of surveys to investigate the impacts of bait collection techniques at each of the sites identified above, following the methods derived from the review.

This report summarises the survey work undertaken which involved monitoring multiple locations in Wales to assess the impacts of various bait collection activities, including:

- Boulder turning at west of Great Orme, Conwy and Penmon-Beaumaris, Anglesey;
- Bait digging at Angle Bay, Pembrokeshire, Four Mile Bridge and Penmon-Beaumaris, Anglesey; and
- Crab shelters at Bangor Pier, Gwynedd and Deganwy, Conwy.

1.1 Objectives

The key objectives of the survey were to:

- Assess any changes to the structure and function of target habitats as a result of the bait collection activities;
- Identify any evidence of direct physical habitat damage/disturbance from bait digging activities;
- Identify any depletion of target and non-target species; and
- Document any changes in sediment composition.

The primary objective of this study was to assess the long-term impacts of bait collection activities. This involved sampling in locations where historical bait collection activities have occurred. Areas with evidence of recent disturbance were therefore avoided to ensure the assessment focused on long-term impacts rather than immediate short-term effects. The evidence of long-term impacts collected from historical bait collection activities will be used by NRW to determine whether impacts observed are affecting the overall condition of the relevant MPA feature and if management measures are required at specific locations.

This report comprises the following sections, with each section focusing on a particular bait collection activity and the associated survey methodology and results:

- Section 2: Methodology;
- Section 3: Survey Results; and
- Section 4: Conclusions.

2 Methodology

2.1 Boulder turning

2.1.1 Sites overview

Boulder turning activities were monitored at west of Great Orme, Conwy and Penmon-Beaumaris, Anglesey. The west of Great Orme site falls within the Aber Afon Conwy Site of Special Scientific Interest (SSSI) and the Penmon-Beaumaris site is situated in the Menai Strait and Conwy Bay Special Area of Conservation (SAC) and Glannau Penmon-Biwmares SSSI. Both sites are subject to boulder turning which has the potential to impact some designated features within each site, as identified in Table 2.

Table 2. Target habitats for sampling at boulder turning sites.

Site	MPA	Relevant Designated features	Targeted designated features
West of Great Orme	Aber Afon Conwy SSSI	• Marine invertebrates • High quality intertidal estuarine communities	Marine invertebrates
Penmon-Beaumaris	Glannau Penmon-Biwmares SSSI	• Communities of animals and plants of mixed sediment and of muddy gravel shores • Four communities of restricted national distribution: ▪ Piddocks burrowed into lower shore limestone overgrown with serrated wrack ▪ Sponges, sea-squirts and serrated wrack on tide-swept lower shore rock ▪ Sponges, sea-squirts, red seaweeds and serrated wrack found on a tides-swept mixture of mud, sand, cobbles and pebbles ▪ Lower shore muddy gravel inhabited by a diverse group of small marine worms • Two species-rich communities of marine plants and animals: ▪ Sponges, sea-squirts and sea-mats on bedrock overhangs ▪ Serrated wrack and various animals under lower shore boulders	• Sponges, sea-squirts and serrated wrack on tide-swept lower shore rock • Serrated wrack and various animals under lower shore boulders
Penmon-Beaumaris	Menai Strait and Conwy Bay SAC	• Mudflats and sandflats not covered by seawater at low tide • Reef	Reef

Whilst boulder turning is commonly used to target ‘peeler crabs’, impacts have been known to affect under-boulder communities as turned boulders are often not replaced back to their previous state.

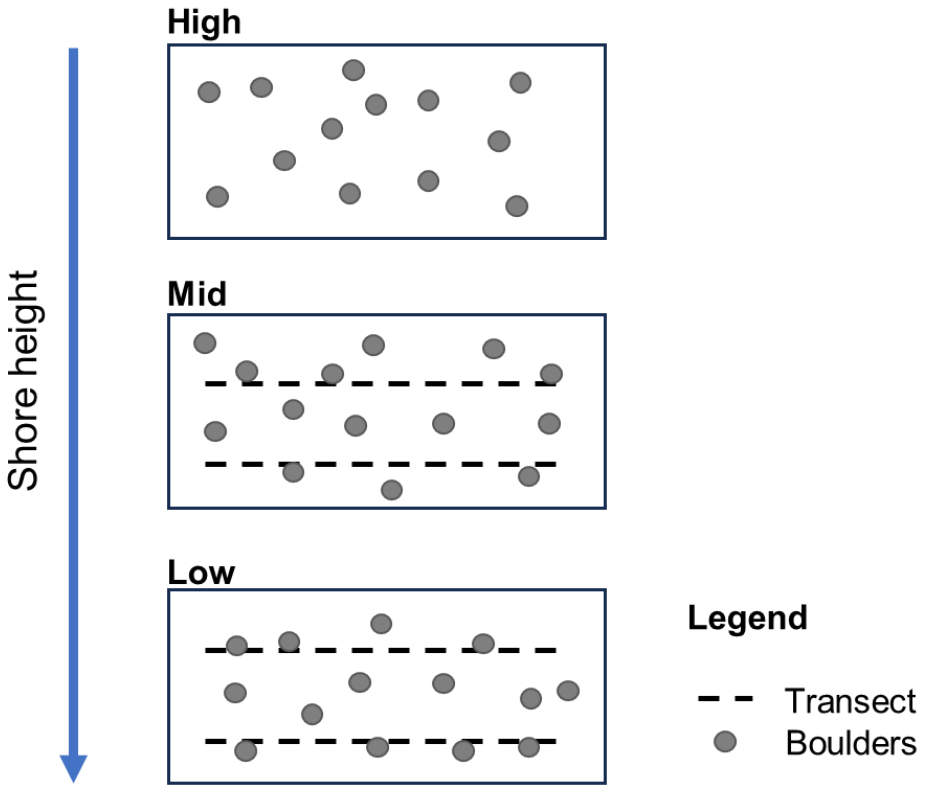
2.1.2 Survey methods

Boulder turning monitoring was carried out at Penmon-Beaumaris and west of Great Orme between 10th and 13th March 2024.

Survey methods used a comparative sampling strategy between areas that are exposed to boulder turning activities (i.e. impact) and areas that experience no boulder turning activities (i.e. control). Control areas were chosen based on preliminary site visits by NRW. Suitable control areas were defined by minimal evidence of bait collection activities, comparable habitat types (e.g. sediments and algal coverage on boulders) and comparable shore heights (mid-low). For boulder turning surveys, control areas were also defined as suitable if most boulders fit the 'Not Turned' classification, as detailed below. Penmon-Beaumaris and west of Great Orme both had suitable control locations within 500 m distance of the impact sites.

A transect sampling method was used to qualitatively assess the intensity and extent of boulder turning at each site. Four transects were placed horizontally (using a tape measure) across the mid (defined by the presence of *Fucus vesiculosus*) and low shore (defined by the presence of *Fucus serratus*), within each impact and control area at each site.

Figure 2. Transect sampling method used to assess the extent of boulder turning.



Transects were 20 m in length (see Figure 3A) and were spaced at least 20-50 m from each other. Along each transect the number of 'suitable' turned vs un-turned boulders (those that fitted through a 0.5 x 0.5 m quadrat and were not embedded in sediment (Figure 3B)), was counted and each boulder was classified as per the categories defined by Moore *et al.* (2010) and Morris *et al.* (2012) (Figure 4):

- **Very Recently Turned** – Boulder sitting proud of the substrata, often with seaweeds beneath and obvious underboulder species facing upwards, such as red crust sponges, white sponges, dogwhelk eggs, and rock encrusting bryozoans, colonial and solitary ascidians. Low cover of acorn barnacles (<20 %).

- **Recently Turned** - Seaweeds that are trapped beneath the boulder are showing signs of anoxia. Remains of dogwhelk eggs, dried solitary and colonial ascidians on the upward facing surfaces. Low cover of acorn barnacles (<20 %).

- **Historically Turned** – Potential evidence of 'dead algae' on the underside of boulders and/ or dead barnacle spat present where the boulder is lying on muddy gravel. Potential fresh growth of young fucoids or green algae present on the otherwise bare upper surface.

- **Not Turned** – At seaweed deficient sites, boulders have a less diverse underboulder community, with minimal algal cover and/or barnacles on the underside of the boulder. In seaweed rich sites, fucoids present on the upper surface with an established underboulder community on the underside.

Figure 3. (A) *In-situ* transect sampling (B) Suitable boulder not embedded in sediment.

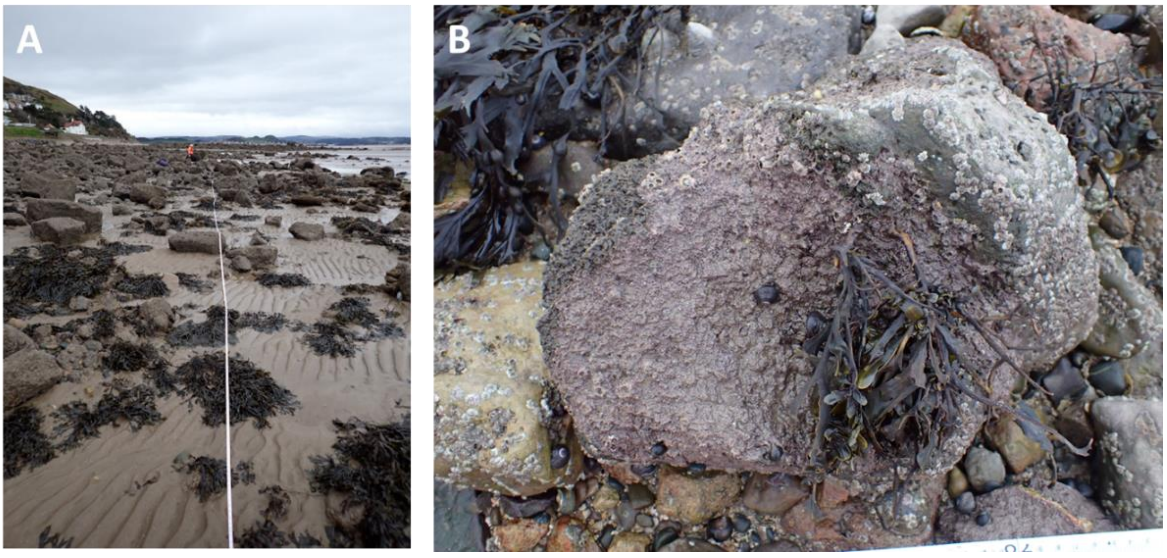
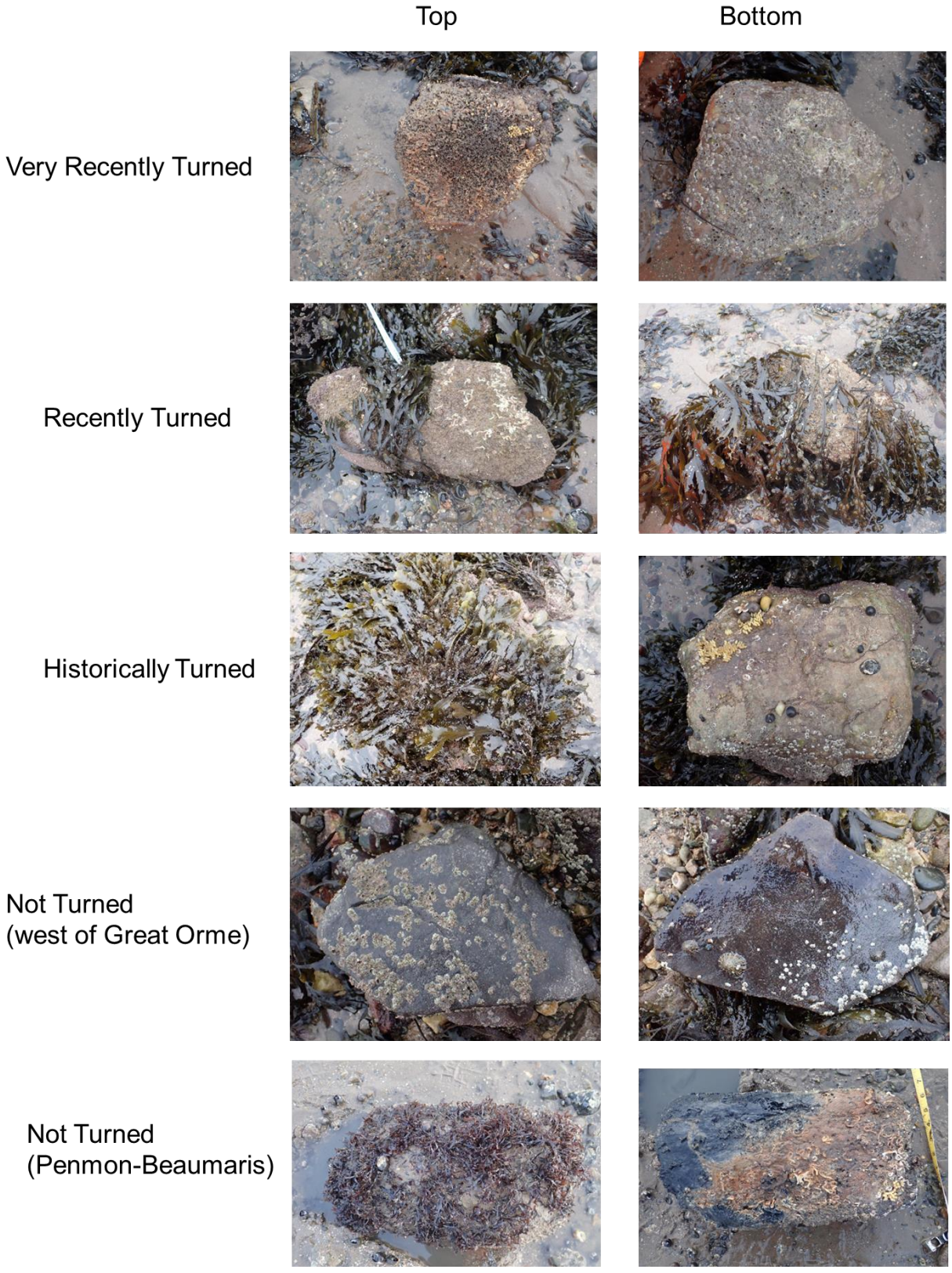


Figure 4. Boulder classifications based on the top and underside of boulder surfaces as defined by Moore *et al.* (2010).



Boulders at the west of Great Orme were barnacle dominated with very little dead algae/seaweed present. An alternative strategy was therefore implemented at this site to properly classify the boulders as ‘historically turned’. This involved assessing the proportion of live vs dead barnacles, and the presence of spat (if any), within a 5 x 5 cm quadrat on the underside of boulders. If the underside of the boulder had a higher proportion of dead barnacles/spat, it was classified as 'historically turned'. Conversely, if there was a greater proportion of live barnacles/spat, the boulder was classified as 'not turned'. This strategy proved to be successful at certain sites in Wales from previous studies (Morris *et al.,* 2012).

In addition, five boulders per transect (within both control and impact areas) were analysed *in-situ* with 5 minutes assigned per boulder, the locations of which are shown in Figure 5.

The following information was recorded for each analysed boulder:

- GPS location and boulder size (length and width (cm)).
- Photographs taken of the top (surface) and underside of the boulder.
- The underside of the boulder was classified (as per the definitions above)
- Any evidence of boulder turning within a 25 m radius along with counts of bait collectors was noted during the survey.
- Substratum characteristics including sediment type and anoxia.
- Faunal organisms were identified on the top (as it was presented during the surveys) and underside of the boulder separately. Organisms were identified to species level where possible. A pre-determined species identification list (based on previous assessments) was prepared to ensure comparability of analysis between several key species and between sites so that any changes in faunal abundance was carefully identified. However, where additional species were identified theses were also recorded. Estimates of percentage cover were made for aggregate and encrusting taxa, including sponges, bryozoa, algae, fucoids, barnacles, fanworm and dog whelk eggs. Counts of individual mobile taxa were also recorded.

Field notes are presented in Appendix Table A1.

Digital photographs of the boulders (top and underside), along with photographs of the broader habitat were also captured at each site and geo-referenced, together with the target notes. These are provided in Appendix Table B1.

Figure 5. *In-situ* transect sampling locations at Penmon-Beaumaris and west of Great Orme. Each monitoring site was divided into two areas control and impact.



2.2 Bait digging

2.2.1 Site overview

Bait digging activities were monitored at Four Mile Bridge and Penmon-Beaumaris, Anglesey. Four Mile Bridge falls within the Beddmanarch - Cymyran SSSI and the Penmon-Beaumaris site is situated in the Menai Strait and Conwy Bay SAC and Glannau Penmon-Biwmares SSSI. Both sites are subject to bait digging activities which has the potential to impact a number of designated features at each site, as identified in Table 3. In particular, muddy gravels and seagrass features were identified as target features for the survey, due to their sensitivity to bait digging impacts.

Table 3. Target habitats for sampling at bait digging sites.

Site	MPA	Relevant Designated features	Targeted designated features
Angle Bay	Milford Haven Waterway SSSI	• Estuaries (contains all shore types and communities) • Specialised marine habitats (including eelgrass beds, rockpools, overhangs and under boulder communities) • Sand gapers and bristle worms in muddy gravel shores • Bristle worms in poorly sorted mixed sediment shores. • Bristle worms in variable salinity muddy gravel shores • Dwarf eelgrass • Assemblage of coastal flowering plants • Assemblage of saltmarsh and intertidal flowering plants	Muddy gravels: • Sand gapers and bristle worms in muddy gravel shores • Bristle worms in variable salinity muddy gravel shores • Dwarf eelgrass *Nanozostera noltei*
Angle Bay	Pembrokeshire Marine SAC	• Estuaries • Mudflats and sandflats not covered by seawater at low tide • Large shallow inlets and bays	• Mudflats and sandflats not covered by seawater at low tide
Four Mile Bridge	Beddmanarch - Cymyran SSSI	• Three species of eelgrass *Zostera* spp. • Intertidal mudflats, sandbanks, species rich muddy gravel	• Eelgrass *Zostera* spp. • Muddy gravel
Penmon-Beaumaris	Glannau Penmon-Biwmares SSSI	• Communities of animals and plants of mixed sediment and of muddy gravel shores • Four communities of restricted national distribution: ▪ Piddocks burrowed into lower shore limestone	• Muddy gravels: ▪ Communities of animals/plants of mixed sediment and of muddy gravel shores;

Site	MPA	Relevant Designated features	Targeted designated features
		overgrown with serrated wrack; ▪ Sponges, sea-squirts and serrated wrack on tide-swept lower shore rock; ▪ Sponges, sea-squirts, red seaweeds and serrated wrack found on a tides-swept mixture of mud, sand, cobbles and pebbles; ▪ Lower shore muddy gravel inhabited by a diverse group of small marine worms. • Two species-rich communities of marine plants and animals: ▪ Sponges, sea-squirts and sea-mats on bedrock overhangs; ▪ Serrated wrack and various animals under lower shore boulders.	▪ Lower shore muddy gravel inhabited by a diverse group of small marine worms
Penmon-Beaumaris	Menai Strait and Conwy Bay SAC	• Mudflats and sandflats not covered by seawater at low tide • Reef	Mudflats and sandflats not covered by seawater at low tide

Figure 6

Figure 6. Extent of target designated features: seagrass and muddy gravels at Four Mile Bridge, Anglesey.

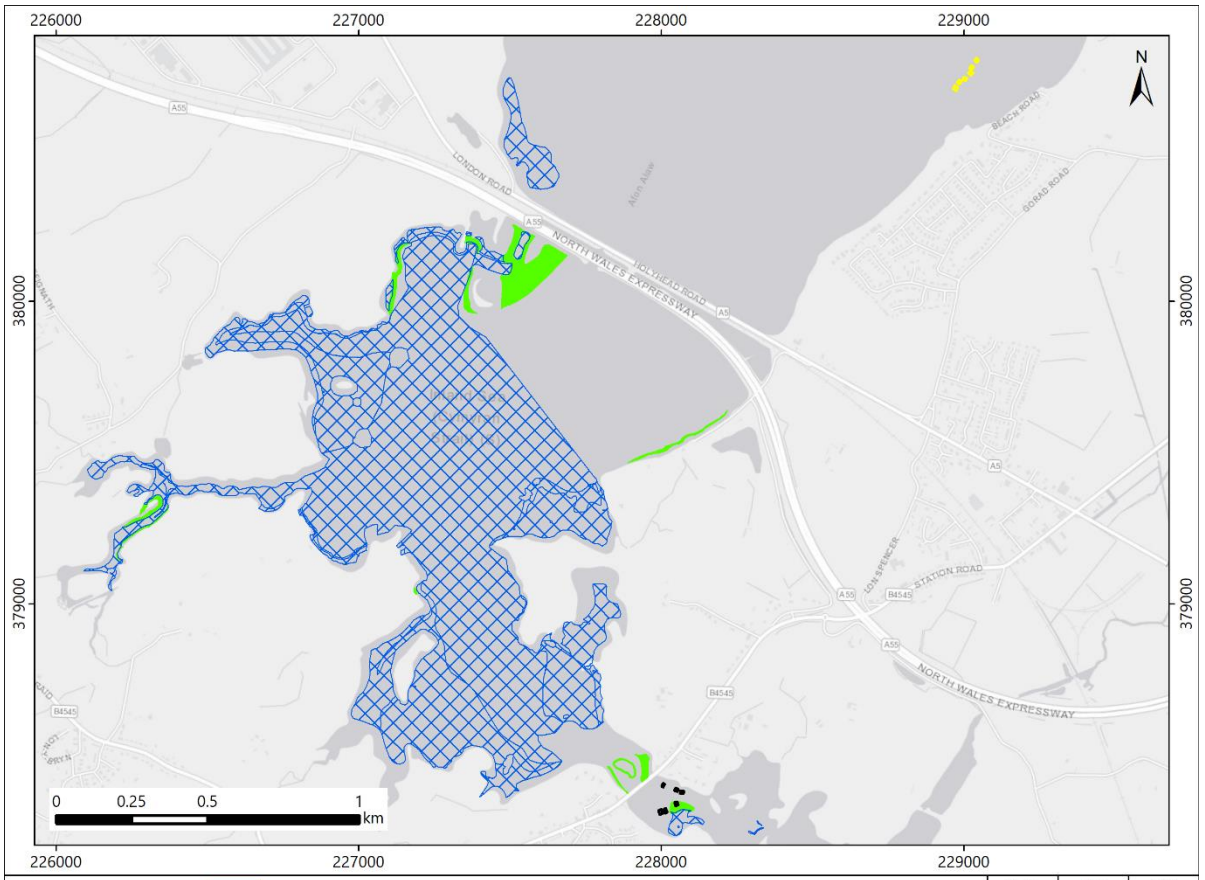
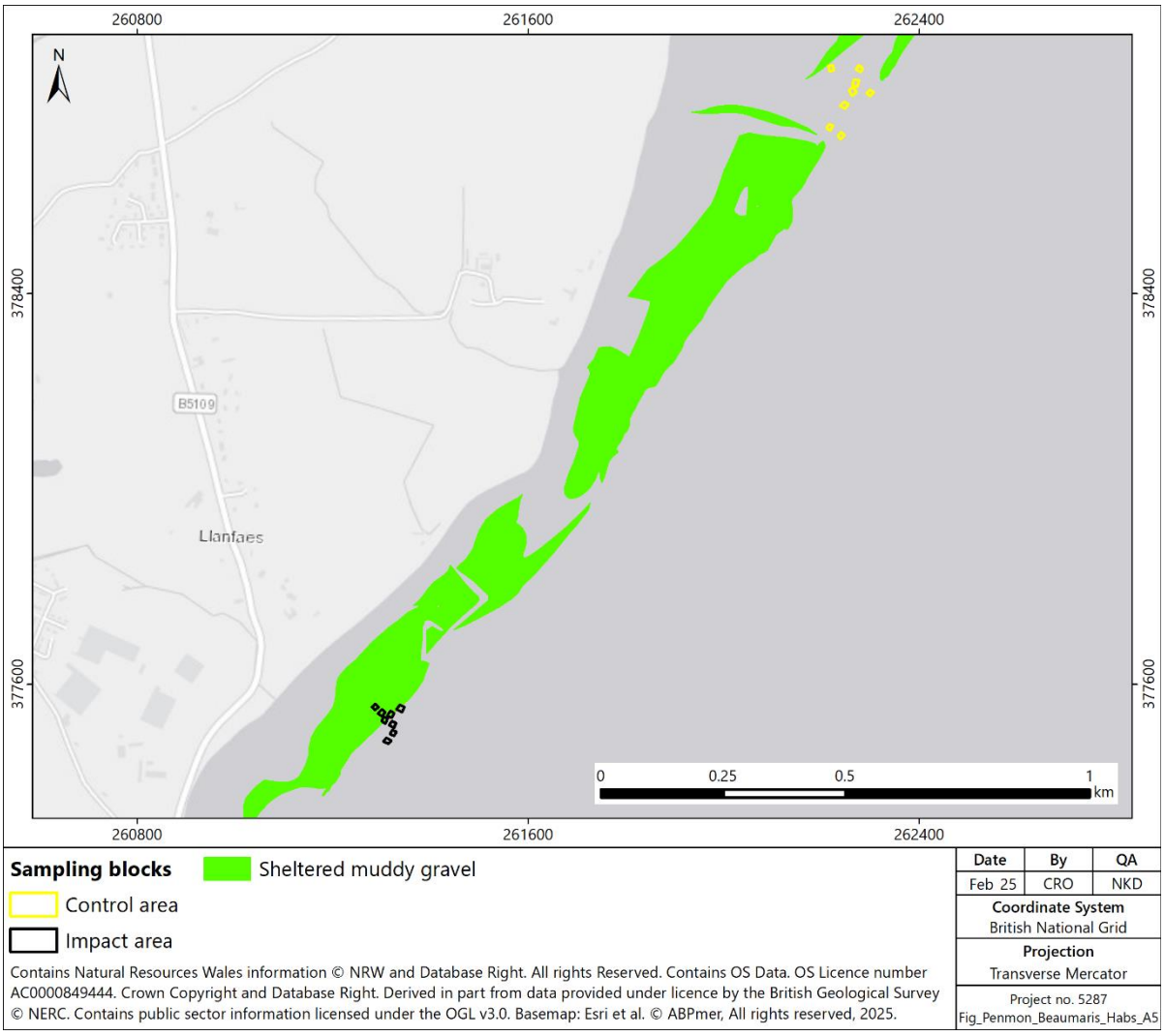


Figure 7. Extent of target designated features: muddy gravels at Penmon-Beaumaris.



2.2.2 Survey methods

Monitoring was carried out at Angle Bay between the 15th and 17th of September 2023. The specific objective of the survey scope was to assess any possible impacts of bait digging on sheltered muddy gravels and seagrass habitats. However, on arrival at the Angle Bay, seagrass extent covered the whole of Angle Bay. As a result, the survey focused on the impact of bait digging to seagrass features only.

Monitoring was carried out at Four Mile Bridge and Penmon-Beaumaris sites between the 2nd and 7th of June 2024. The original objective of the survey scope was to determine any possible impacts of bait digging on muddy gravels and seagrass habitats. However, preliminary site visits undertaken by NRW noted bait digging activities were not evident within areas of seagrass at Four Mile Bridge, and seagrass was not present within the vicinity of the survey at Penmon-Beaumaris. As a result, the survey only focused on the impact of bait digging on muddy gravel features at both Four Mile Bridge and Penmon-Beaumaris.

Survey methods included a comparative sampling strategy between areas that were exposed to intensive bait digging and areas that experience less (or no) bait digging activities.

The areas selected for monitoring at the two sites, which are subject to different levels of bait digging activity, were defined as:

- Impact area – ‘Dug’ area where previous bait digging activity was evident (Figure 8)
- Control area - ‘Un-dug’ area nearby with no/minimal evidence of bait digging).

Figure 8. Impact area with evidence of previous bait digging activities at Four Mile Bridge

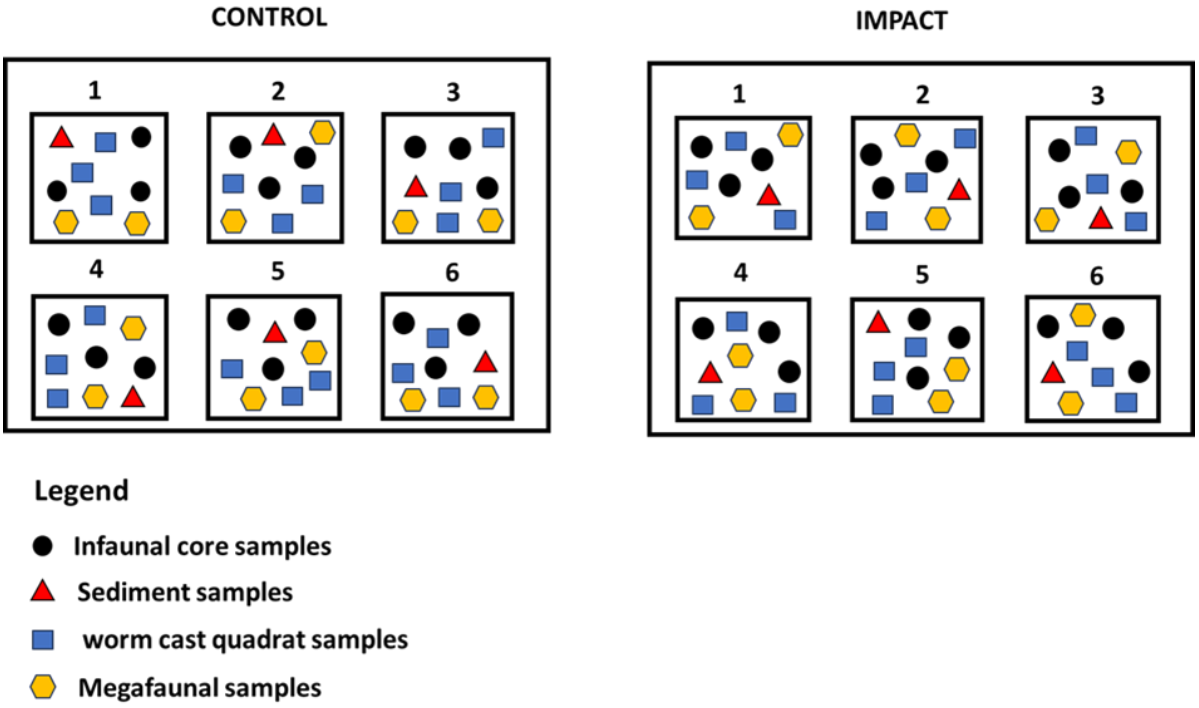


No suitable control could be identified at the Four Mile Bridge site because all areas showed signs of historical digging, as such the control area for Four Mile Bridge was selected at an alternative nearby site (within 3 km) and outside the inland sea. As far as possible the habitats within the selected control area were comparable to the impact site. However, appropriate caveats and assumptions were applied to the interpretation of results to account for potential differences in habitat and environmental conditions between sites.

The sampling strategy followed a Control-Impact (CI) design as shown in the schematic in

Figure 9 below. Within control and impact areas, six sampling blocks (each 10 m^2), were sampled at Angle Bay and Four Mile Bridge, and eight sampling blocks at Penmon-Beaumaris.

Figure 9. Control-Impact sampling. Each area (control vs. impact) was divided into 'blocks' (within which samples were collected for infaunal, megafaunal and sediment monitoring.



Within each sampling block, three 0.01 m² infaunal core samples and one sediment core sample to 15 cm depth were collected. Further details on the processing of infaunal and sediment samples are presented in Section 2.4. Additionally, three sets of worm cast counts were conducted within a 0.25 m² quadrat within each of the sampling blocks to determine the presence/absence of polychaetes based on their tubes/casts. Megafaunal counts, aiming to identify larger infauna often missed during infaunal core sampling e.g. Razor shell *Ensis magnus* or the common cockle *Cerastoderma edule,* were also incorporated. Megafaunal sampling involved collecting sediment dug to the anoxic layer depth within a 0.25 m² quadrat and placing it into plastic bags. Two samples were collected per sampling block. The extracted sediment samples were sieved over a 5 mm sieve on site and megafauna identified and counted *in-situ*.

All sample replicates (both core and quadrats) were collected randomly per sampling block.

A hand-held Global Positioning System (GPS) was used to mark each sample location. Detailed field notes were recorded to capture the nature of the habitat at each sample. Information recorded included:

- Date and time;
- Block and sample number;
- GPS waypoint;
- Sediment type (Folk classification);
- Anoxic layer depth;
- Notable habitat features (e.g., tubes, casts, feeding pits, faecal mounds);
- Evidence of bird feeding (e.g., footprints); and

- Evidence of anthropogenic disturbance (e.g. bait digging).

Field notes are presented in Appendix Table A2. Field notes for quadrat stations sampled at Angle Bay

	Treatment	Block no.	Quadrat No.	Seagrass species	Seagrass (%)	Canopy height 1 (cm)	Canopy height 2 (cm)	Canopy height 3 (cm)	Seagrass condition	Algal (%)	Epiphyte (%)	Worm cast (count)
Angle Bay	Control	AC1	AC1.QA	Z. noltei	80	9	9	14	Good	0	0	4
Angle Bay	Control	AC1	AC1.QB	Z. noltei	90	9	8	10	Good	1	0	1
Angle Bay	Control	AC1	AC1.QC	Z. noltei	90	9	8	9	Good	0	0	5
Angle Bay	Control	AC2	AC2.QA	Z. noltei	75	9	7	11	Good	0	0	4
Angle Bay	Control	AC2	AC2.QB	Z. noltei	45	7	10	6	Good	0	0	2
Angle Bay	Control	AC2	AC2.QC	Z. noltei	95	9	8	8	Good	0	0	3
Angle Bay	Control	AC3	AC3.QA	Z. noltei	75	10	12	7	Good	0	0	5
Angle Bay	Control	AC3	AC3.QB	Z. noltei	45	7	8	10	Good	0	0	3
Angle Bay	Control	AC3	AC3.QC	Z. noltei	65	8	7	10	Good	0	0	3
Angle Bay	Control	AC4	AC4.QA	Z. noltei	40	26	10	30	Good	0	0	1
Angle Bay	Control	AC4	AC4.QB	Z. noltei	70	9	8	6	Good	0	0	5
Angle Bay	Control	AC4	AC4.QC	Z. noltei	80	11	10	9	Good	0	0	0
Angle Bay	Control	AC5	AC5.QA	Z. noltei	90	7	8	6	Good	0	0	0
Angle Bay	Control	AC5	AC5.QB	Z. noltei	95	11	10	10	Moderate	0	0	1
Angle Bay	Control	AC5	AC5.QC	Z. noltei	90	11	12	12	Good	0	0	1
Angle Bay	Control	AC6	AC6.QA	Z. noltei	85	11	10	10	Good	0	0	1
Angle Bay	Control	AC6	AC6.QB	Z. noltei	90	8	9	7	Good	0	0	0
Angle Bay	Control	AC6	AC6.QC	Z. noltei	95	6	9	14	Good	0	0	2
Angle Bay	Impact	AI1	AI1.QA	Z. noltei	30	22	7	9	Moderate	5	0	1
Angle Bay	Impact	AI1	AI1.QB	Z. noltei	60	6	9	9	Good	1	0	0
Angle Bay	Impact	AI1	AI1.QC	Z. noltei	20	10	8	7	Poor	25	0	1
Angle Bay	Impact	AI2	AI2.QA	Z. noltei	30	7	6	8	Moderate	0	0	1
Angle Bay	Impact	AI2	AI2.QB	Z. noltei	70	8	7	12	Good	0	0	2
Angle Bay	Impact	AI 2	AI2.QC	Z. noltei	15	5	8	5	Moderate	0	0	2

Angle Bay	Impact	AI 3	AI3.QA	Z. noltei	15	6	7	8	Good	0	0	0
Angle Bay	Impact	AI 3	AI3.QB	Z. noltei	10	7	5	5	Moderate	0	0	0
Angle Bay	Impact	AI 3	AI3.QC	Z. noltei	50	4	6	6	Good	0	0	0
Angle Bay	Impact	AI4	AI4.QA	Z. noltei	70	6	7	6	Good	0	0	1
Angle Bay	Impact	AI4	AI4.QB	Z. noltei	60	7	8	6	Moderate	0	0	0
Angle Bay	Impact	AI4	AI4.QC	Z. noltei	70	8	8	9	Good	0	0	2
Angle Bay	Impact	AI5	AI5.QA	Z. noltei	90	10	8	6	Good	0	0	4
Angle Bay	Impact	AI5	AI5.QB	Z. noltei	60	8	11	9	Good	0	0	2
Angle Bay	Impact	AI5	AI5.QC	Z. noltei	60	11	8	8	Good	0	0	5
Angle Bay	Impact	AI6	AI6.QA	Z. noltei	95	7	10	7	Good	0	0	1
Angle Bay	Impact	AI6	AI6.QB	Z. noltei	85	8	10	12	Good	14	0	0
Angle Bay	Impact	AI6	AI6.QC	Z. noltei	80	11	8	9	Good	0	0	1

Table A3.

Digital photographs of the sediment surface, characteristic species and features, bait digging basins/mounds and the broader habitat were also captured at each block and geo-referenced, together with the target notes. Sample photos are provided in Appendix Table B

Figure 10. Sampling block locations with Control and Impact Areas at Angle Bay

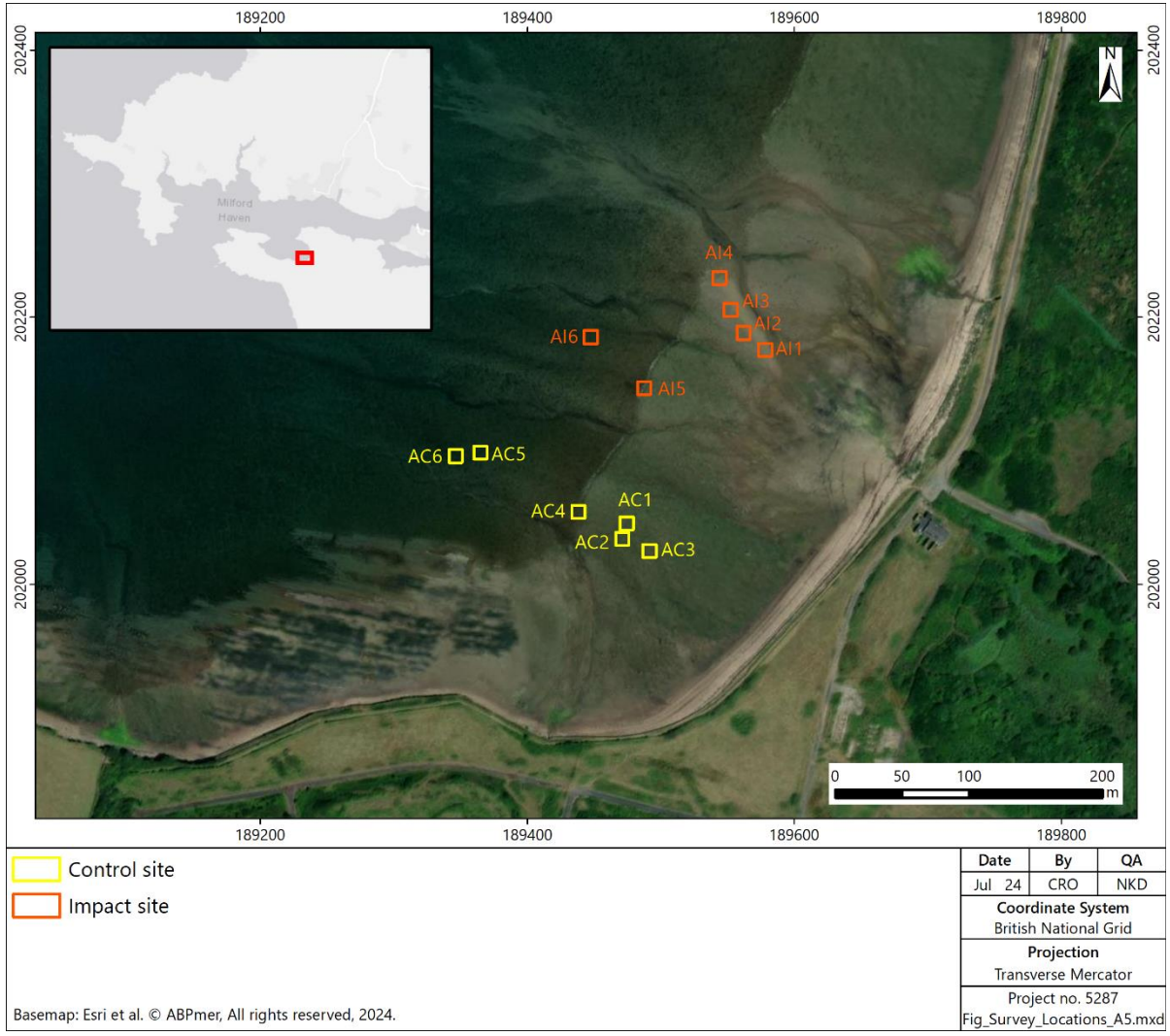
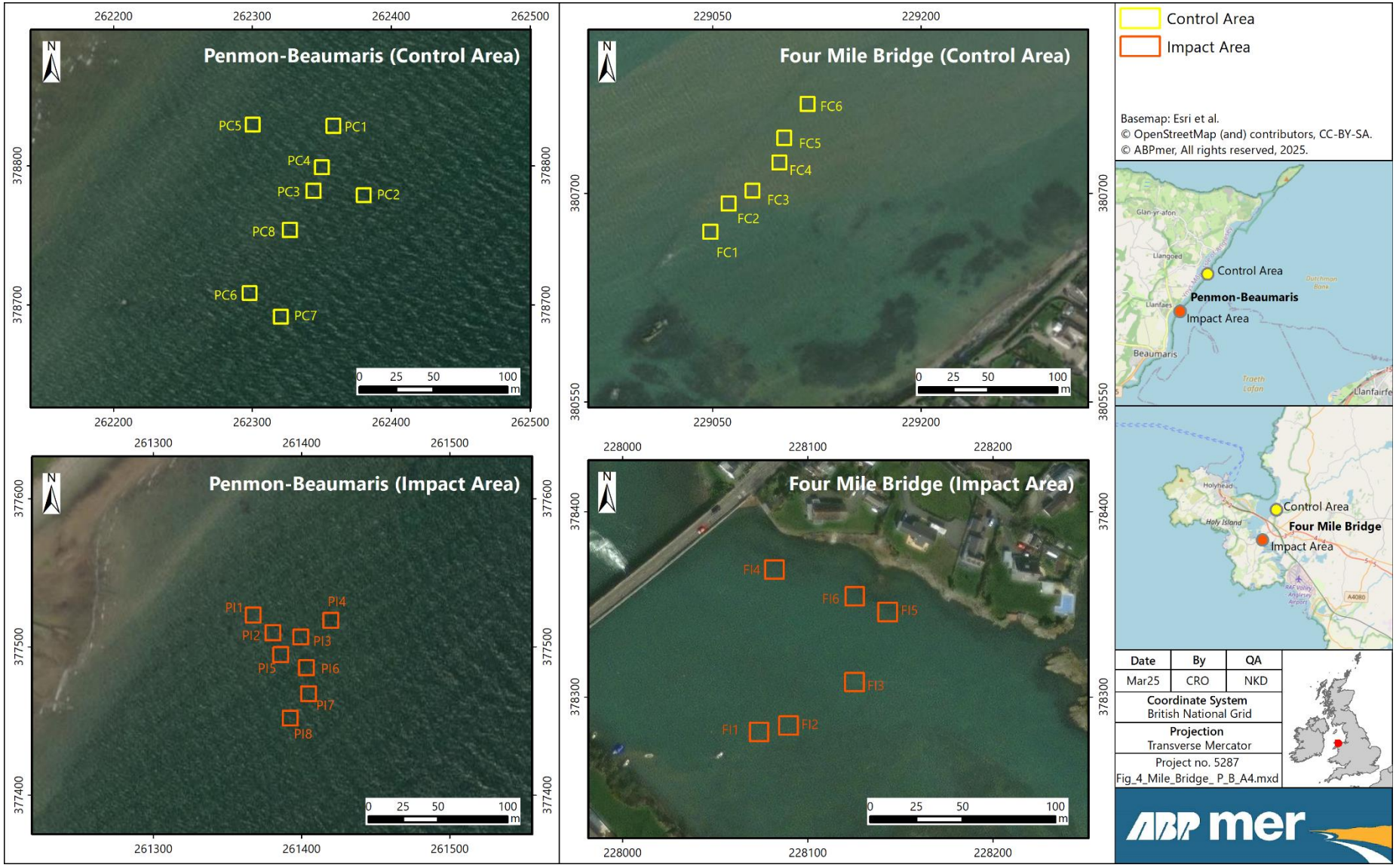


Figure 11. Sampling block locations within control and impact areas, located in the low shore, at Four Mile Bridge and Penmon-Beaumaris.



2.3 Crab shelter provision

2.3.1 Site overview

Assessment of crab shelter provision as a bait collection technique was monitored at Bangor Pier, Gwynedd and Deganwy, Conwy where tyres and tiles have been observed being used to collect peeler crabs. Bangor Pier is adjacent to the Menai Strait and Conwy Bay SAC and Deganwy is located within the Aber Afon Conwy SSSI. Both sites are subject to crab shelter provision which has the potential to impact some of the designated features within each site, as identified in Table 3. Mudflats and sandflats and marine invertebrates were identified as target features for the survey, due to their demonstrated sensitivity to the impacts of crab shelter provision impacts, which can lead to significant changes in species composition, reduced biodiversity, and altered habitat complexity (Sheehan 2007, Sheehan *et al.,* 2008)

Table 4. Target habitats for sampling at crab shelter sites.

Site	MPA	Relevant Designated features	Targeted designated features
Bangor Pier, Gwynedd	Adjacent to Menai Strait and Conwy Bay SAC	• Mudflats and sandflats not covered by seawater at low tide • Large shallow inlets and bays	Mudflats and sandflats not covered by seawater at low tide
Deganwy, Conwy	Aber Afon Conwy SSSI	• All intertidal habitats and species groups • Marine invertebrates • High quality intertidal estuarine communities	Marine invertebrates

2.3.2 Survey methods

Monitoring was carried out at Bangor Pier and Deganwy sites between 20-23 August 2024.

Assessment of crab shelter provision impacts entailed a comparative sampling strategy (similar to bait digging as described in Section 2.2.2 between areas that had the presence of crab shelters (impact) and areas where no evidence of crab shelter provision was observed (control).

It should be noted that the tyres at Bangor Pier could not be sampled due to difficulties in contacting the owner. As an alternative, tyres located a few hundred meters west of the Bangor Pier were sampled, although these appeared to be abandoned and not regularly checked. Nevertheless, it was considered that the impact within and under these tyres would be similar to those placed at Bangor Pier.

The areas of impact selected at the two monitoring sites were subject to different levels of crab sheltering activity. Deganwy was identified as a gutter collection site, with gutters (serving as crab shelters) laid in rows at approximately 1-2 m intervals (Figure 12A). At Bangor Pier, crab shelters took the form of tyres (Figure 12B). The areas of impact were defined as the gutters and tyres themselves along with a 1 m buffer zone surrounding the crab shelters and defined ‘pathways’ or tracks which were created by collectors moving

between the shelters. Since the impacts of crab shelters are generally localised, control sites were assigned as patches near to shelters across the same shore height, but at least 15 m away, which had no observable disturbance.

Figure 12. (A) Gutters laid at Deganwy and (B) tyres at Bangor Pier.



The sampling strategy followed a Control-Impact (CI) design as shown in the schematic in Figure 13. Within control and impact areas, four sampling blocks were sampled at the mid-shore position at Deganwy and Bangor Pier, as the crab shelters were located at this shore position. Given the highly localised nature of the impacts, four individual crab shelters were selected at each monitoring site to represent the impact 'sampling blocks'.

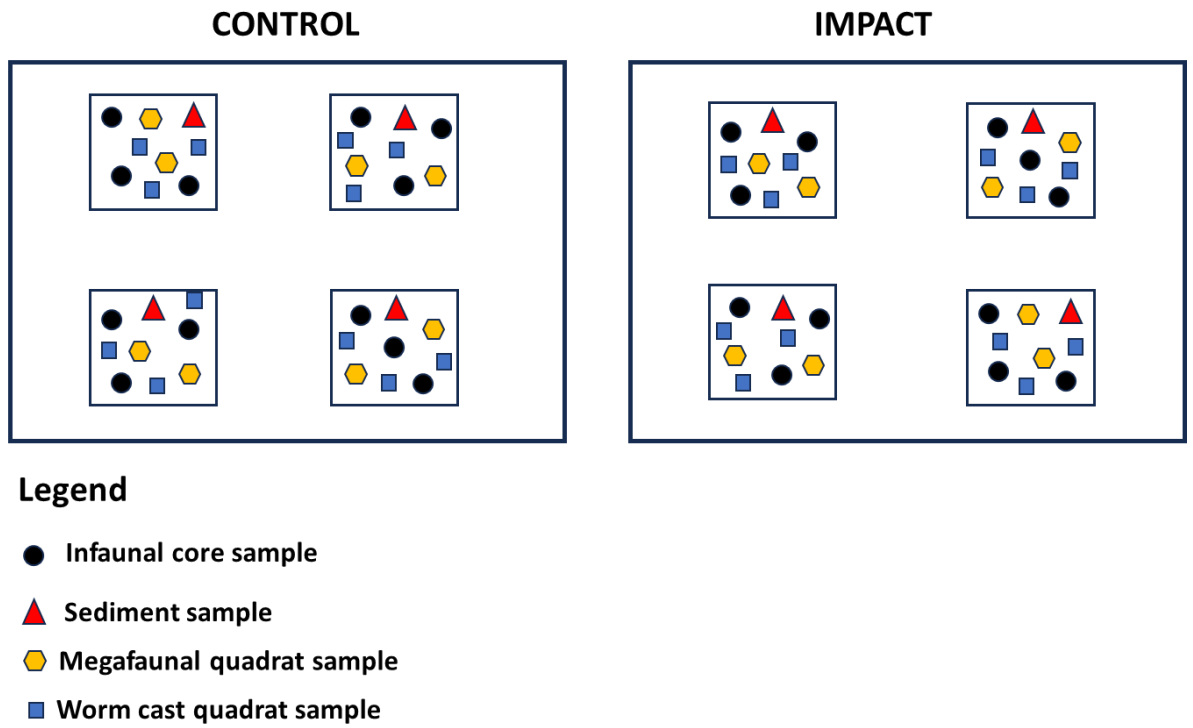
For each control and impact (crab shelter) sampling block, three 0.01 m² infaunal core samples and one sediment core sample (15 cm depth) were collected. Further details on the processing of infaunal and sediment samples are presented in Section 2.4. At the impact sampling blocks, two of the infaunal cores were sampled beneath the shelters at a 45-degree angle and the third was sampled within the 'pathways' surrounding the shelters where trampling was evident. However, at Bangor Pier there was no evidence of trampling surrounding the tyres, and as such all three infaunal cores were collected beneath individual tyres, two sampled at 45-degree angles underneath the tyre rim and one within the exposed centre of the tyre.

Epifaunal coverage on the gutters and tyres was also recorded to qualitatively assess floral and faunal growth on crab shelters. This involved *in-situ* observations of epifauna present on the structures; with estimates of percentage cover for aggregate taxa (including algae, fucoids, barnacles etc.) and counts of individual mobile taxa recorded for three replicate crab shelters at each monitoring site. Additionally, three sets of worm cast counts were conducted using a 0.25 m² quadrat within each of the sampling blocks to assess the presence or absence of polychaetes based on their tubes and casts.

Megafaunal sampling, aimed at identifying larger infauna, was also conducted. This involved collecting sediment to the anoxic layer depth within a 0.25 m² quadrat and placing the sediment into plastic bags. Two samples were collected from each sampling block. The megafaunal samples were sieved on site through a 5 mm sieve, and the megafauna identified and counted *in-situ*.

All sample replicates (both core and quadrat) were collected randomly per sampling block. The location of the samples collected for the assessment of crab shelter provision are shown in Figure 14.

Figure 13. Control-Impact sampling for crab sheltering impacts. Each area (control vs. impact) was divided into 4 sampling 'blocks' within which samples were collected for infaunal, megafaunal and sediment monitoring.



A hand-held GPS was used to mark each station location. Detailed field notes were recorded to capture the nature of the habitat at each station. Information recorded included:

- Date and time;
- Block and sample number;
- GPS waypoint;
- Sediment type (Folk classification);
- Anoxic layer depth;
- Notable habitat features (e.g., tubes, casts, feeding pits, faecal mounds);
- Evidence of bird feeding (e.g., footprints); and
- Evidence of anthropogenic disturbance (e.g. trampling).

Field notes are presented in Appendix Table A4.

Digital photographs of the sediment surface, characteristic species and features, bait collection activity and the broader habitat were also captured at each sampling block and geo-referenced, together with the target notes. Station photos are provided in Appendix Table B3.

No historical surveys have been undertaken at Bangor Pier or Deganwy, therefore comparisons with the 2024 samples could not be made.

Figure 14. Sampling locations within control and impact areas in the mid-shore at Deganwy and Bangor Pier



2.4 Sample analysis

Infaunal core samples and sediment samples, collected for particle size (PSA) and total organic content (TOC) analysis, were analysed using the same approach for both bait digging and crab shelter provision.

Upon collection, infaunal cores were sieved over a 0.5 mm sieve and preserved in 10 % buffered formalin before being sent to the laboratory for macrofaunal abundance and biomass analysis.

The infaunal samples were analysed by Hull Marine Laboratory, an accredited Marine Biological Analytical Quality Control Scheme (NMBAQC) laboratory. All work was undertaken in conformance with ISO 16665 standards and the NMBAQC Scheme Guidelines (2010). Fauna was sorted from the sieved samples using low power binocular microscopes. Macrofaunal specimens were identified to species level (where practicable) and enumerated. Biomass (wet weight) was recorded for each major Phyla.

A minimum of 10% of all core samples were re-analysed for internal quality assurance for sample processing; this was carried out for both the extraction of fauna and for identification.

The full results of the faunal analysis are provided in Appendix C.

The sediment sample analysis was undertaken by ABPmer using the NMBAQC standardised methodology. The PSA was carried out using a Mastersizer laser diffractor which produces detailed sedimentary profiles for fine sediments (clay, sand and silts). TOC content was calculated through Loss on Ignition (LOI), whereby samples were dried for 24 hours at 105ºC before being burned to a constant weight at 450ºC for 12 hours.

The full results of the sediment analysis (PSA and TOC) are provided in Appendix D.

2.5 Post survey analysis

Following the completion of each survey, raw data were transferred from field notes to electronic spreadsheets. GPS waypoints were downloaded and were subsequently used to create maps showing the locations of monitoring sites (accurate to within 5 m).

All Geographical Information System (GIS) outputs were generated in ArcGIS version 10.7.1 and metadata were produced in accordance with MEDIN standards in the MESH data exchange format.

A range of statistical analyses was used to (i) describe and compare sediment composition and benthic faunal assemblages between areas; (ii) assess the longer-term impacts of bait collection activities between control and impact areas within each monitoring site and (iii) assess and compare the differences in faunal composition between the current monitoring and historic data (where applicable).

Univariate statistical descriptors of faunal (infaunal or epifaunal) assemblages (abundance, number of taxa present, Simpson’s diversity index and biomass) and where applicable, sediment composition (gravel, sand and mud), were analysed using RStudio version 4 (Posit Team, 2024). Statistical 2-way Analysis of Variance (ANOVA) analyses were

performed on environmental and biological variables in RStudio. Shapiro-Wilkson and Levene's tests were used to test for normality and homogeneity of variance in data. In cases where data did not meet the required assumptions for parametric testing, non-parametric analyses were conducted.

Multivariate analyses were performed using the Plymouth Routines in Multivariate Ecological Research (PRIMER) v.7 software package (Clarke *et al.,* 2014; Clarke and Gorley, 2015) with PERMANOVA+ add-on package (Anderson *et al.,* 2008), to investigate the patterns present within the faunal dataset. The following routines and tools were employed:

- **Transformation** procedures was carried out before analysis to downweigh the dominant species and increase the contribution of rarer species in the multivariate analysis:
    - Infaunal data from bait digging and crab shelter provision surveys and Epifaunal count data collected during boulder turning surveys underwent square-root transformation;
    - Percentage cover data underwent ASIN transformation and records of "<1%" were converted to 0.5% for quantitative comparisons;
- **DIVERSE** component used to calculate the following diversity indices for each sample: total number of taxa (S) and individuals (N) and Simpson's diversity index (1- ʎ). Simpson's diversity (1- ʎ) index is a dominance index (ranging from 0-1) where smallest values correspond to assemblages whose total abundance is dominated by one, or a very few, of the species present and highest values correspond to assemblages with equal numbers of individuals of the species present;
- **PCA (Principal Component Analysis)** to assess the interrelationships between sediment samples and to identify patterns within the data;
- **RELATE** used to match multivariate patterns in the environmental and biological data. The RELATE routine provides a means of testing for correlations between biological communities and environmental variables (in this case, PSA data).
- **Non-metric Multidimensional Scaling (MDS) Ordination** to visualise the relationship between samples within the control and impact areas at each site by creating a configuration of the samples in multidimensional space. The "map" represents community patterns and attempts to position more similar points closer together to reflect their resemblance;
- **SIMPER (similarity percentage**) analysis to compare the similarity between taxa within the control and impact areas at each site. This routine identifies the species responsible for within-group similarities or dissimilarities between the areas and their contribution to the similarity or dissimilarity;
- **ANOSIM (**analysis of similarity) to assess the extent of the similarities and differences between areas or year to identify changes to faunal composition, whereby the R (test) statistic indicates the level of similarity of or difference (Table 5);

Table 5. Interpretation of the R statistic resulting from ANOSIM analysis

R Statistic	Extent of the similarity or difference	R Statistic	Extent of the similarity or difference
0.75 < R < 1.00	Highly different	0.10 < R < 0.25	Similar with some differences (high overlap)
0.50 < R < 0.75	Different	R < 0.10	Highly similar
0.25 < R < 0.50	Different with some overlap		

PERMANOVA (Permutational Multivariate Analysis of Variance) to assess the statistical differences in epifaunal community composition between (i) the control and impact areas and (ii) boulder categories based on the Bray-Curtis similarity matrix (for analyses where species were present across all samples)

The AZTI Marine Biotic Index (AMBI) (Borja *et al.,* 2000) was also used to define the Infaunal Quality Index (IQI) for each sample, to assess the ecological status of macrobenthic infaunal samples. The IQI is based on a weighted average of the taxa richness, the AMBI Ecological Group (EG) score (a weighted average sensitivity score of all individuals within a sample) and Simpson's diversity. The AMBI describes the sensitivity of a macrobenthic community to anthropogenic and natural disturbance. Definitions of each group are presented in Table 6.

Table 6. Definitions of AMBI EG Score as per Borja *et al.* (2000)

AMBI EG Score	Definition
EG I (disturbance sensitive species)	Species that are very sensitive to organic enrichment and pollution and are typically found in pristine conditions. Examples: specialist carnivores and some deposit feeding tubicolous polychaetes.
EG II (disturbance indifferent species)	Species indifferent to enrichment, always present in low densities with non-significant variations with time. Examples: suspension feeders, less selective carnivores and scavengers.
EG III (disturbance tolerant species)	Species that can tolerate significant organic enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment. Examples: surface deposit-feeding species, such as tubicolous spionids.
EG IV (Second order opportunistic species)	Species that thrive in environments with high levels of organic pollution and abundant in heavily disturbed areas. Examples: small sized polychaetes: subsurface deposit-feeders, such as cirratulids.
EG V (First order opportunistic species)	Species that dominate in heavily polluted environments; and extremely tolerant to high levels of organic enrichment. Examples: deposit feeders, which proliferate in reduced sediments.

3 Survey Results

This section presents the results from the intertidal bait collection surveys undertaken in 2024. This section provides a comparison between sediment composition and faunal communities at control and impact areas, and provides a comparison with historic data to provide context to any observed differences in faunal assemblages between the control and impact areas.

The section is structured as follows:

- Section 3.1: Boulder turning;
- Section 3.2: Bait digging;
- Section 3.3: Crab shelter provision.

3.1 Boulder turning

Analysis of epifaunal abundance and community composition was undertaken to investigate the site level differences between boulder tops and bottoms in control and impact areas at west of Great Orme and Penmon-Beaumaris. Overarching percentage cover records (for example dead and live barnacles) were removed to avoid double counting of taxa where individual species had been identified.

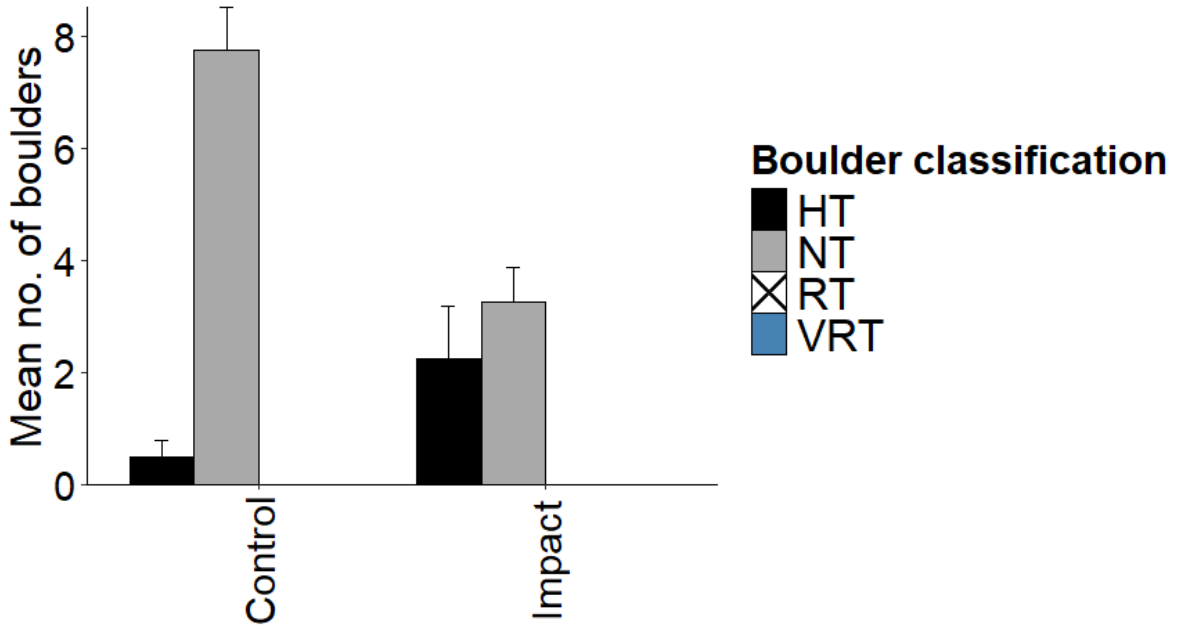
3.1.1 West of Great Orme

3.1.1.1 Boulder turning activity

Evidence of historic boulder turning activity was observed at west of Great Orme (Figure 15), however, no evidence of recent boulder turning (i.e., recently or very recently turned boulders) was found.

Overall, the impact area showed a greater boulder turning intensity compared to the control area (Figure 15). Within the impact area, on average 41 % of boulders recorded along each transect were classified as historically turned with the remainder classified as not turned. Since the survey was conducted in March, before the main activity of the season had begun, any recently turned boulders would likely date back to the previous autumn. In comparison, within the control area only 6 % of boulders were classified as historically turned. The control area therefore showed little evidence of bait collection activity and as such is considered to provide an appropriate control/baseline to enable a comparison of potential impacts. Despite the levels of boulder turning observed, the analyses conducted in the following sections have compared turned and unturned boulders to determine any evidence of impacts from boulder turning activities.

Figure 15. Mean (± SE) number of boulders by category (HT = Historically turned, NT = Not turned, RT = Recently turned and VRT = Very recently turned) per area, observed across transects on the mid/low shore at west of Great Orme.



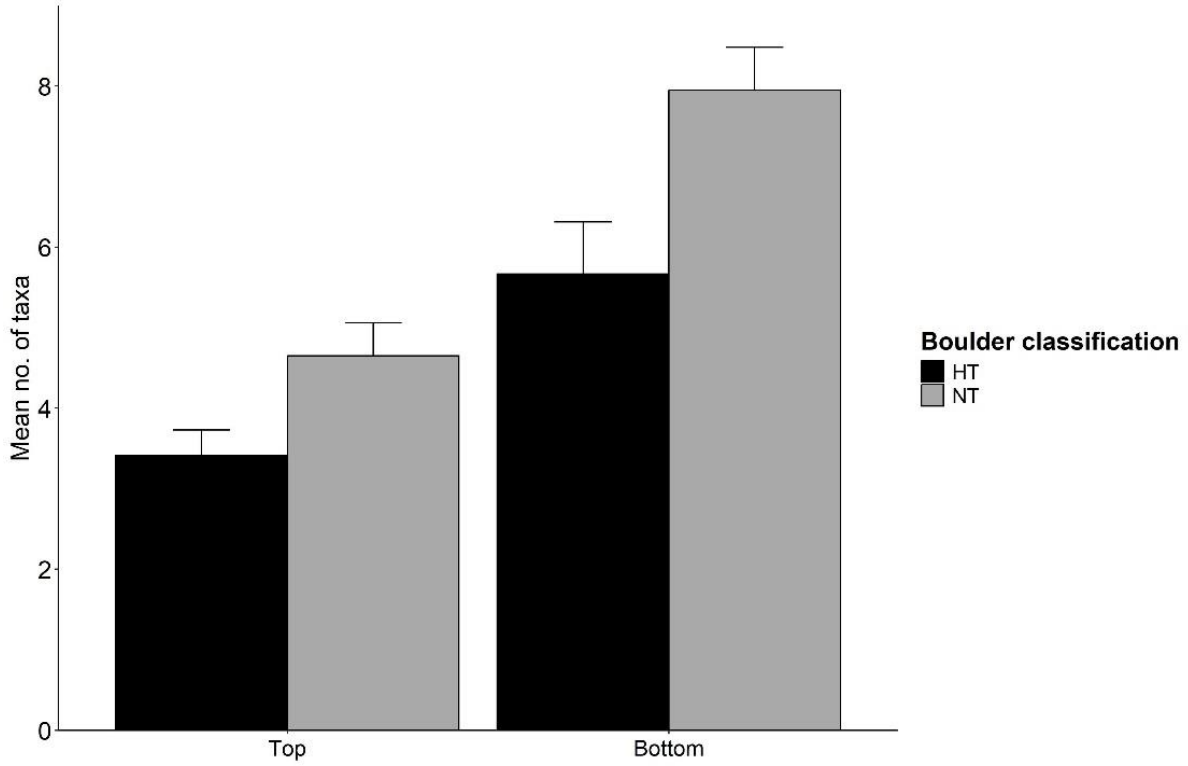
3.1.1.2 Turned or not turned boulders

To provide a true assessment of boulder turning impacts, between impact and control areas, only the turned boulders in the impact area, and not turned boulders in the control area were taken forward for the analysis within this section to examine differences in community composition. In addition, to assess the long-term impacts of boulder turning, comparisons of faunal abundance and community composition between historically turned and not turned boulders (across control and impact areas) were conducted. At the west of Great Orme, there was no evidence of recent boulder turning (recently turned and very recently turned). Therefore, the immediate effects of boulder turning were not assessed.

The boulders at the west of Great Orme site were barnacle dominated with very little dead algae/seaweed.

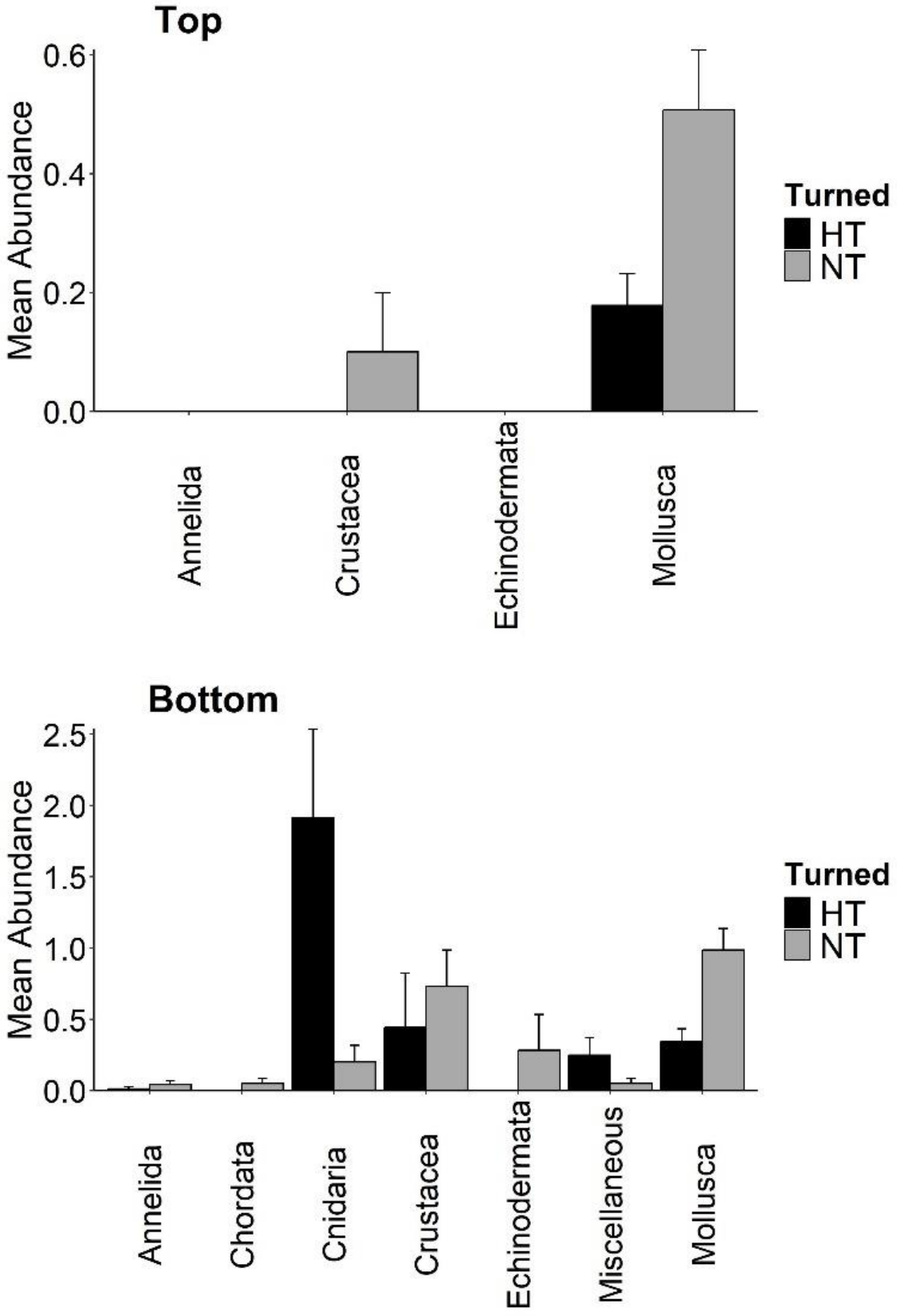
Differences in taxonomic richness between historically turned and not turned boulders (top and bottom of boulders) is shown in Figure 16. Species richness was found to be higher on not turned boulders on the top and bottom side of the boulders. However, significant differences in species richness between historically turned and not turned boulders was only observed on the bottom of the boulder (ANOVA: $F = 7.25$, $p < 0.05$).

Figure 16. Mean (± SE) of species richness on the top and bottom of 'Not turned' (NT) and 'Historically turned' (HT) boulders at west of Great Orme.



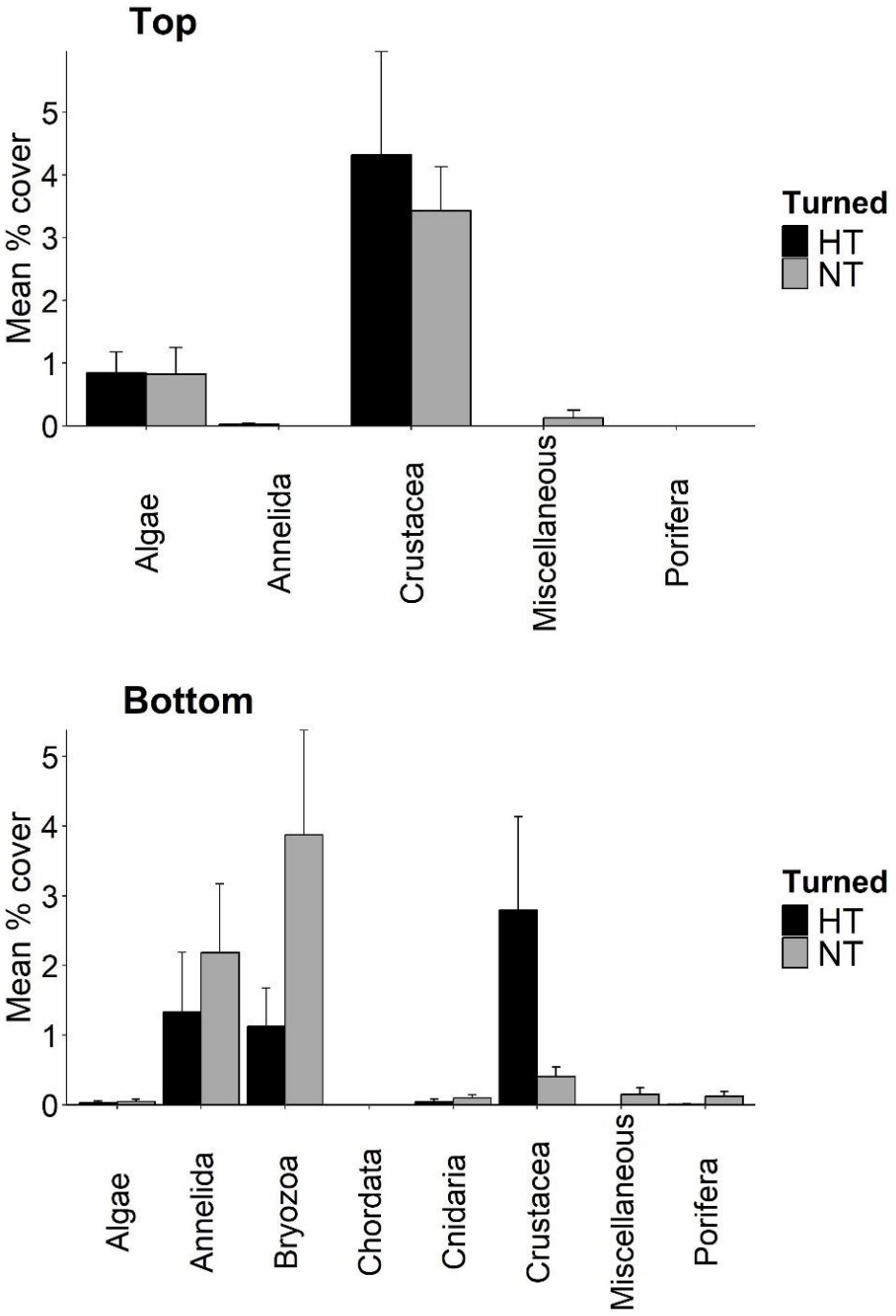
Average abundance, represented by different phyla on the top and bottom of boulders, between 'turned' categories (not turned vs historically turned) is shown in Figure 17. The relative abundances of most phyla appeared to be more prominent on the not turned boulders compared to historically turned boulders, particularly on the bottom of the boulders. For instance, abundance of molluscs on the bottom of not turned boulders were found to be significantly higher compared to historically turned boulders ($p < 0.05$). This was attributed to the mollusc species *Patella vulgata*, *Gibbula* sp. and *Littorina littorea* which were consistently found in the not turned boulders. In contrast, Cnidaria (i.e. *Actinia*) was found to be significantly higher in historically turned boulders ($p < 0.05$).

Figure 17. Mean (± SE) abundance of different taxonomic groups on the top and bottom of ‘Not turned’ (NT) and ‘Historically turned’ (HT) boulders between at west of Great Orme.



The percentage cover of encrusting species, represented by different phyla between not turned and historically turned boulders, is shown in Figure 18, with the top and underside of boulders analysed separately. Crustacea was the dominant phylum on the top side of boulders, showing a greater coverage in comparison to the remaining phyla, which was low (below 5% coverage). It was observed that barnacle species *Austrominius modestus* and *Semibalanus balanoides* contributed to the greater coverage of Crustacea. This faunal group had a greater coverage on the historically turned boulders both on the top and bottom surfaces, yet these differences were not found to be significant ($p > 0.05$).

Figure 18. Mean (± SE) percentage cover of different taxonomic groups on the top and bottom of 'Not turned' (NT) and 'Historically turned' (HT) boulders between at west of Great Orme.



Multivariate analyses were conducted to assess the long-term impacts on community structure. MDS plots for faunal abundance and percentage cover of taxa, with comparisons made between historically turned and not turned boulders on the top and bottom side of boulders, are presented in Figure 19 and Figure 20. Stress values from MDS plots ranged between 0.16-0.17 and suggest a moderate fit, hence, the plots provide a useful summary of the data but may not capture all the relationships between data points.

The nMDS plots show the community structure (including percentage cover and faunal abundance) show a clear separation of the historically turned boulders compared to the not turned boulders on both the top and bottom side of the boulder surfaces. PERMANOVA tests statistically validated these findings with faunal community composition (including percentage cover and faunal abundance), differing significantly between historically turned and not turned boulders. This was evident on the top ($p < 0.01$) and bottom side of boulders ($p < 0.01$). The only exception to this was faunal abundance on the top side of boulders, which was not significantly different between historically turned and not turned boulders ($p > 0.05$). Faunal community composition (including abundance and percentage cover) was also found to differ significantly between the top and bottom side of the boulder ($p < 0.01$), irrespective of boulder turning activities.

Figure 19. Non-metric MDS showing relationship between treatment (HT = historically turned and NT = not turned) and side of the boulder on the abundance of taxa at west of Great Orme.

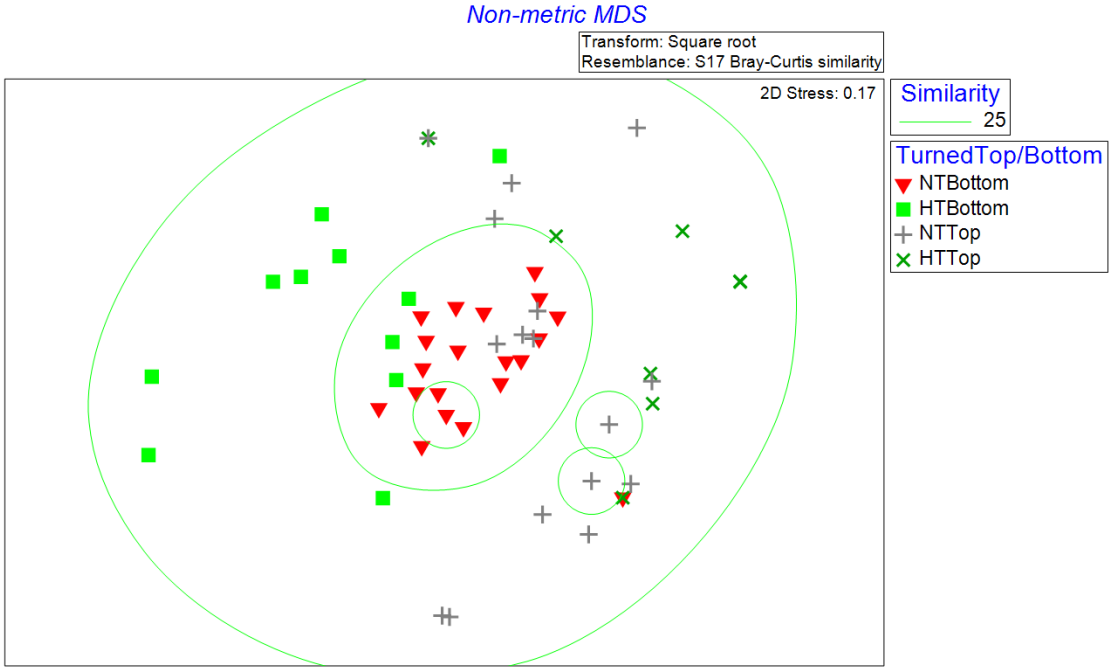
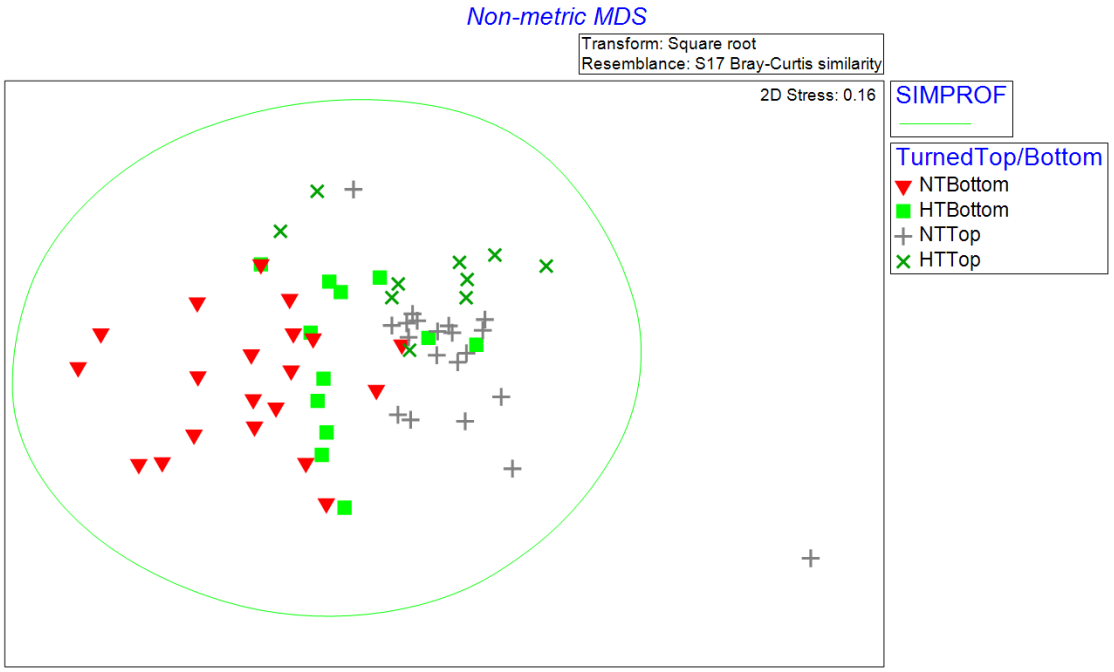


Figure 20. Non-metric MDS showing relationship between treatment (HT = historically turned and NT = not turned) and side of the boulder on the percentage cover of taxa at west of Great Orme.



SIMPER analysis was performed to identify characteristic taxa that contributed to the significant differences in community composition between different group types: HT-Bottom, HT-Top, NT-Bottom and NT-Top. The analysis assessed the average similarity within each group and determined which species were the primary drivers of the observed differences and these alongside the AMBI EG scores are shown in Table 7 and Table 8.

SIMPER corroborated the findings presented in the nMDS plots as the average dissimilarity between historically turned and not turned boulders ranged between 64-75% across both community datasets and boulder surfaces. On the top side of the boulder, differences in percentage cover were mainly attributed to the relatively greater presence of *S. balanoides* and *Fucus serratus* in historically turned boulders (Table 7), suggesting they appear to colonise in these disturbed environments.

On the bottom side of the boulder, percentage cover of *A. modestus* and *Spirobranchus* were more prevalent on the historically turned boulders, whereas *Spirobinae* and encrusting calcified Bryozoa were relatively greater on not turned boulders.

SIMPER analyses showed that differences in community abundance data were mainly attributed to the relatively greater presence of mollusc species *P. vulgata* and *Gibbula* sp. and Amphipoda on the not turned boulders (Table 8). This was evident on both top and bottom sides of boulders and suggests the potential sensitivity of the taxa to boulder-turning activities. This seems to align with the AMBI EG Scores, particularly for *P. vulgata* and *Gibbula* sp. (EG I) which were classified as a disturbance-sensitive species. The remaining taxa were classified as disturbance indifferent (EG II), with some (e.g. *Actinia*) having a relatively greater abundance on historically turned boulders.

Table 7. The dominant encrusting taxa (i.e. percentage cover) contributing to overall percentage dissimilarity between historically turned and not turned at west of Great Orme, as per SIMPER routine on square-root transformed percentage data.

Boulder	Species	AMBI EG Score	Mean Abundance: historically turned	Mean Abundance: not turned	% Dissimilarity	% Cumulative Contribution
Top	*Semibalanus balanoides*	I	3.53	2.43	18.47	29.01
Top	*Fucus serratus*	Not listed	2.62	0.14	16	54.13
Top	*Austrominius modestus*	II	2.07	2.9	14.9	77.54
Bottom	*Austrominius modestus*	II	2.36	0.79	20.52	28.31
Bottom	*Spirorbinae*	II	0.06	1.34	14.3	48.05
Bottom	*Bryozoa enc.*	II	0.63	1.26	14.09	67.49
Bottom	*Spirobranchus*	II	0.82	0.07	8.45	79.15

Table 8. The dominant mobile taxa (i.e. faunal abundance) contributing to overall percentage dissimilarity between historically turned and not turned at west of Great Orme, as per SIMPER routine on square-root transformed data.

Boulder	Species	AMBI EG Score	Mean Abundance: Historically turned	Mean Abundance: not turned	% Dissimilarity	% Cumulative Contribution
Top	*Patella vulgata*	I	0.38	0.85	17.34	22.9
Top	*Gibbula sp.*	I	0.34	0.79	17.23	45.66
Top	*Littorina littorea*	II	0.68	0.36	15.8	66.51
Top	*Littorina saxatilis*	II	0.25	0.41	11.63	81.88
Bottom	*Patella vulgata*	I	0.4	2.04	12.79	17.26
Bottom	*Amphipoda*	Not listed	0.76	1.15	9.45	30.01
Bottom	*Gibbula sp.*	I	1.31	2.02	9.28	42.53
Bottom	*Actinia*	II	1.22	0.17	8.89	54.52
Bottom	*Nucella lapillus*	Not listed	0.2	0.63	4.92	61.16
Bottom	*Littorina littorea*	II	0.09	0.49	3.92	66.46

Boulder	Species	AMBI EG Score	Mean Abundance: Historically turned	Mean Abundance: not turned	% Dissimilarity	% Cumulative Contribution
Bottom	*Littorina saxatilis*	II	0.09	0.55	3.92	71.75

3.1.1.3 Epifaunal community composition

To assess the broader site level impacts of boulder turning activities, the epifaunal community composition on all observed boulders, between control and impact areas were assessed. Across both control and impact areas at west of Great Orme a total of 44 individual taxa was recorded from the 40 boulders (top and bottom), 12 boulders classified as historically turned and 8 boulders classified as not turned from the impact area. The control area had 20 boulders classified as not turned.

Differences in species richness between control and impact areas is shown in Figure 21. Generally, species richness between impact and control areas was similar on either the tops or bottoms of the boulders, with no significant differences observed (ANOVA: $p > 0.05$). The abundance of crustaceans was elevated in impact areas compared to the control area on the bottom boulders (Figure 22), although this was not significant ($p > 0.05$). However, significant differences were observed in the abundance of miscellaneous taxa between control and impact areas on the bottom boulders ($p < 0.05$). It was found the abundance of the cnidarian *Actinia* contributed to the greater abundance in the impact area.

Percentage cover of the different taxa, as shown in Figure 23 indicated fanworm (included within Annelida) were only observed on the bottom of boulders and shared similar coverage between control and impact areas. In contrast, barnacles (included within Crustacea) had a greater coverage on the top side of boulders and appeared to be more prominent in the impact area on the top and bottom side of the boulders, although no differences were detected between control and impact area on either boulder surface ($p > 0.05$). At the west of Great Orme site, taxa including Porifera, Bryozoa and Chordata (miscellaneous) were found exclusively on the bottom of boulders.

Figure 21. Mean (± SE) of species richness on the top and bottom of boulders within impacted and control areas at west of Great Orme.

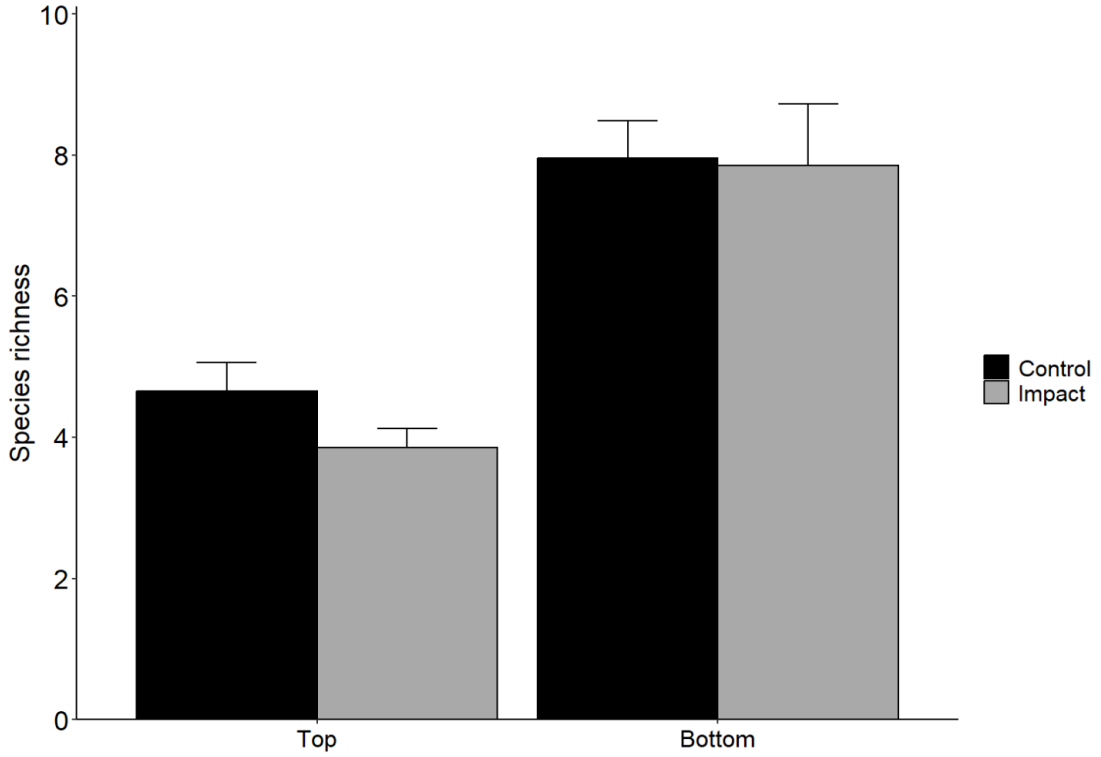


Figure 22. Mean (SE) abundance of different taxonomic groups on the top and bottom of boulders within impacted and control areas at west of Great Orme.

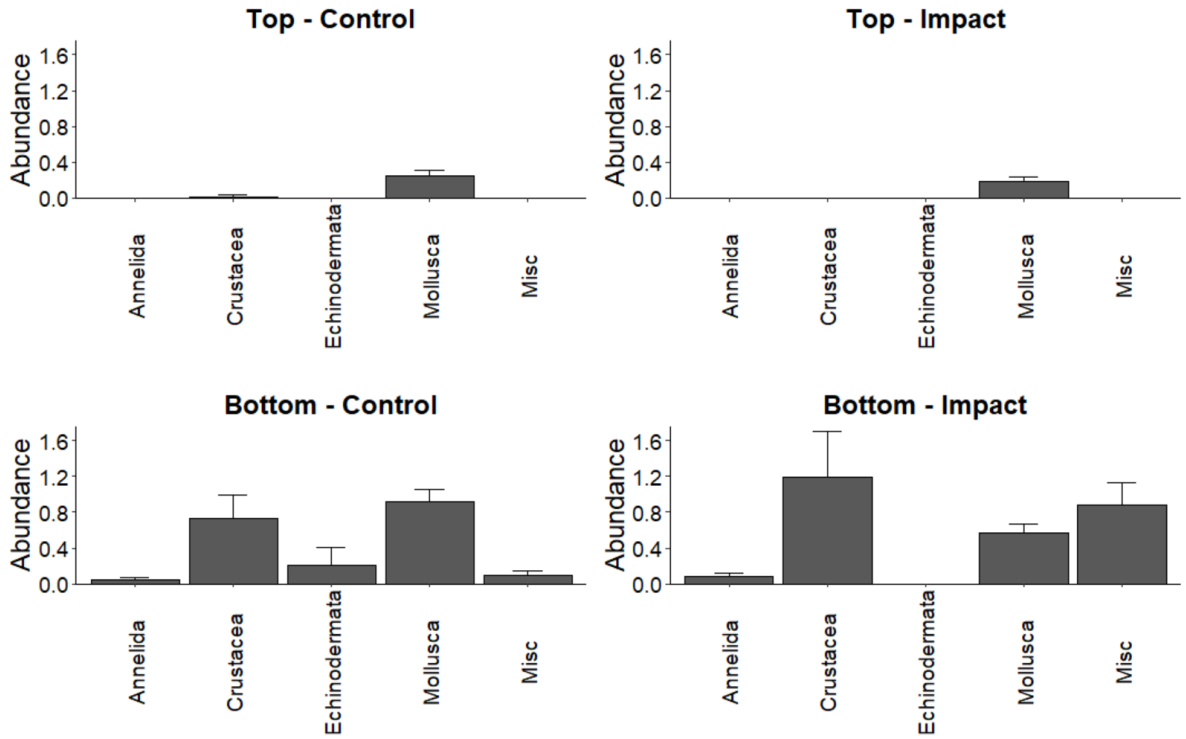
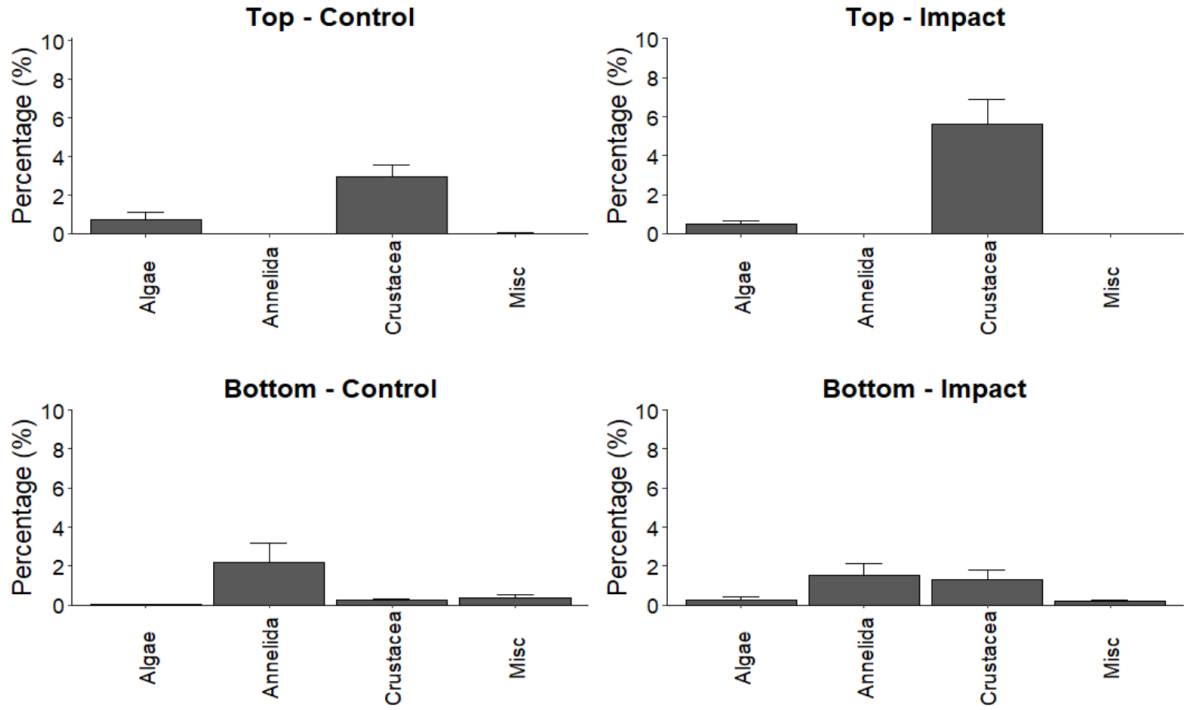


Figure 23. Mean (SE) percentage cover of different taxonomic groups on the top and bottom of boulders within impacted and control areas at west of Great Orme.



MDS plots for faunal abundance and percentage cover of taxa for each boulder are shown in Figure 24 and Figure 25. Stress values from MDS plots ranged between 0.16-0.18 suggesting a moderate fit, hence, the plots provide a useful summary of the data but may not capture all the relationships between data points.

The community structure (including both faunal abundance and percentage cover) on the top and bottom of boulders show visually that there are no clear differences between control and impact sites. However, there was minor separation between boulder bottoms between control and impact areas. PERMANOVA tests showed a significant interaction between treatment (control and impact) and side of the boulder (top and bottom) on both the abundance ($p < 0.01$) and percentage cover ($p < 0.01$) of taxa. The results indicated that significant differences in community abundance and percentage cover were observed between control and impact areas on the bottom side of the boulders. Similar results were found for the top side of the boulders. In addition, the differences in faunal community were more pronounced when comparing the top and underside of the boulders than comparing control and impact areas.

The inter-sample variability within each group for the abundance data is moderate, particularly for bottom boulders at the impact area (Figure 24). This indicates the faunal assemblages within this group are relatively heterogeneous and are not similar in terms of community structure. Further analysis revealed that the small cluster of boulders (bottom side of boulder) from the impact area had fewer taxa and lower abundance compared to the other samples.

SIMPER analysis was conducted to identify the species contributing most to the dissimilarity in species composition between different group types: Control-Top, Impact-Top, Control-Bottom, and Impact-Bottom. The analysis assessed the average similarity within each group and determined which species were the primary drivers of the observed differences and these alongside the AMBI EG scores are shown in Table 9 and Table 10. The differences in Crustacea and Mollusca groups identified in Figure 22 and Figure 23 were apparent in the SIMPER analysis for faunal percentage cover. Impact areas (both top and bottom of boulders) tended to have higher percentage covers of *A. modestus* and *S. balanoides* compared to the control areas (Table 9). This difference contributed towards a significant portion of the dissimilarity. Control areas show higher percentage cover of *Spirorbinae* and encrusting calcified Bryozoa.

For community abundance data, Amphipoda and *P. vulgata* were significant contributors to the dissimilarity of the bottom of boulders between impact and control areas as well as Actinia and *Gibbula* sp (Table 10). Impact areas had more Amphipoda and *Actinia* on the bottom of the boulders, while in the control areas *P. vulgata* and *Gibbula* sp. and *Littorina saxatalis* were key species contributing to the dissimilarity on the top of boulders between impact and control areas with higher abundance of both *P. vulgata* and *Gibbula* sp. in the impacted areas.

Figure 24. Non-metric MDS showing relationship between treatment (control and impact) and side (top and bottom) of the boulder on the abundance of taxa at west of Great Orme.

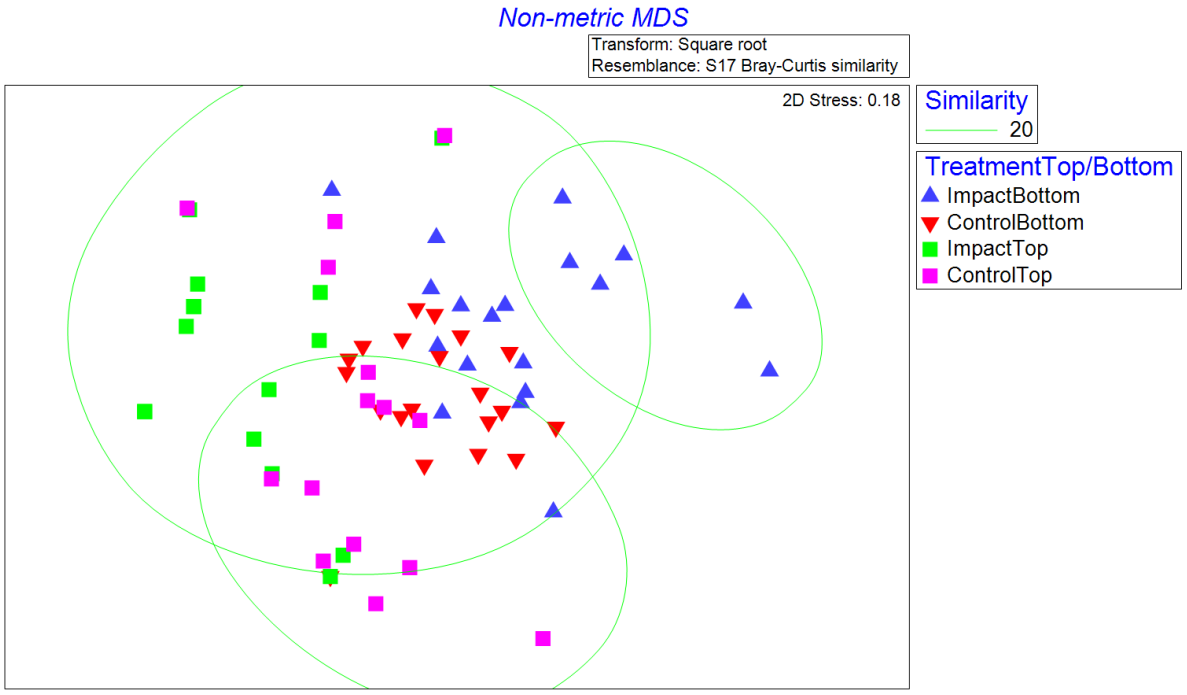


Figure 25 Non-metric MDS showing relationship between treatment (control and impact) and side (top and bottom) of the boulder on the percentage cover of taxa at west of Great Orme.

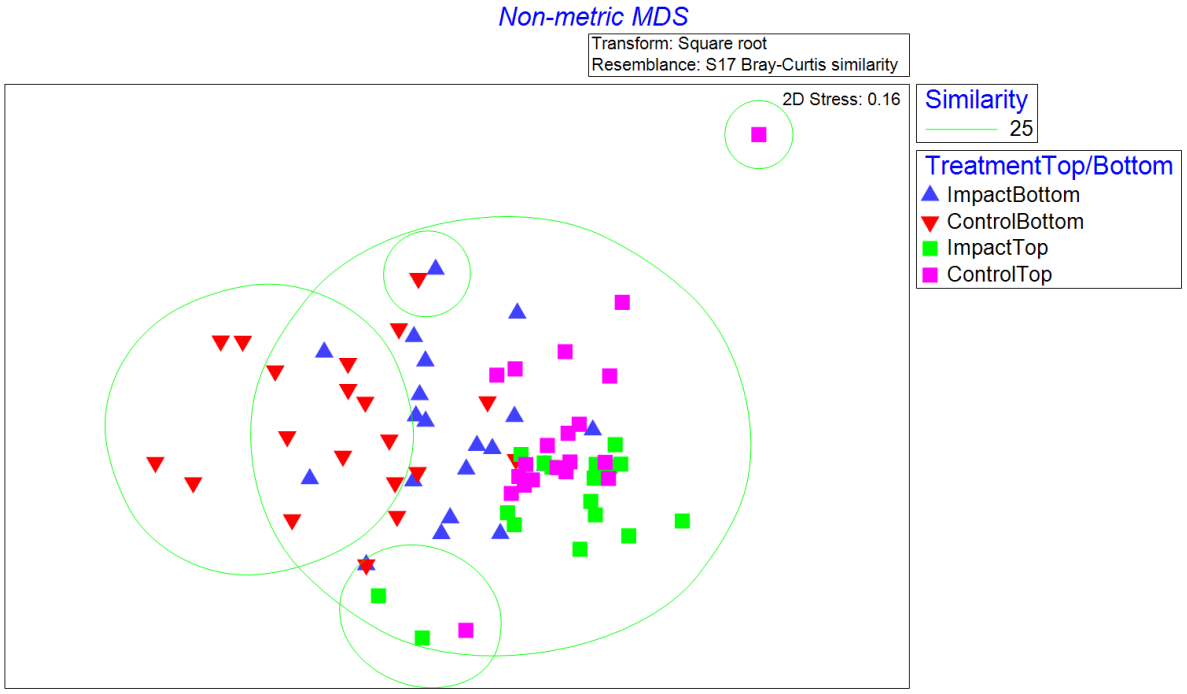


Table 9. The dominant encrusting taxa (percentage cover) contributing to overall percentage dissimilarity between control and impact areas at west of Great Orme, as per SIMPER routine on ASIN transformed percentage data.

Boulder	Species	AMBI EG Score	Mean Abundance: Impact	Mean Abundance: Control	% Dissimilarity	% Cumulative Contribution
Top	*Austrominius modestus*	II	2.12	0.79	16.48	23.22
Top	*Spirorbinae*	II	0.39	1.34	14.02	42.98
Top	*Bryozoa enc.*	II	0.89	1.26	13.66	62.23
Top	*Semibalanus balanoides*	I	0.88	0.38	9.03	74.97
Bottom	*Semibalanus balanoides*	I	4.66	2.43	20.07	35.32
Bottom	*Austrominius modestus*	II	2.94	2.9	13.85	59.69
Bottom	*Fucus serratus*	Not listed	1.46	0.14	9.28	76.02

Table 10. The dominant mobile taxa (faunal abundance) contributing to overall percentage dissimilarity between control and impact areas at west of Great Orme, as per SIMPER routine on square-root transformed data.

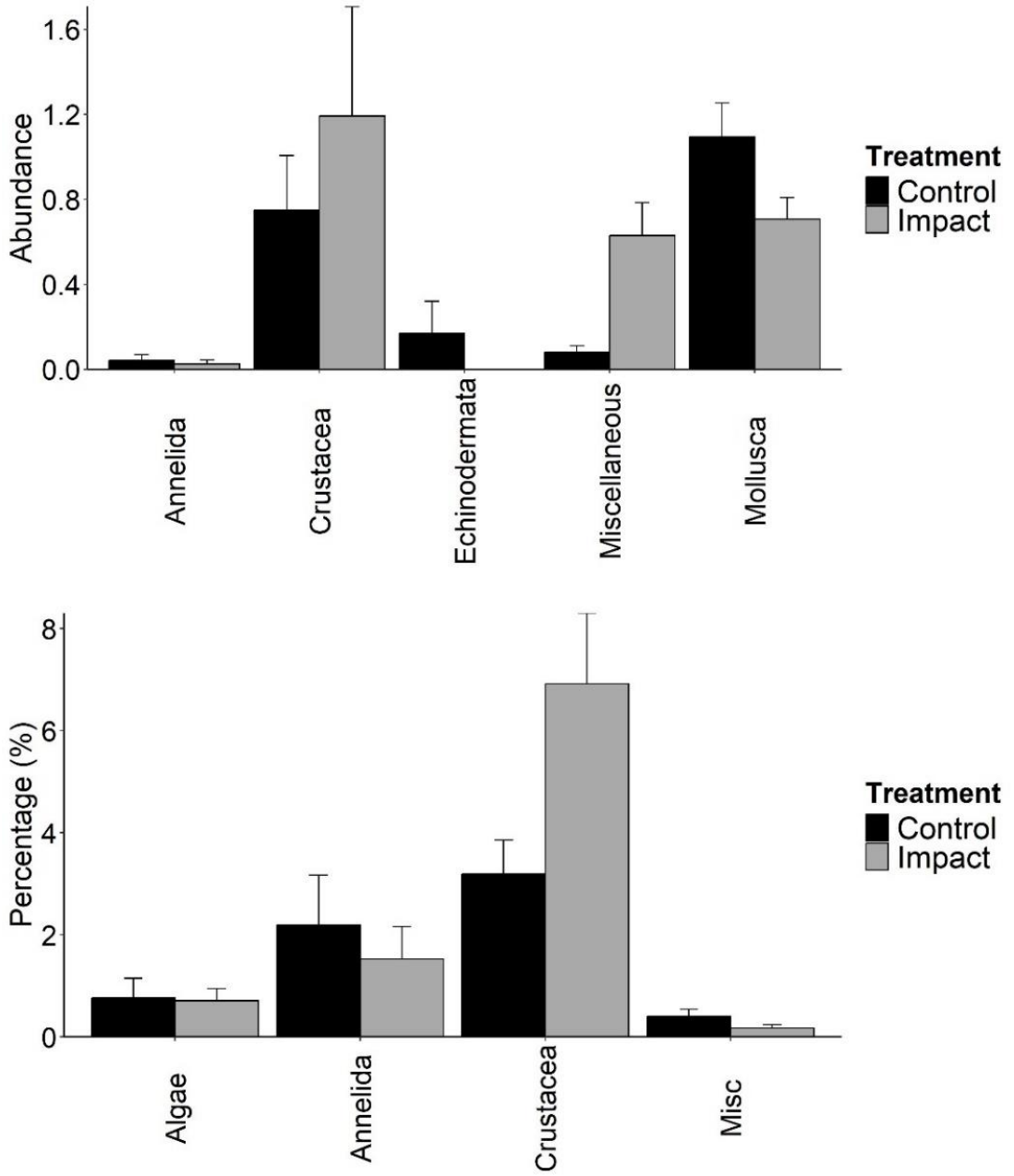
Boulder	Species	AMBI EG Score	Mean Abundance: Impact	Mean Abundance: Control	% Dissimilarity	% Cumulative Contribution
Top	*Littorina littorea*	II	0.91	0.41	18.24	24.35
Top	*Patella vulgata*	I	0.48	0.85	16.08	45.81
Top	*Gibbula sp*	I	0.25	0.79	14.71	65.45
Top	*Littorina saxatilis*	II	0.68	0.36	13.85	83.93
Bottom	*Amphipoda*	Not listed	1.6	1.15	10.42	15.59
Bottom	*Patella vulgata*	I	0.98	2.04	9.36	29.59
Bottom	*Actinia*	II	1.48	0.17	8.65	42.54
Bottom	*Gibbula sp*	I	1.55	2.02	7.42	53.64
Bottom	*Nucella lapillus*	Not listed	0.42	0.63	4.38	60.19
Bottom	*Littorina littorea*	II	0.43	0.49	4.13	66.37
Bottom	*Littorina saxatilis*	II	0.43	0.55	4.1	72.51

To further assess the impacts of boulder turning at the wider site level (control vs impact), the epifauna on the top and bottom of boulders were combined within the analysis (and

effectively assumed to form a single epifaunal community). This approach aimed to address the interchanging of boulder tops and bottoms as a result of boulder turning activity. As part of this assessment and to provide a true reflection of boulder turning impacts, only not turned boulders in the control area were included within analysis to examine differences in community composition. Mean abundance and percentage cover of different phyla is presented in Figure 26. No discernible differences in epifaunal abundance (across all taxonomic groups) were detected between control and impact areas ($p > 0.05$). The abundance of amphipods (included within Crustacea) and cnidarian *Actinia* (included within Miscellaneous) were higher in the impact area compared to the controls. In contrast, molluscs (including *Gibbula* sp., *P. vulgata* and *L. saxatalis*) were more abundant in the control area. However, no significant differences in epifaunal abundance were observed between the control and impact area for any individual phyla ($p > 0.05$).

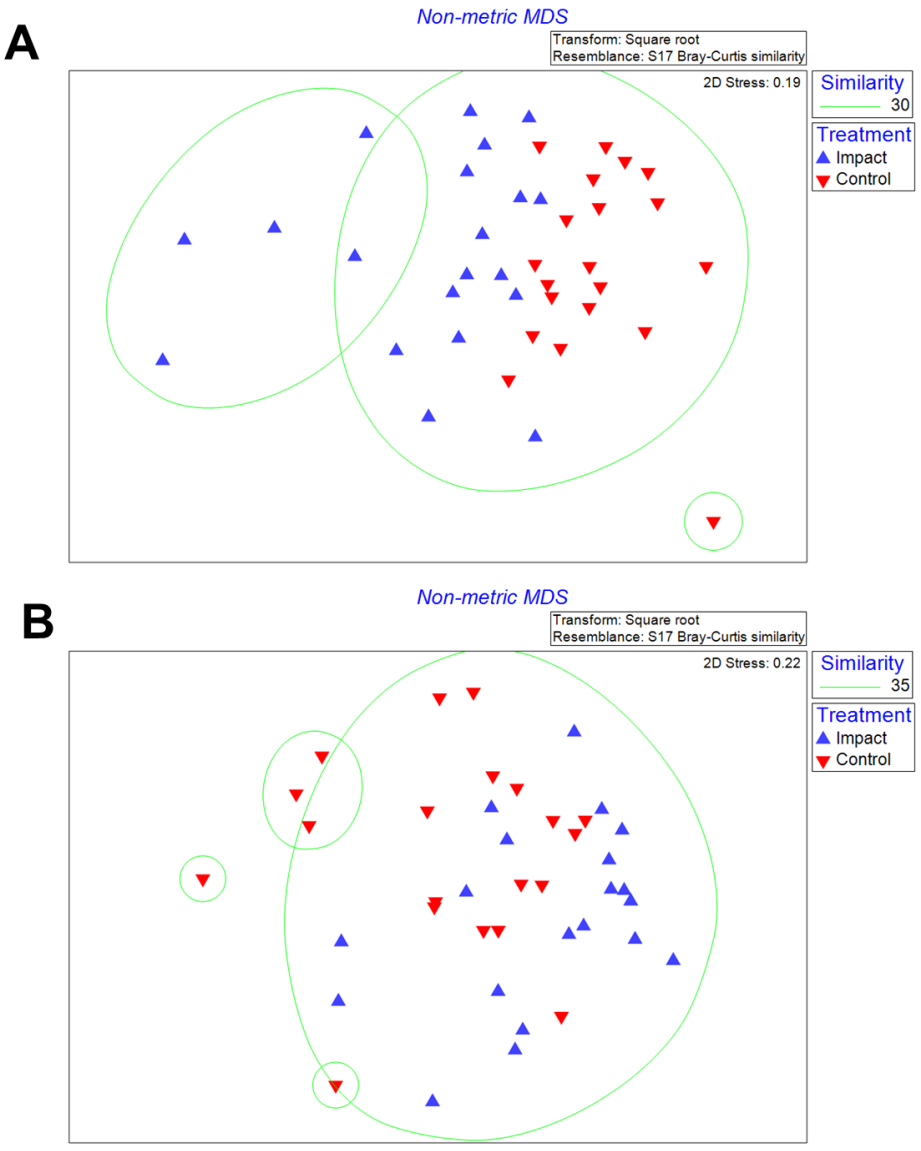
Percentage cover of encrusting fauna (across all taxonomic groups) overall was found to be significantly higher in the impact area compared to control ($p < 0.01$). Barnacles *A. modestus* and *S. balanoides* (included within Crustacea) was the only phylum that had a significantly higher coverage on boulders within the impact area compared to the control area ($p < 0.001$).

Figure 26. Mean (SE) abundance (top) and percentage cover (bottom) of different taxonomic groups present on boulders within impacted and control areas at west of Great Orme.



MDS plots for faunal abundance and percentage cover of epifaunal taxa on the entire boulder are shown in Figure 27. Stress values from the MDS plots ranged between 0.19-0.22 suggesting the arrangement of points in the plot provides a reasonable assessment but does not accurately reflect the true distances or dissimilarities among the data points in two-dimensional space, and interpretations should be made with caution.

Figure 27. Non-metric MDS showing relationship between treatment (control and impact) on the abundance (A) and percentage cover (B) of taxa at west of Great Orme.



The community structure of the faunal abundance data shows a separation between control and impact areas. The results of the ANOSIM test supported these findings where significant differences between control and impact areas were observed with some overlap ($R = 0.241$, $p < 0.01$). SIMPER analyses demonstrated characteristic taxa which included *P. vulgata*, *Gibbula* sp. and *Actinia,* of which the mollusc species were prevalent in the control area whereas the cnidarian *Actinia* was relatively more abundant in the impact area.

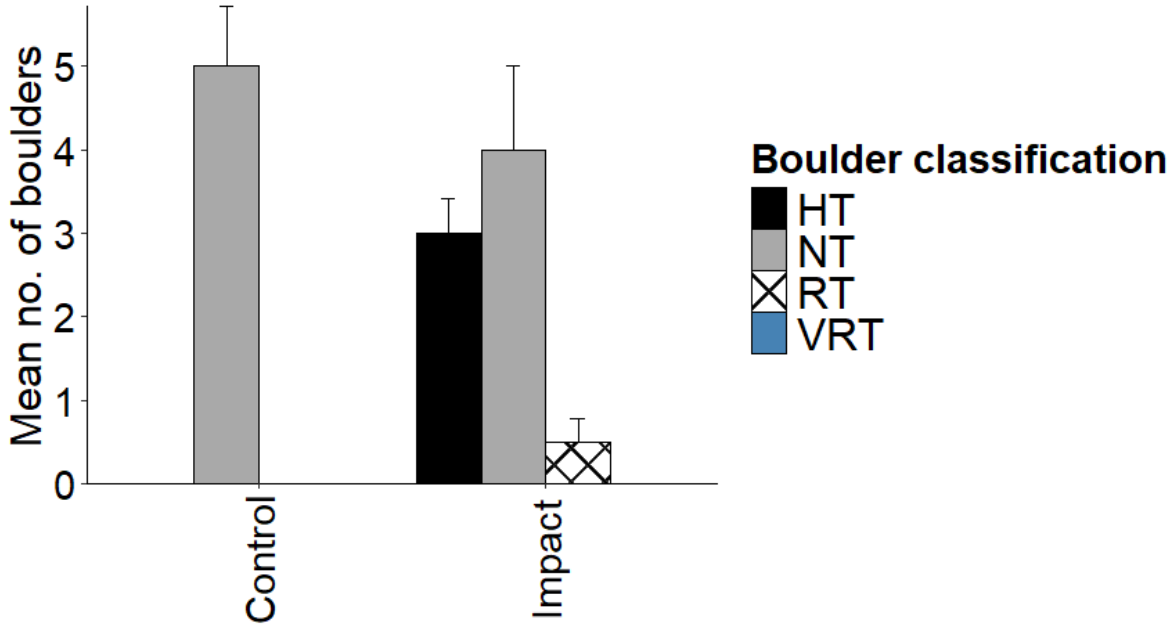
Conversely, the community structure from the percentage cover data indicated an overlap between control and impact areas. This was corroborated by the ANOSIM analysis ($R = 0.144$, $p < 0.01$) which indicated the encrusting faunal community was highly similar between control and impact areas with some differences. SIMPER analyses indicated that barnacles *S. balanoides* and *A. modestus* and *F.* serratus were relatively more abundant in the impact area. Conversely encrusting calcified Bryozoa and *Spirobinae* were prevalent in the control area.

3.1.2 Penmon-Beaumaris

3.1.2.1 Boulder turning activity

Boulder turning activity was observed at Penmon-Beaumaris, with greater intensity in the impact area (Figure 28). While most turned boulders were historically turned, there was some evidence of recent boulder turning. Since the survey was conducted in March, before the main activity of the season had begun, any recently turned boulders would likely date back to the previous autumn. Within the impact area, on average 7 % of boulders recorded along each transect were classified as recently turned, 40 % as historically turned and the remainder classified as not turned. The control area showed no evidence of boulder turning and consisted only of unturned boulders. Thus, the control site is considered to provide an appropriate control/ baseline to enable a comparison of potential impacts. Despite the levels of boulder turning observed, the analyses conducted in the following sections has compared turned and unturned boulders to determine any evidence of impacts from boulder turning activities.

Figure 28. Mean (± SE) number of boulders by category (HT = Historically turned, NT = Not turned, RT = Recently turned and VRT = Very recently turned) per area, observed across transects on the mid/low shore at Penmon-Beaumaris.



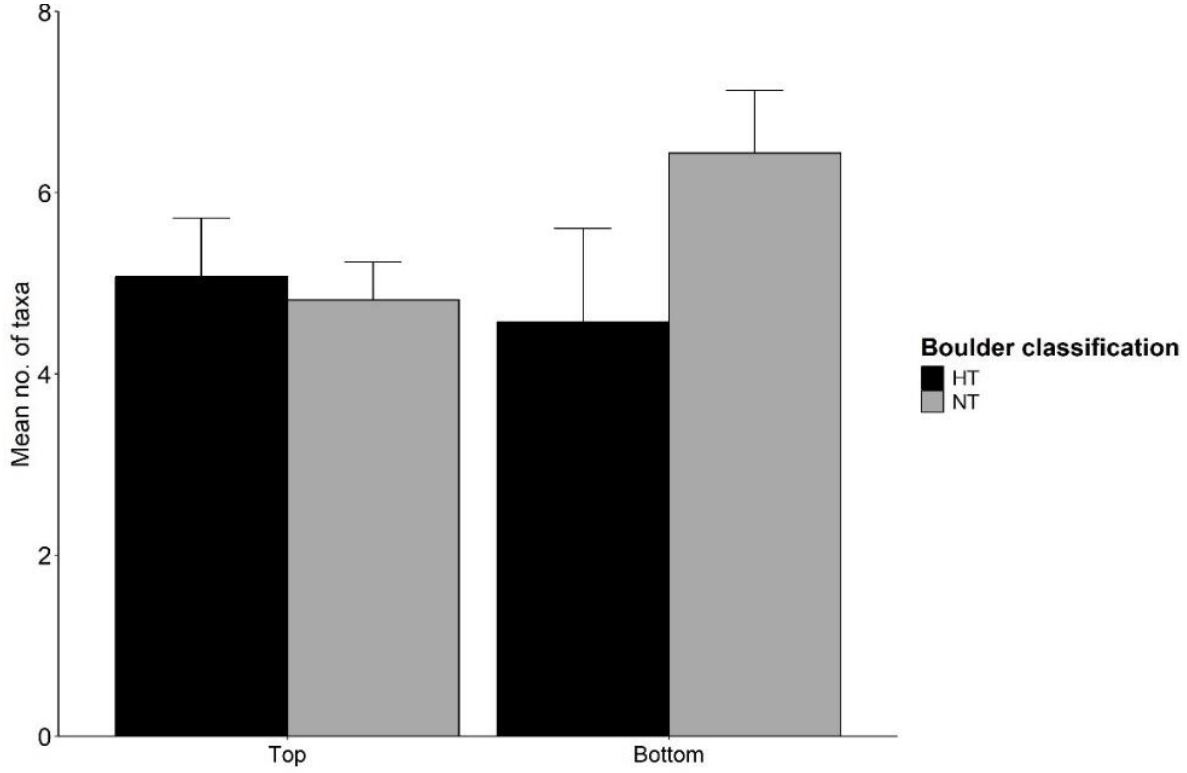
3.1.2.2 Turned or not turned boulders

To provide a true assessment of boulder turning impacts, between impact and control areas, only the turned boulders in the impact area, and not turned boulders in the control area were included in analysis within this section to examine differences in community composition. Comparisons of faunal abundance and community composition between historically turned and not turned boulders (across control and impact areas) were conducted to assess the long-term impacts of boulder turning. Despite evidence of recent boulder-turning activities (observed from three boulders within the impact area: two classified as recently turned and one as very recently turned), these boulders were excluded from the statistical analyses due to low replication. This exclusion was also to

avoid confounding effects from long-term impacts. Instead, a qualitative description of the fauna present on the recently turned boulders is provided in Section 3.1.2.3.

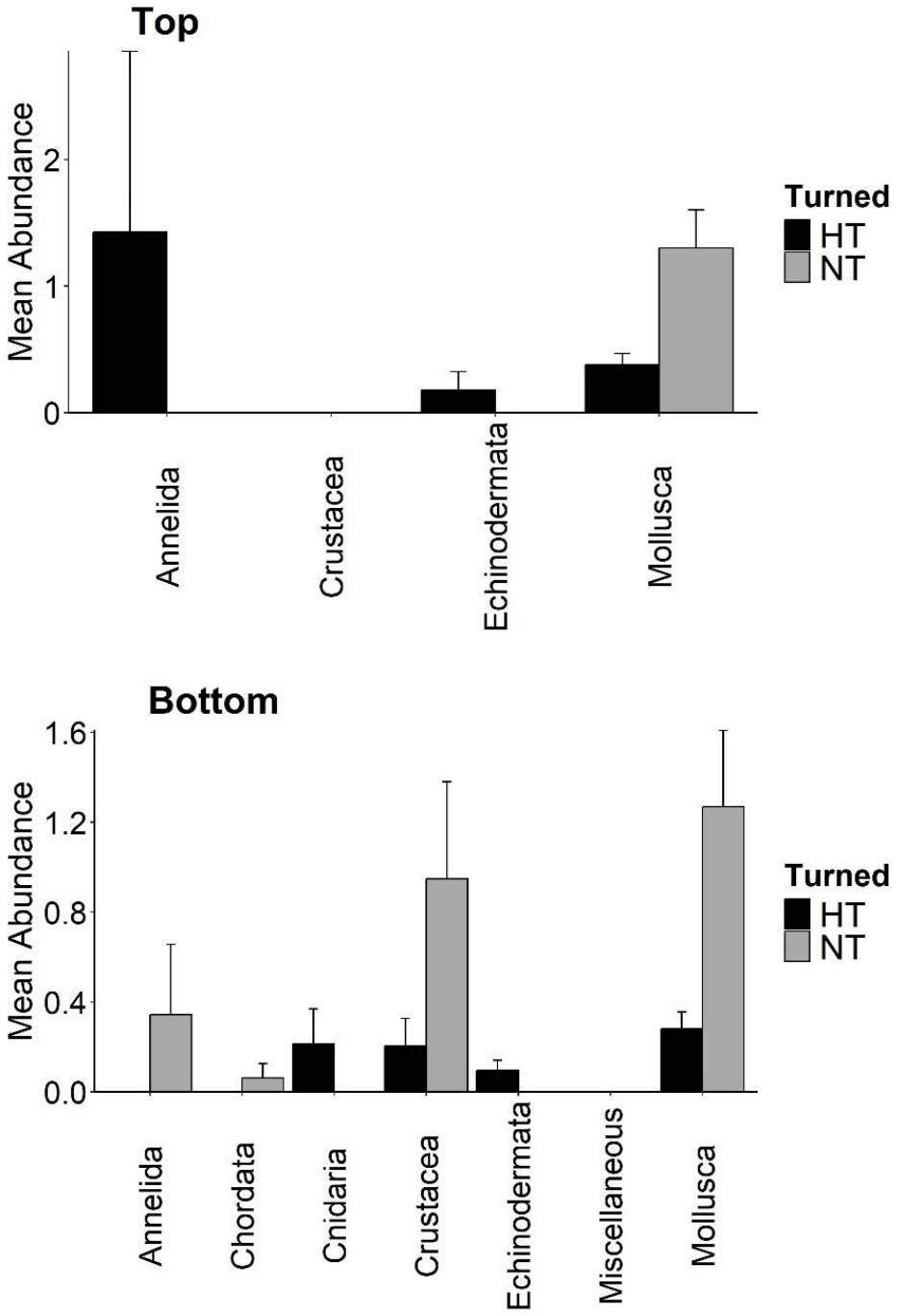
Differences in species richness between historically turned and not turned boulders (top and bottom of boulders) is shown in Figure 29. On the top side of the boulder, species richness was found to be relatively similar between historically turned and unturned boulders. In contrast, taxonomic richness was observed to be higher in the not turned boulder category on the bottom side of boulder, however, this was not significant (ANOVA: $F = 2.37$, $p > 0.05$).

Figure 29. Mean (± SE) of species richness on the top and bottom of 'Recently turned' (RT) 'Historically turned' (HT) and 'Not turned' (NT) at Penmon-Beaumaris.



The abundance of phyla represented on the top and bottom of boulders between different levels of turning (not turned vs historically turned) is shown in Figure 30. The diversity of phyla on the top boulders was limited, of which Annelida and Molluscs dominated. Molluscs on both the top and bottom boulders were relatively abundant on the not turned boulders. On the top side of not turned boulders, mollusc species *L. littorea* were prevalent. On the bottom of not turned boulders, species of *Anomiidae* and *Gibbula* sp. were more abundant. The abundance of molluscs on the not turned boulders was significantly higher compared to historically turned boulders ($p < 0.01$). Crustaceans (mainly amphipods) displayed similar patterns on the bottom boulders and were more abundant on not turned boulders, but this was not significant ($p > 0.05$). Taxa belonging to Cnidaria (i.e. *Actinia*) and Echinodermata (*Asteria rubens* and sea urchin) had a greater abundance on historically turned boulders, but none of these were significant ($p > 0.05$).

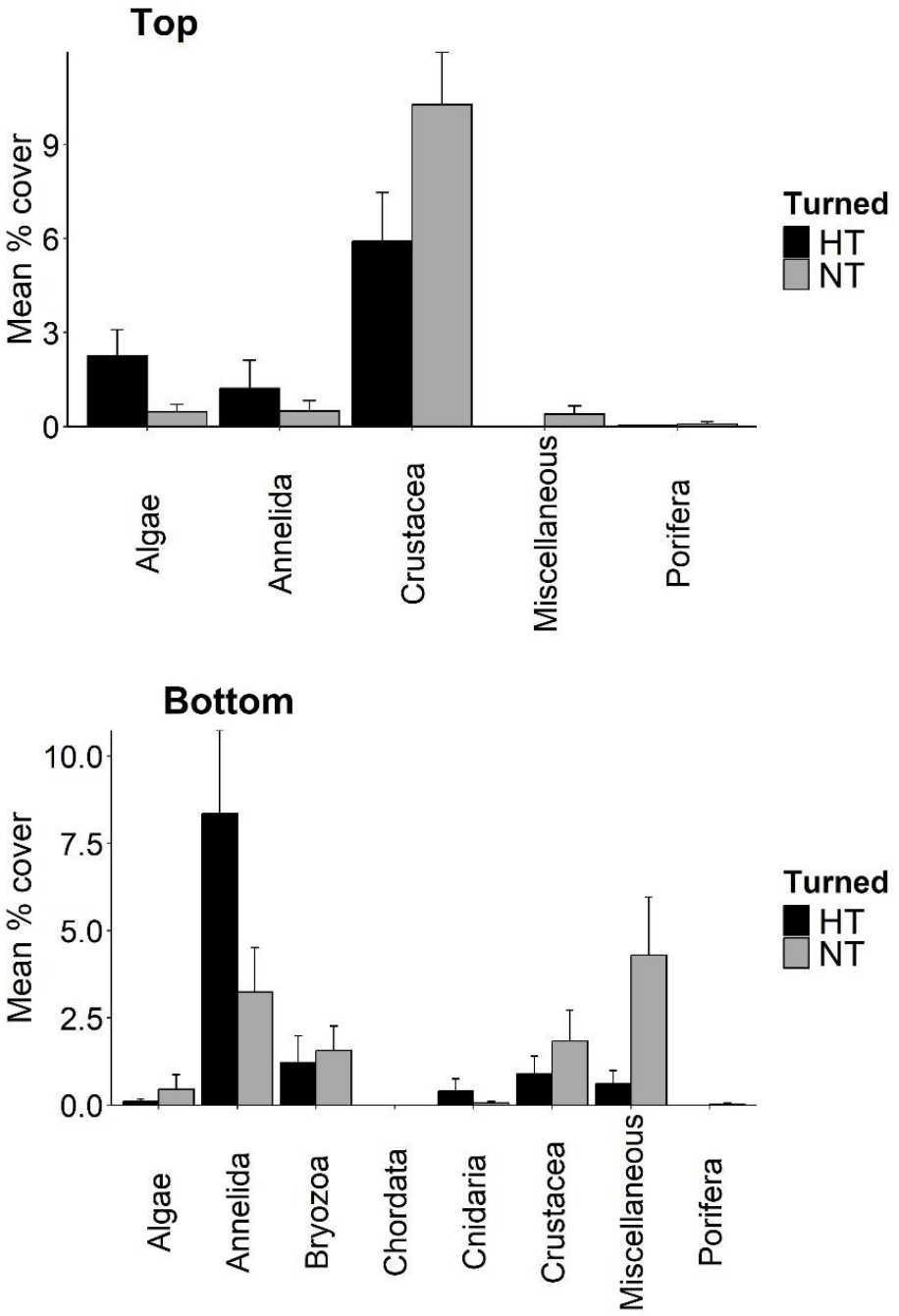
Figure 30. Mean (± SE) abundance of different taxonomic groups on the top and bottom of 'Not turned' (NT) and 'Historically turned' (HT) boulders between at Penmon-Beaumaris.



The percentage cover of encrusting species, represented by different phyla between not turned and historically turned boulders, is shown in Figure 31 with the top and underside of boulders analysed separately. On the top side of the boulder, crustaceans (barnacles *A. modestus* and *S. balanoides*) dominated the other phyla. In addition, crustacea was the only phylum (except for miscellaneous) that was more prevalent on the not turned boulders compared to the other taxa which had a greater coverage on historically turned boulders. The high coverage of crustaceans on not turned boulders was found to be significant ($p < 0.05$). Algal species (encrusting *Corallinacea* and *Fucus serratus*) and Annelida (tubeworm

Spirorbinae) had a greater coverage on historically turned boulders compared to not turned boulders, but these were not significant ($p > 0.05$).

Figure 31. Mean (± SE) percentage cover of different taxonomic groups on the top and bottom of 'Not turned' (NT) and 'Historically turned' (HT) boulders between at Penmon-Beaumaris.



The nMDS plots for faunal abundance and percentage cover of taxa with comparisons made between historically turned and not turned boulders on the top and bottom side of boulders are presented in Figure 32 and Figure 33. Stress values from MDS plots ranged between 0.12-0.13 and suggest a reasonably moderate fit.

Figure 32. Non-metric MDS showing relationship between treatment (HT = historically turned and NT = not turned) and side of the boulder on the abundance of taxa at Penmon-Beaumaris.

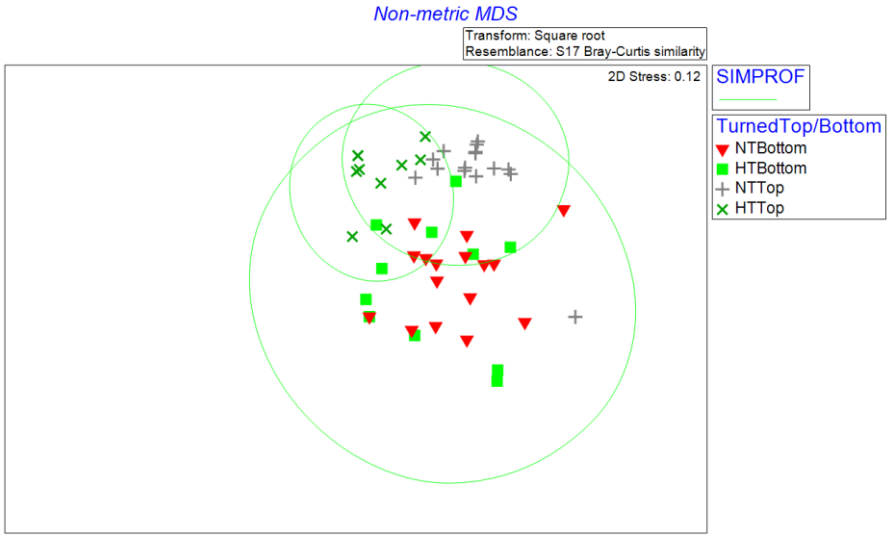
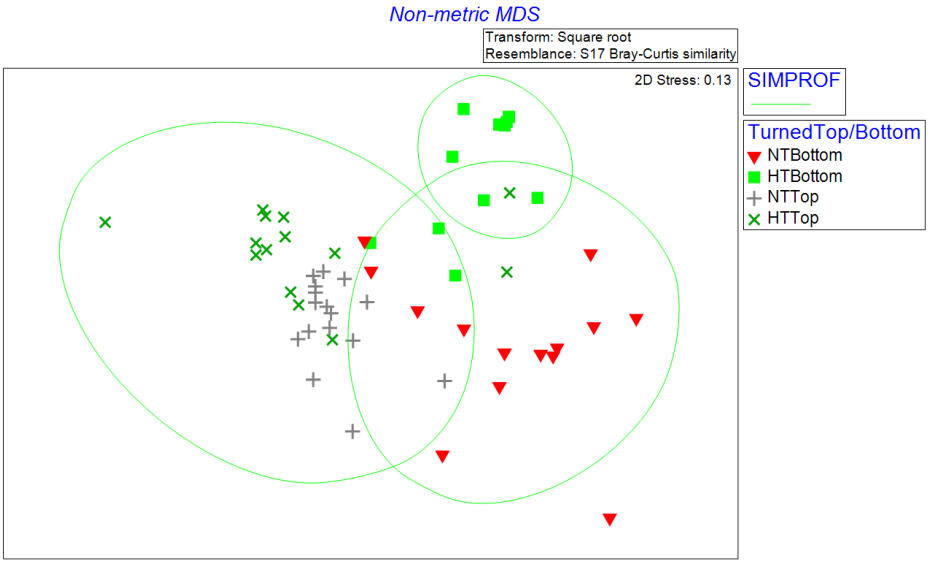


Figure 33. Non-metric MDS showing relationship between treatment (HT = historically turned and NT = not turned) and side of the boulder on the percentage cover of taxa at Penmon-Beaumaris.



Annelida was the dominant phylum on the bottom of boulders. Annelids *Spirorbinae* and the fanworm *Spirobranchus* were the main taxa observed and were more prevalent on the historically turned boulders, but this difference was not significant ($p > 0.05$). Taxa belonging to Bryozoa and miscellaneous (mainly *Nucella lapillus* eggs) had a greater coverage on not turned boulders, but neither were found to be significant ($p > 0.05$).

However, the exception was faunal abundance on the top side of the boulders as no significant differences were observed between historically turned and not turned boulders ($p > 0.05$). This was mainly attributed to a historically turned boulder replicate, which had a single taxa (*L. littorea*) present. Faunal community composition (including abundance and percentage cover) was also found to differ significantly between the top and bottom side of the boulder ($p < 0.01$), irrespective of boulder turning activities.

SIMPER analysis was performed to identify characteristic taxa that contributed to the significant differences in community composition between different group types: HT-

Bottom, HT-Top, NT-Bottom and NT-Top. The analysis assessed the average similarity within each group and determined which species were the primary drivers of the observed differences, and these alongside the AMBI EG scores are shown in Table 11 and Table 12.

Table 11. The dominant encrusting taxa (percentage cover) contributing to overall percentage dissimilarity between historically turned and not turned at Penmon-Beaumaris, as per SIMPER routine on square-root transformed percentage data.

Boulder	Species	AMBI EG Score	Mean Abundance: Historically turned	Mean Abundance: Not turned	% Dissimilarity	% Cumulative Contribution
Top	*Austrominius modestus*	II	1.1	4.32	16.59	24.57
Top	*Semibalanus balanoides*	I	4.47	4.12	13.8	45.01
Top	*Fucus serratus*	Not listed	2.18	0	10.32	60.3
Top	*Fucoid sporelings*	Not listed	1.34	0	5.12	67.88
Top	*Corallinacea enc.*	Not listed	0.33	0.56	3.37	72.87
Bottom	*Spirorbinae*	II	3.94	0.28	36.6	40.41
Bottom	*Spirobranchus*	II	0	1.86	15.63	57.67
Bottom	*Semibalanus balanoides*	I	0.58	1.16	9.83	68.52
Bottom	*Bryozoa enc.*	II	0.57	0.89	8.56	77.97

Table 12. The dominant mobile taxa (faunal abundance) contributing to overall percentage dissimilarity between historically turned and not turned at Penmon-Beaumaris, as per SIMPER routine on square-root transformed data.

Boulder	Species	AMBI EG Score	Mean Abundance: historically turned	Mean Abundance: not turned	% Dissimilarity	% Cumulative Contribution
Top	*Littorina littorea*	II	0.47	2.4	39.54	39.54
Top	*Patella vulgata*	I	1.12	0.32	20.84	60.38
Top	*Nucella lapillus*	Not listed	0.34	0.63	12.12	72.5
Bottom	*Amphipoda*	Not listed	0.73	1.37	18.93	18.93
Bottom	*Gibbula sp.*	I	1.03	2.04	18.53	37.46
Bottom	*Anomiidae*	I	0.25	1.48	12.93	50.39
Bottom	*Littorina littorea*	II	0.47	0.47	7.86	58.25
Bottom	*Nucella lapillus*	Not listed	0.53	0.3	6.93	65.17
Bottom	*Littorina saxatilis*	II	0.09	0.4	6.34	71.51

SIMPER corroborated the findings presented in the nMDS plots as the average dissimilarity between historically turned and not turned boulders ranged between 68-91% across both community datasets and boulder surfaces. On the top side of the boulder, differences in percentage cover were mainly attributed to the relatively greater presence of *A. modestus* and encrusting *Corallinacea* on not turned boulders. Conversely, taxa like *F. serratus* and fucoid sporelings had relatively greater abundance on historically turned boulders. Similar patterns were observed on the bottom of boulders where the percentage cover of *Spirorbinae* was more prevalent on historically turned boulders. Barnacles *S. balanoides* appear to be evenly distributed across the boulders on both the top and bottom surfaces, despite being classed as disturbance-sensitive (EG I).

Differences in community abundance data were mainly attributed to the relatively greater abundance of *L. littorea* (on the top side of boulder) and Amphipoda, *Gibbula* sp. and Anomiidae (bottom side of boulder) on not turned boulders, which suggests their potential sensitivity to boulder turning activities. This seems to align with the AMBI EG Scores, particularly for *Anomiidae* and *Gibbula* sp. (EG I) which were classified as a disturbance-sensitive species.

3.1.2.3 Epifaunal community composition

To evaluate the wider site-level effects of boulder turning activities, the composition of the epifaunal community on all observed boulders was compared between control and impact areas. Penmon-Beaumaris was an algal dominated site. A total of 51 individual taxa were recorded from the 40 boulders (top and bottom) at Penmon-Beaumaris across both control and impact areas. Within the impact area, 14 boulders were classified as historically

turned, 3 as not turned, 2 as recently turned and a single boulder was classified as very recently turned. In the control area, 16 boulders were classified as not turned and 4 as recently turned.

Recently turned boulders indicated a similar taxonomic richness on either side of the boulders (average of 5-6 taxa), yet the relative percentage cover of taxa was greater on the top side of the boulder, particularly for encrusting *Corallinacea* and annelids (*Spirobranchus* and *Spirobinae*). Barnacles were present on the top side of the boulder, but there was a greater presence of dead barnacles. Mobile taxa were reportedly low in abundance (less than 5 individuals) and were not diverse. A single boulder that was classified as very recently turned had a greater diversity of taxa and abundance on the top side of the boulders, with a greater proportion of live barnacles in comparison to dead barnacles. Molluscs and echinoderms were more prominent on the top side compared to the bottom.

Differences in species richness between control and impact areas is shown in Figure 34. Diversity of taxa was more prominent in the control area, particularly on the bottom of boulders, however, no significant differences were observed between control and impact areas on either boulder surface (ANOVA: $F = 2.55$, $p > 0.05$).

Mean abundance of different taxa is presented in Figure 35. Molluscs were found to be highly abundant on the top and bottom of boulder surfaces and were prominent in the control areas (mainly *Anomiidae* and *Gibbula* sp.). Notably, their abundance on the bottom of boulders was statistically significant ($p < 0.05$). Crustaceans (primarily amphipods) were also highly abundant in the control areas compared to impact on the bottom boulders, however this was not significant ($p > 0.05$).

Figure 34. Mean (± SE) of species richness on the top and bottom of boulders within impacted and control areas at Penmon-Beaumaris.

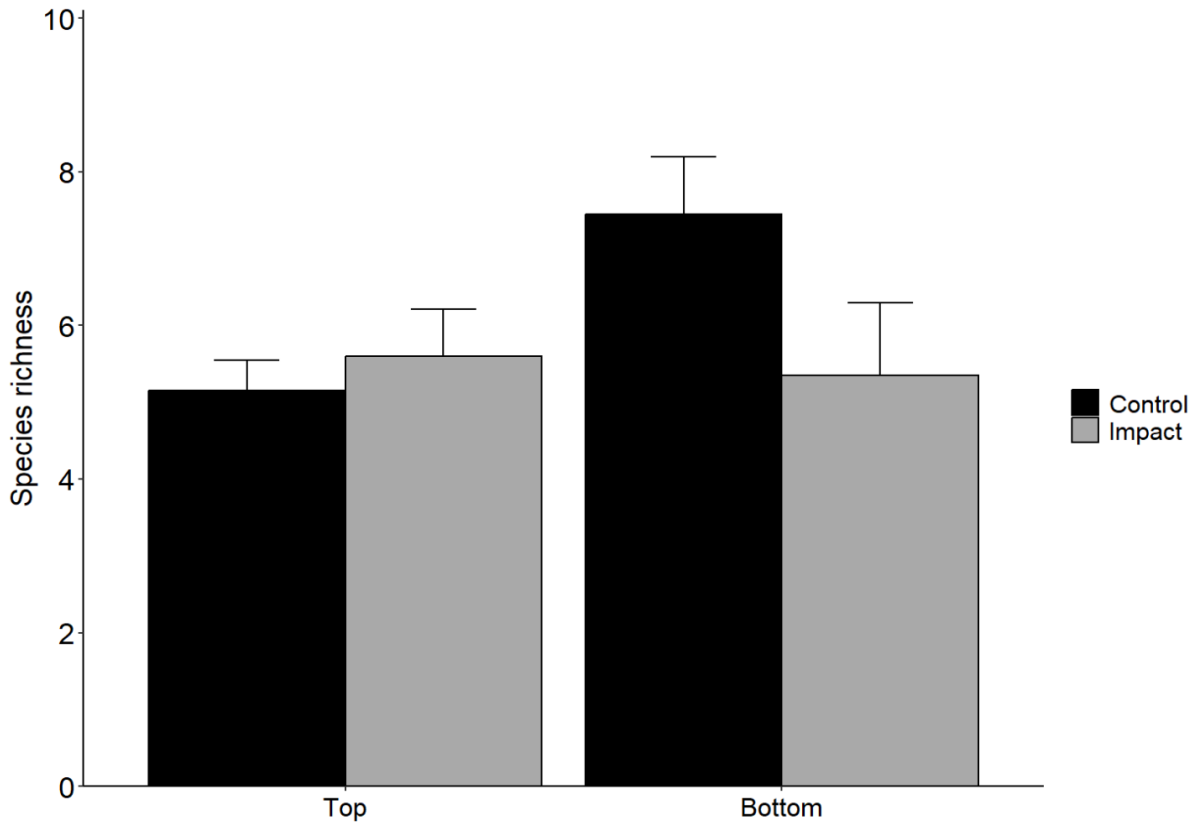


Figure 35. Mean (SE) abundance of different taxonomic groups on the top and bottom of boulders within impacted and control areas at Penmon-Beaumaris.

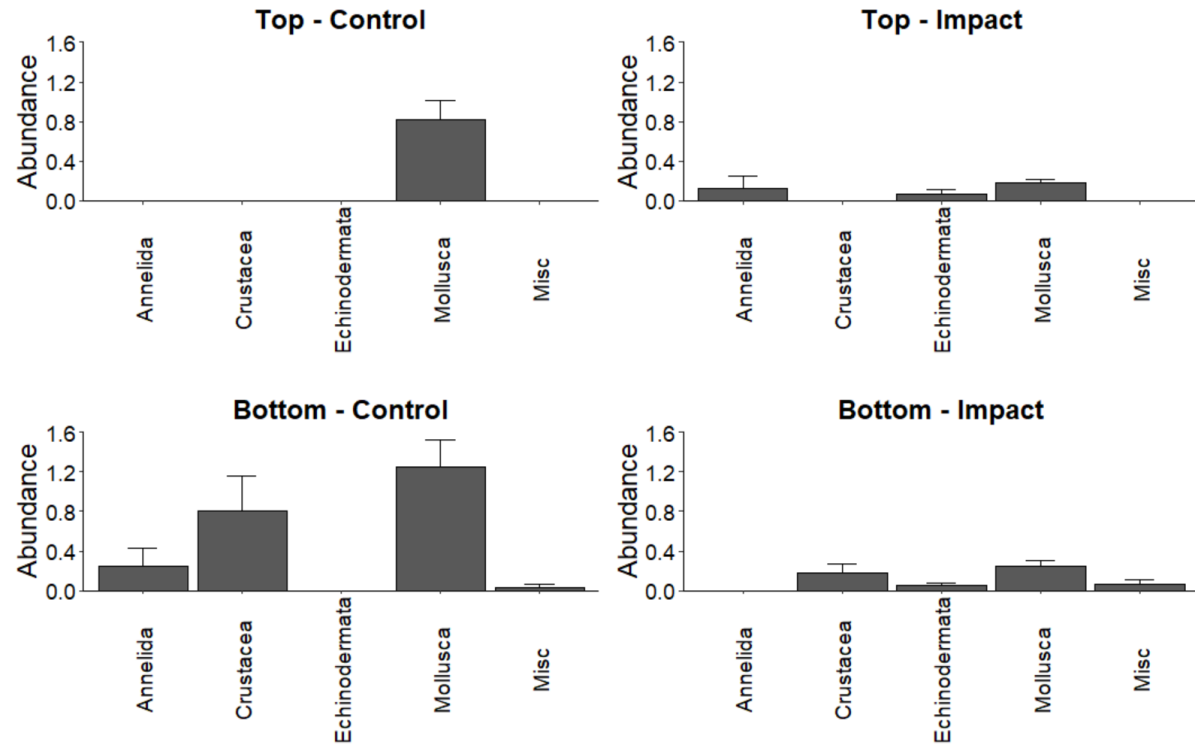
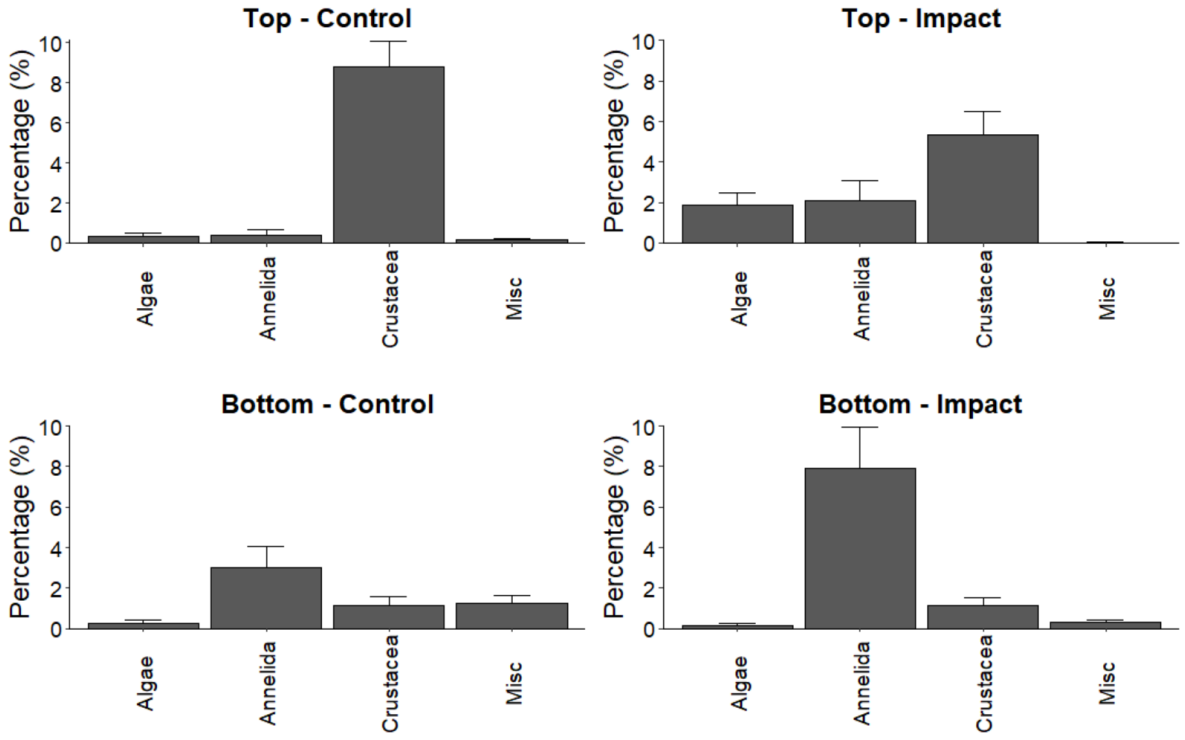


Figure 36. Mean (SE) percentage cover of different taxonomic groups on the top and bottom of boulders within impacted and control areas at Penmon-Beaumaris.



The percentage cover of different taxa is shown in Figure 36. Annelida and Crustacea were the dominant phyla reported on both boulder surfaces. The percentage coverage of crustaceans (barnacles *A. modestus* and *S. balanoides*) was observed to be significantly higher in the control area in relation to the impact area ($p < 0.05$), but was only evident on the top side of boulders. In contrast, algal taxa (encrusting *Corallinacea* and *F. serratus*) on the top side of boulders were significantly more prevalent in the impact area compared to the control area ($p < 0.05$). Annelida (i.e. *Spirobranchus*) was also observed to be more abundant in the impact area on the bottom of boulders, although this was not significant ($p > 0.05$).

MDS plots for faunal abundance and percentage cover of taxa for each boulder are shown in Figure 37 and Figure 38. Stress values from MDS plots ranged between 0.13-0.14 and suggest a reasonably moderate fit.

The nMDS plot for faunal abundance demonstrate that community structure appears to differ between control and impact areas on the top of the boulders, with no clear differences on the bottom of boulders (Figure 37). In contrast, the nMDS plot for percentage cover (Figure 38) indicates clear differences between control and impact areas on the bottom of the boulders as well as on the top of the boulders to a lesser degree. Furthermore, there is an indication of differences in faunal community abundance when comparing the top and underside of the boulders. However, this difference appeared to be more pronounced in the percentage cover community data. PERMANOVA tests confirmed these observations, finding significant differences in faunal community composition (including percentage cover and faunal abundance) between control and impact areas (p =

0.001), between the top and bottom of boulders (p = 0.001), and in the interaction effect between these variables (p = 0.001).

SIMPER analysis was conducted to identify the species contributing most to the dissimilarity in species composition between different group types: Control-Top, Impact-Top, Control-Bottom, and Impact-Bottom. The analysis assessed the average similarity within each group and determined which species were the primary drivers of the observed differences, and these alongside the AMBI EG scores are shown in Table 13 and Table 14.

On the top side of the boulder, the percentage cover of *A. modestus, S. balanoides, F. serratus* and fucoid sporelings were key species contributing to dissimilarity between control and impact areas; with higher percentage cover of *A. modestus* in the control area. In contrast, *F. serratus* and fucoid sporelings were more prevalent in the impact area. Dissimilarity on the bottom of boulders was attributed to the percentage cover of *Spirorbinae* which was relatively greater in the impact area compared to *Spirobranchus* and encrusting calcified Bryozoa which were more abundant in the control area.

Dissimilarity in community abundance data on the top side of boulders was primarily due to the greater abundance of *L. littorea* in the control area and the higher abundance of *P. vulgata* in the impacted area. Differences on the bottom of the boulders between control and impacted areas was primarily due to a higher abundance of *Gibbula* sp., Amphipoda and *Anomiidae* in the control area. This suggests their potential sensitivity to impacts which is supported with the AMBI EG Scores, particularly for *Anomiidae* and *Gibbula* sp. (EG I) which are classified as a disturbance-sensitive species.

Figure 37. Non-metric MDS showing relationship between treatment and side of the boulder on the abundance of taxa at Penmon Beaumaris.

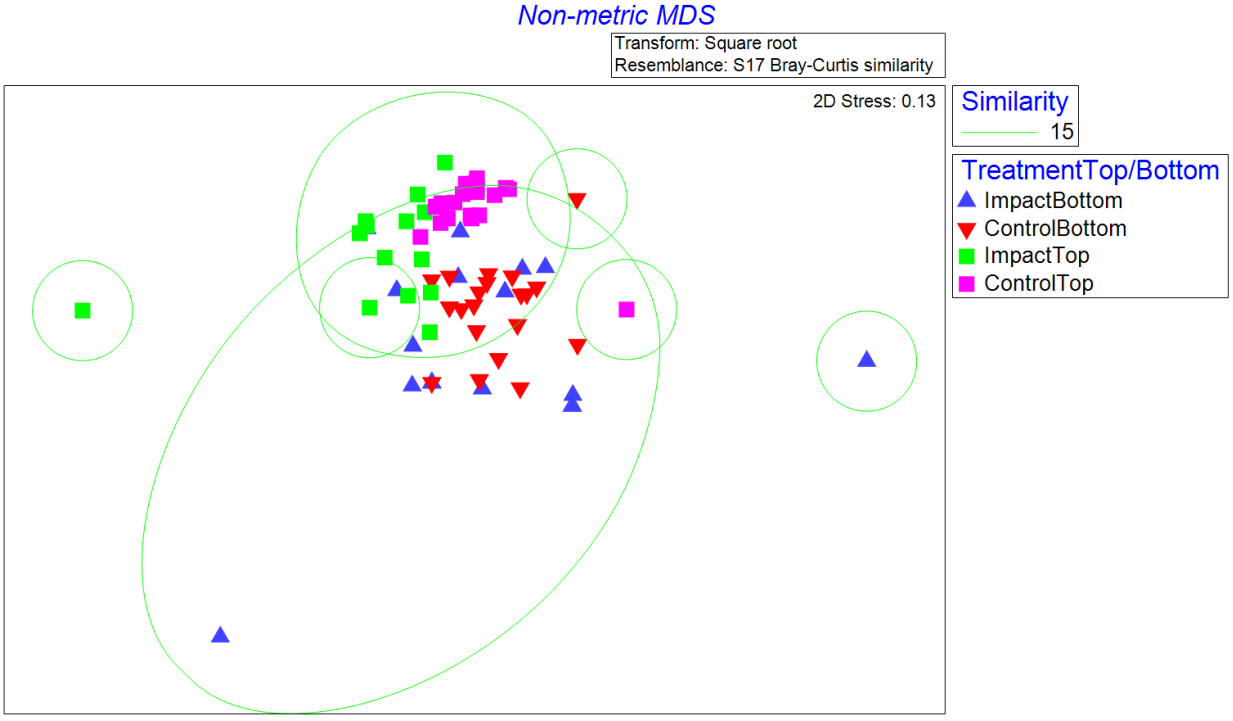


Figure 38. Non-metric MDS showing relationship between treatment and side of the boulder on the percentage cover of taxa at Penmon Beaumaris.

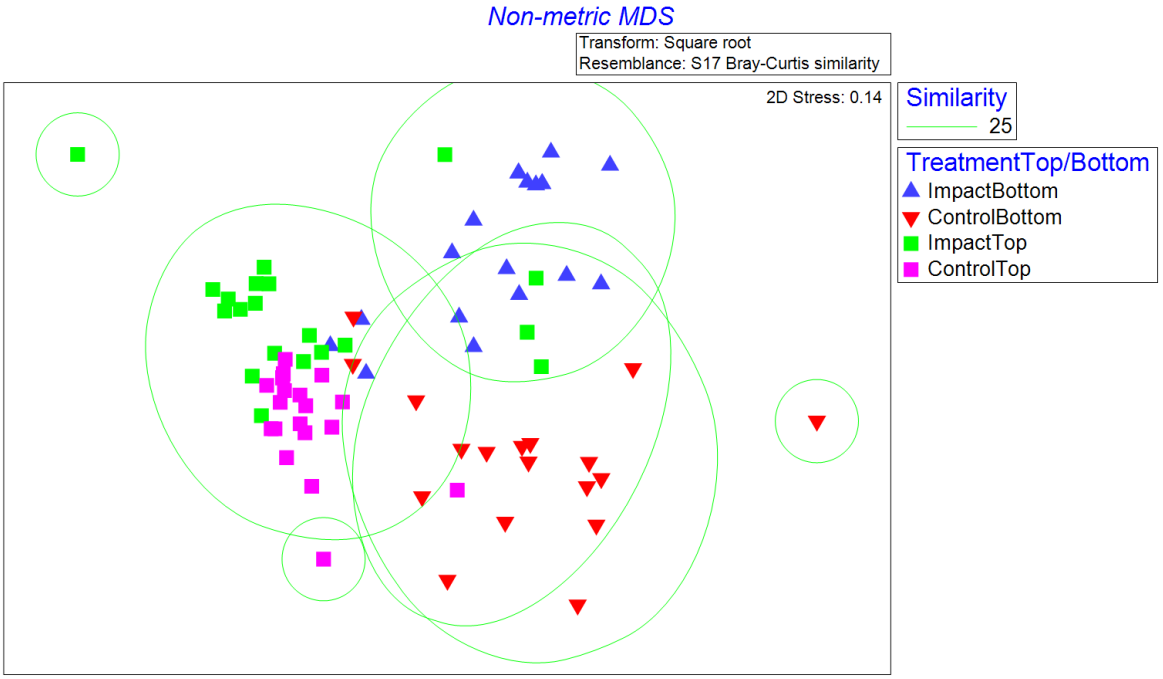


Table 13. The dominant encrusting taxa (percentage cover) contributing to overall percentage dissimilarity between control and impact areas at Penmon-Beaumaris, as per SIMPER routine on ASIN transformed percentage data.

Boulder	Species	AMBI EG Score	Mean Abundance: Impact	Mean Abundance: Control	% Dissimilarity	% Cumulative Contribution
Top	*Austrominius modestus*	II	1.39	4.66	16.29	24.13
Top	*Semibalanus balanoides*	I	4.48	4.1	13.5	44.13
Top	*Fucus serratus*	Not listed	1.64	0	7.49	55.23
Top	*Fucoid sporelings*	Not listed	1.21	0	4.64	62.1
Top	*Corallinacea enc.*	Not listed	0.43	0.45	3.1	66.7
Top	*Spirorbinae*	II	0.69	0	2.89	70.99
Bottom	*Spirorbinae*	II	3.54	0.21	29.31	32.78
Bottom	*Spirobranchus*	II	0.05	1.86	13.83	48.24
Bottom	*Bryozoa enc.*	II	0.67	1.6	11.28	60.86

Boulder	Species	AMBI EG Score	Mean Abundance: Impact	Mean Abundance: Control	% Dissimilarity	% Cumulative Contribution
Bottom	*Semibalanus balanoides*	I	1.05	0.9	9.62	71.61

Table 14. The dominant mobile taxa (faunal abundance) contributing to overall percentage dissimilarity between control and impact areas at Penmon-Beaumaris, as per SIMPER routine on square-root transformed data.

Boulder	Species	AMBI EG Score	Mean Abundance: Impact	Mean Abundance: Control	% Dissimilarity	% Cumulative Contribution
Top	*Littorina littorea*	II	0.5	2.72	32.93	42.88
Top	*Patella vulgata*	I	0.89	0.49	12.35	58.96
Top	*Nucella lapillus*	Not listed	0.38	0.5	8.87	70.52
Bottom	*Gibbula sp.*	I	0.85	2.08	14.89	18.79
Bottom	*Amphipoda*	Not listed	0.53	1.24	12.66	34.77
Bottom	*Anomiidae*	I	0.28	1.63	11.03	48.69
Bottom	*Littorina littorea*	II	0.42	0.66	6.45	56.82
Bottom	*Patella vulgata*	I	0.27	0.46	5.13	63.3
Bottom	*Nucella lapillus*	Not listed	0.34	0.48	4.97	69.57
Bottom	*Littorina saxatilis*	II	0.12	0.32	4.3	74.99

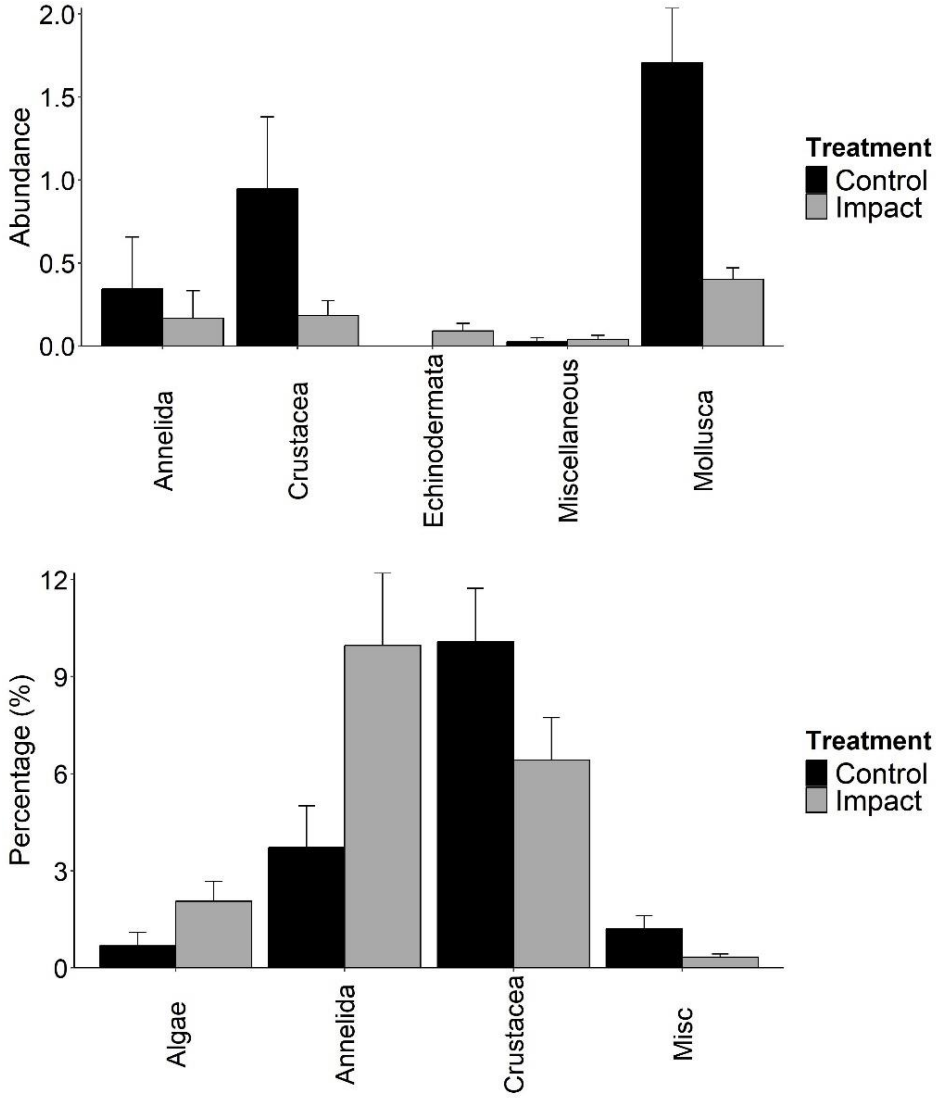
To address the issue of boulder tops and bottoms being interchanged due to varying degrees of boulder turning, the epifauna from both the top and bottom of boulders have been merged within the analysis (and effectively assumed to form a single epifaunal community). This approach was selected to further evaluate the effects of boulder turning at the broader site level (control vs impact). As part of this assessment to accurately assess the impacts of boulder turning between impact and control areas, only the unturned boulders in the control area were included in the analysis to examine differences in community composition.

Mean abundance and percentage cover of different taxonomic groups are presented in Figure 39. Epifaunal abundance (across all taxonomic groups) was significantly greater in the control area compared to the impact area ($p < 0.01$). The abundance of Annelida, Crustacea and Mollusca were all higher in the control area compared to the impact area, although significant differences ($p < 0.001$) were only observed for molluscs (mainly *Anomiidae* and *L. littorea*).

The percentage cover of encrusting fauna (across all taxonomic groups) was similar between control and impact areas, with no significant differences observed ($p < 0.05$). Despite this, percentage cover of fucoid sporelings and green algal turf (included within

Algae) were found to be significantly higher in the impact area compared to controls (p < 0.01).

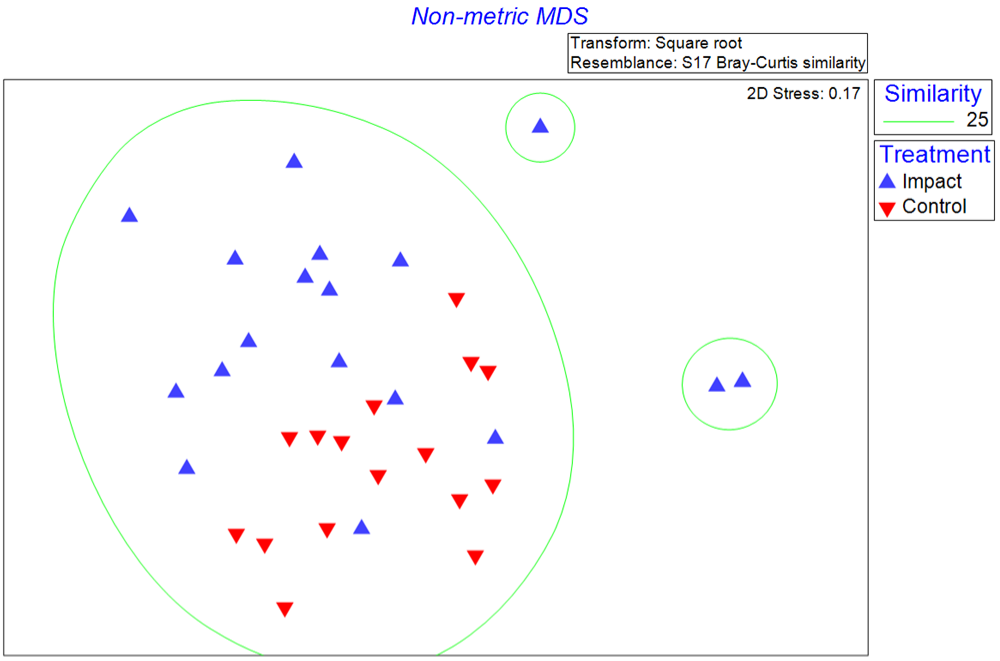
Figure 39. Mean (SE) abundance (top) and percentage cover (bottom) of different taxonomic groups present on boulders within impacted and control areas at Penmon-Beaumaris.



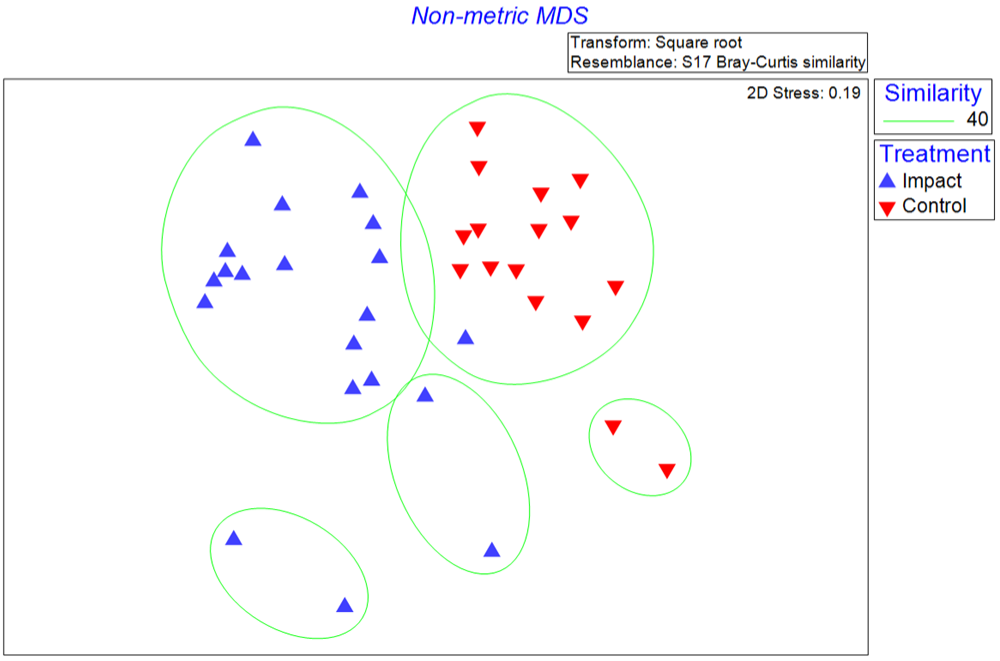
MDS plots for faunal abundance and percentage cover of epifaunal taxa on the entire boulder are shown in Figure 40. Stress values from the MDS plots ranged between 0.17-0.19 suggesting a moderate fit.

Figure 40. Non-metric MDS showing relationship between treatment (control and impact) on the abundance (A) and percentage cover (B) of taxa at Penmon-Beaumaris.

A


Non-metric MDS
Transform: Square root
Resemblance: S17 Bray-Curtis similarity
2D Stress: 0.17
Similarity
25
Treatment
Impact
Control

B


Non-metric MDS
Transform: Square root
Resemblance: S17 Bray-Curtis similarity
2D Stress: 0.19
Similarity
40
Treatment
Impact
Control

The faunal communities from the abundance data show an overlap between control and impact areas, with some boulders from the impact area being highly dissimilar from the main group. The findings from the nMDS plot were corroborated by the ANOSIM analysis ($R = 0.23$, $p < 0.01$), which indicated similarities in faunal abundances between control and impact areas with some differences observed. SIMPER identified *L. littorea, Gibbula* sp. and *Anomiidae* as characteristic taxa which were relatively more abundant in the control area.

The faunal community of encrusting organisms from the percentage cover data indicated distinct groupings between control and impact areas. The ANOSIM test supported these findings ($R = 0.508$, $p < 0.01$) with significant differences in faunal communities observed between control and impact areas. Characteristic taxa included *A. modestus,* juvenile barnacles and *N. lapillus* eggs which were prevalent in the control areas. In contrast, *Spirorbinae* and *F. serratus* were more abundant in the impact area.

3.1.3 Anthropogenic activities

Signs of anthropogenic activities were identified during the survey at Penmon-Beaumaris. The types of anthropogenic activities identified were grouped into the following categories:

- Dog walking; and
- Bait digging.

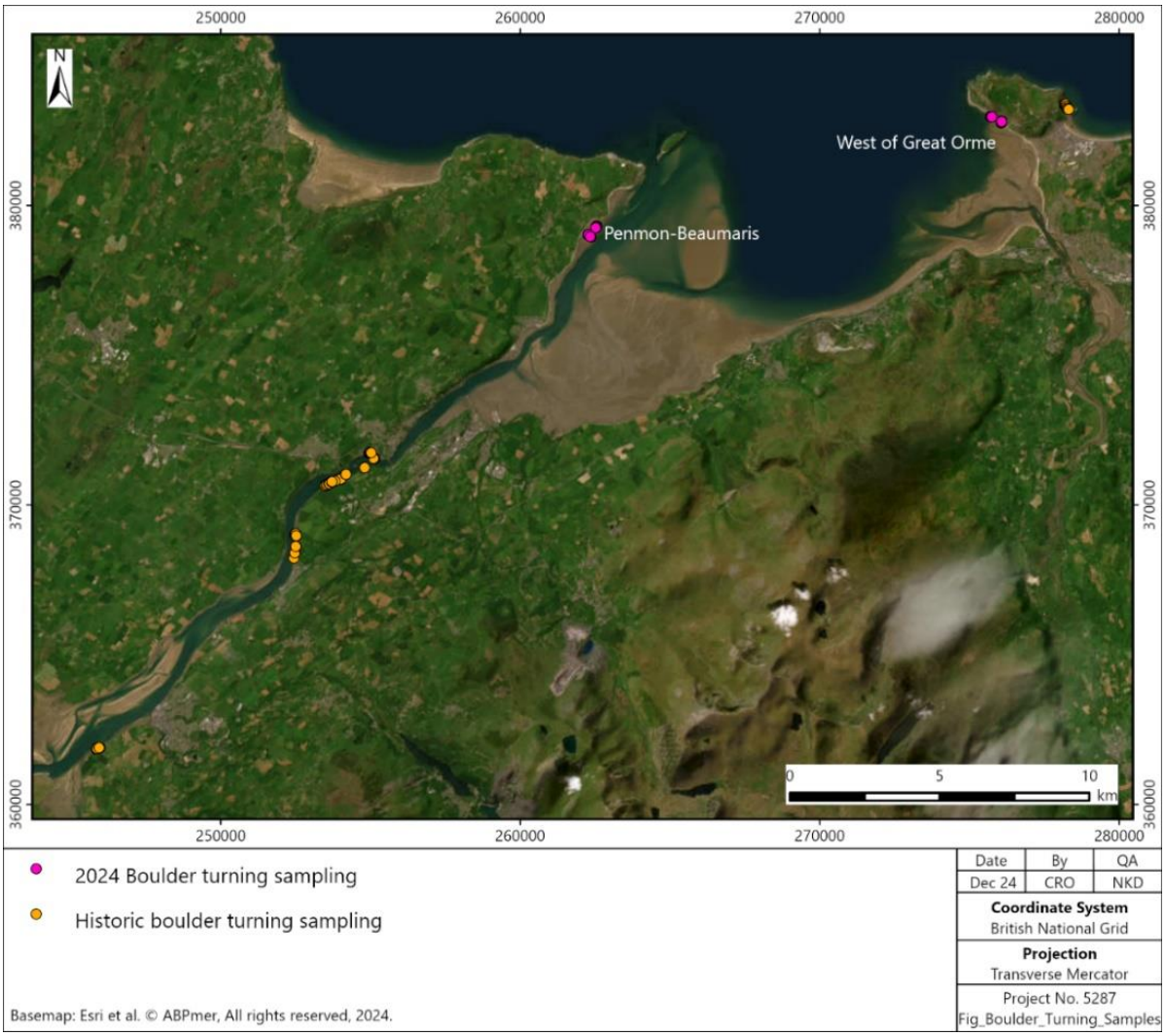
Dog walking was frequently observed at Penmon-Beaumaris for extended periods of time. Whilst there were no active bait collectors on site, there were signs of bait digging activity occurring within the vicinity in the lower shore areas, near the low water mark. This did not overlap with the boulders which were sampled in upper low/mid shores.

3.1.4 Historic comparison

Comparison of the results of the current 2024 survey against historic surveys within the area could not be undertaken for boulder turning activities.

Historical boulder turning surveys were undertaken between 2005 and 2019 within a different area of the Menai Strait approximately 10 km away. However, none of the survey locations corresponded with the locations of the current 2024 survey, as shown in Figure 41. Since these historic surveys were conducted at different locations, comparing them directly with the 2024 survey would not be appropriate due to variations in habitats and the conditions the boulders were exposed to. As a result, historical comparisons were not performed.

Figure 41. Location of previous boulder turning sampling undertaken between 2005 and 2019 in comparison to the 2024 survey.



3.1.5 Discussion

3.1.5.1 West of Great Orme

Boulder turning activities were evident at the west of Great Orme, but the intensity was considered moderate, with only 41% of the boulders in the impact area being turned. Additionally, there was no evidence of recent boulder turning (i.e., recently or very recently turned boulders) as only historically turned boulders were observed. This suggests that the site has not been regularly frequented by bait collectors since the previous autumn.

The boulders at the west of Great Orme site were dominated by barnacles at both the impact and control areas, with very little dead algae or seaweed present. The high wave and tidal energy at this site likely explain the limited growth of algae and seaweed.

Species richness was found to be generally higher on the bottom of boulders compared to fauna identified on the top of boulders, irrespective of boulder turning. The bottom of boulders generally supports a higher species composition, providing a more suitable

microhabitat that shields organisms from direct sunlight, desiccation, and temperature fluctuations (Cacabelos *et al.,* 2019). Additionally, the bottom contains crevices that offer niches for different species, supporting a diverse range of organisms (Schaefer *et al.,* 2023).

There were significant differences between the community composition on the top and bottom of boulder surfaces subject to different boulder turning (not turned vs historically turned). On the bottom, disturbance-sensitive mobile taxa such as molluscs *P. vulgata* and *Gibbula* sp. were significantly more abundant on not turned boulders. This suggests certain molluscs still appear to be impacted from historic boulder turning activities and have not shown signs of recovery. In contrast, disturbance-indifferent species like *Actinia* were more prevalent on historically turned boulders and demonstrate resilience.

Sessile organisms like the barnacle *A. modestus* showed greater coverage on historically turned boulders, especially on the bottom surfaces. Although these differences were not statistically significant, it suggests that *A. modestus* has the tendency to recover from boulder turning impacts, consistent with its AMBI classification as disturbance indifferent. On the top surfaces of boulders, coverage was similar between historically turned and not turned boulders. This pattern was also observed for the disturbance-sensitive barnacle *S. balanoides*, indicating a preference for residing on the top surfaces. The increased coverage of *S. balanoides* on the top of historically turned boulders suggests recovery has occurred, further supported by the presence of predominantly live barnacles on these surfaces. The recovery of barnacle populations is enhanced by the presence of adult barnacles, which act as nuclei for recruitment. A study by Gómez-del Campo *et al.* (2024) demonstrated that over 90% of barren surfaces began to recover within six months when some adults were left on the rocks. Whilst the exact timeline or age of turned boulders is not known, the presence of adult barnacles clearly plays an important role in accelerating the recolonisation process. In contrast, other taxa like encrusting Bryozoa and *Spirorbinae* have not shown signs of recovery, as their coverage was noticeably lower on the bottom surfaces of historically turned boulders. Some taxa such as *Nucella lapillus* and their eggs appeared to have not shown any signs of impact as their presence were found to be evenly distributed between the control and impact areas.

Overall, the results indicate that the long-term effects of boulder turning were evident at both the boulder and site levels. Certain faunal groups, such as molluscs, bryozoans, and annelids, were still negatively impacted, while crustaceans showed signs of recovery. Some species (e.g. *N. lapillus* and their eggs) appeared to not be impacted. The low intensity and lack of fresh boulder turning at this site may have facilitated the recovery of faunal assemblages. Fauna that prefer the top surfaces of boulders, like barnacles, recovered faster compared to those on the bottom surfaces, such as molluscs.

3.1.5.2 Penmon-Beaumaris

Boulder turning activities were evident at Penmon-Beaumaris, with a moderate intensity as 47% of the boulders in the impact area had been turned. Recent boulder turning activities (i.e., recently or very recently turned boulders) were rare and historically turned boulders were more present.

There were significant differences between the community composition on the top and bottom of boulder surfaces subject to different boulder turning (not turned vs historically turned). Mollusc species were significantly more abundant on not turned boulders,

suggesting ongoing impacts from boulder turning activities, particularly for disturbance-sensitive species like *Gibbula* sp. and *Anomiidae*. However, *P. vulgata* was more abundant on the top side of historically turned boulders compared to not turned boulders, which suggests some form of recovery.

Algal species *Fucus serratus* and fucoid sporelings were only present on the top side of historically turned boulders compared to the top side of not turned boulders, indicating faster colonisation after turning, possibly facilitated by reduced wave and tidal exposure at this site. *Spirorbinae* were more prevalent on the bottom of historically turned boulders, suggesting they have thrived in the more disturbed environment. Other encrusting taxa including green algal turf were more prominent on boulders located in the impact area compared to controls.

Sessile crustacean species *S. balanoides* appeared to be evenly distributed between historically turned and not turned boulders on both the top and bottom surfaces, despite being classed as disturbance sensitive. This suggests barnacles appeared to recover from the impacts associated with boulder turning. This was not observed for the disturbance-indifferent *A. modestus* which was prevalent on the top side of not turned boulders. The lower abundance of *A. modestus* on the historically turned boulders could be related to the native *S. balanoides* outcompeting the invasive *A. modestus*. While *A. modestus* often has a competitive advantage, *S. balanoides* can outcompete it under certain conditions, such as colder temperatures (Connell, 1961) and earlier larval settlement (Blythe, 2008). Furthermore, both species prefer residing on the top surfaces of boulders.

Overall, the results indicate that historical boulder turning has long-term impacts on community composition at both the boulder and site levels. Mobile taxa, such as molluscs, were still negatively affected (except for *P. vulgata*), while sessile barnacles, algae, and annelids showed signs of recovery. Fauna that prefer the top surfaces of boulders, like barnacles, appeared to have recovered faster compared to those on the bottom surfaces, such as molluscs. The moderate intensity and low frequency of recent boulder turning at this site may have facilitated the recovery of faunal assemblages over time.

3.2 Bait digging

This section presents the results from the intertidal bait digging surveys at Angle Bay in September 2023, and Penmon-Beaumaris and Four Mile Bridge, Anglesey in June 2024 and provides a comparison between sediment composition and faunal communities at control and impact areas.

3.2.1 Angle Bay

3.2.1.1 Sediment composition

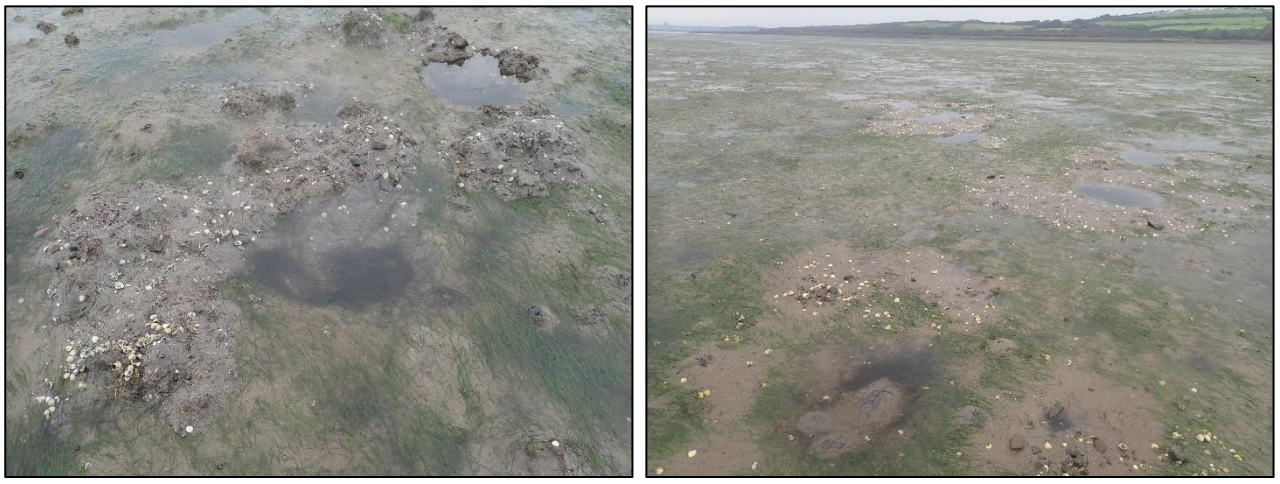
A single sediment core for PSA and TOC was collected for each block. The sediment classifications based upon PSA data collected during the September 2023 survey are presented in Table 15. Sediments were classified as sand to muddy sand across the Angle Bay site.

Table 15. Sediment classification based on particle size data and total organic carbon (TOC) content for each block in Angle Bay in September 2023

Block	Area	Sediment description	Major sediment fractions % Gravel	Major sediment fractions % Sand	Major sediment fractions % Mud	TOC (% Volume LOI)
AC1	Control	Muddy Sand	0.0	66.8	33.2	1.07
AC2	Control	Muddy Sand	0.0	72.2	27.8	1.80
AC3	Control	Muddy Sand	0.0	57.3	42.7	1.50
AC4	Control	Muddy Sand	0.0	79.8	20.2	1.45
AC5	Control	Muddy Sand	0.0	64.4	35.6	1.78
AC6	Control	Muddy Sand	0.0	65.8	34.2	1.95
AI1	Impact	Muddy Sand	0.0	89.0	11.0	0.67
AI2	Impact	Muddy Sand	0.0	81.3	18.7	1.05
AI3	Impact	Sand	0.0	90.9	9.1	0.95
AI4	Impact	Sand	0.0	98.7	1.3	0.87
AI5	Impact	Muddy Sand	0.0	87.9	12.1	1.04
AI6	Impact	Muddy Sand	0.0	77.9	22.1	2.02

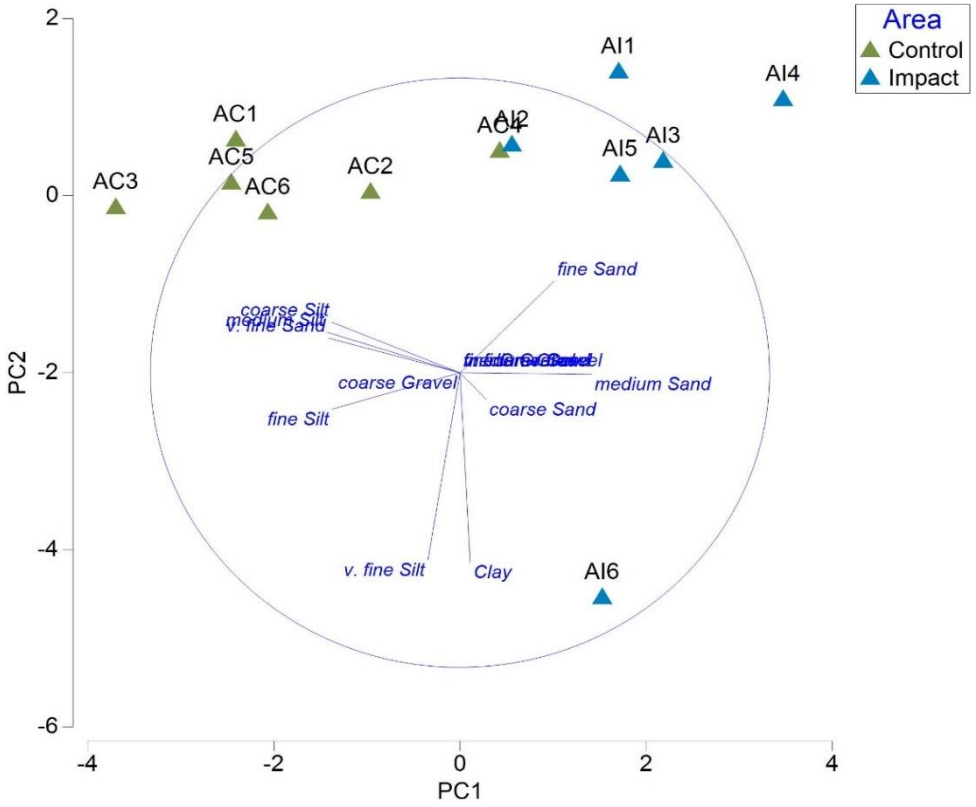
Finer, muddier sediments were generally observed within control areas which had a higher percentage of mud content than stations within impact areas. No gravel fractions were found in any of the sediment samples during the PSA analysis, however, during the survey gravel and shell fragments were observed on the sediment surface, particularly in the impact area. These were particularly apparent at the edges of historic bait digging holes (Figure 42).

Figure 42. Gravel and shell fragments observed on the sediment surface within the impact area.



PCA was carried out on the sediment data to analyse the differences in sediment size between impact (dug) and control (undug) areas. The resulting 2D plot is shown in Figure 43.

Figure 43. A 2D PCA ordination showing the contribution of each sediment size class at each block within Angle Bay



The two-dimensional axes PC1 and PC2 capture 82.1 % of the total variance and as such the plot can be considered as a very good representation of the higher dimensional relationship between stations (Clarke and Warwick, 2001). Despite the overarching sediment classification being largely the same across all stations (Table 15) the PCA plots suggests groupings by site, with separation between the control and impacts sites as a result of differences in the sediment fractions. The control stations were dominated by the very fine sand and coarse and medium silt fractions, whereas the majority of the impact stations were dominated by the fine sand fractions (Figure 43).

The cause of the different sediment fractions cannot be defined from the results of this survey across the site. These differences could be due to different physical parameters, possibly influenced by both current and historic bait digging activities. Despite this uncertainty, analysis was undertaken to determine whether there was a relationship between sediment composition and infaunal communities. To determine the strength of this relationship, the infaunal abundance data were compared with the sediment data using the RELATE multivariate statistical routine.

Results of the RELATE test indicate that there was very little correlation, and no significant relationship, between faunal composition and the PSA data (Rho = 0.142, p = 0.22). As such, differences in faunal communities between sites is unlikely to be a result of the sediment composition.

Total organic carbon content was also sampled within each of the blocks at Angle Bay, the results are presented in Table 15. The average TOC (% volume LOI) per station within the control area was higher than recorded within the impact area, with an average TOC of 1.59 and 1.10 respectively. The difference between control and impact areas was statistically significant (p = 0.03) and was marginally correlated to patterns observed within the infaunal abundance data (Rho = 0.302, p = 0.01). The results are consistent with the presence of slightly finer sediments at the control sites which would be expected to have a higher organic content.

Analysis of the faunal data was undertaken to investigate the structure and composition of faunal communities present within Angle Bay at this snapshot in time.

3.2.1.2 Infaunal community composition

The average abundance, diversity and biomass of infauna recorded within each block are presented in Table 16. Individual station results are presented in Appendix E. Abundance and biomass were generally higher within the control area in comparison to the impact area.

The mean number of taxa in each station in the control area was 15, compared to 12 within the impact area. The average number of individuals at each station within the control area was 128 compared to 118 within the impact area. Average diversity was marginally higher within the impact area (1-ʎ = 0.366) as compared to the control area (1-ʎ = 0.244). However, average biomass was lower within the impact area (2.03 g) compared to the control area (3.83 g). Despite the differences in metrics observed between control and impact areas, none of these were found to be statistically significant (t-test: p > 0.05).

Table 16. Average abundance, biomass and diversity (Simpsons index (1- ʎ)) within control and impact areas

Block	Area	No. of taxa	No. of Individuals	Diversity (1-ʎ)	Biomass (g)
AC1	Control	12	116	0.107	2.01
AC2	Control	15	136	0.228	4.12
AC3	Control	17	154	0.244	4.05
AC4	Control	14	114	0.238	8.67
AC5	Control	12	93	0.178	0.68
AC6	Control	17	155	0.466	3.45
AI1	Impact	14	81	0.288	0.49
AI2	Impact	17	152	0.510	1.59
AI3	Impact	11	151	0.292	0.88
AI4	Impact	10	73	0.387	4.29
AI5	Impact	11	123	0.365	2.94
AI6	Impact	10	129	0.355	1.96

k-dominance comparison curves (shown in

Figure 44) present the cumulative dominance of average taxa abundance at control and impact areas. The higher the curve in a k-dominance plot, the lower the evenness and richness of (and more dominated) the infaunal assemblage. As can be seen in

Figure 44 within the control area, fewer species are dominating the community which suggests that the control area is less diverse and dominated by a smaller number of species. In comparison the impact area is more diverse and has a more even community assemblage.

Figure 45 shows the mean abundance and biomass for each major taxonomic group within control and impact areas. As can be seen from the figure, molluscs contributed most to the levels of abundance and biomass observed within both the control and impact area. Annelida, and to a lesser degree crustacea, also contributed to the abundance within the impact area. In contrast the abundance of both of these taxonomic groups was much lower within the control area, of which only Annelida was found to be significant (t-test: $p < 0.05$). Overall biomass within the impact area was much lower than observed within the control area.

To investigate any potential statistical differences in faunal communities present within the control and impact areas, an MDS plot for infaunal abundance data at each station was produced, shown in Figure 46. The stress value of 0.22 is moderate suggesting there are distortions in the MDS plot. The arrangement of points in the plot provides a reasonable assessment but does not accurately reflect the true distances or dissimilarities among the data points in the two-dimensional space, and interpretations should be made with caution. There was a high level of overlap between the control and impact areas, with overlapping grouping of blocks within each, indicating that i) the communities in the control and impact areas are similar and ii) within area variability (block) is low. Samples from the control area are more closely grouped, and less dispersed, than those in the impact area. The community overlap was corroborated by an ANOSIM test which found a high overlap between communities ($R = 0.072$, $p = 0.02$).

Figure 44. k-dominance curve for average abundance of taxa at control and impact areas at Angle Bay

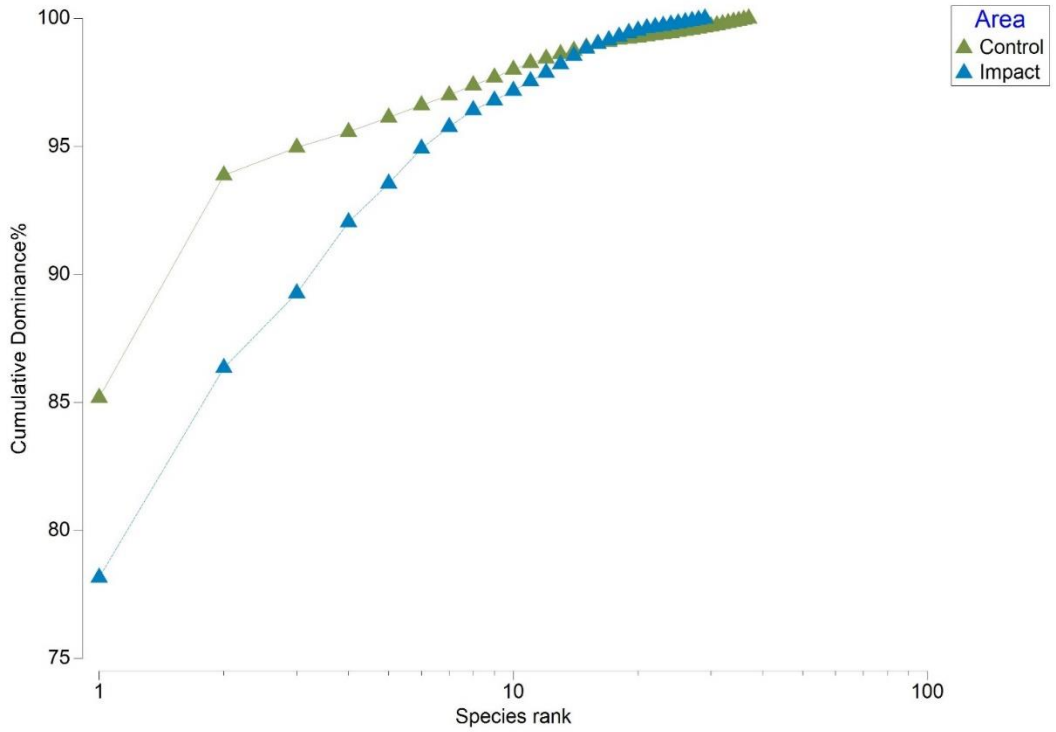


Figure 45. Mean (± 95% CI) abundance and biomass (g) of characterising faunal groups in samples from control and impact areas at Angle Bay.

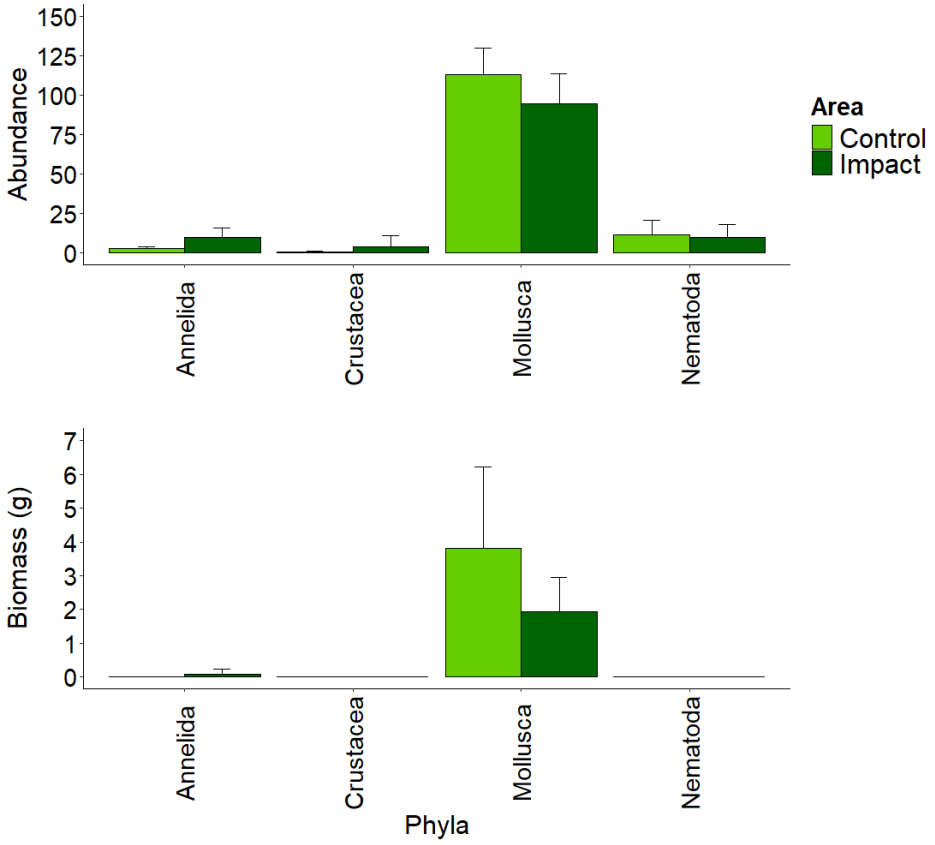


Figure 46. MDS plot of Bray-Curtis Similarity of individual samples derived from the square-root transformed abundance data (per 0.01 m²)



SIMPER analysis was performed to identify those taxa characteristic of each area and also those contributing to any differences between communities in the impact and control areas, noting that there is no overall statistical difference between the two areas. The results are presented in Table 17 and Table 18. The AZTI Marine Biotic Index (AMBI) Ecological Group (EG) scores for each species identified during the SIMPER analysis have also been included within the tables.

The AMBI (Borja et al., 2000) describes the sensitivity of a macro benthic community to anthropogenic and natural disturbance. EG I describes the most sensitive taxa to natural or anthropogenic disturbance, and EG V represent the most opportunistic taxa (i.e., those able to best colonise disturbed environments).The AMBI index is designed to evaluate the health and ecological status of marine and estuarine ecosystems by assessing the composition of benthic communities. The index categorises benthic species into five groups according to their tolerance to pollution/disturbance. It helps in determining the level of disturbance or pollution in these environments. Definitions of each group are presented in Table 19.

Table 17. The dominant taxa contributing to overall percentage similarity in control and impact areas as per SIMPER routine on square-root transformed abundances (80% cut-off)

Species	AMBI EG Score	Mean Sqrt. Abundance	% Similarity	% Cumulative Contribution
Control: *Group similarity 63.91*				
Peringia ulvae	III	10.32	50.55	79.10
Nematoda	III	2.29	4.21	85.69
Impact: *Group similarity 55.41*				
Peringia ulvae	III	9.39	43.72	78.91
Nematoda	III	1.97	3.20	84.69

Table 18. The dominant taxa contributing to overall percentage dissimilarity between control and impact sites, as per SIMPER routine on square-root transformed abundances. Average dissimilarity = 64.11%

Species	AMBI EG Score	Mean Sqrt. Abundance: Control	Mean Sqrt. Abundance: Impact	% Dissimilarity	% Cumulative Contribution
Nematoda	III	2.29	1.97	6.69	16.09
Peringia ulvae	III	10.32	9.39	6.02	30.58
Tubificoides benedii	V	0.06	1.04	2.72	37.13
Cerastoderma edule	III	1.00	0.73	1.97	41.87
Capitella sp.	V	0.00	0.72	1.96	46.59
Tubificoides pseudogaste	V	0.13	0.71	1.92	51.22
Abra tenuis	III	0.61	0.34	1.75	55.44
Littorina saxatilis	II	0.47	0.36	1.56	59.20
Nephtys hombergii	II	0.55	0.41	1.52	62.86
Cerastoderma edule juv.	III	0.50	0.35	1.52	66.52
Pygospio elegans	III	0.11	0.48	1.33	69.71
Melinna palmata	III	0.36	0.25	1.28	72.80
Heteromastus filiformis	IV	0.32	0.30	1.19	75.68
Austrominius modestus	II	0.06	0.43	1.12	78.38
Animalia eggs	Not listed	0.33	0.06	0.97	80.73

Table 19. Definitions of AMBI EG Score as per Borja et al. (2000)

AMBI EG Score	Definition
EG I (disturbance sensitive species)	Species that are very sensitive to organic enrichment and pollution and are typically found in pristine conditions. Examples: specialist carnivores and some deposit feeding tubicolous polychaetes.
EG II (disturbance indifferent species)	Species indifferent to enrichment, always present in low densities with non-significant variations with time. Examples: suspension feeders, less selective carnivores and scavengers.
EG III (disturbance tolerant species)	Species that can tolerate significant organic enrichment. These species may occur under normal conditions, but their populations are stimulated by organic enrichment. Examples: surface deposit-feeding species, such as tubicolous spionids.
EG IV (Second order opportunistic species)	Species that thrive in environments with high levels of organic pollution and abundant in heavily disturbed areas. Examples: small sized polychaetes: subsurface deposit-feeders, such as cirratulids.
EG V (First order opportunistic species)	Species that dominate in heavily polluted environments; and extremely tolerant to high levels of organic enrichment. Examples: deposit feeders, which proliferate in reduced sediments.

The predominant species contributing to the similarity in benthic communities at both the control and impact areas were the mudsnail *Peringia ulvae*, and *Nematoda.* Both species are regularly associated with seagrass *N. noltei.* Both species are considered disturbance tolerant species (EG III) under AMBI.

Table 18 indicates the species for which a difference in their relative abundance contributed most to any difference between the control and impact areas, noting that the overall composition is not statistically different. There were fewer *P. ulvae, Cerastoderma edule* and *Abra tenuis* at stations within the impact area as compared to the control area. In contrast abundances of *Tubificoides* species, *Capitella sp*. and *Pygospio elegans* were higher in the impact area as compared to the control area. No disturbance sensitive species were recorded within either the control or impact area, but a number of disturbance indifferent (EG II) species, specifically *Littorina saxatilis, Nephtys hombergii* and *Austrominius modestus,* were recorded in both areas.

The only non-native species identified within the infaunal samples, at both the control and impact areas, was the Modest barnacle *A. modestus.*

To further assess spatial variability of infaunal communities, a nested ANOSIM analysis was employed, including both area and block, to test for differences within and between treatments. Results of the nested ANOSIM found no significant difference between control and impact areas (R = 0.087, p = 0.12) and similarly found a high overlap between communities within blocks and within areas (R = 0.167, p = 0.02). This suggests low spatial variability and patchiness in community composition across the Angle Bay site.

3.2.1.3 Megafauna community composition

Megafaunal sampling was incorporated into the survey strategy to identify larger infauna often missed during infaunal core sampling.

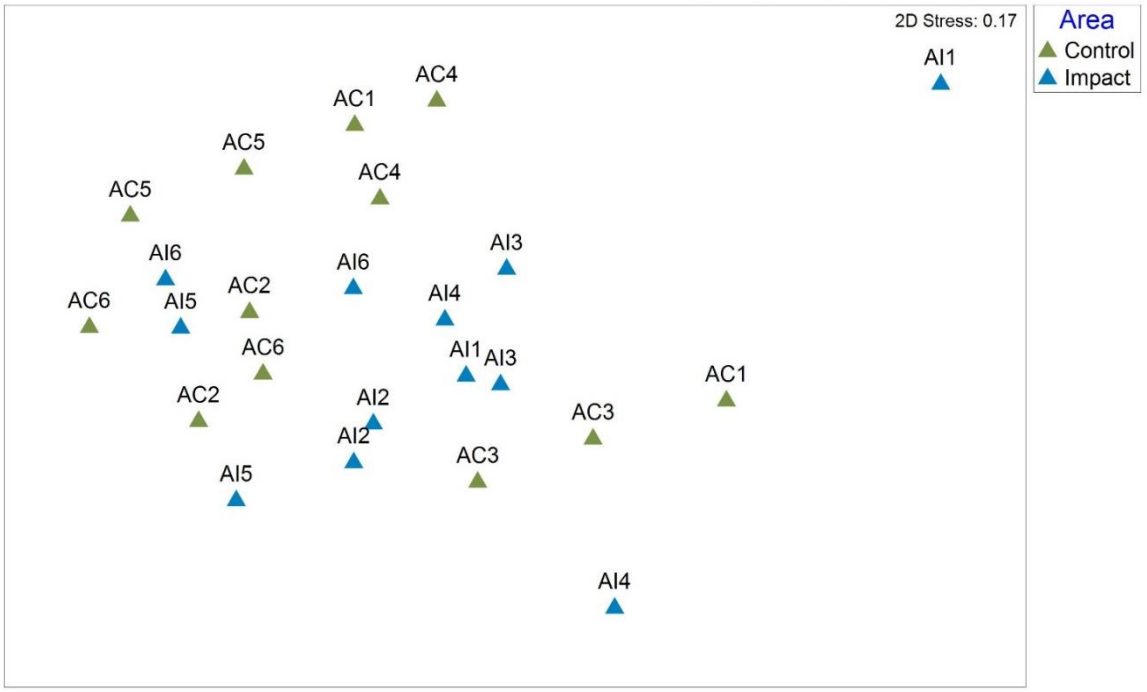
Species, characteristic of *Nanozostera noltei* beds, recorded within the megafaunal samples included the common cockle *Cerastoderma edule*, the Baltic tellin *Macoma balthica* and *Nephtys sp.* Average abundances of *C. edule* and *M. balthica* were marginally higher in control areas than impact areas with an average of 29 and 1.3 *C. edule* and *M. balthica* per sample respectively in control areas and 25 and 1 *C. edule* and *M. balthica* per sample in impact areas. The opposite was observed for *Nephtys sp.* with an average of 1.6 per sample in control areas and 1.9 per sample in impact areas.

Additional species recorded within the megafaunal samples included the polychaete *P. elegans* and possible records of the invasive Manila clam *Ruditapes philippinarum* which was recorded in eight of the 24 samples.

A very high degree of overlap between the megafauna communities recorded within control and impact areas (R = 0.009. p = 0.5) was demonstrated by the ANOSIM analysis and as shown in the associated MDS plot (Figure 47).

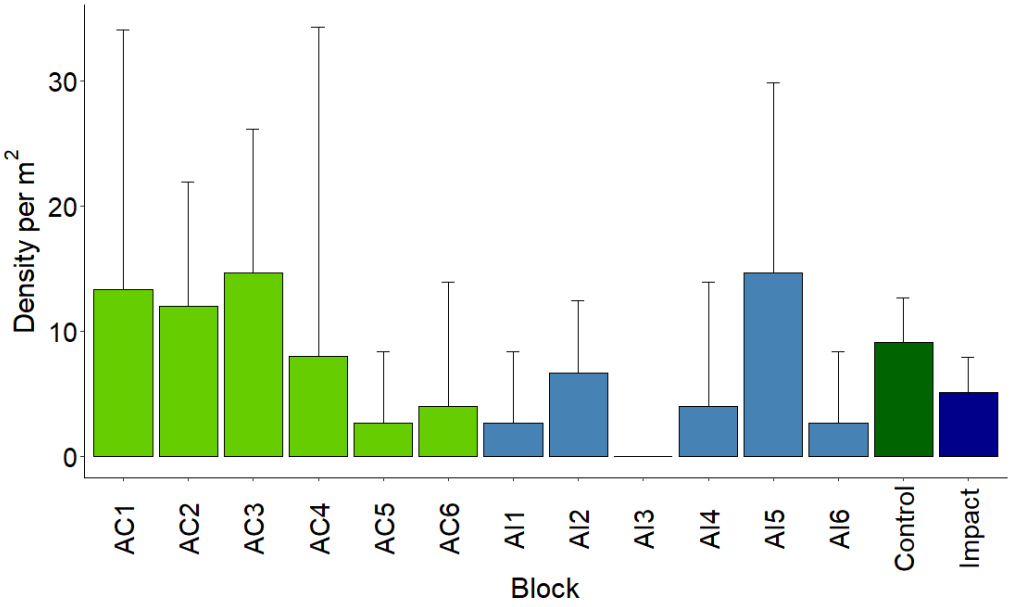
The lugworm *Arenicola marina* was only recorded within one infaunal core sample, however due to its large size *A. marina* is often missed during core sampling. Similarly, only one juvenile *Arenicola* was identified within the control area (block AC1) during the megafaunal sampling, however evidence of its presence was observed regularly across the site.

Figure 47. MDS plot of Bray-Curtis Similarity of individual samples derived from the square-root transformed megafauna abundance data (per 0.25 m²)



As a result, quadrat counts of lugworm casts were undertaken using a 0.25 m² quadrat within each block. Three counts were undertaken in each sampling block within the impact and control areas to determine the presence/absence of polychaetes based on their tubes/casts. The average density per m² of worm cast counts are shown in Figure 48. Densities of casts were variable across both the control and impact areas ranging from zero up to 20 per m². Blocks within control areas had a higher density of worm cast counts with an average of 9 casts per m² in comparison to impact areas where the average was 5 casts per m². Although, this was not statistically significant (t-tests: t = 1.873, df = 32.302, *p* = 0.07).

Figure 48. Mean (± 95% CI) density per m² of worm cast counts in each sampling block with an average captured in control and impact areas overall.

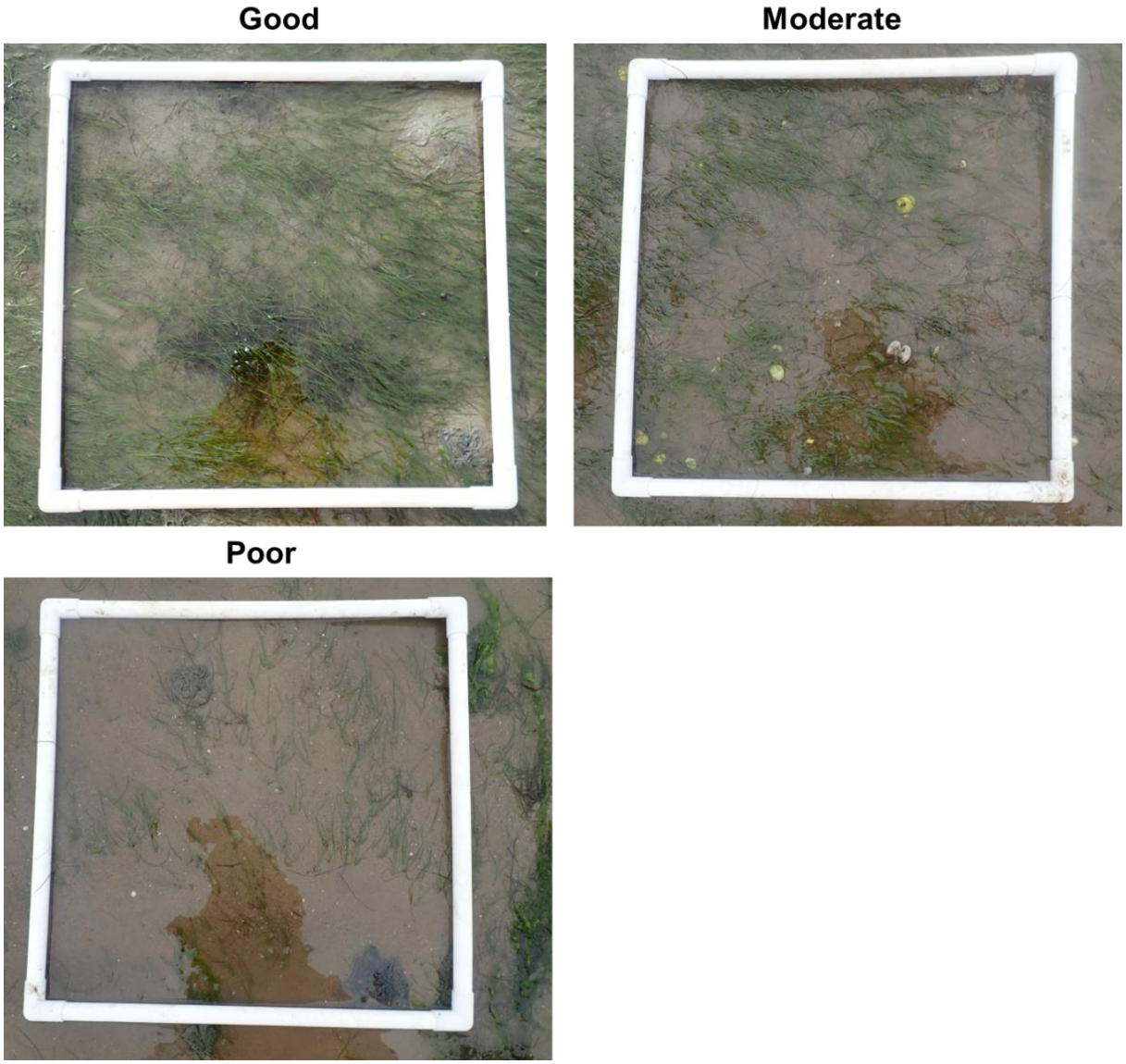


3.2.1.4 Seagrass condition

Seagrass condition was assessed by sampling percentage cover of seagrass, alongside additional measures including epiphyte coverage, macroalgal percentage cover and seagrass blade length within three 0.25 m² quadrats at each block.

All seagrass identified at Angle Bay was dwarf eelgrass *Nanozostera noltei.* Seagrass condition was initially assessed in-situ by visually inspecting epiphyte and macroalgal cover within each quadrat in Angle Bay. Collectively, seagrass condition was considered to be good at the majority of the 36 stations sampled with the exception of AC5.B, AI1.A, AI2.C, AI3.B and AI4.B where condition was considered moderate. Station AI1.C was the only station where condition was considered poor. Photographic examples of seagrass condition are shown in Figure 49.

Figure 49. Examples of seagrass condition observed across Angle Bay

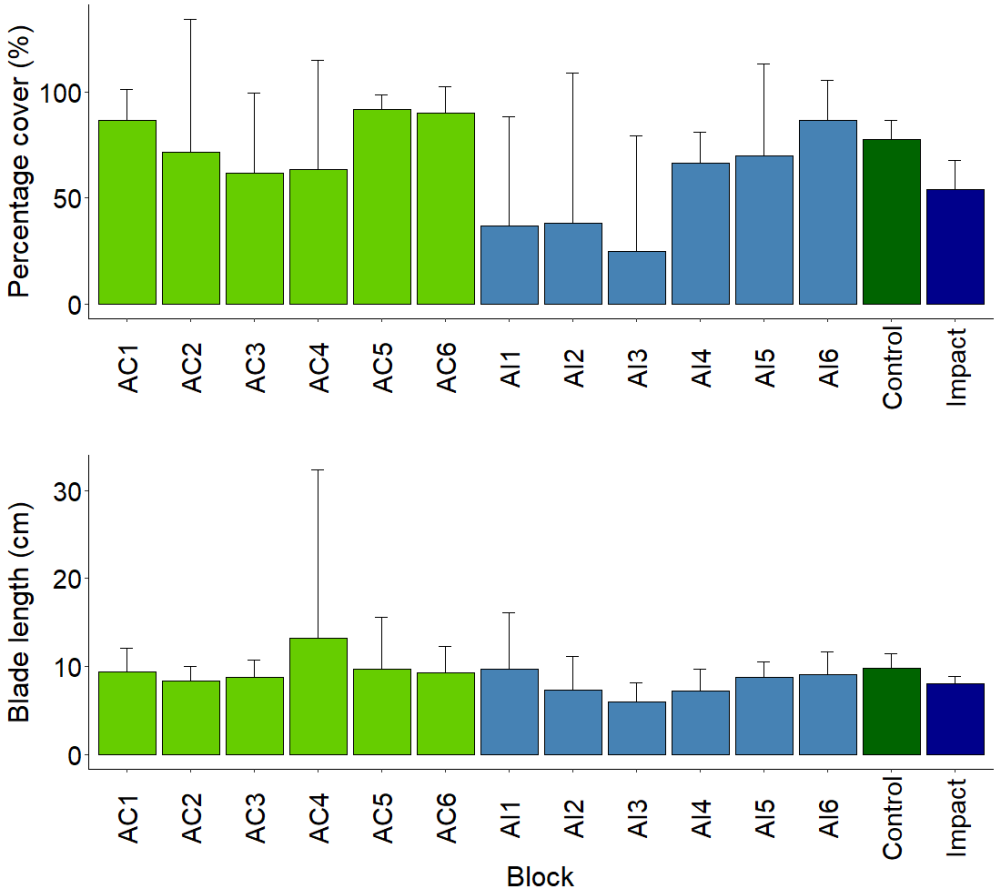


Percentage cover of seagrass within quadrats ranged from 10 % to 95 % coverage. The average coverage in the control area was 78 % in comparison to 54 % in the impact area. The difference in seagrass cover between control and impact areas was statistically

significant (t-tests: t = 3.049, df = 29.333, *p* = 0.005). Average blade length was also longer in the control area with an average length of 9.8 cm in comparison to 8.0 cm in the impact area, yet this was not significant (t-tests: t = 3.049, df = 29.333, *p* = 0.054) (Figure 50).

Algal cover within the quadrats was generally low, ranging from 0-5 %, across both control and impact areas, with the exception of AC1.C where 25 % algal coverage was recorded. No epiphytes on the seagrass were recorded in either control or impact areas.

Figure 50. Mean (± 95% CI) percentage cover and average blade length for seagrass *N. noltei* in control and impact areas.



3.2.1.5 Anthropogenic activities

Signs of anthropogenic activities within Angle Bay were identified during the survey. The types of anthropogenic activities identified were grouped into the following categories:

- Vehicles disturbance;
- Abrasion/ trampling;
- Bait digging;
- Aquaculture; and
- Litter.

Bait digging activity was observed each day during the survey. Bait collectors were observed digging for lugworm (*A. marina*) using both hole digging and suction extraction methods. Bait digging activity was predominantly observed to the north and eastern sides of the bay with diggers accessing the site on foot (Figure 51).

Figure 51. Bait digging activity observed across Angle Bay



Evidence of historic bait collection was also observed, again predominantly to the northern side of the bay and in the central area with historic bait dig holes observed (Figure 52).

Figure 52. Evidence of previous bait digging activity at Angle Bay



Within the same general area, to centre of the bay, and following the water flow from the freshwater stream, additional tyre tracks were also observed. This was later identified as being caused by a quad bike used to access the lower shore oyster trestles.

Only occasional evidence of litter was observed throughout the bay.

3.2.2 Penmon-Beaumaris

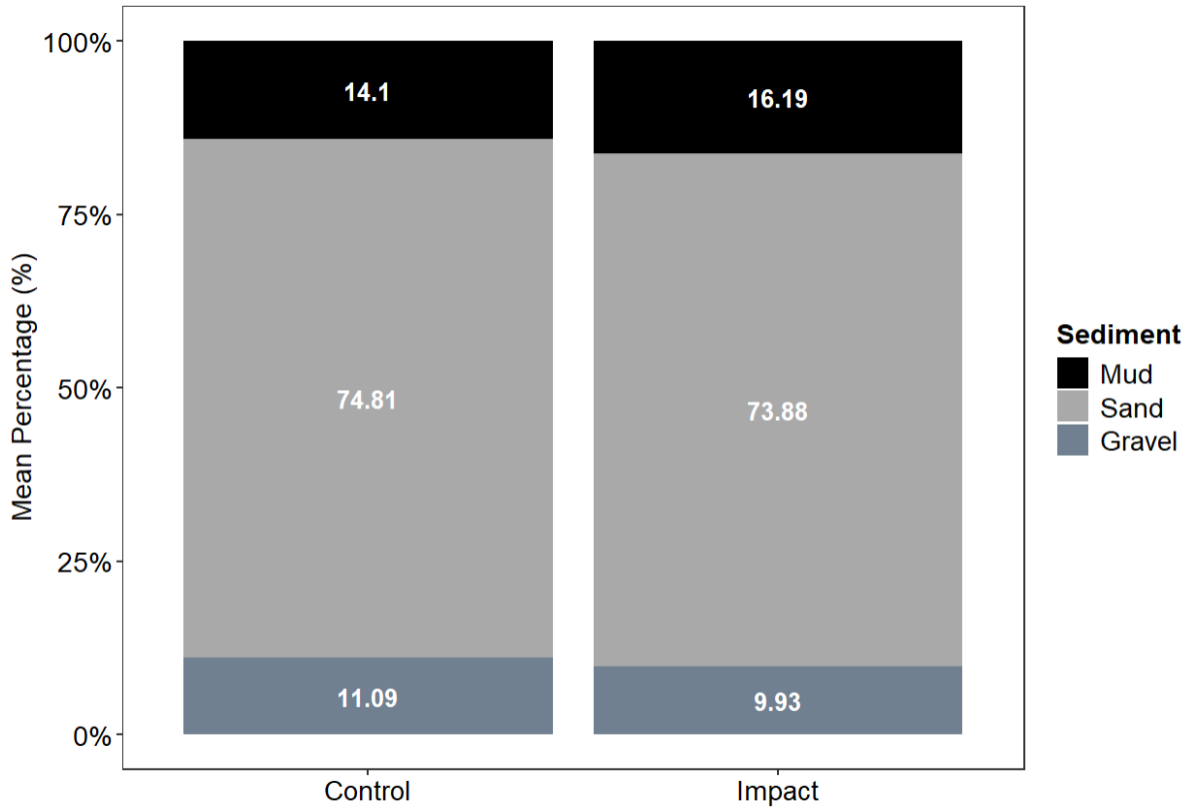
3.2.2.1 Sediment composition

The sediment classifications based on PSA data collected during the June 2024 survey are presented in Table 20. Overall, sediments at Penmon-Beaumaris were similar between impact and control areas. Both areas were predominately classified as having gravelly muddy sand with little difference in the percentages of gravel, sand or mud between the two areas (Figure 53).

Table 20. Sediment classification based on particle size data and total organic carbon content (TOC) for each block in Penmon-Beaumaris in June 2024

Block	Area	Sediment description	% Gravel	% Sand	% Mud	%TOC
PC1	Control	Gravelly Muddy Sand	13.9	74.7	11.4	0.67
PC2	Control	Gravelly Muddy Sand	14.9	74.1	11.0	1.33
PC3	Control	Slightly Gravelly Muddy Sand	3.5	85.7	10.8	0.99
PC4	Control	Gravelly Sand	6.9	85.2	7.9	0.89
PC5	Control	Gravelly Muddy Sand	14.8	45.2	40.0	2.68
PC6	Control	Gravelly Muddy Sand	19.3	71.3	9.5	1.41
PC7	Control	Slightly Gravelly Sand	3.3	87.9	8.9	0.98
PC8	Control	Gravelly Muddy Sand	12.1	74.6	13.3	0.91
PI1	Impact	Gravelly Muddy Sand	22.0	48.7	29.3	1.80
PI2	Impact	Gravelly Muddy Sand	9.2	73.4	17.4	1.36
PI3	Impact	Slightly Gravelly Muddy Sand	4.8	84.3	10.9	1.37
PI4	Impact	Gravelly Muddy Sand	8.2	73.8	18.0	1.07
PI5	Impact	Gravelly Muddy Sand	12.2	72.0	15.8	1.07
PI6	Impact	Gravelly Muddy Sand	8.8	79.6	11.6	1.09
PI7	Impact	Gravelly Muddy Sand	6.3	81.6	12.2	1.31
PI8	Impact	Gravelly Muddy Sand	8.0	77.6	14.4	1.45

Figure 53. Mean particle size distribution at control and impact areas at Penmon-Beaumaris.

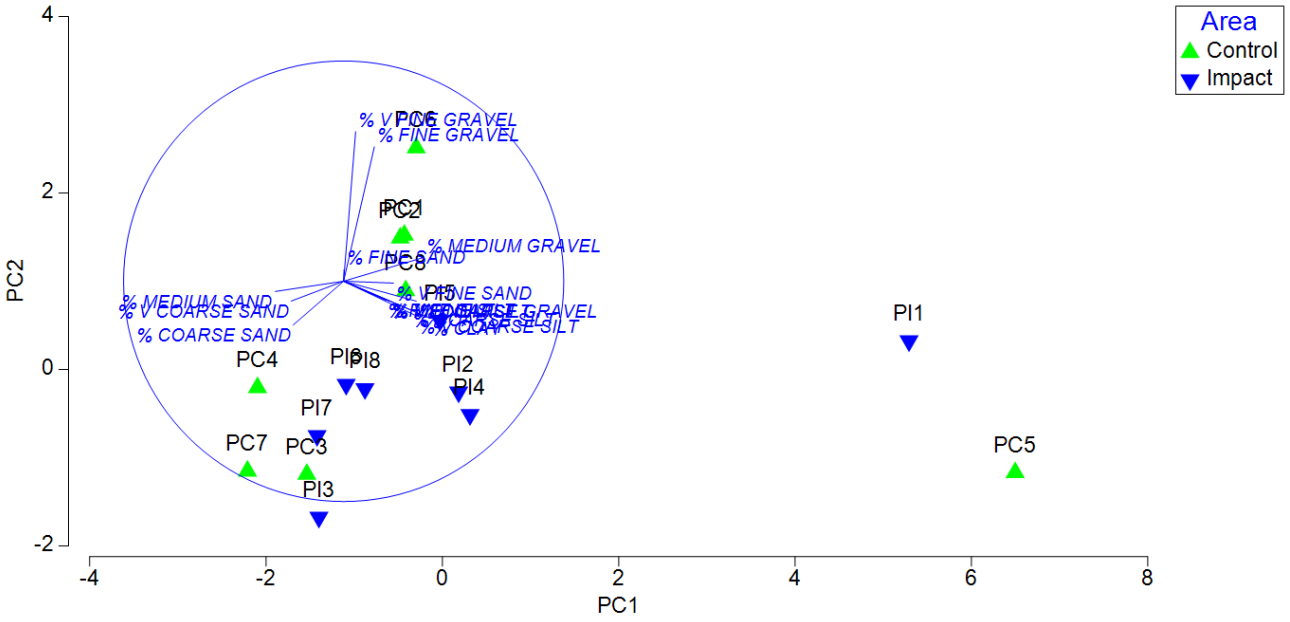


PCA was carried out on the sediment data to analyse any differences in sediment size between impact (dug) and control (undug) areas. The resulting 2D plot is shown in Figure 54. The two-dimensional axes PC1 and PC2 capture 86.5 % of the total variance and as such the plot can be considered as a very good representation of the higher dimensional relationship between blocks (Clarke and Warwick, 2001). The PCA plot suggests some grouping by area, but no clear distinction between the two. The control stations were slightly more dominated by coarse and medium sand fractions, whereas the majority of the impact stations were dominated by fine sand fractions.

Analysis was undertaken to determine whether there was a relationship between sediment composition and infaunal communities. To determine the strength of this relationship the infaunal abundance data were compared with the sediment data using the RELATE multivariate statistical routine.

Results of the RELATE test indicated there was a moderate positive correlation between faunal composition and the PSA data and this relationship was significant (Rho = 0.379, *p* = 0.023). This suggests that the differences in faunal community composition between the control and impact areas may be a reflection of the differences observed in the PSA data between these areas. However, these results should be interpreted with caution, as the faunal composition was averaged per sampling block to match the PSA replication, which may not provide a true representation of the faunal composition in these areas.

Figure 54. A 2D PCA ordination showing the contribution of each sediment size class at each block within Penmon-Beaumaris



As expected, TOC within the sediment at Penmon-Beaumaris was positively correlated with mud content and negatively correlated with sand content (Figure 60). Hence, similar to the above, the average TOC (% volume LOI) per station (Figure 61) also shows no significant difference between control and impact areas (Kruskal-Wallace, X2(1) = 2.16, *p* > 0.05).

Figure 55. Relationship between TOC content and the sediment composition of samples taken from Penmon-Beaumaris.

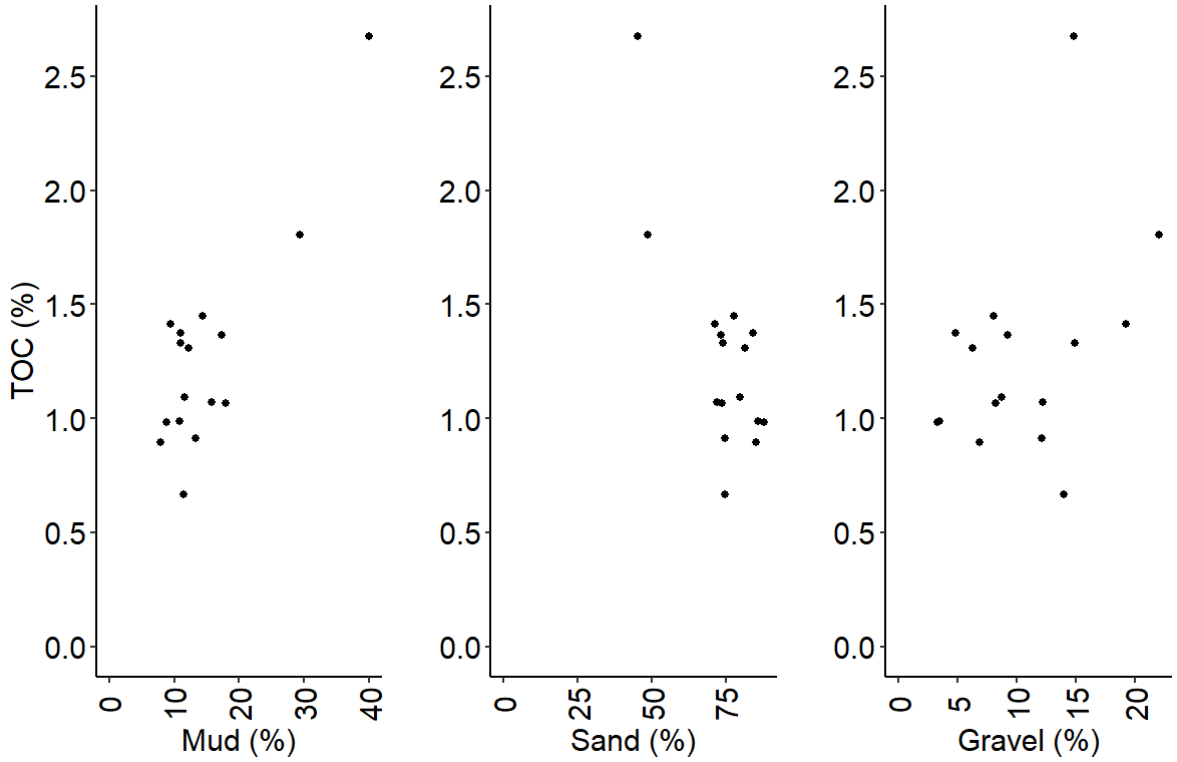
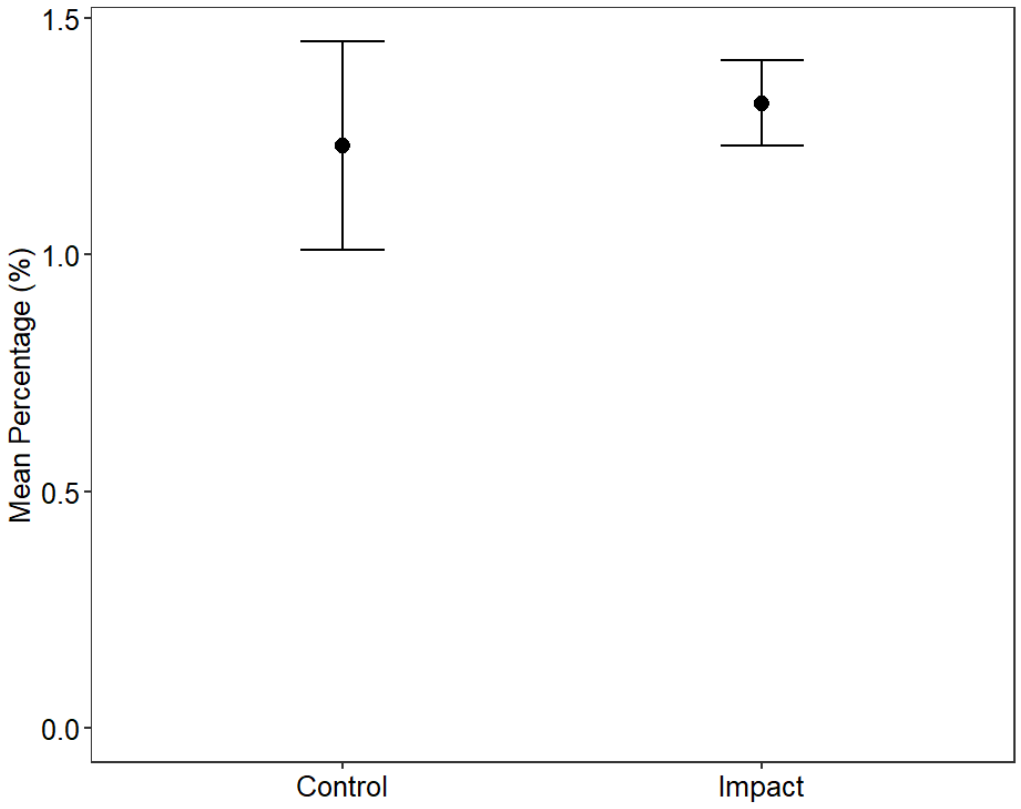


Figure 56. Mean percentage (± SE) of TOC within sediment samples taken in control and impact areas at Penmon-Beaumaris.



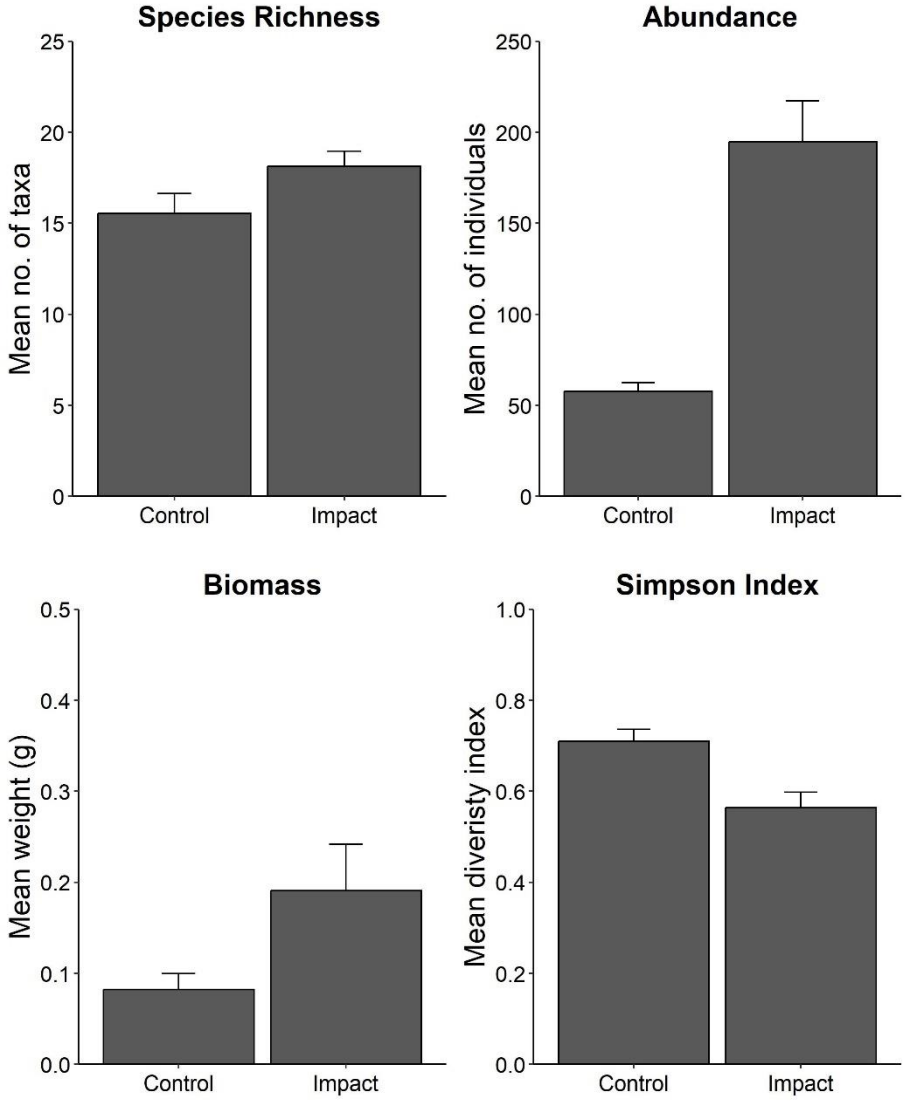
3.2.2.2 Infaunal community composition

Analysis of the faunal data was undertaken to investigate the structure and composition of faunal communities present within Penmon-Beaumaris at this snapshot in time.

A total of 139 individual taxa were recorded from 48 infaunal core samples collected from the control and impact areas at Penmon-Beaumaris monitoring sites. Of these, Annelida was the most diverse taxa, with 53 species recorded.

Average abundance, species richness and biomass were higher within the impact area compared to the control area. In comparison average diversity (Simpson's index (1- ʎ)) was lower at the impact area in comparison to the control area. Statistically significant differences were observed in abundance (ANOVA: $F = 67.66$, $p < 0.05$), biomass (ANOVA: $F = 4.08$, $p < 0.05$) and Simpson's diversity (ANOVA: $F = 11.59$, $p < 0.05$) (Figure 57).

Figure 57. Mean (± SE) abundance, species richness, biomass and Simpson's diversity index (1- ʎ) at control and impact areas at Penmon-Beaumaris.



k-dominance comparison curves (shown in Figure 58) present the cumulative dominance of average taxa abundance at control and impact areas. The higher the curve in a k-dominance plot, the lower the evenness and richness of (and more dominated) the infaunal assemblage. As can be seen in Figure 58 within the impact area, a small number of species are dominating the community (80%) which suggests that the impact area is less diverse and is indicative of a disturbed environment with a few resilient taxa. In comparison the control area is more diverse and has a more even community assemblage.

Figure 58. k-dominance curve for average abundance of taxa at control and impact areas at Penmon-Beaumaris

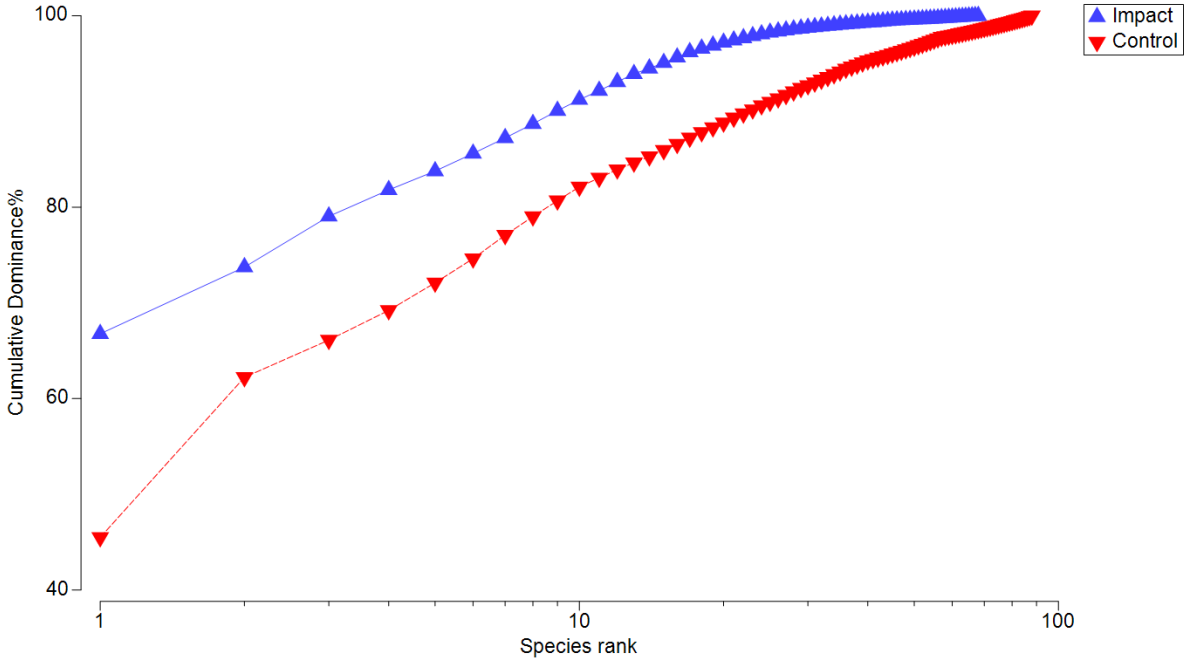


Figure 59 shows the mean abundance and biomass for each major taxonomic group within control and impact areas. As can be seen from the figure, abundance and biomass of Annelida was high in the impact area, driven primarily by the abundance of *Tubificoides benedii* and *Mediomastus fragilis*. Nematoda (the predominant species within miscellaneous) were also found in much larger numbers within the impact area compared to the control. Statistically significant differences in abundance between impact and control areas were only observed for Annelida and miscellaneous taxa. Crustacea biomass was significantly higher in the impact areas ($p < 0.05$) due to the presence of *Crangon crangon* (Figure 59).

The nMDS shows there is a relatively clear difference in the species communities between control and impact areas (Figure 60). This separation is further supported by the results of an ANOSIM (R = 0.6, $p = 0.001$) which indicates a moderate difference in species community composition between control and impact areas. The result was statistically significant, further supporting the conclusion that the areas differ in their species composition.

Figure 59. Mean (± SE) abundance and biomass within each taxonomic group for control and impact areas at Penmon-Beaumaris.

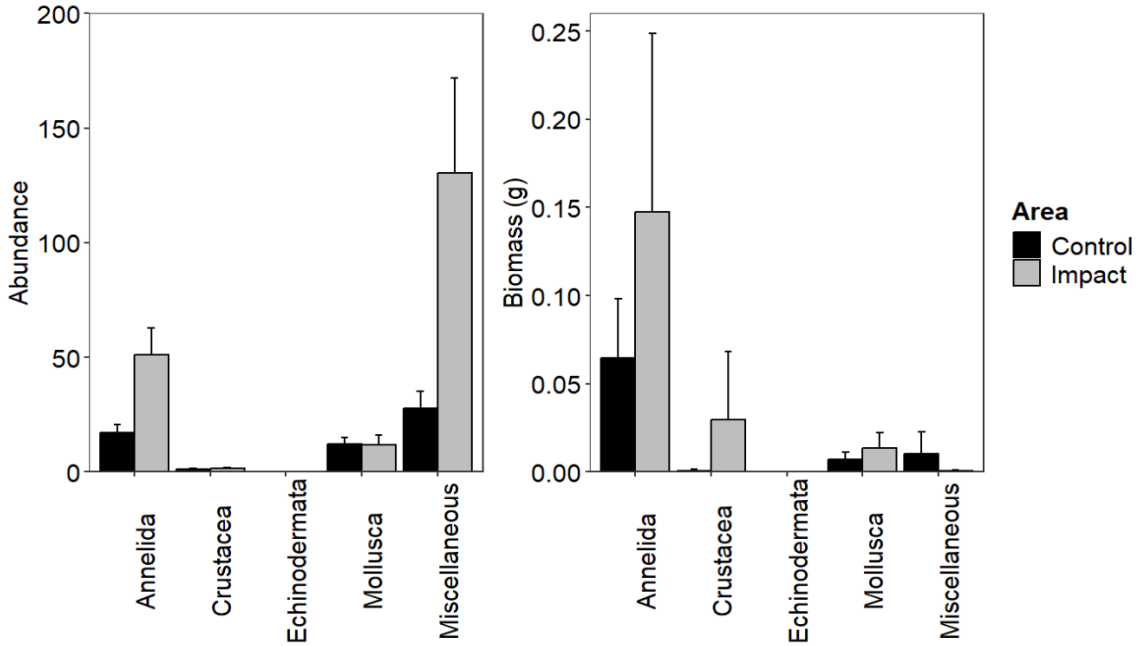
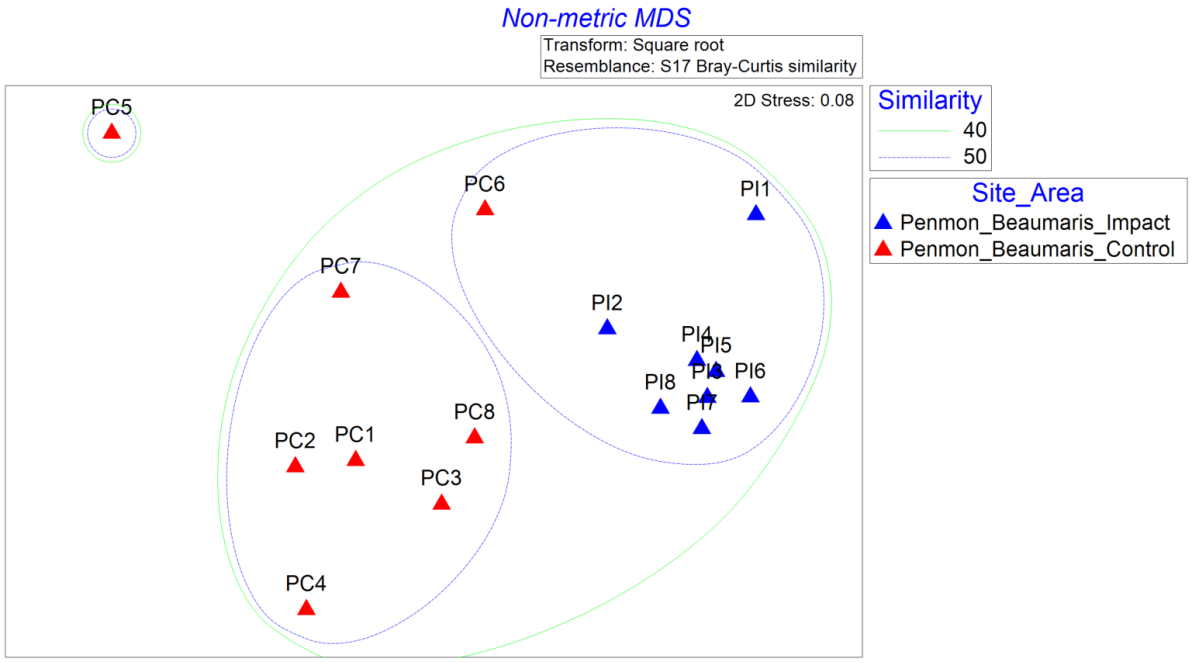


Figure 60. Non-metric MDS showing the relationship between the species communities in control and impact areas at Penmon-Beaumaris.



SIMPER analysis was performed to identify characteristic taxa of each area as well as those that contributed to the significant differences between communities in the impact and control areas. The results are presented in Table 21 and Table 22. AMBI EG scores for

each species identified during the SIMPER analysis have also been included within the tables.

The predominant taxa contributing to the similarity in benthic communities at both the control and impact areas were Nematoda, cockle *Cerastoderma edule* and the polychaete *M. fragilis.* All species are considered disturbance tolerant species (EG III) under AMBI (Table 21).

Table 21. The dominant taxa contributing to overall percentage similarity in control and impact areas at Penmon-Beaumaris, as per SIMPER routine on square-root transformed abundances (80% cut-off)

Species ***Impact: Group similarity 57.64***	**AMBI EG Score**	**Mean Sqrt. Abundance**	**% Similarity**	**% Cumulative Contribution**
Nematoda	III	10.63	20.87	36.2
Mediomastus fragilis	III	3.33	6.17	46.91
Tubificoides benedii	V	2.91	5.44	56.35
Cerastoderma edule	III	2.11	4.19	63.61
Chaetozone gibber	IV	1.7	2.87	68.59
Scoloplos armiger	III	1.37	2.65	73.18
Peringia ulvae	III	1.53	2.34	77.23
Species ***Control:*** *Group similarity 45.33*	**AMBI EG Score**	**Mean Sqrt. Abundance**	**% Similarity**	**% Cumulative Contribution**
Nematoda	III	4.78	15.56	34.32
Cerastoderma edule	III	2.99	10.69	57.9
Lanice conchilega	II	1.05	2.58	63.59
Notomastus	III	0.93	1.89	67.75
Mediomastus fragilis	III	1.09	1.81	71.75

Table 22 indicates the species for which a difference in their relative abundance contributed most to any difference between the control and impact areas. The SIMPER showed that the taxa contributing most to dissimilarity between control and impact areas were Nematoda, *M. fragilis*, *T. benedii and Chaetozone gibber* which were all more abundant in the impact area. Based on the AMBI, all of these are classified as either disturbance tolerant species (EG III) or opportunistic species (EG IV or V).

The only non-native species identified from the infaunal samples was the red seaweed *Dasysiphonia japonica* which was found at an individual station in both control and impact areas at Penmon-Beaumaris. This species has previously been identified in Wales with occurrences reported further west in the Menai Strait in 2013, 2014 and 2019 (NBN Atlas, 2025a). This is the first record occurring outside of its previously known extent.

Table 22. The dominant taxa contributing to overall percentage dissimilarity between control and impact areas at Penmon-Beaumaris, as per SIMPER routine on square-root transformed abundances. Average dissimilarity = 60.92%

Species	AMBI EG Score	Mean Sqrt. Abundance: Control	Mean Sqrt. Abundance: Impact	% Dissimilarity	% Cumulative Contribution
Nematoda	III	4.78	10.63	9.62	15.79
Mediomastus fragilis	III	1.09	3.33	4.11	22.54
Tubificoides benedii	V	0.98	2.91	3.36	28.06
Chaetozone gibber	IV	0.3	1.7	2.44	32.07
Peringia ulvae	III	0.3	1.53	2.2	35.68
Cerastoderma edule	III	2.99	2.11	2.11	39.14
Tubificoides pseudogaster		0.72	1.1	1.88	42.23
Scoloplos armiger	III	0.45	1.37	1.71	45.04
Alitta virens	III	0.04	1.05	1.69	47.82
Lanice conchilega	II	1.05	0.27	1.59	50.42
Melinna palmata	III	0.25	1.14	1.57	52.99
Cirratulidae	IV	0.21	0.94	1.42	55.32
Lagis koreni	IV	0.89	1	1.39	57.6
Notomastus	III	0.93	0.87	1.27	59.69
Scalibregma inflatum	III	0.17	0.83	1.24	61.72

3.2.2.3 Megafaunal community composition

Megafaunal sampling was incorporated into the survey strategy to identify larger infauna often missed during infaunal core sampling.

A total of 15 individual taxa were recorded from 32 megafaunal samples. SIMPER analysis identified characteristic taxa which included sand mason casts *Lanice conchilega*, polychaete tubes, the brown shrimp *C. crangon* and the green crab *C. maenas*. Sand mason casts (*L. conchilega*) were the most abundant taxa with almost twice the number of casts (on average) in the control area than in impact area. There were similar numbers of *C. maenas* between areas, however, there were approximately three times as many *C. crangon* in the impact area compared to control (Figure 61). Despite these elevations, no statistical differences were observed between impact and control areas for any phyla (Kruskal Wallis: $p < 0.05$).

Additional species recorded within the megafaunal samples included the polychaete *Nephtys* sp. and molluscs *Littorina littorea*, *Tritia reticulata*, *Tittorina littorina* and *Buccinum undatum*. These species were recorded in 1-4 megafaunal samples across the survey.

An overlap between megafaunal communities was observed between the control and impact areas (Figure 62), and this was demonstrated by the ANOSIM analysis (R = 0.161, p = 0.01), which indicated the communities are similar with some differences.

Figure 61. Mean (± SE) abundance of different phyla as part of the megafaunal community at Penmon-Beaumaris.

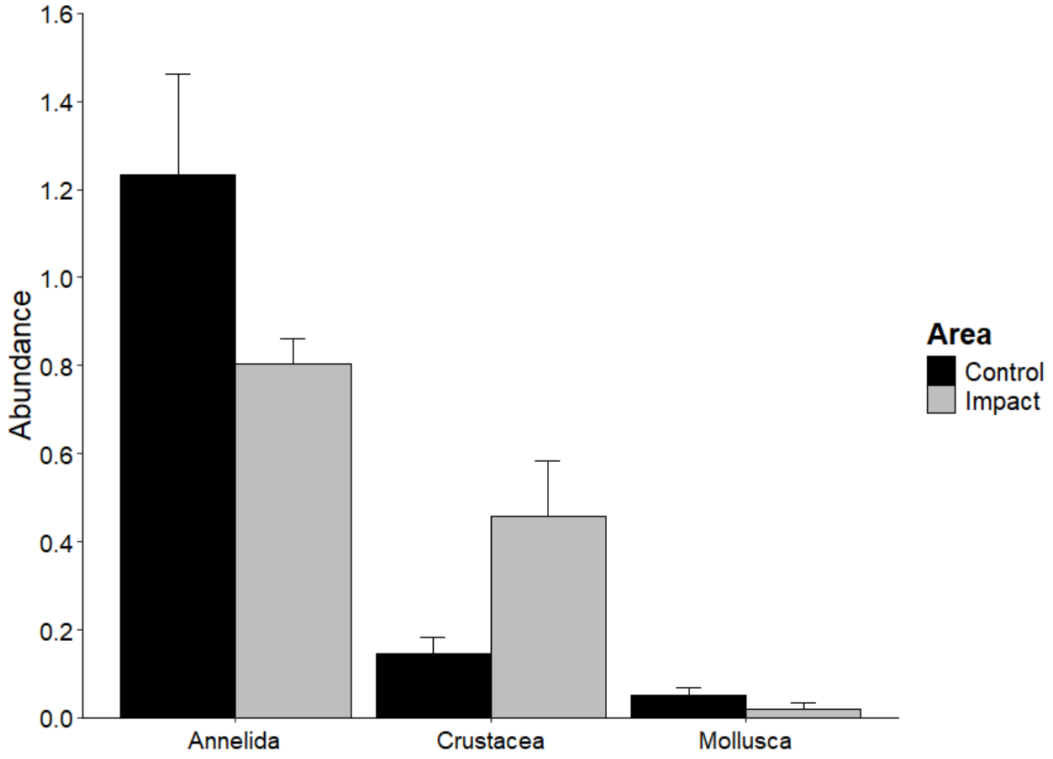
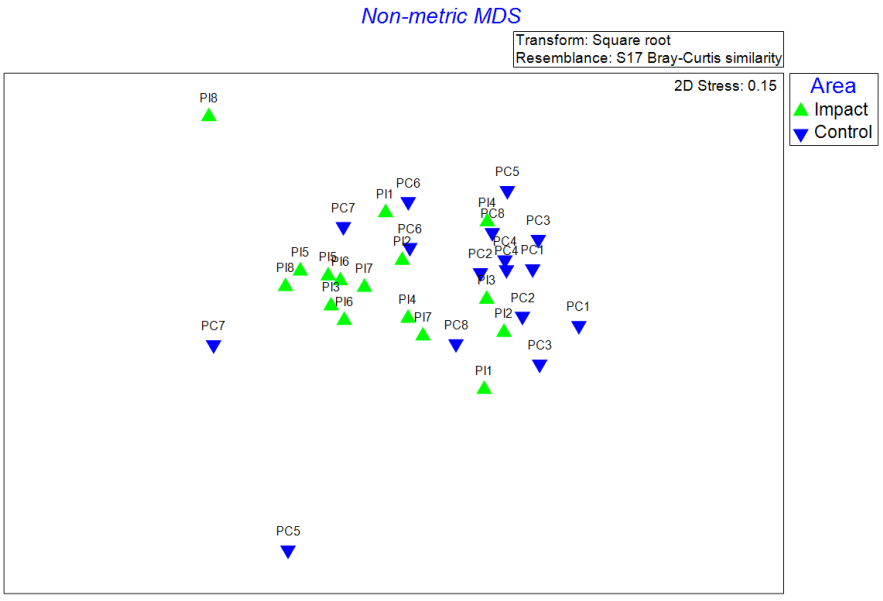


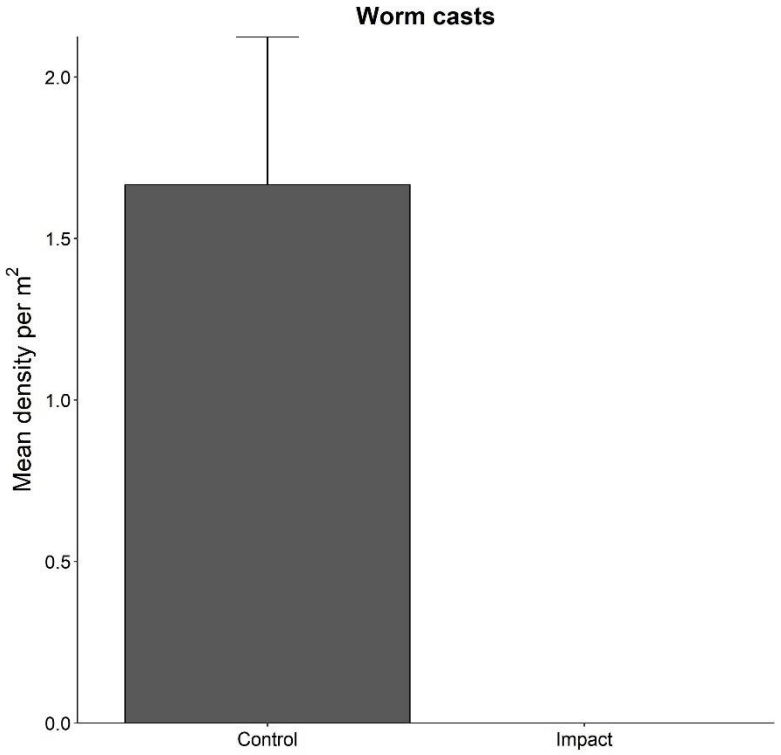
Figure 62. nMDS of Bray-Curtis Similarity of individual samples derived from the square-root transformed megafauna abundance data (per 0.25 m²) showing the relationship between the megafaunal communities in control and impact areas at Penmon-Beaumaris.



The ragworm *Alitta virens,* a species targeted by bait diggers at Penmon-Beaumaris, was recorded within 18 infaunal core samples, of which the majority were in the impact area. Ragworm were also observed during the megafaunal sampling, with two individuals observed in the impact area and one in the control area. No lugworms (i.e. *Arenicola*

marina) were observed. Wormcasts were not found within the impact area, however, an average of 1.7 ± 0.46 per m^2 worm casts were recorded in the control area (Figure 63).

Figure 63. Mean (± SE) density per m² of worm cast counts at control and impact areas at Penmon-Beaumaris.



3.2.2.4 Anthropogenic disturbances

Signs of anthropogenic activities were identified during the survey at Penmon-Beaumaris. The types of anthropogenic activities identified were grouped into the following categories:

- Public walking/trampling; and
- Bait digging.

Trampling was frequently observed at Penmon-Beaumaris. Whilst there were no active bait collectors on site, signs of bait digging activities were evident within the vicinity of sampling areas and were located in the lower shore areas.

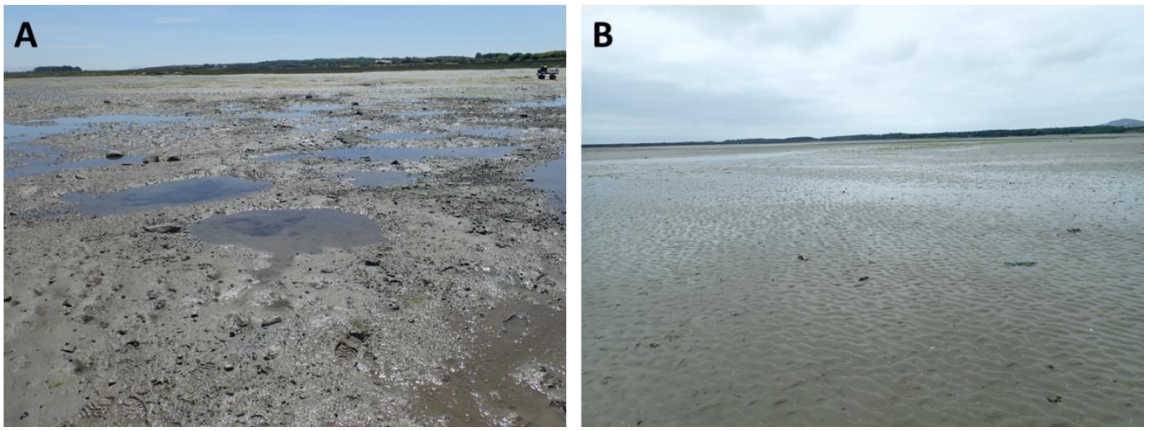
3.2.3 Four Mile Bridge

At Four Mile Bridge a suitable control site could not be found within 1-2 km of the impact site, as all the muddy gravel habitats showed signs of historical digging.

A nearby site was therefore used as a control. The control site was located 3 km north of Four Mile Bridge outside the inland sea. However, the habitat characteristics at the selected control area differed from the impact area. Muddy gravels (the predominant habitat at the impact area) were not evident at the control area which consisted of sandy sediments (Figure 64).

Potential differences in sediments and infauna between control and impact areas were therefore considered in this context (i.e. difference between the control and impact areas could be likely a result of samples being collected from different sites, and not necessarily a result of bait digging activities). In addition, appropriate caveats and assumptions were applied to the interpretation of results to account for potential differences in habitat and environmental conditions between sites. Overall, this strategy was undertaken to provide a wider site overview of impacts.

Figure 64. (A) Impact and (B) control areas for Four Mile Bridge.



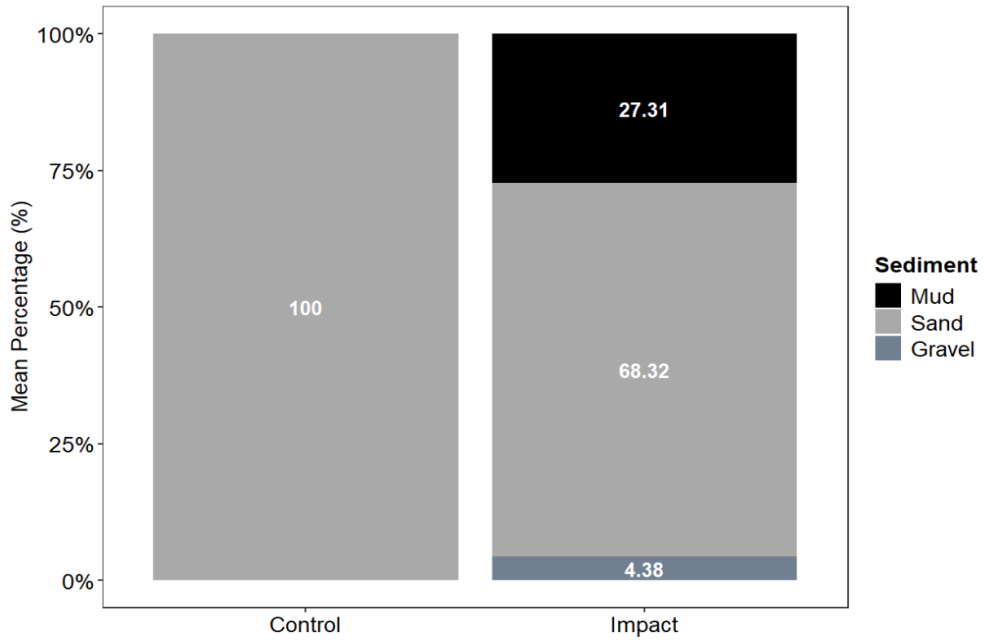
3.2.3.1 Sediment composition

The sediment classifications based on PSA data collected during the June 2024 survey are presented in Table 23. In the control area, sediments were classified as sand, with 100 % of the sediment composition being sand. The impact area was classified as muddy sand or gravelly muddy sand (Figure 65). This difference between areas was visually supported from site photographs presented in Figure 64.

Table 23. Sediment classification based on particle size data and total organic carbon content for each block in Four Mile Bridge in June 2024

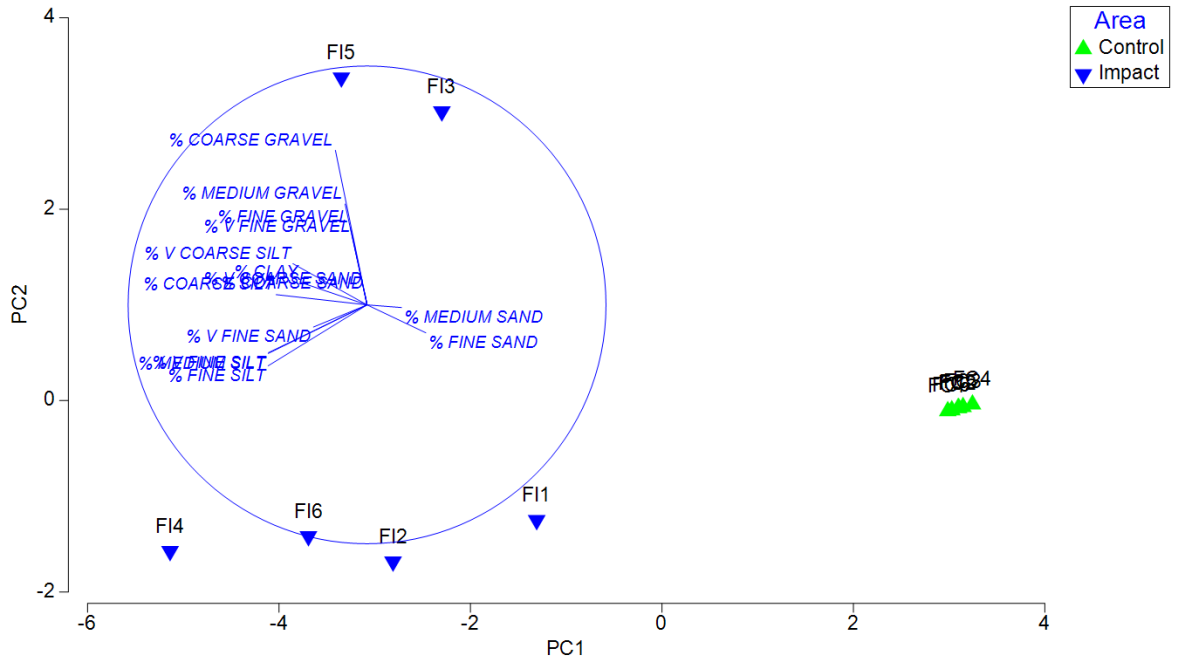
Block	Area	Sediment description	% Gravel	% Sand	% Mud	%TOC
FC1	Control	Sand	0.0	100	0.0	0.64
FC2	Control	Sand	0.0	100	0.0	0.70
FC3	Control	Sand	0.0	100	0.0	0.81
FC4	Control	Sand	0.0	100	0.0	0.70
FC5	Control	Sand	0.0	100	0.0	0.77
FC6	Control	Sand	0.0	100	0.0	0.63
FI1	Impact	Muddy Sand	0.0	81.1	18.9	1.37
FI2	Impact	Muddy Sand	0.0	76.4	23.6	1.78
FI3	Impact	Gravelly Muddy Sand	10.8	67.3	21.9	1.39
FI4	Impact	Muddy Sand	0.0	59.8	40.3	1.93
FI5	Impact	Gravelly Muddy Sand	15.5	56.0	28.5	2.27
FI6	Impact	Muddy Sand	0.0	69.4	30.7	1.99

Figure 65. Mean particle size distribution at control and impact areas at Four Mile Bridge.



PCA was carried out on the sediment data to analyse the differences in sediment particle size between impact and control areas. The resulting 2D plot is shown in Figure 66. The two-dimensional axes PC1 and PC2 capture 95.3 % of the total variance and as such the plot can be considered as a very good representation of the sampling blocks. The PCA plot shows a clear difference in sediment fractions between the control and impact areas. Control blocks were strongly driven by fine sand fractions. In contrast, impact blocks were dominated by very fine silt fractions and coarse gravel to some degree.

Figure 66. A 2D PCA ordination showing the contribution of each sediment size class at each block within Four Mile Bridge.



A RELATE test was conducted to determine if the differences in PSA data between impact and control areas are reflected in the faunal community composition. The results of the RELATE test showed a moderate positive correlation between faunal composition and PSA data and the relationship was significant (Rho = 0.58, p = 0.002). The findings indicate that the variations in faunal community composition between the control and impact areas are likely due to the differences in particle size between these areas. This is to be expected, given sediment compositions greatly differed between the control and impact areas (Figure 64).

As expected, TOC was positively correlated with mud content and negatively correlated with sand content of the sediment at Four Mile Bridge (Figure 67). Hence, the significant difference between impact and control sites is also reflected in the TOC content (Kruskal-Wallace, $X^2(1) = 8.31$, $p < 0.05$) of the sediment as impacted areas contained higher proportions of mud and therefore higher TOC (Figure 68).

Figure 67. Relationship between TOC content and the sediment composition of samples taken from Four Mile Bridge.

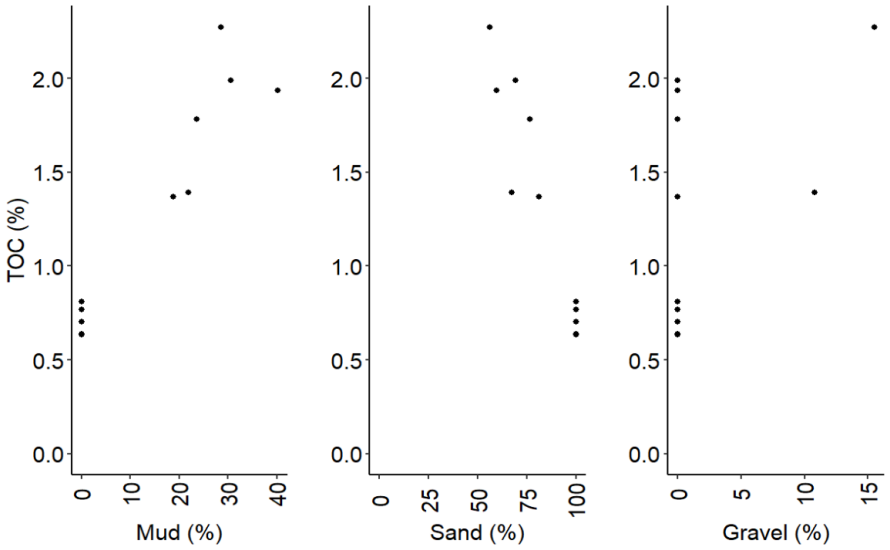
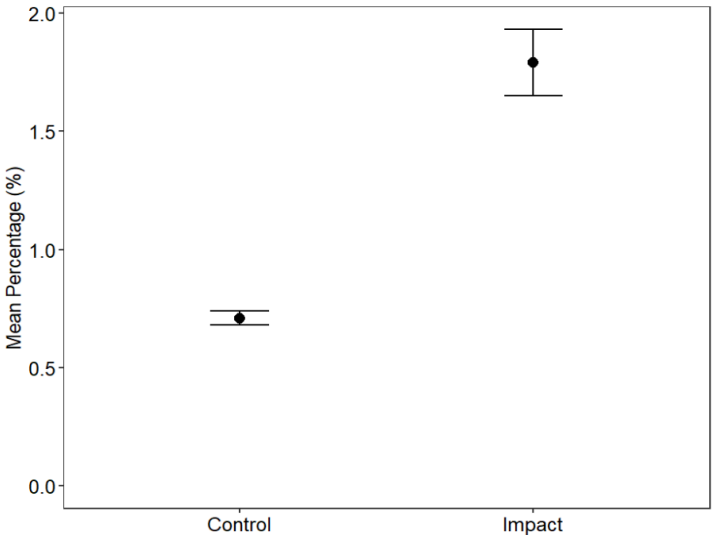


Figure 68. Mean percentage (± SE) TOC within sediment samples taken in control and impact areas at Four Mile Bridge.

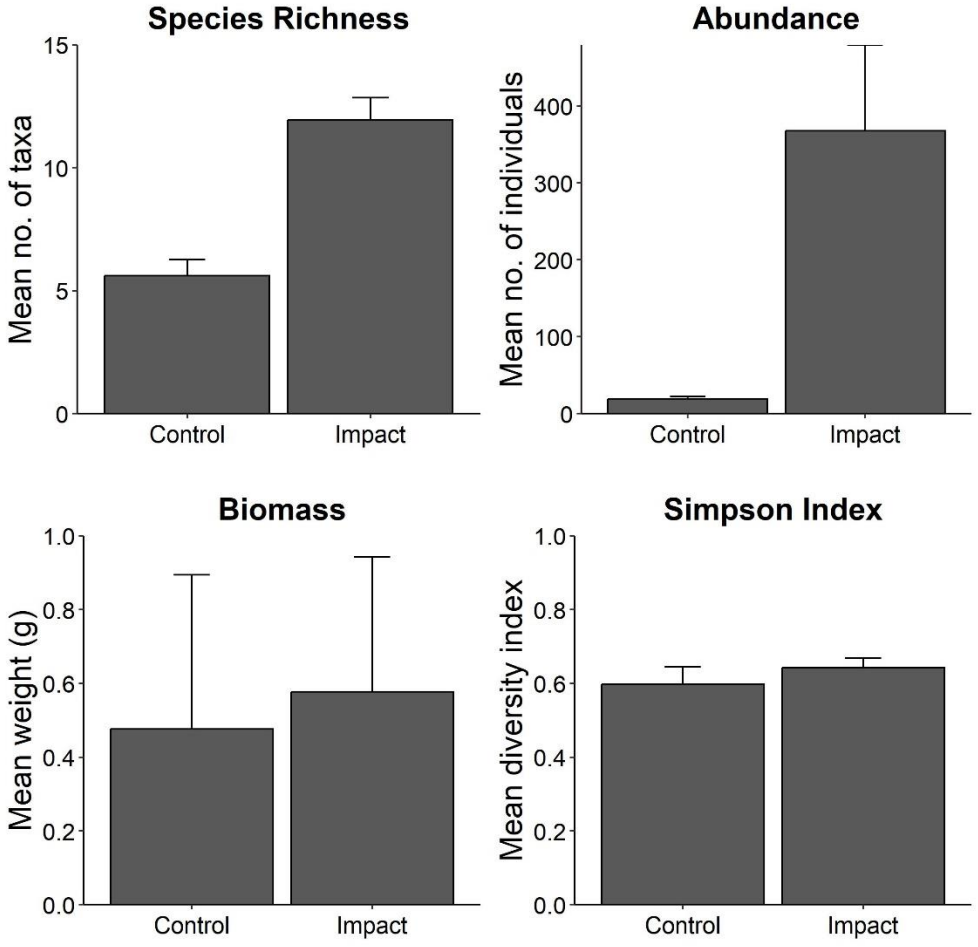


3.2.3.2 Infaunal community composition

A total of 56 individual taxa were recorded from 48 infaunal core samples collected from the control and impact areas at Four Mile Bridge monitoring sites. Of these, Annelida was the most diverse taxa, with 26 species recorded.

Abundance, species richness and biomass were higher within the impact area compared to the control area (Figure 69). Simpson's diversity index was similar between control and impact areas. Given the distinct differences in sedimentary habitats between the control and impact areas, conducting statistical analyses on infaunal community metrics was deemed inappropriate. Such analyses would inevitably yield significant differences, which would not be meaningful for the purposes of this study.

Figure 69. Mean (± SE) abundance, species richness, biomass and Simpson's diversity index at control and impact areas at Four Mile Bridge.



The k-dominance comparison curves presented in Figure 70 indicate dominance in the impact area with a small number of species, which suggests diversity in the impact area is low and appears to show levels of disturbance. Conversely, the control area appears to show an even distribution of abundance amongst species.

The different faunal groups that contributed to the overall abundance and biomass between control and impact areas is presented in Figure 71. While it is acknowledged that sediment characteristics differed between the control and impact areas, a high-level

assessment of differences in species composition between these areas was conducted. Abundance of the annelid *T. benedii*, mudsnail *Peringia ulvae*, and crustacean *Corophium volutator* was high in the impact areas. Nematoda (the predominant abundance within miscellaneous) were also found in much larger numbers within the impact area compared to the control. Large numbers of *P. ulvae* was likely the main contributor to high Molluscan biomass for the impact area at Four Mile Bridge. It should be noted that these species are predominately found in mud habitats which may explain their prevalence in the impact area compared to the sand dominated control area. In general, there was low abundance of taxa in the control areas. The high biomass value for molluscs in the control areas was attributed to the presence of one cockle (*C. edule;* Figure 71).

Figure 70. k-dominance curve for average abundance of taxa at control and impact areas at Four Mile Bridge.

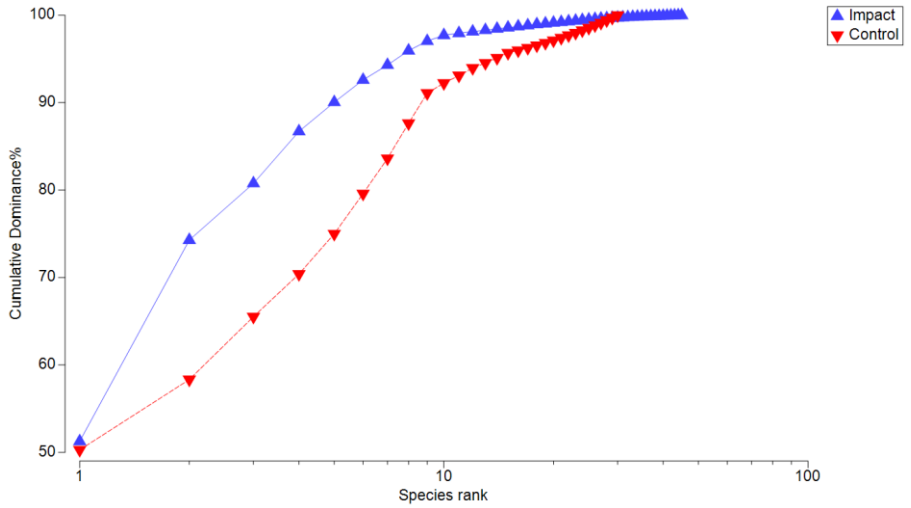
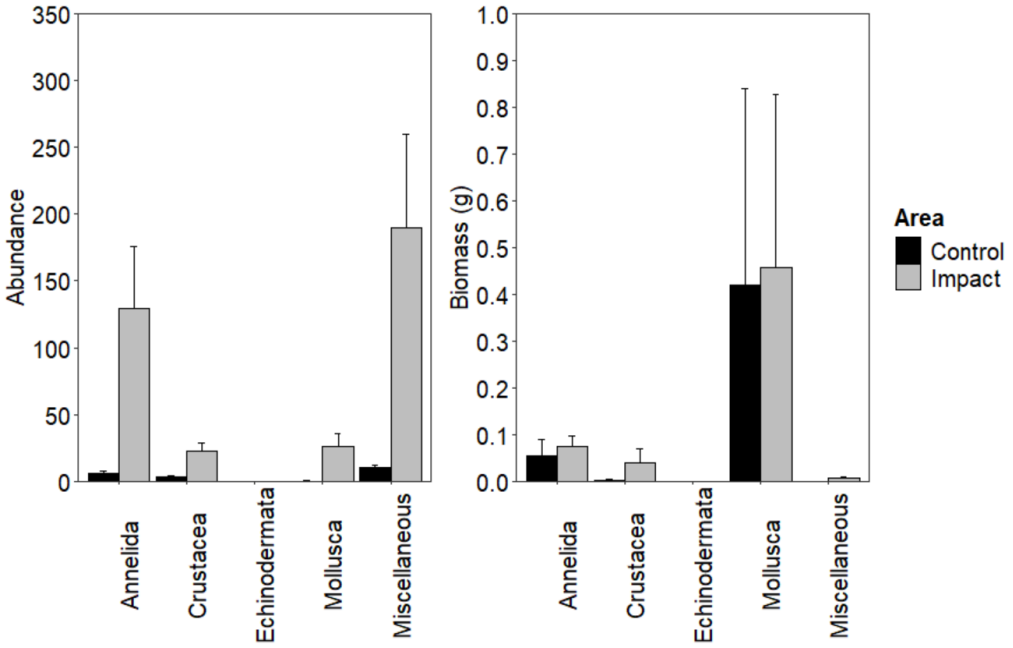


Figure 71. Mean (± SE) abundance and biomass within each taxonomic group at control and impact areas at Four Mile Bridge.



The nMDS shows there is a clear difference in the species communities between control and impact areas (Figure 72). This separation is further supported by the results of an ANOSIM (R = 0.8, *p* = 0.001). This indicates a high degree of dissimilarity between the two areas, suggesting that the species community composition differs significantly between the control and impact areas. This is not unexpected, given that the sediment composition differed between the control and impact areas.

Figure 72. nMDS showing the relationship between the species communities in control and impact areas at Four Mile Bridge.



SIMPER analysis showed the predominant taxa contributing to the similarity in benthic communities at the impact area was Nematoda, *T. benedii, C. volutator and P. ulvae* (Table 24). These species are often found in muddier sediments and tend to dominate in disturbed or organic enriched environments. This is further supported by the high TOC values recorded in the impact area at Four Mile Bridge. All are considered disturbance tolerant species (EG III) or opportunistic species (EG V). At the control area, Nematoda, *Scoloplos armiger* and *Bathyporeia sarsi* contributed to similarity in benthic communities. *S. armiger* and *B. sarsi* are often found in fine sandy sediments correlating with the predominant sediments observed at the impact and control areas (Section 3.2.3.1). Table 25 presents the species for which a difference in their relative abundance contributed most to any difference between the control and impact areas. The dominant taxa which contributed most to the dissimilarity between control and impact areas were Nematoda, *T. benedii*, *C. volutator* and *P. ulvae* which were all more abundant at impact areas. This is again likely due to presence of muddy sediments in the impact area compared to the control area. All species contributing to differences between control and impact areas and with higher abundance within the impact area are considered disturbance tolerant species (EG III), or opportunistic species (EG IV and EG V) based on AMBI.

All species with higher abundance in the control area are considered disturbance sensitive (EG I) or disturbance tolerant (EG III). In particular amphipod species *Bathyporeia pilosa*, *B. sarsi* and *Corophium arenarium* were only found in the control area of Four Mile Bridge. This may suggest the potential sensitivity of these species to disturbance related effects. However as discussed above these species are often associated with sandier sediments

and as such may be a reflection of the different sediments present at the control and impact areas.

Non-native species were not identified from the infaunal samples sampled at Four Mile Bridge.

Table 24. The dominant taxa contributing to overall percentage similarity in control and impact areas at Four Mile Bridge, as per SIMPER routine on square-root transformed abundances (80% cut-off)

Species ***Impact: Group similarity 47.85***	**AMBI EG Score**	**Mean Sqrt. Abundance**	**% Similarity**	**% Cumulative Contribution**
Nematoda	III	11.37	18.18	38
Tubificoides benedii	V	7.13	9.89	58.67
Corophium volutator	III	3.91	6.56	72.39
Peringia ulvae	III	3.36	2.76	78.16
Ampharete cf. acutifrons	Not listed	1.94	2.61	83.62
Species ***Control: Group similarity 38.23***	**AMBI EG Score**	**Mean Sqrt. Abundance**	**% Similarity**	**% Cumulative Contribution**
Nematoda	III	2.85	24.56	64.25
Scoloplos armiger	III	0.65	4.22	75.28
Bathyporeia sarsi	I	0.56	2.08	80.72

Table 25. The dominant taxa contributing to overall percentage dissimilarity between control and impact areas at Four Mile Bridge, as per SIMPER routine on square-root transformed abundances. Average dissimilarity = 80.20%

Species	**AMBI EG Score**	**Mean Abundance: Impact**	**Mean Abundance : Control**	**% Dissimilarity**	**% Cumulative Contribution**
Nematoda	III	11.37	2.85	15.47	19.29
Tubificoides benedii	V	7.13	0.62	11.96	34.21
Corophium volutator	III	3.91	0.06	8.77	45.15
Peringia ulvae	III	3.36	0.06	5.71	52.27
Ampharete cf. acutifrons	Not listed	1.94	0.06	4.37	57.71
Tharyx	IV	1.9	0.06	3.98	62.68
Manayunkia aestuarina	III	2.26	0.06	3.88	67.52
Capitella	V	1.59	0.62	2.78	70.99
Scoloplos armiger	III	1.28	0.65	2.42	74
Pygospio elegans	III	0.23	0.52	1.43	75.78
Bathyporeia pilosa	I	0	0.66	1.39	77.51
Bathyporeia sarsi	I	0	0.56	1.3	79.14
Corophium arenarium	III	0	0.53	1.16	80.58

3.2.3.3 Megafaunal community composition

A total of 5 individual taxa were recorded from 24 megafaunal surface samples, of which 17 (11 from impact and 6 from control) samples had taxa present. Annelida, Crustacea and Mollusca groups were more abundant in the impact area. *C. maenas*, *C. edule*, and polychaete tubes were higher in abundance in the impact area compared to the control (Figure 73) potentially due to a preference of mud habitats. Statistically significant differences between impact and control areas were only observed for *C. edule* ($p < 0.05$). Amphipods and Nephtys *sp*. were only present at the control area in low numbers which may reflect the difference in sediment type between the control (sand) and impact (mud) areas.

The number of worm casts per m^2 was also recorded in each block within control and impact areas. An average of 6.6 ± 1.1 per m^2 worm casts were recorded in the control area compared to 1.6 ± 0.5 per m^2 in the impact area (Figure 74). This difference was statistically significant (Kruskal-Wallace, $X^2(1) = 24.7$, $p < 0.05$).

Figure 73. Mean (± SE) abundance of megafaunal taxa at Four Mile Bridge.

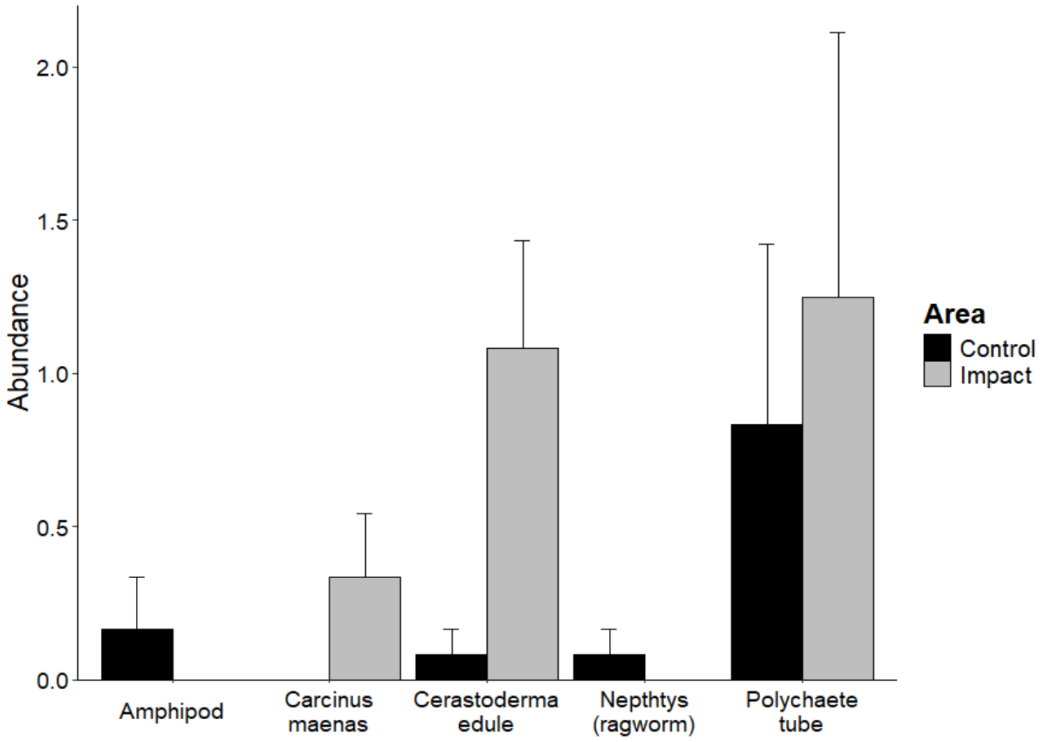
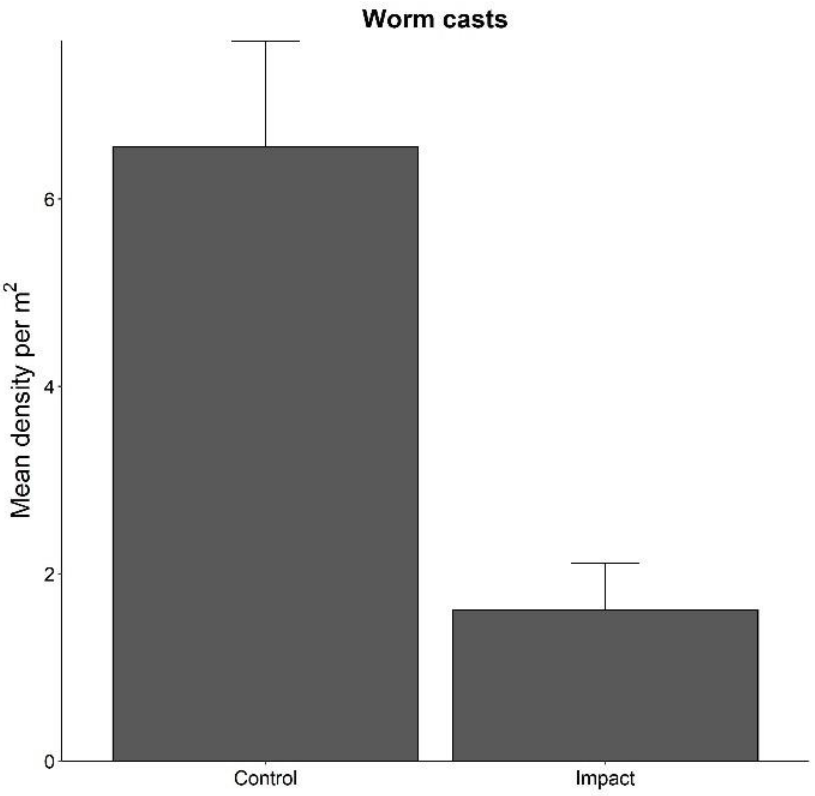
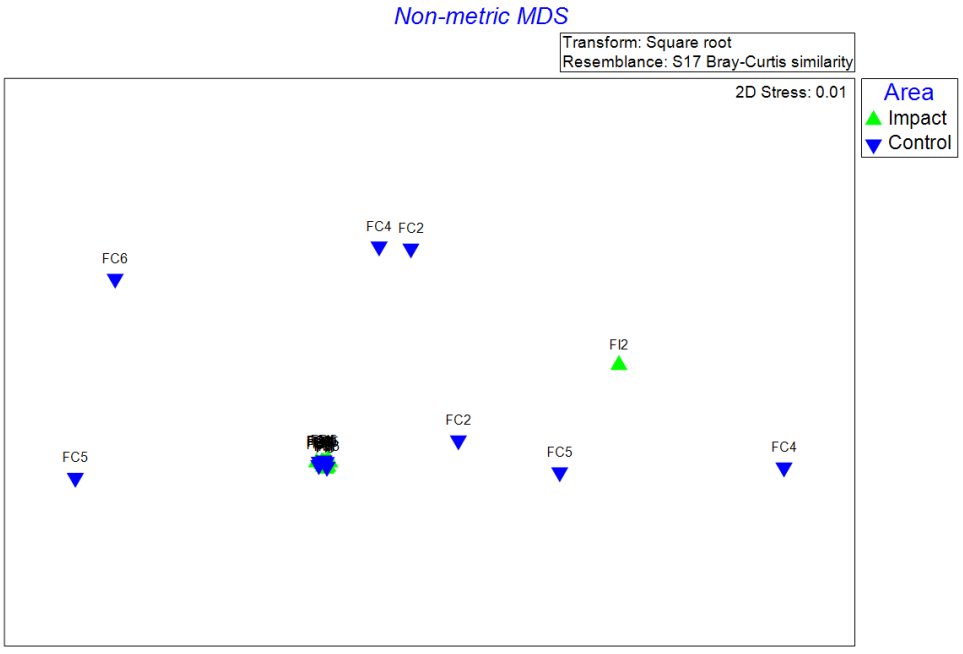


Figure 74. Mean (± 95% CI) density per m² of worm cast counts at control and impact areas at Four Mile Bridge.



The nMDS plot shown in Figure 75, indicates some overlap of megafaunal communities between control and impact areas. This overlap is further supported by the results of an ANOSIM (R = 0.168, *p* = 0.008*)* which indicates that megafaunal communities are similar with some differences. However, this observation was based on 8 samples with the remaining samples having no megafauna present.

Figure 75. Non-metric MDS showing the relationship between the megafaunal communities in control and impact areas at Four Mile Bridge.



3.2.3.4 Anthropogenic disturbances

Signs of anthropogenic activities were identified at Four Mile Bridge. The types of anthropogenic activities identified were grouped into the following categories:

- Public walking/trampling;
- Bait digging; and
- Recreational activities (fishing, kayaking).

Whilst there were no active bait collectors on site, signs of bait digging activities were evident at the impact area. Current bait collection was taking place further upstream away from the impact sampling area, but historic holes were evident within the sampling area. No signs of bait collection were observed at the control area. In addition, recreational activities were observed at the Four Mile Bridge impact area.

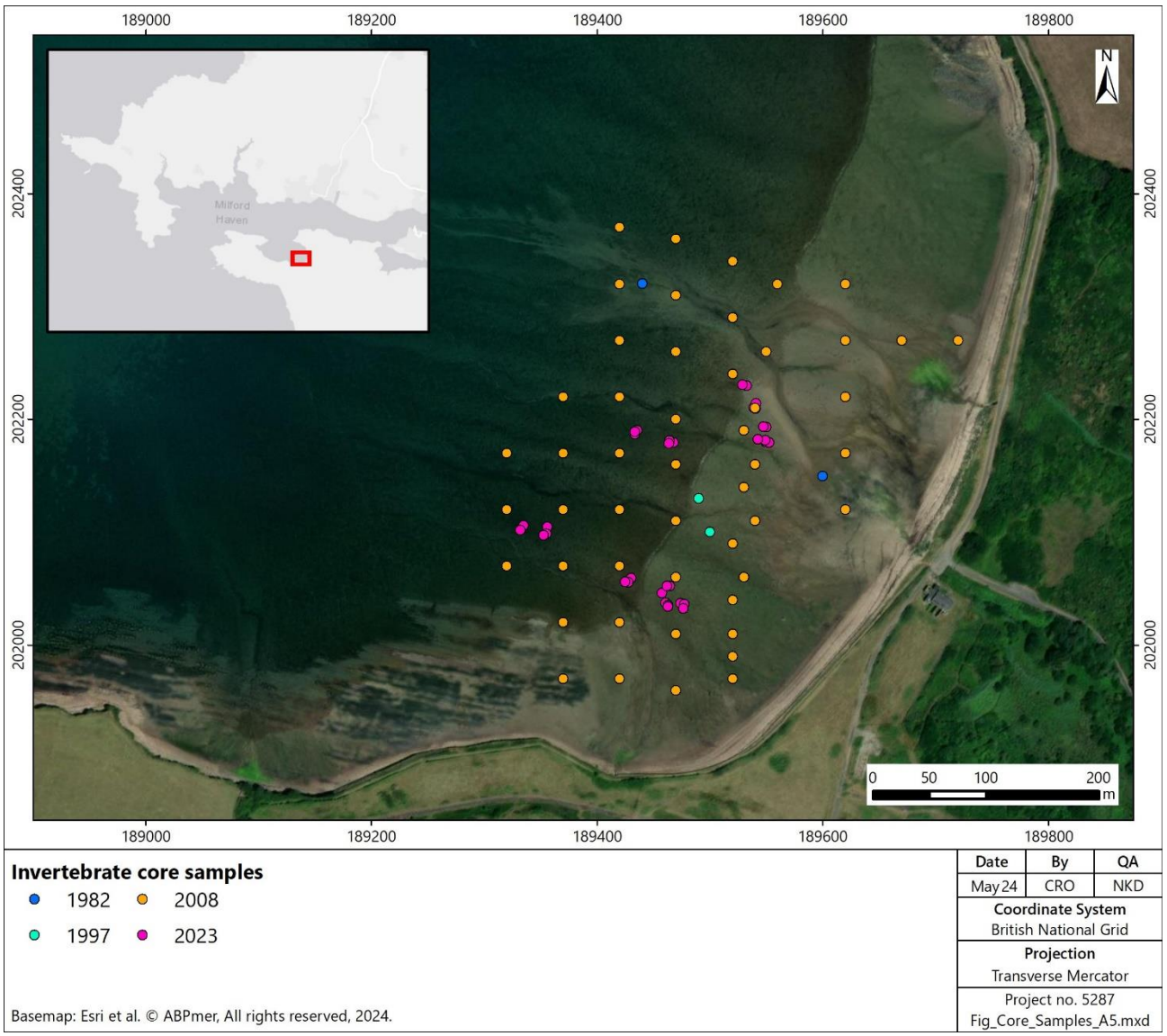
3.2.4 Historic comparison

Where possible, comparisons with historic data from within the vicinity of the survey sites can provide a baseline (i.e., control data) for which comparisons between impact areas can be assessed. The use of this approach was considered at Four Mile Bridge where it was not possible to identify a control area on site. However, the only available historic data at Four Mile Bridge was a single survey from 2003 (Moore, 2004), which consisted of *in-situ* identification of biotopes and species present on tidally exposed habitats (mainly boulders and cobbles). Due to the different methodology and type of data collected from this survey, a historical comparison of faunal assemblages was not appropriate, and as such, it was not pursued at this monitoring site.

3.2.4.1 Angle Bay

To provide context to any observed differences in faunal assemblages between the control and impact areas at Angle Bay the data was put into the context of historic datasets. A comparison of the results of the current survey against historic surveys within the area is provided in this section. Historic data collected from the vicinity of the current Angle Bay sample locations was available from 1982 (1982 Rostron PMSA -Milford Haven sediment survey, Rostron, 1983), 1997 (1996-97 Rostron PMSA -Sea Empress oil spill sediment shore impact assessment, Rostron, 1998) and 2008 (2008 CCW / ASML Pembrokeshire Marine SAC *Zostera noltii* Monitoring, Bunker 2012). A description of each of these surveys is provided in Appendix F. These data aim to act as a proxy for baseline conditions prior to the introduction of bait digging within Angle Bay. The locations of samples collected from each historic survey year, in relation to the 2023 samples, are shown in Figure 76.

Figure 76. Location of previous infaunal sampling undertaken in 1982, 1997 and 2008 relative to the 2023 sample locations.



The exact methods of sample collection are not known for the 1997 survey. During the 1982 surveys 0.1 m² day grab samples were collected and sieved over 1 mm mesh, in contrast to the 0.01 m² infaunal core samples sieved over 0.5 mm mesh during the current 2023 study. The 2008 survey used in-situ observations from sieved cores in the field. Data between surveys are therefore not directly comparable. Consequently, to allow some form of comparable assessment across years all data have been converted to the highest comparable format, presence/absence. However, due to the semi-quantitative nature of presence/ absence data and incompatibility of the collected data comparison between abundance and biomass of species is not possible, to allow in-depth investigation of changes in community structure. Further, it should also be noted that only two replicates from the 1982 and 1997 data spatially overlapped with the 2023 survey extent. The low number of replicates for both 1982 and 1997 will impact the reliability of the results.

No statistically significant differences in faunal communities were detected between control and impact areas in 2023 and as such all the data for 2023 has been analysed together. Furthermore, no data on previous bait digging intensity or location is available to compare the potential levels of impact against each of the years of historic data. It is therefore not possible to identify which data might provide a better indication of a true ‘baseline’ or provide an indication of ‘undisturbed’ habitat at the site.

The total number of species, the average number of species per sample, and the minimum and maximum number of species from a sample in a given year are shown in Table 26. Abundance, biomass and diversity could not be calculated due to the presence/absence nature of the historic data available.

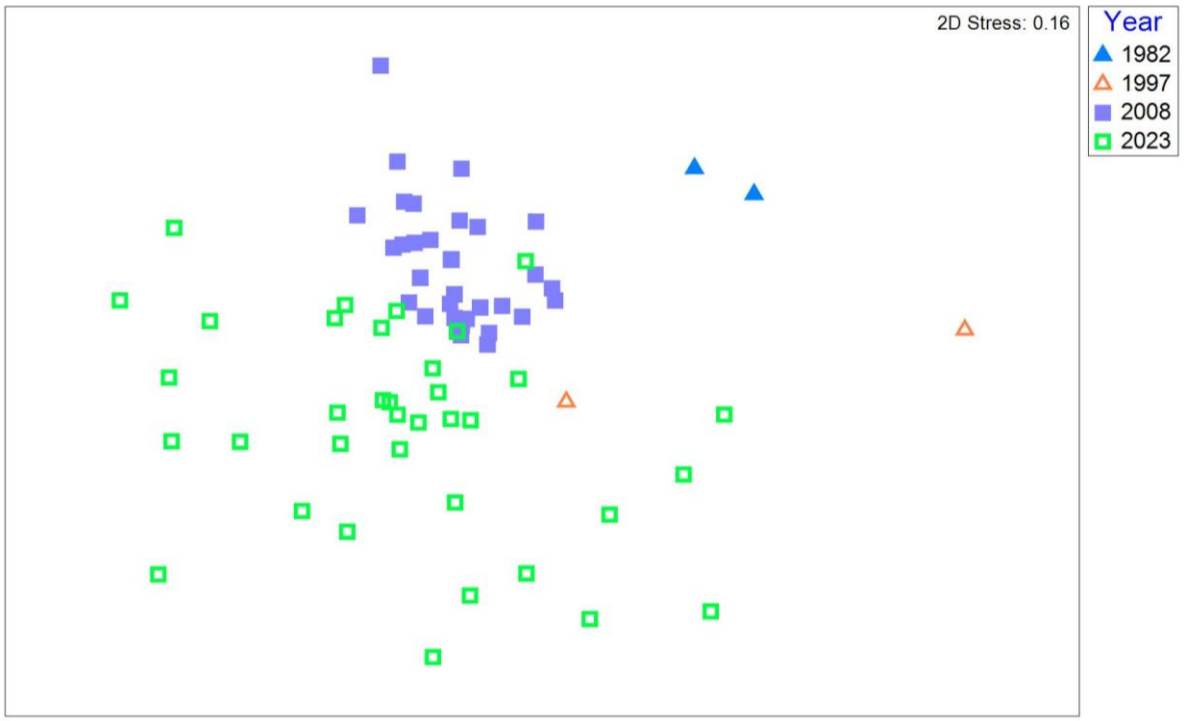
The total number of species within samples between 1982 and 2023 ranged from 10 in 1982, 16 in 1997 and 2008 to 38 in 2023 suggesting the diversity or number of species present across Angle Bay may have increased since 1982. However, the very low number of sample replicates for 1982 and 1997 in comparison to 2008 and 2023 will have influenced this result. The large increase in total species sampled in 2023 compared to 2008, despite there being fewer samples collected, does however suggest an increase in the number of species present at Angle Bay. This is similarly seen by the average number of species in each sample which was much lower in 2008 in comparison to all other years. This, however, might be a result of the sampling method in 2008 which only utilised in-situ species identification from sieved cores in the field in comparison to laboratory identification as undertaken in both 1982 and 2023. It was highest in 1997, however, this is based on only two samples. The sampling methods used in 1997 are unknown.

Table 26. Total, average, minimum and maximum number of species identified in samples in 1982, 1997, 2008 and 2023.

Year	No. of samples	Total species	Average no. of species	Minimum no. of species	Maximum no. of species
1982	2	10	6.5	6	7
1997	2	16	9.5	6	13
2008	50	16	3.3	0	9
2023	36	38	6.7	2	11

To investigate any potential statistical differences in faunal communities present between years an MDS plot for infaunal presence/ absence data at each station was produced, shown in Figure 77. There was a clear separation between the infaunal communities observed between years (1982, 1997, 2008 and 2023). The 1997 data was collected as a direct result of the 1996 Sea Empress oil spill disaster. This is likely to have directly impacted the faunal assemblages present and therefore differences in faunal communities in 1997 and all other years cannot be directly attributed to bait digging impacts.

Figure 77. MDS plot of Euclidean distance of individual samples derived from the presence/absence transformed historic infaunal data.



These differences were corroborated by ANOSIM which found a difference between communities between years (R = 0.5, *p* = 0.001). Pairwise comparison further identified differences between years, particularly between 2008, 1982 and 1997 and also between 2023 and 1982 (Table 27). There were some less obvious differences between 2023, 2008 and 1997. Faunal groups between 1982 and 1997 were highly similar, however, the statistical significance of this results is very low.

Table 27. Pairwise tests for differences between faunal samples between years.

Groups	R Statistic	Extent of the similarity or difference	Significance (*p*)
1982, 1997	0.00	Highly similar	0.66
1982, 2008	0.98	Highly different	0.005
1982, 2023	0.68	Different	0.001
1997, 2008	0.91	Highly different	0.004
1997, 2023	0.44	Different with some overlap	0.05
2008, 2023	0.45	Different with some overlap	0.001

SIMPER analysis was performed to identify those taxa characteristic of each year as well as those contributing to any differences between communities between years. Species identified as characterising for samples collected from 1982 were *Scoloplos armiger*, *Nephtys hombergii* and *P. elegans*. In 1997 the characterising species were *P. elegans, C. edule and P. ulvae.* Similarly, in both 2023 and 2008 *C. edule* and *P. ulvae* were the characterising species. In 2023 *Nematoda* were also identified as characterising the samples. All species are characteristic of sheltered muddy sand shores and *N. noltei* beds and all are either disturbance tolerant or disturbance indifferent species, none are classified as opportunistic or indicative of particularly disturbed environments.

Across years the key species identified as contributing to differences in communities were *Littorina littorea, Nematoda, N. hombergii, P. ulvae, Phyllodoce mucosa, P. elegans, S. armiger* and *Tubificoides benedii*. In particular, between 1982 and 1997 *P. ulvae* contributed most to the differences in species composition with none identified in samples in 1982 and being present in all samples (n=2) in 1997. Comparing 1982 and 2008, a decrease in occurrence of *N. hombergii, P. elegans* and *S. armiger* from presence in 100% of samples in 1982 (n=2) to no samples in 2008 (n= 50) resulted in the key difference between samples. A similar pattern was also true between 1997 and 2008 where fewer occurrences of *N. hombergii, P. elegans* and *S. armiger* were observed in the latter survey.

The key difference in faunal communities between 1982 and 2023 was a change from 100% occurrence to 0% occurrence of *S. armiger* and the converse for *P. ulvae* over the same period. A 75% and 100% reduction in occurrence of *P. elegans* and *S. armiger,* respectively, was recorded in 1997 in comparison to 2023. In addition, an increase of *Nematoda* from zero occurrences to 61% occurrence also contributed to differences between both 1997 and 2008 and 2023.

It should be noted, that whilst differences in the occurrence of species across Angle Bay have been observed, the key characterising species across years has remained largely similar with *S. armiger, N. hombergii, P. elegans, C. edule* and *P. ulvae,* all species characteristic of *N. noltei* beds, being the main species identified.

As highlighted above due to the low number of replicates for both 1982 and 1997, different methodologies and the lack of quantitative abundance and biomass data, the observed changes in faunal occurrence should be interpreted with care.

No corresponding sediment classification data are available for each of the sample sites in the previous surveys It is therefore not possible to compare changes in sediment composition across years. In addition, it is not possible to assess whether any of the observed changes in faunal occurrence are a result of changes in sediment structure across Angle Bay.

Furthermore, no data on bait digging intensity or location is available to compare the potential levels of impact against each of the years of historic data. Although potential differences in faunal communities have been observed between years, it is not possible to attribute this to bait digging activity.

3.2.4.2 Penmon-Beaumaris

Multiple historic surveys of infaunal communities have been undertaken at Penmon-Beaumaris. A comparison has therefore been made to understand any long-term changes in community composition over time.

To minimise the effects of spatial variability, historical data collected within a 500 m radius of the 2024 Penmon-Beaumaris control and impact areas were selected. Four suitable historic surveys were therefore included in the analysis:

- 1997 MNCR east Anglesey littoral survey (Brazier *et al.,* 1999);
- 2002 CCW Marine mud and muddy gravel characterisation in the Menai Strait (Barnes, 2003);
- 2004 CCW / IECS Menai Strait & Conwy Bay SAC muddy gravel (LMX) core sampling (Allen *et al.,* 2004); and
- 2013 NRW/ASML Menai Strait and Conwy Bay SAC muddy gravel survey (Moore, 2018).

A description of each of these surveys is provided in Appendix F. The locations of the historic samples in relation to the 2024 samples are shown in

Figure 78 Information on bait digging location or intensity was not collected during the historic surveys, and as such a comparison of the impact of bait digging over time cannot be made. However, an assessment of temporal changes to faunal composition is presented below. A range of different sized cores were used for the historic surveys (0.0083 m², 0.0814 m^2 or 0.01 m²), but all samples were sieved over a 0.5 mm mesh for infaunal analyses. To enable a comparison across surveys, all abundance data were standardised to 1 m^2. In addition, the historical species data were:

- Processed in accordance with the ‘Data Preparation/ Formatting Specification’ (Green, 2020) and taxon names checked against the Marine Species of the British Isles and Adjacent Seas (MSBIAS) subset of the World Register of Marine Species (WoRMS).
- Four samples from the 1997, 2002, and 2013 surveys, which were originally reported using the SACFOR scale, were excluded to standardise abundance data for analysis.
- Species recorded as "P" (indicating presence) were standardised to a count of 1 to align with abundance-based comparisons.
- Abundance of juveniles were grouped with adults to avoid double-counting and ensure only unique taxa were reported.

Figure 78. Location of historic infaunal sampling undertaken in 1997, 2002, 2004 and 2013 (numbers represent replicate samples collected for each historic survey sampling location) relative to the 2024 samples in control and impact areas.



In total, there were 39 historic samples suitable for comparison against the 2024 study. However, due to the extensive spatial distribution of muddy gravel habitats at Penmon-Beaumaris, coupled with statistically significant differences in faunal communities detected between control and impact areas in 2024, the historical community data analyses were separated into these two areas to minimise confounding effects from spatial variability. For the purposes of historical comparisons, the distinction between control and impact areas does not correspond to bait digging activity but instead reflects two distinct spatial areas.

The number of samples in each survey in proximity to the control or impact areas are shown in Table 28. It is important to note that only one sample was collected in close proximity to the control or impact areas in 1997, as well as relatively low numbers of samples in 2002. Hence, these samples may not be fully representative of the community within the control and impact areas during these years. Given different sampling designs between the surveys, with some surveys taking replicate cores per block within an area and some taking single cores per block, cores were pooled separately for control and

impact areas, and an average abundance was calculated for each (i.e. not averaged per block).

Table 28. Total number of samples taken within the control and impact areas from the 1997, 2002, 2004, 2013 and 2024 surveys.

Year	Control area	Impact area
1997	1	0
2002	6	2
2004	10	5
2013	10	5
2024	24	24

In general, abundance of most taxonomic groups was higher in the impact area compared to the control area (

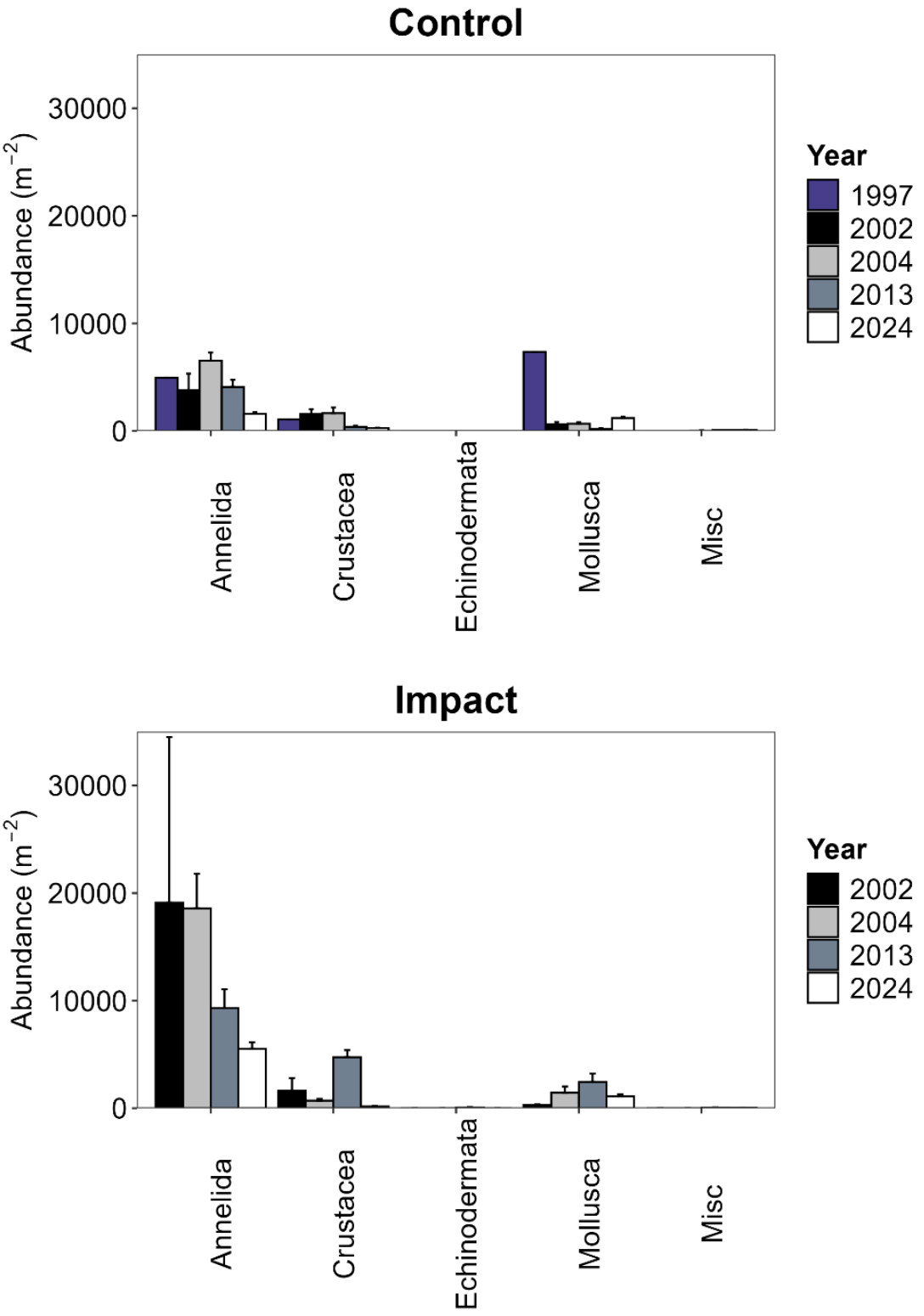
Figure 79). Annelida were much more abundant in the impact areas across all years, but both control and impact areas showed a decline in Annelida abundance between 2002 and 2024. A high abundance of Mollusca were observed in 1997 in the control area due to a high count of *Mytilus edulis*. However, as only one sample was collected in 1997, this may not be representative of abundance of Molluscs across the entire area.

Nematoda abundance was predominately higher in the impact areas compared to the control (Table 29). Particularly high counts of Nematoda were observed in the impact area in 2004 and 2024.

Table 29. Mean abundance (m^{-2}) (± SE) of Nematoda within control and impact areas from the 1997, 2002, 2004, 2013 and 2024 surveys.

Year	Control area	Impact area
1997	0	-
2002	1,920 ± 1,706	1,090 ± 545
2004	2,193 ± 507	15,020 ± 3477
2013	375 ± 79	3,480 ± 1782
2024	3,104 ± 517	14,017 ± 2212

Figure 79. Mean (± SE) abundance per 1 m^2 of taxa between 1997 and 2024 for control and impact areas at Penmon-Beaumaris.



The nMDS plots for control and impact areas (Figure 80, Figure 81 respectively) show that there were distinct differences in infaunal community groups between years. The control area also shows an indication of different communities between samples within the same years (2002 and 2013).

SIMPER analysis was performed to identify characteristic taxa within each year for impact area and control area separately. The analysis assessed the average similarity within each year and the results are presented in Table 30 and Table 31. The SIMPER results corroborated the community patterns observed in the nMDS plots, as they indicated changes in characteristic taxa through time within the control and impact area. In addition, most of the taxa observed were disturbance-tolerant (EG III) or opportunistic species (EG IV or EG V) according to AMBI. Although changes in faunal taxa were observed over the years in both the control and impact areas, the AMBI scores remained relatively stable, suggesting that these types of species tend to prosper in these environments that have undergone some sort of disturbance.

Figure 80. nMDS showing differences in species communities in the control area between 1997 and 2024 at Penmon-Beaumaris.

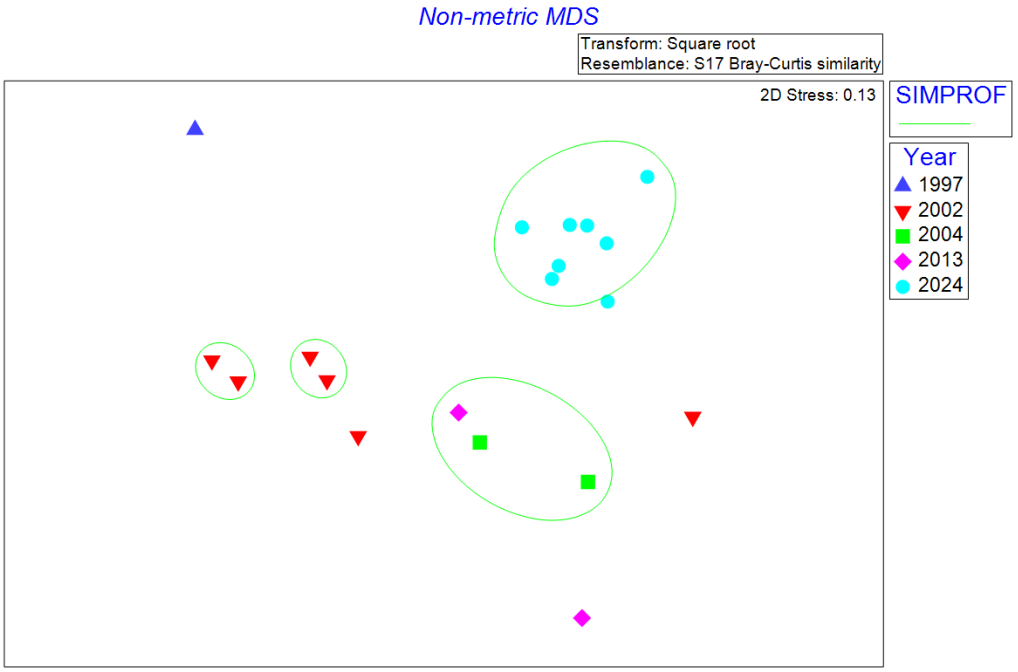


Figure 81. nMDS showing differences in species communities in the impact area between 2002 and 2024 at Penmon-Beaumaris.

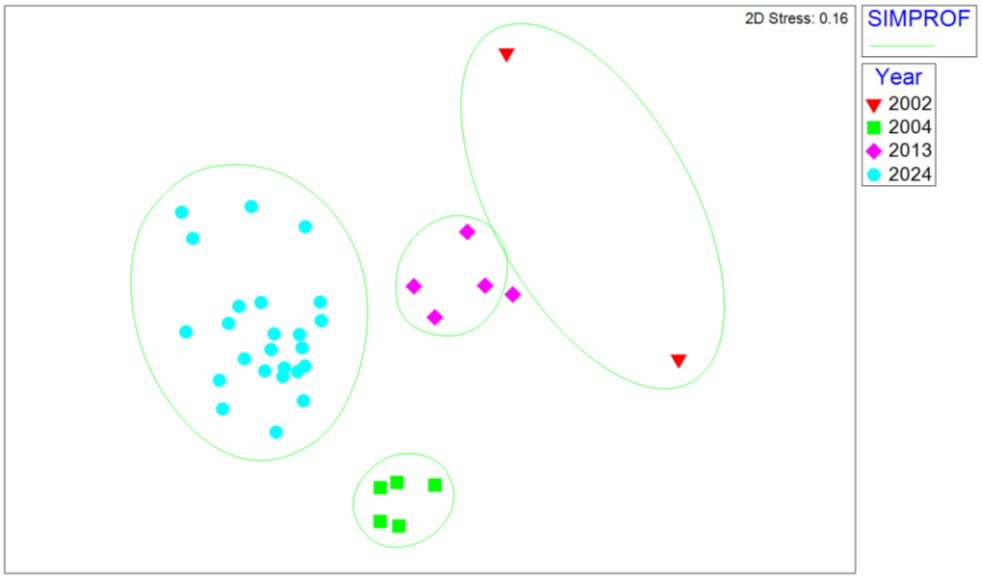


Table 30. The dominant taxa contributing to overall percentage similarity in control area between 1997 and 2024 at Penmon-Beaumaris, as per SIMPER routine on square-root transformed abundances.

Species	AMBI EG Score	Mean Sqrt. Abundance	% Similarity	% Cumulative Contribution
1997				
(less than 2 samples)				
2002				
Galathowenia oculata	III	20.82	3.38	8.86
Scoloplos armiger	III	16.99	3.18	17.2
Spiophanes bombyx	III	14.93	2.99	25.05
2004				
Nematoda #indet	III	40.36	6.93	15.71
Tharyx sp.	IV	41.93	5.97	29.25
Tubificoides pseudogaster	V	25.36	4.79	40.11
2013				
Aonides oxycephala	III	19.31	4.06	17.62
Mediomastus fragilis	III	12.62	1.88	25.78
Eunereis longissima	III	6.73	1.69	33.11
2024				
Nematoda #indet	III	50.29	15.46	34.33
Cerastoderma edule	III	29.86	10.44	57.51
Lanice conchilega	II	10.46	2.49	63.04

Table 31. The dominant taxa contributing to overall percentage similarity in impact area between 2002 and 2024 at Penmon-Beaumaris, as per SIMPER routine on square-root transformed abundances.

Species	AMBI EG Score	Mean Sqrt. Abundance	% Similarity	% Cumulative Contribution
2002				
Tubificoides benedii	V	100.67	10.31	35
Naididae	V	18.7	4.55	50.43
Mediomastus fragilis	III	31.95	2.63	59.35
2004				
Nematoda #indet	III	118.36	17.32	26.08
Tharyx sp.	IV	90.51	13.16	45.91
Mediomastus fragilis	III	64.3	8	57.96
2013				
Mediomastus fragilis	III	50.02	6.95	10.92
Corophium volutator	III	40.9	6.05	20.43
Tubificoides benedii	V	35.98	4.9	28.13
2024				
Nematoda #indet	III	109.73	20.85	36.45
Mediomastus fragilis	III	33.31	6.01	46.96
Tubificoides benedii	V	29.06	5.4	56.41

It should be noted that, while the methodologies from the historic datasets share some similarities with the 2024 survey, differences in faunal communities may be attributed to variations in sample sizes and taxonomic resolution. Specifically, some species were not identified to the lowest taxonomic level, and different naming conventions were used. When combining species lists from the different surveys for this historic assessment, the taxonomic richness may be artificially elevated due to these variations in naming conventions, which can influence the interpretation of distinct faunal communities. Given the latter, the observed changes in faunal communities between the years should be interpreted with caution.

Overall, both the control and impact areas have shown changes in species communities over time. Therefore, it is not possible to determine whether changes over time within the impact area are due to bait digging. Changes observed between years could be a result of environmental variability, or differences in survey design (including sample sizes and taxonomic resolution). Furthermore, there is an unknown understanding of bait digging intensity or locations during the historical surveys.

No corresponding sediment classification data are available for each of the sample sites in the previous surveys. It is therefore not possible to compare changes in sediment composition across years. In addition, it is not possible to assess whether any of the observed changes in faunal occurrence are a result of changes in sediment structure across the control and impact area of Penmon-Beaumaris.

3.2.5 Discussion

3.2.5.1 Angle Bay

An intertidal survey to assess the impacts of bait collection activities on sensitive features was undertaken at Angle Bay in September 2023. As seagrass covered virtually the whole of Angle Bay, the survey focused on the impact of bait digging on this feature. A range of survey techniques were employed to assess potential differences in sediment composition, infaunal and megafaunal composition and seagrass condition between impact (dug) and control (un-dug) areas.

Bait diggers were observed digging for lugworm each day during the survey period using both hole digging and suction collection techniques. Bait digging activity was predominantly observed to the north and eastern sides of the bay with diggers accessing the site on foot. No bait digging activity was observed within the control area. Survey impact area locations were selected to avoid freshly dug holes but were chosen within areas where historic bait digging activity was evident to assess longer term impacts of bait digging activity.

It is well documented that bait digging can result in a loss of fine sediment fractions which can particularly impact sheltered muddy gravel habitats (Watson et al., 2017). There is some evidence of a loss of finer silt fractions within impact areas at Angle Bay. Finer, muddier (silt) sediments were generally observed within control areas whereas the majority of the impact areas were dominated by the fine sand fractions. In addition, gravel fractions although not identified during the PSA analysis, were observed during the survey on the sediment surface alongside shell debris. These were particularly apparent in the impact area at the edges of historic bait digging holes.

It is also well documented that sediment composition is an important factor for determining the distribution of infaunal communities (Cooper et al. 2011). The potential permanent loss of fine sediment fractions from the sediment and subsequent shift in sediment classification, as a result of bait digging, could have lasting impacts on infaunal communities even after the cessation of digging activities. However, despite the observed differences in sediment composition there was very little correlation, and no significant relationship, between faunal composition and the PSA data.

Faunal analysis identified a high degree of overlap between infaunal and megafaunal communities within control and impact areas. Results indicated that not only were the communities in the control and impact areas similar but that within area variability was low. This suggests low spatial variability and patchiness in community composition across the Angle Bay site.

Benthic communities at both the control and impact areas were characterised by species regularly associated with seagrass *N. noltei.* Although there was no overall statistical difference between infaunal composition in control and impact areas, there were fewer *P. ulvae, C. edule* and *A. tenuis* at stations within the impact area. In contrast abundances of *Tubificoides* species, *Capitella sp*. (both First order opportunistic species) and *P. elegans* were higher in the impact area.

The cockle *C. edule* and *A. tenuis* provide important prey resource for over wintering birds. Depletion in their numbers could have wider implications for site management. However, the differences observed between control and impact areas within the present study were not statistically significant and would not suggest depletion of the species in certain areas of the Angle Bay site.

The lugworm *A. marina* was only recorded within one infaunal core sample (impact area block AI2) and within one megafaunal sample (control area block AC1), however evidence of its presence was observed regularly across the site. Quadrat counts of lugworm casts identified variable densities of casts across both the control and impact. Blocks within control areas had a higher density of worm cast counts with an average of 9 casts per m² in comparison to impact areas where the average was 5 casts per m², however, the difference was not statistically significant. *Arenicola sp.* are a target bait digging species and therefore a reduction in the presence of *Arenicola sp*. in impact areas would be expected.

All seagrass identified at Angle Bay was dwarf eelgrass *N. noltei.* Although some difference in seagrass condition was noted between control and impact areas during the 2023 monitoring, seagrass condition was considered to be good at 30 of 36 stations. However, moderate and poor conditions were found at 5 stations (AC5.B, AI1.A, AI2.C, AI3.B and AI4.B) and 1 (AI1.C) station, respectively. Moderate and poor condition seagrass beds were all recorded within the impact area with the exception of one location in the control area.

There was a statistically significant difference between the average percentage coverage of seagrass in the control and impact areas, with an average coverage in the control area of 78 % in comparison to 54 % in the impact area. Average blade length was also longer in the control area with an average length of 9.8 cm, but differences in blade length between control and impacts areas was not significant.

To provide further context to the results of the current survey a comparison of the results with historic datasets was undertaken with the assumption that the earlier datasets could provide a proxy for baseline conditions prior to the introduction of bait digging within Angle Bay. However, the survey methods and subsequent analyses undertaken during each of the historic surveys were not directly comparable with differences in sampling methods, sieve sizes and post-sample infaunal analysis undertaken between surveys. As such the data collected was not directly comparable. In addition, the lack of quantitative abundance data, with only species presence/absence comparisons possible, and the low number of replicates (n=2) for both 1982 and 1997 mean that results should be interpreted with care.

Furthermore, no corresponding sediment classification data are available to assess whether any of the observed changes in faunal occurrence are a result of changes in sediment structure across Angle Bay over time. Similarly, no data on bait digging intensity exists from previous years.

The results of the historic comparison, although likely to be to some degree a result of difference in sampling approach, show an increase in the number of species present across Angle Bay between 1982 and 2023, suggesting a potential increase in diversity across the site. More detailed analysis to investigate any potential differences in faunal communities present between 1982, 1997, 2008 and 2023 found that there was a clear separation between the infaunal communities observed between years. However, whilst differences in the occurrence of species across Angle Bay between years was observed it should be noted that the key characterising species across years has remained largely similar with *S. armiger, N. hombergii, P. elegans, C. edule* and *P. ulvae,* all species characteristic of *N. noltei* beds, being the main species identified. Overall, this would suggest limited impacts of bait digging activity at Angle Bay as these trends were apparent across the whole site (and as such at least some areas would have been subject to bait digging activity through time).

Historic data on the previous extent of seagrass beds at Angle Bay was not available for comparison, however the large extent of seagrass beds, across the entirety of the site in 2023, suggests an increase in seagrass extent. This is also likely to have influenced the faunal communities present across Angle Bay, in particular species such as *P. ulvae* and *C. edule* the occurrence of which has increased (or for *P. ulvae* gone from absence to presence) in samples between 1982 and 2023.

3.2.5.2 Penmon-Beaumaris

Sediment analysis at Penmon-Beaumaris revealed that both control and impact areas had similar sediment compositions, predominantly gravelly muddy sand. Therefore, the differences in faunal communities between control and impact areas are unlikely to be a result of sediment differences, despite the results of the RELATE test suggesting otherwise. This is because the faunal composition was averaged per sampling block, which may not provide a true representation of the faunal composition in the control and impact areas.

Macrofaunal abundance and biomass were significantly higher in the impact areas, whereas Simpson’s diversity index was significantly lower. These results suggest that the impact area is dominated by a few species, with an uneven distribution of relative abundance. The k-dominance plots also indicated that the community in the impact area is less diverse and shows signs of disturbance.

Multivariate analysis of the infaunal data showed a significant difference in communities between control and impact areas. Further analyses revealed that Nematoda, *T. benedii*, and *M. fragilis* were highly abundant in impact areas. These taxa are classified as disturbance-tolerant or opportunistic and often thrive in disturbed or organic-enriched environments. The dominance of these disturbance-tolerant species in the impact area, coupled with high abundance and low diversity, suggests some form of disturbance.

The ragworm *A. virens* was found to be more abundant in the impact area compared to the control area, although this was not significant. The higher presence of *A. virens* in the impact area is likely to be expected considering it is targeted by bait diggers. Previous studies assessing the impacts of bait digging have noted that the creation of large areas of physically disturbed habitat favoured the proliferation of opportunistic species such as *A. viren*s (Evans *et al.,* 2015). Additionally, the non-native species *D. japonica* was identified at Penmon-Beaumaris, marking its first occurrence outside of its previously known extent (west of Menai Strait).

Megafaunal communities were similar between control and impact area with some differences noted. *L. conchilega* casts were more abundant in control areas, while *C. crangon* was three times more abundant in the impact areas, yet none of these were significant. *C. crangon* has been reported to scavenge animal material and often aggregates around areas of sediment disturbance, which may explain its local abundance due to regular disturbance.

Comparison of the current survey outputs with historic datasets was undertaken to provide insights into potential changes in community structure over time. This comparison was set in the context of differences in methodologies and taxonomic resolution between surveys. Changes in infaunal communities over time were observed when comparing the 2024 data to historical datasets between 1997 and 2013. The control area historically had lower abundance of taxa compared to the impact area. However, it is not possible to determine whether changes over time within the impact area are due to bait digging. The interpretation of faunal changes is constrained by the absence of sediment data, differences in taxonomic resolution, and the lack of information on bait-digging intensity or location.

Overall, the results suggest sediment composition did not substantially change between control and impact areas due to bait digging. While evidence of recent bait-digging activities was noted in the control area, these areas were avoided during sampling. Nonetheless, it is possible that broader environmental factors, beyond bait digging, could be influencing the benthic communities in the control areas at this site.

3.2.5.3 Four Mile Bridge

A suitable control site could not be found at Four Mile Bridge. All sites within 1-2 km of the site showed evidence of bait digging. A control site approximately 3 km away was investigated but analysis showed that the sediment composition was too different for it to be suitable as a control site.

The abundance and diversity at the potential control site were noticeably lower, with an average of 5 taxa and 19 individuals. Biomass was also relatively low, primarily due to the low abundance of small-sized taxa present (e.g., Nematoda, *S. armiger*, and *B. sarsi*). These findings are reflective of the sandy sediment habitat identified at the control site,

and is further supported by literature which highlight that finer sand environments offer fewer niches and less food, leading to less diverse and abundant benthic communities (Snelgrove 1999, Giere 2009).

Therefore, the control site does not provide an appropriate control/baseline to enable a comparison of potential bait digging impacts on infaunal composition. Furthermore, no suitable historic data could be found for Four Mile Bridge with which to provide a baseline comparison with the impact area. It is therefore acknowledged that there are limitations in the assessment of bait digging impacts at this site.

However, the survey results indicated that the impact area experienced some level of disturbance. This is supported by the k-dominance plots, which showed the impact area was dominated by a few resilient taxa. SIMPER analyses corroborated this, with Nematoda, *T. benedii*, *P. ulvae*, and *C. volutator* being highly abundant in the impact area and broadly classified as disturbance-tolerant or opportunistic species. These species often thrive in disturbed or organic-enriched environments, which is further supported by the high TOC values recorded in the impact area at Four Mile Bridge.

Although comparisons could not be drawn between the impact and control sites nor with historic baseline data, the results indicated some level of disturbance in the impact area and a high abundance of disturbance-tolerant species. Collectively, the results suggest some impact from bait digging activities.

3.3 Crab shelter provision

This section presents the results from the intertidal crab sheltering surveys at Bangor Pier, Gwynedd and Deganwy, Conwy, in August 2024 and provides a comparison between sediment composition and faunal communities at control and impact areas.

3.3.1 Bangor Pier

3.3.1.1 Sediment composition

Sediment classification for samples at Bangor Pier collected are presented in Table 32. The sediments at Bangor Pier were solely classified as sandy mud for all samples collected in the control and impact areas and consisted primarily of fine mud fractions (Figure 82). The TOC of the sediment was similar between control and impact areas (Figure 83). Coarse gravel sediment was not recorded at this site.

Table 32. Sediment classification based on particle size data and total organic carbon content for Bangor Pier in August 2024.

Block	Area	Sediment description	% Gravel	% Sand	% Mud	%TOC
BI1	Impact	Sandy Mud	0.0	40.7	59.4	4.0
BI2	Impact	Sandy Mud	0.0	38.5	61.5	4.5
BI3	Impact	Sandy Mud	0.0	39.2	60.8	4.0
BI4	Impact	Sandy Mud	0.0	40.3	59.7	3.8
BC1	Control	Sandy Mud	0.0	36.4	63.7	4.2

Block	Area	Sediment description	% Gravel	% Sand	% Mud	%TOC
BC2	Control	Sandy Mud	0.0	28.9	71.1	4.1
BC3	Control	Sandy Mud	0.0	34.34	65.6	3.8
BC4	Control	Sandy Mud	0.0	36.4	63.6	4.34

Figure 82. Mean particle size distribution at control and impact areas at Bangor Pier.

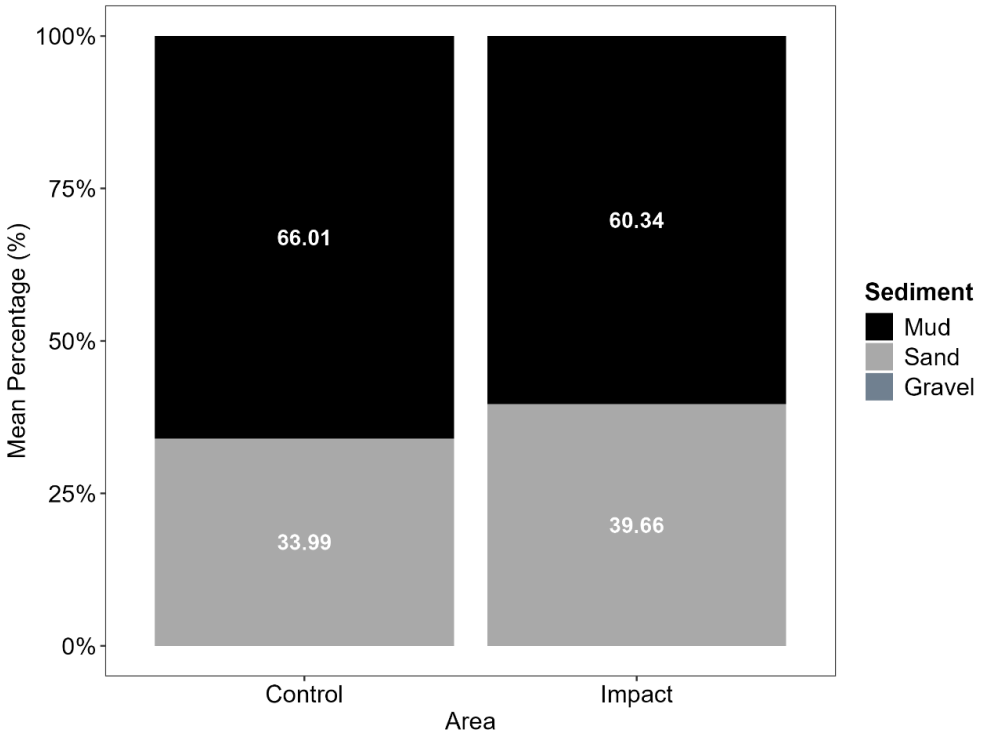
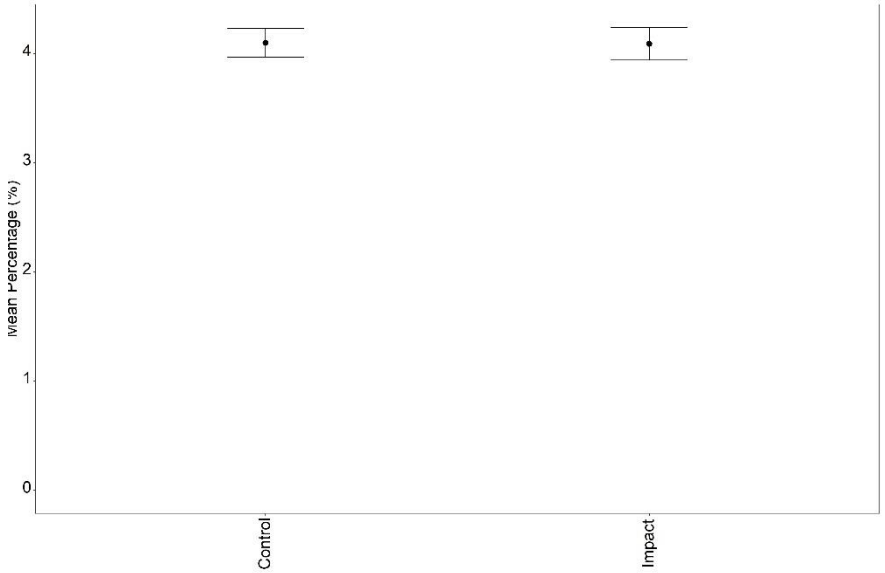


Figure 83. Mean percentage (± SE) TOC within sediment samples taken in control and impact areas at Bangor Pier.

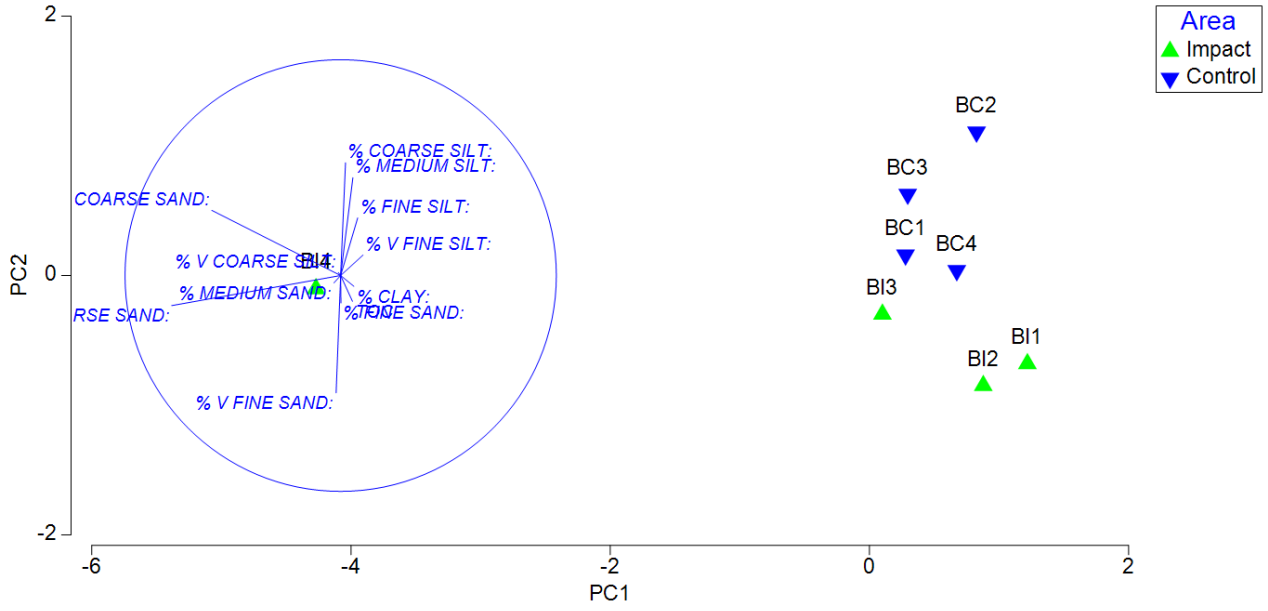


PCA was carried out on the sediment data to analyse the differences in sediment particle size between impact and control areas. The resulting 2D plot is shown in Figure 84. The

two-dimensional axes PC1 and PC2 capture 80.3 % of the total variance and as such the plot can be considered as a very good representation. The PCA plot shows the sampling blocks at Bangor Pier were mainly dominated by fine sand and silt fractions, with little differentiation between the control and impact areas, suggesting the control provides a suitable comparison site from a sediment perspective. Sampling block BI4 was separated from the other blocks due to having a medium-coarse sand fraction. However, it is important to note that only one sediment core was taken per tyre, which may limit the robustness of the comparison.

A RELATE test was conducted to assess whether the variations in PSA data between impact and control areas are mirrored in the faunal community composition. The RELATE test indicated there was a moderate positive correlation between faunal composition and the PSA data and this relationship was significant (Rho = 0.420, p = 0.046). The results suggest that the differences in faunal community composition between the control and impact areas may be a reflection of the differences observed in the PSA data between these areas. It should be noted the faunal composition was averaged per sampling block to align with the PSA replication, which may not accurately represent the faunal composition in these areas. Additionally, while the results were statistically significant, the sediment composition between the control and impact areas was not notably different.

Figure 84. A 2D PCA ordination showing the contribution of each sediment size class at each block within Bangor Pier.



3.3.1.2 Infaunal community composition

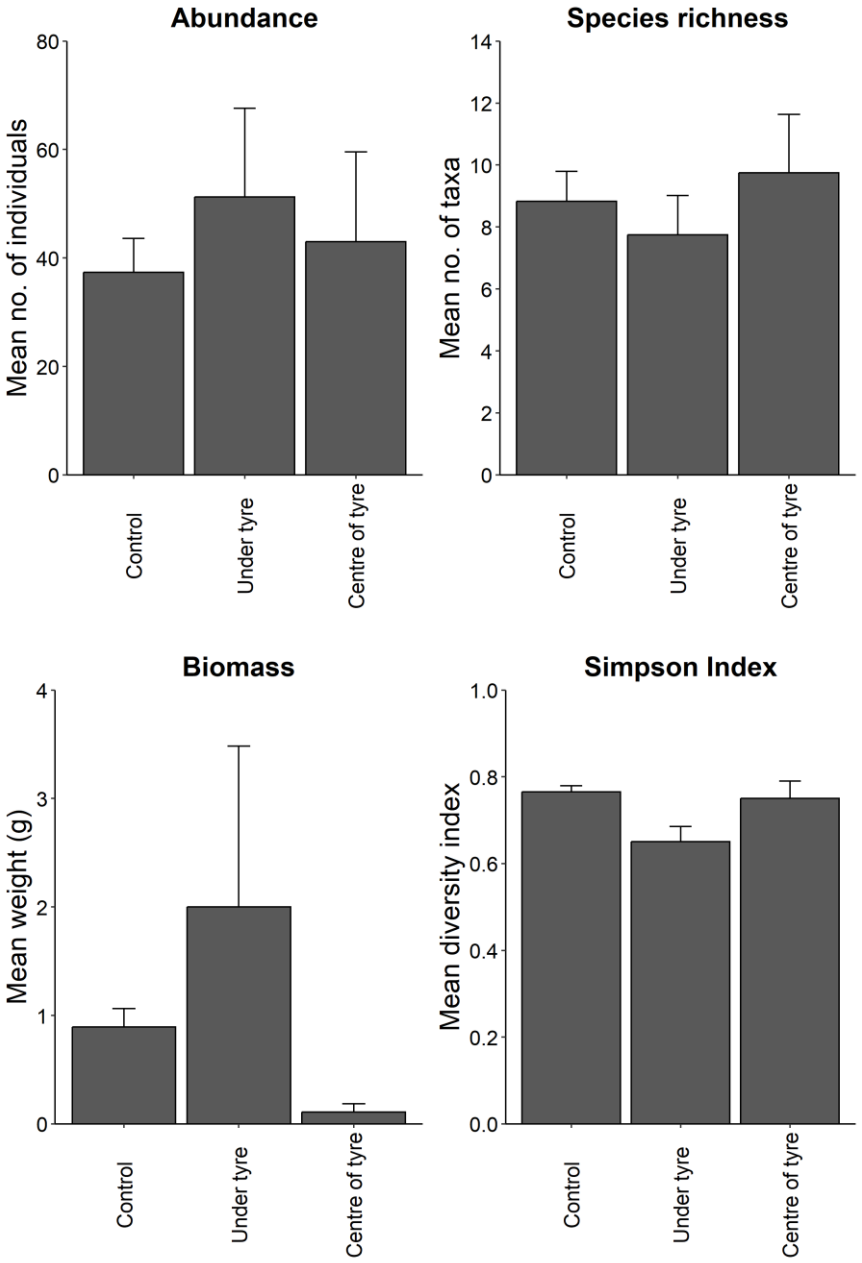
A total of 37 individual taxa were recorded from the 24 infaunal core samples collected across control and impact areas at Bangor Pier. Annelida was the most diverse taxa, with 19 species recorded.

Within the impact area, infaunal core samples were taken from underneath the rubber of the tyre as well as within the centre of the tyre. The graphs below distinguish between

these two sub-areas of the impact area, however given the low sample size, statistical analyses were run on the impact areas as a whole (i.e. these sub-areas combined).

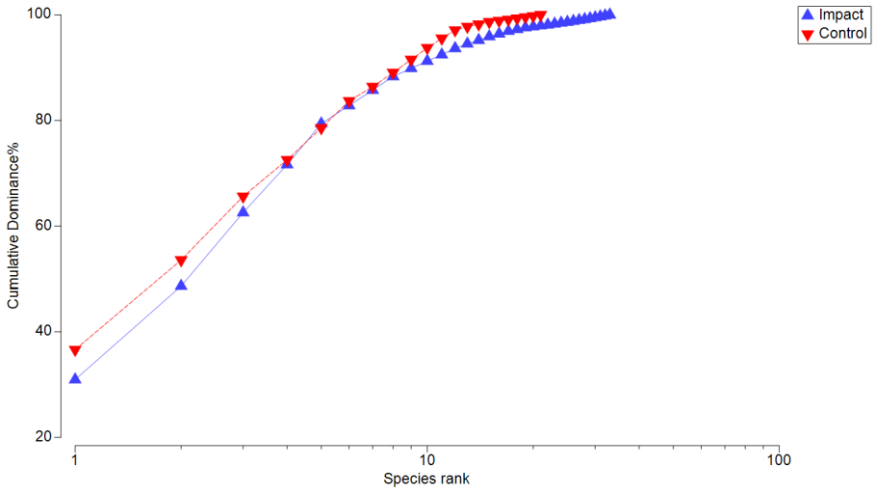
Abundance, species richness and Simpson's diversity were similar between control and impact (under tyre and centre of tyre) areas. Biomass was lower in the control areas than under the tyres, however, biomass in the centre of the tyres was very low in comparison (Figure 85). Taxa recorded from the centre of tyres consisted primarily of small annelids (e.g., *Polydora ciliata*) and nematodes. Despite their relatively high abundance, their small size likely contributed to the low biomass observed in the centre of tyres. No significant differences were observed between the control and impact areas for either parameter (ANOVA: $p < 0.05$).

Figure 85. Mean (± SE) abundance, species richness, biomass and Simpson's diversity index at control and impact (under tyres and centre of tyres) areas and Bangor Pier.



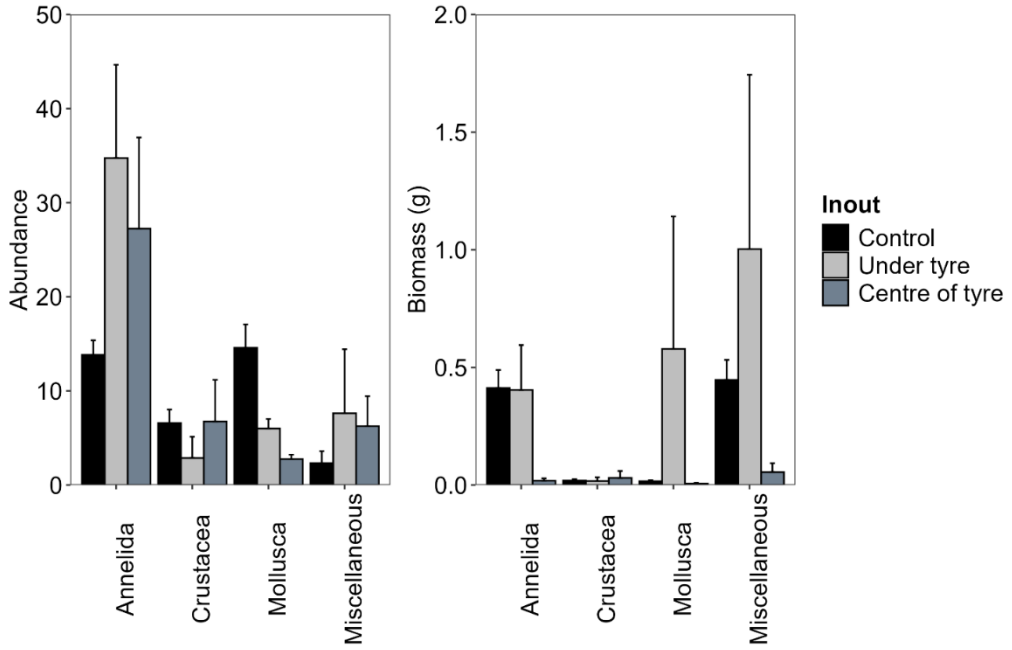
The k-dominance comparison curves presented in Figure 86 appears to indicate communities at the control and impact areas are similar. In addition, the plot suggests there is no indication of disturbance due to the lack of dominance. The community at the control and impact areas appears to have an even distribution of abundance amongst the species present.

Figure 86. k-dominance curve for average abundance of taxa at control and impact areas at Bangor Pier.



The different faunal groups that contributed to the overall abundance and biomass between control and impact areas are presented in Figure 87. Abundance of Annelida was high in the impact areas, driven primarily by the abundance of *T. benedii*, *Tubificoides pseudogaster* and *Hediste diversicolor*. Nematoda (within miscellaneous) were also found in much larger numbers within the impact areas compared to the controls. Notably, the abundance of molluscs was significantly higher in the control area compared to the impact area ($p < 0.05$). This increase in mollusc abundance was primarily driven by the presence of the mudsnail *P. ulvae*, which was the dominant contributor in the control areas. For biomass, miscellaneous taxa (including Animalia, Platyhelminthes, Nemertea and Nematoda) was the dominant faunal group followed by Mollusca and Annelida. No significant differences between control and impact areas were found for any of the phyla ($p > 0.05$).

Figure 87. Mean (± SE) abundance and biomass per 0.01 m^2 within each taxonomic group for control and impact (under tyres and centre of tyres) areas at Bangor Pier.



The nMDS shows there is a relatively clear difference in the species communities between control and impact areas (Figure 88). This separation is further supported by the results of an ANOSIM (R = 0.6, p = 0.001*)* which indicates a moderate difference in species community composition between control and impact areas. The result was statistically significant, further supporting the conclusion that the areas differ in their species composition. The nMDS also shows that the community composition within the centre of the tyre and underneath the tyres were relatively similar and an ANOSIM between these two showed they were not significantly different (R = 0.2, p = 0.06). The stress value from the nMDS plot was 0.17 suggesting a moderate fit, hence, the plots provide a useful summary of the data but may not capture all the relationships between data points.

The SIMPER analysis showed the predominant taxa contributing to the similarity in benthic communities at the impact area was *T. benedii* and *P. ulvae*. At the control area, *P. ulvae* and *C. volutator* contributed to similarity in benthic communities (Table 33).

In addition, SIMPER showed that the taxa which contributed most to the dissimilarity between control and impact areas were *T. benedii and T. pseudogaster* which were more abundant in the impact area, as well as *C. volutator*, *P. ulvae* and *Scoloplos armiger* which were more abundant in the control areas (Table 34). Based on the AMBI, the species which contributed the most to the dissimilarity were classified as disturbance tolerant species (EG III) and opportunistic species (EG V) in the control and impact areas, respectively. Despite the observed differences in taxa abundances between the control and impact areas, the AMBI scores suggest that the species are either disturbance-tolerant or opportunistic and thrive in these environments. This tolerance is observed in both areas, suggesting no differences between the control and impact areas.

The only non-native species identified from the infaunal samples was the pile worm *Alitta succinea* which was found at an individual station in the control area at Bangor Pier. This species has not been previously identified in Wales. The closest known occurrence was reported in the Dee Estuary in 2015 (NBN Atlas, 2025b).

Figure 88. Non-metric MDS showing the relationship between the species communities in control and impact areas at Bangor Pier.

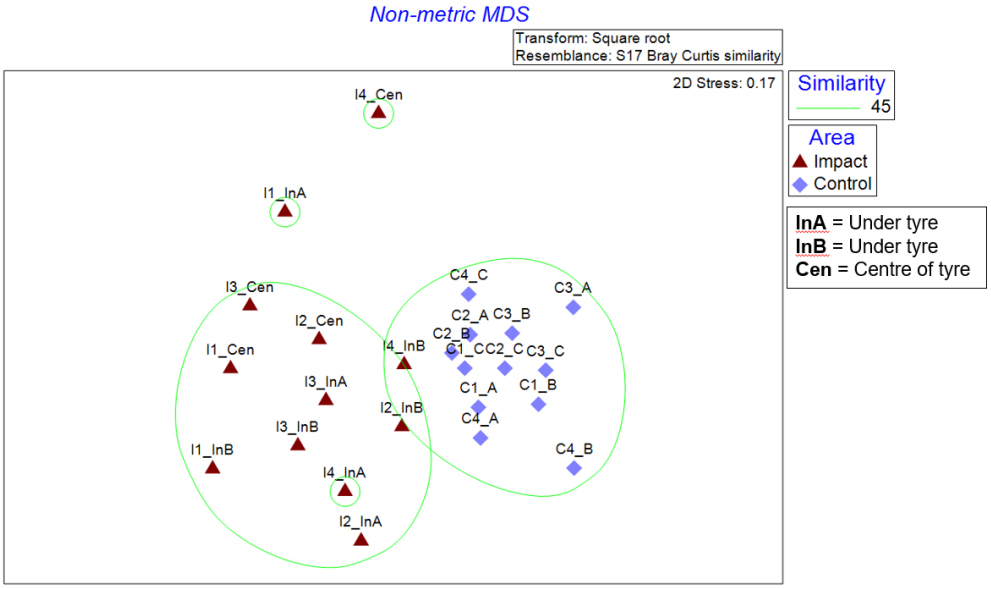


Table 33. The dominant taxa contributing to overall percentage similarity in control and impact areas at Bangor Pier, as per SIMPER routine on square-root transformed abundances (80% cut-off)

Species	AMBI EG Score	Mean Sqrt. Abundance	% Similarity	% Cumulative Contribution
Impact: *Group similarity 44.16*				
Tubificoides benedii	V	3.65	19.27	43.63
Peringia ulvae	III	1.99	10.41	67.21
Tubificoides pseudogaster	V	1.92	4.88	78.26
Hediste diversicolor	III	0.86	2.65	84.26
Control: *Group similarity 61.41*				
Peringia ulvae	III	3.61	20.03	32.62
Corophium volutator	III	2.35	11.29	51
Scoloplos armiger	III	1.91	8.5	64.84
Hediste diversicolor	III	1.51	7.68	77.35
Alitta virens	III	0.8	2.64	81.65

Table 34. The dominant taxa contributing to overall percentage dissimilarity between control and impact areas at Bangor Pier, as per SIMPER routine on square-root transformed abundances. Average dissimilarity = 62.90%

Species	AMBI EG Score	Mean Abundance: Impact	Mean Abundance: Control	% Dissimilarity	% Cumulative Contribution
Tubificoides benedii	V	3.65	0.68	9.78	15.55
Corophium volutator	III	0.73	2.35	6.13	25.3
Peringia ulvae	III	1.99	3.61	5.28	33.69
Tubificoides pseudogaster	V	1.92	0.58	5.16	41.89
Scoloplos armiger	III	0.51	1.91	5.07	49.95
Nematoda	III	1.46	0.96	4.53	57.15
Hediste diversicolor	III	0.86	1.51	3.17	62.19
Capitella	V	0.49	1.02	3.15	67.19
Alitta virens	III	0.42	0.8	2.37	70.97
Aphelochaeta marioni	IV	0.32	0.76	2.29	74.61
Manayunkia aestuarina	III	0.2	0.57	1.87	77.59
Collembola	Not listed	0.48	0	1.66	80.23

3.3.1.3 Megafaunal community composition

Four different taxa were recorded from 16 megafaunal surface samples taken at Bangor Pier (Figure 89). Six of the megafaunal samples had no megafauna within them. Characteristic taxa included *C. maenas,* unidentified cirratulid and polychaete tubes. *C. maenas* and polychaete tubes were higher in abundance in the impact area compared to the control. It is worth noting, however, that overall abundance in the megafaunal samples were low. No worm casts were observed within the sampling areas (control or impact) at Bangor Pier.

An overlap of megafaunal communities was observed between individual control and impact sampling blocks at Bangor Pier (Figure 90). ANOSIM corroborated these findings as megafaunal communities were not significantly different between control and impact areas at Bangor Pier ($R = -0.035$, $p > 0.05$). This is expected since the diversity and abundance of fauna were low.

Figure 89. Mean (± SE) abundance of megafaunal taxa at Bangor Pier.

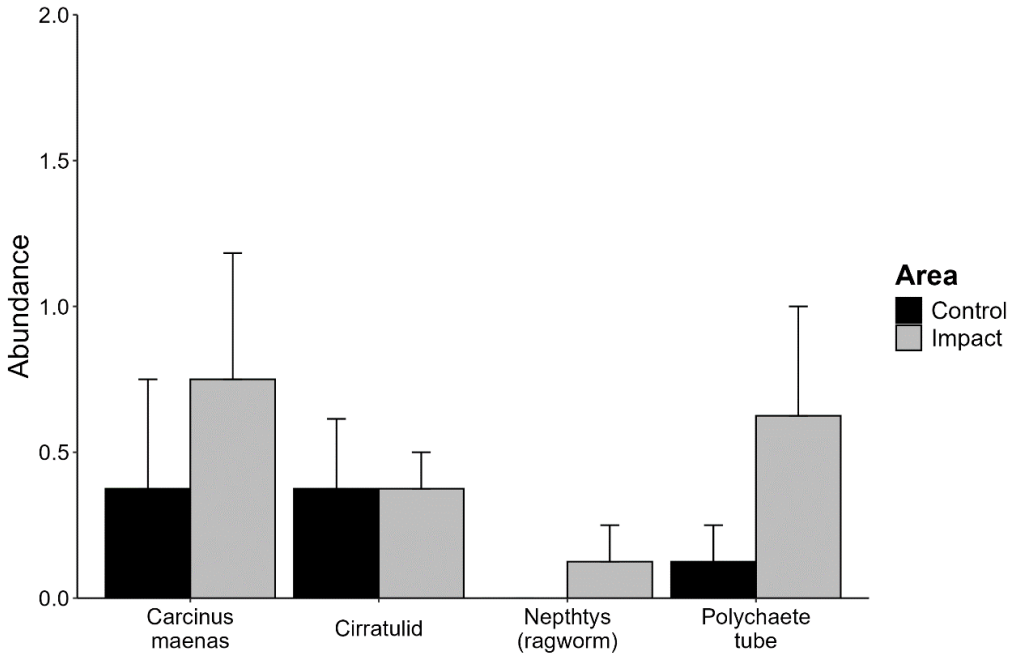
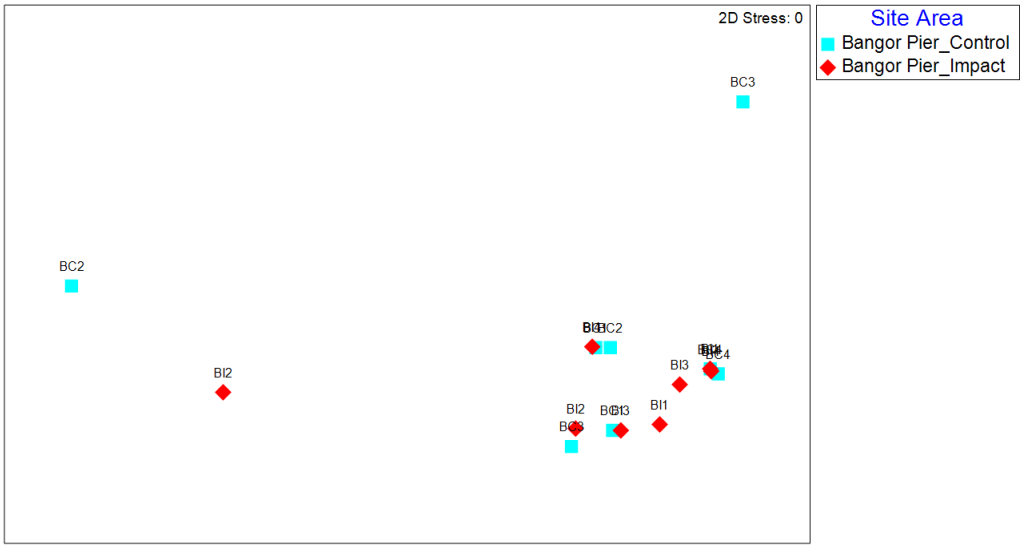


Figure 90. nMDS showing the relationship between the megafaunal communities in control and impact areas at Bangor Pier.



3.3.1.4 Epifaunal coverage

A diversity of epifauna was found on the tyres at Bangor Pier (Figure 91 and Table 35). The acorn barnacle *Balanus crenatus* was the most abundant species on the tyres, although the majority were live, dead barnacles were present. Other common epifauna included bladderwrack (*Fucus vesiculosus*) and common periwinkle (*Littorina littorea*). Mussels (*Mytilus* sp.), dog whelks (*Nucella lapillus*) and limpets were also observed, but these were rare.

Table 35. Estimates of percentage cover (for aggregate taxa) and counts of individual mobile taxa observed on the tyres at Bangor Pier.

Species	Tyre 1	Tyre 2	Tyre 3
Percentage cover (%)			
Balanus crenatus (live)	50	45	50
Balanus crenatus (dead)	15	30	10
Fucus vesiculosus	20	10	40
Counts of individuals			
Littorina littorea	14	2	4
Mytilus sp.	1	0	0
unidentified limpet	1	0	0
Nucella lapillus	1	0	0

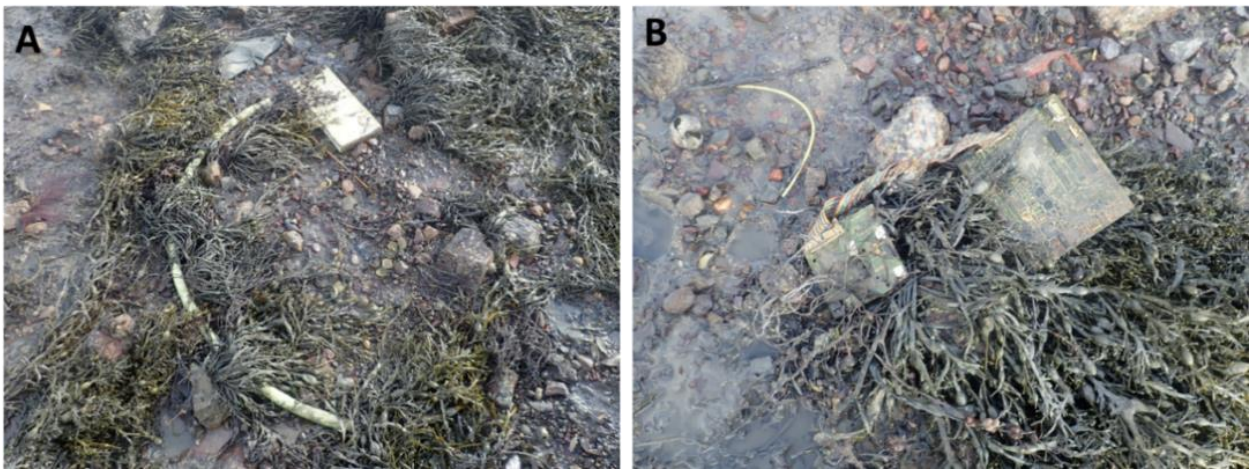
Figure 91. Epifauna present on tyres at Bangor Pier.



3.3.1.5 Anthropogenic disturbances

At Bangor Pier, there were no signs of trampling or recent bait collection from tyres places at the site. However, a large amount of litter was found in the area, including plastic and electrical components from computers/laptops, as shown in Figure 92.

Figure 92. Presence of A) plastic litter and (B) electrical components at Bangor Pier monitoring site.



3.3.2 Deganwy

3.3.2.1 Sediment composition

Sediment classification for samples collected from Deganwy during the August 2024 survey are presented in Table 36. Sediments were mainly classified as muddy sand across the impact and control areas except for blocks DC3 and DC4, which were classified as sandy mud. Coarse sand was found to be significantly more prominent in the impact area (Figure 93) compared to control area at Deganwy (Kruskal-Wallace, $X^2(1) = 5.33$, $p < 0.05$).

The TOC of the sediment was similar across both control and impact areas (Figure 94).

Table 36. Sediment classification based on particle size data and total organic carbon content (TOC) for Deganwy in August 2024.

Block	Area	Sediment description	% Gravel	% Sand	% Mud	%TOC
DI1	Impact	Muddy Sand	0.0	86.4	13.6	1.1
DI2	Impact	Muddy Sand	0.0	68.1	31.9	1.4
DI3	Impact	Muddy Sand	0.0	76.2	23.8	1.4
DI4	Impact	Muddy Sand	0.0	83.1	17.0	1.5
DC1	Control	Muddy Sand	0.0	87.3	12.7	1.7
DC2	Control	Muddy Sand	0.0	73.1	27.0	1.4
DC3	Control	Sandy Mud	0.0	34.4	65.6	1.4
DC4	Control	Sandy Mud	0.0	36.4	63.6	1.7

Figure 93. Mean particle size distribution at control and impact areas at Deganwy.

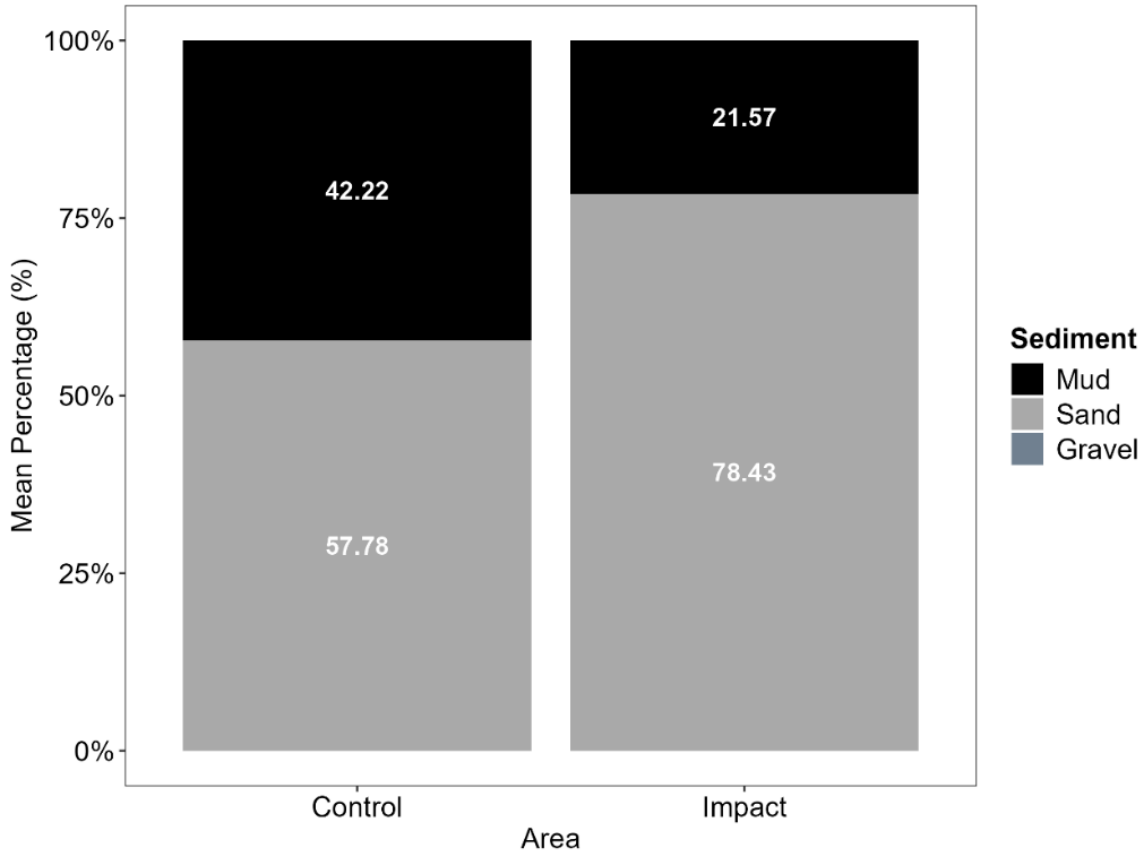
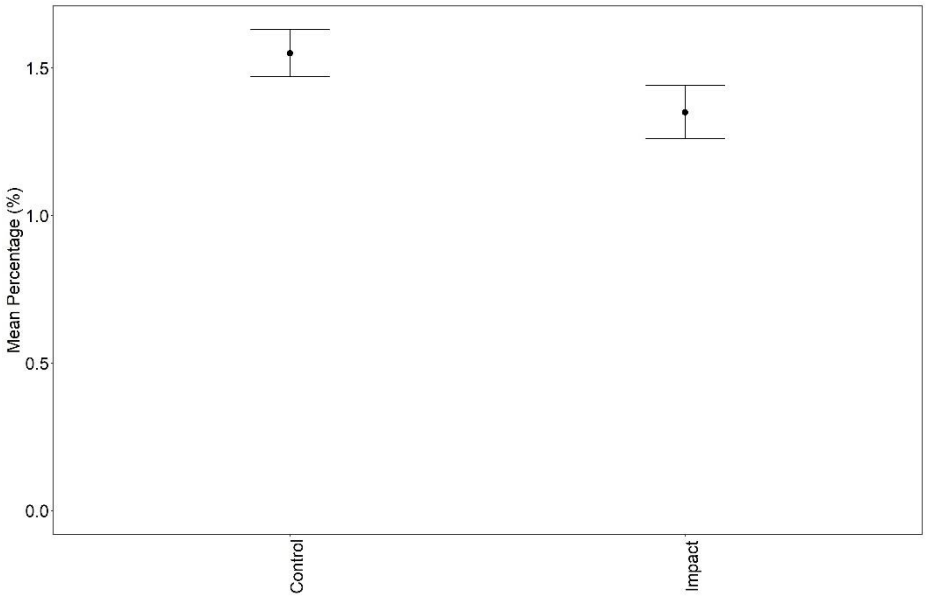


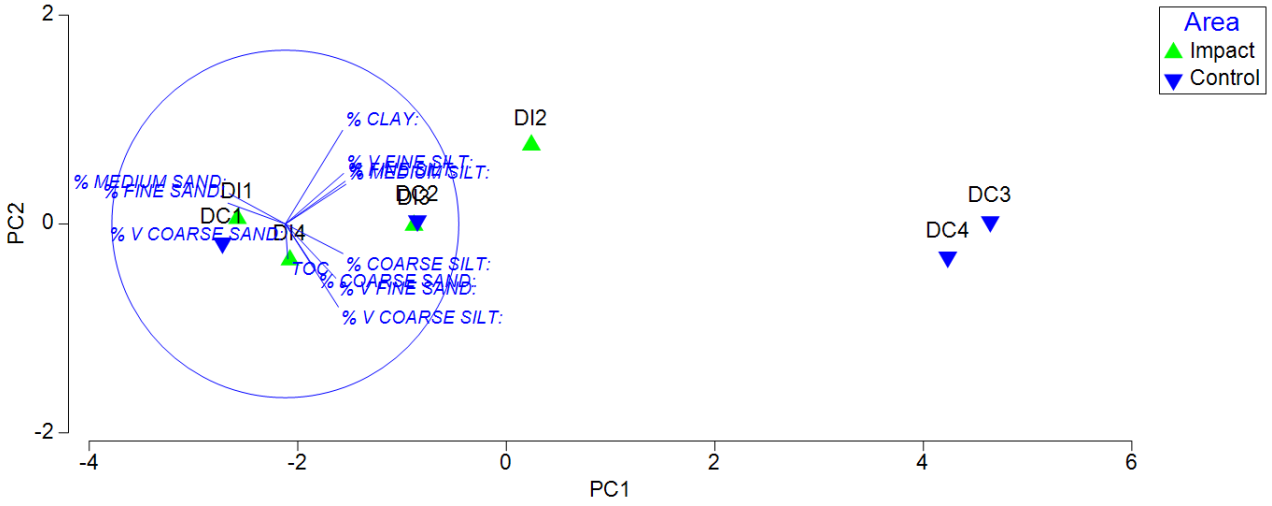
Figure 94. Mean percentage (± SE) TOC within sediment samples taken in control and impact areas at Deganwy.



PCA was carried out on the sediment data to analyse the differences in sediment particle size between impact and control areas. The resulting 2D plot is shown in Figure 95. The two-dimensional axes PC1 and PC2 capture 98.3 % of the total variance and as such the plot can be considered as a very good representation. The PCA plot provides supporting evidence that the overarching sediment classification at Deganwy is relatively similar between control and impact areas (Table 36). However, there were subtle variabilities within the areas. Most of the sampling blocks within the control and impact areas consisted primarily of fine sediment fractions. In contrast, two sampling blocks DC3 and DC4 in the control area were dominated by very fine silt.

A RELATE test was conducted to determine if the differences in PSA data between impact and control areas are reflected in the faunal community composition. Results of the RELATE test indicated that there was very weak correlation, and no significant relationship between faunal composition and the PSA data (Rho = -0.134, p = 0.721). As such, differences in faunal communities between areas is unlikely to be a result of the sediment composition.

Figure 95. A 2D PCA ordination showing the contribution of each sediment size class at each block within Deganwy.

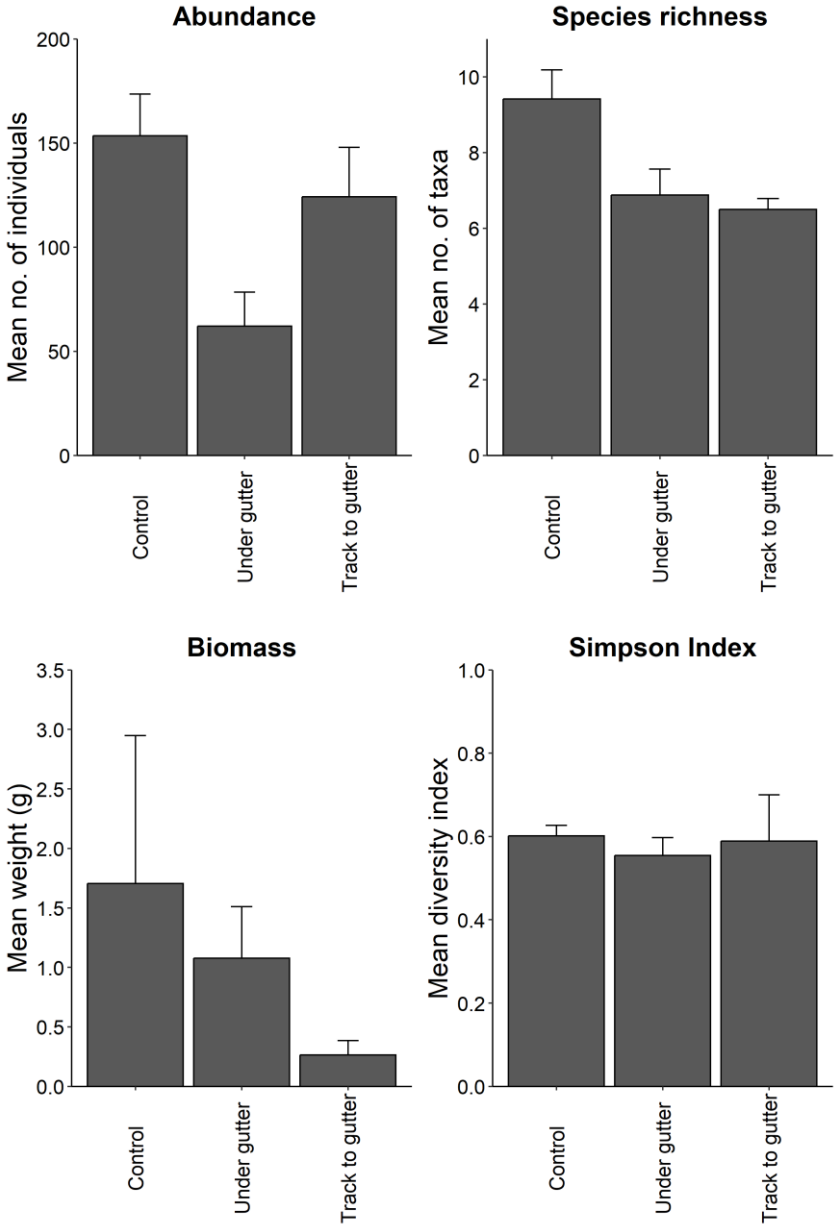


3.3.2.2 Infaunal community composition

A total of 37 individual taxa were recorded from the 24 infaunal core samples collected across control and impact areas at Bangor Pier. Within the impact area, infaunal core samples were taken from underneath the gutters as well as within the track around the gutters. The graphs below distinguish between these two sub-areas of the impact area, however, given the low sample size, statistical analyses were run with these sub-areas combined.

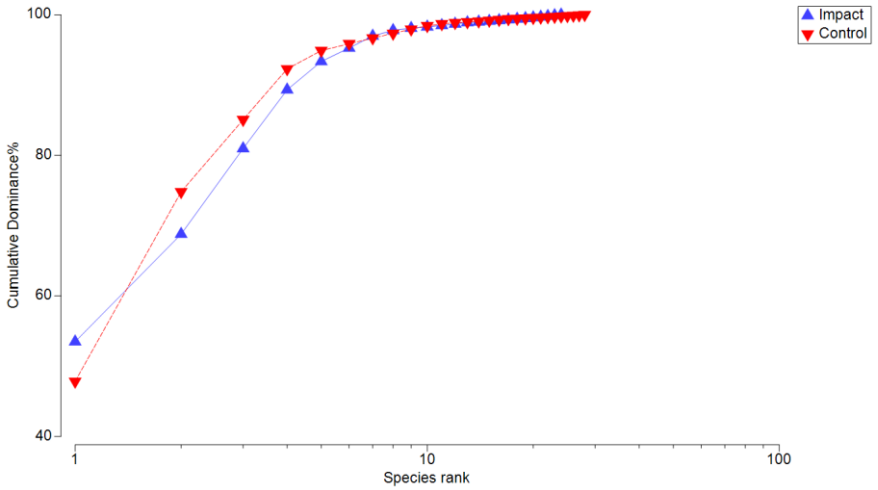
Infaunal abundance was significantly higher in the control area compared to the impact area (ANOVA: F = 6.7, p < 0.05), despite the elevated abundance observed within the tracks. Simpson's diversity was similar between the control and impact areas (under gutters and in tracks), whereas species richness and biomass were lower in the impact area compared to the control area (Figure 96). However, significant differences between control and impact areas were only observed for species richness (ANOVA: F = 7.74, p < 0.05).

Figure 96. Mean (± SE) abundance, species richness, biomass and Simpson's diversity index at control and impact (under gutters and tracks to gutters) areas and Deganwy.



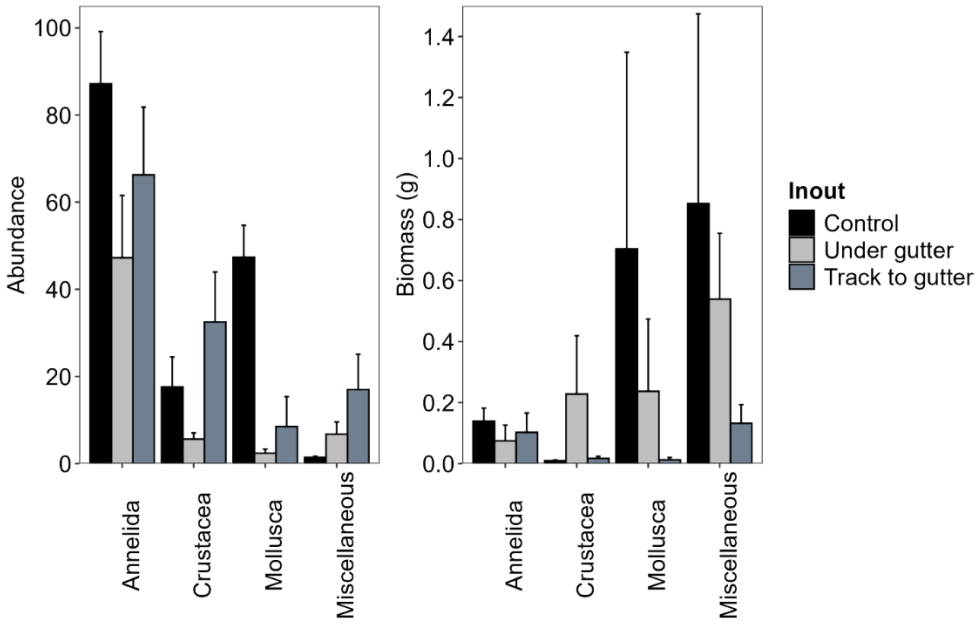
The k-dominance comparison curves presented in Figure 97 indicate that the communities at the control and impact area are highly similar and suggest than no one area is more disturbed than the other. This demonstrates that the community at the control and impact areas have an even distribution of abundance amongst the species.

Figure 97. k-dominance curve for average abundance of taxa at control and impact areas at Deganwy.



The different faunal groups that contributed to the overall abundance and biomass between control and impact areas is presented in Figure 98. Abundance of Annelida and Mollusca was high in the control area, driven primarily by the abundance of *T. benedii*, *P. ulvae* and *C. volutator*. The abundance of Mollusca was significantly higher in the control area compared to the impact area ($p < 0.05$). Nematoda (within miscellaneous) were found in larger numbers within the impact area compared to the control, however this was not statistically significant ($p > 0.05$). The biomass of miscellaneous taxa and Mollusca were the dominant faunal groups and were prominent in the control area. No significant differences between control and impact areas were found for any of the phyla ($p > 0.05$).

Figure 98. Mean (± SE) abundance and biomass per 0.01 m^2 within each taxonomic group for control and impact (under gutters and track to gutter) areas at Deganwy.



The nMDS shows some separation between the control and impact areas (Figure 99), however, one block (i.e. I4) within the impact area had a slightly different community composition compared to the rest of the blocks in the impact area. The results of an ANOSIM (R = 0.5, *p* = 0.001*)* indicates there is a difference in species community composition between control and impact areas. The nMDS also shows that the community composition under the gutters or in the tracks around the gutters were highly similar and an ANOSIM between these two showed corroborated these findings as being highly similar with no significant differences observed (R = 0.07, *p* = 0.2).

SIMPER analysis showed the predominant taxa contributing to the similarity in benthic communities at both control and impact areas were *T. benedii*, Nematoda and *P. ulvae and C. volutator* (Table 37).

The species that contributed to the significant differences between communities in the impact and control areas is presented in Table 38. SIMPER showed that the taxa which contributed most to the dissimilarity between control and impact areas were *P. ulvae*, *T. benedii and C. volutator* which were all more abundant in the control areas. It was notable that Nematoda abundance was higher in the impact areas compared to the control. Based on the AMBI, the species which contributed the most to the dissimilarity were classified as disturbance tolerant species (EG III) or opportunistic species (EG V). Despite the observed differences in taxa abundances between the control and impact areas, the species' AMBI scores indicate they are tolerant to disturbances. This tolerance is evident in both areas, suggesting no differences between the control and impact areas.

Non-native species were not identified from the infaunal samples sampled at Deganwy.

Figure 99. nMDS showing the relationship between the species communities in control and impact areas at Deganwy.

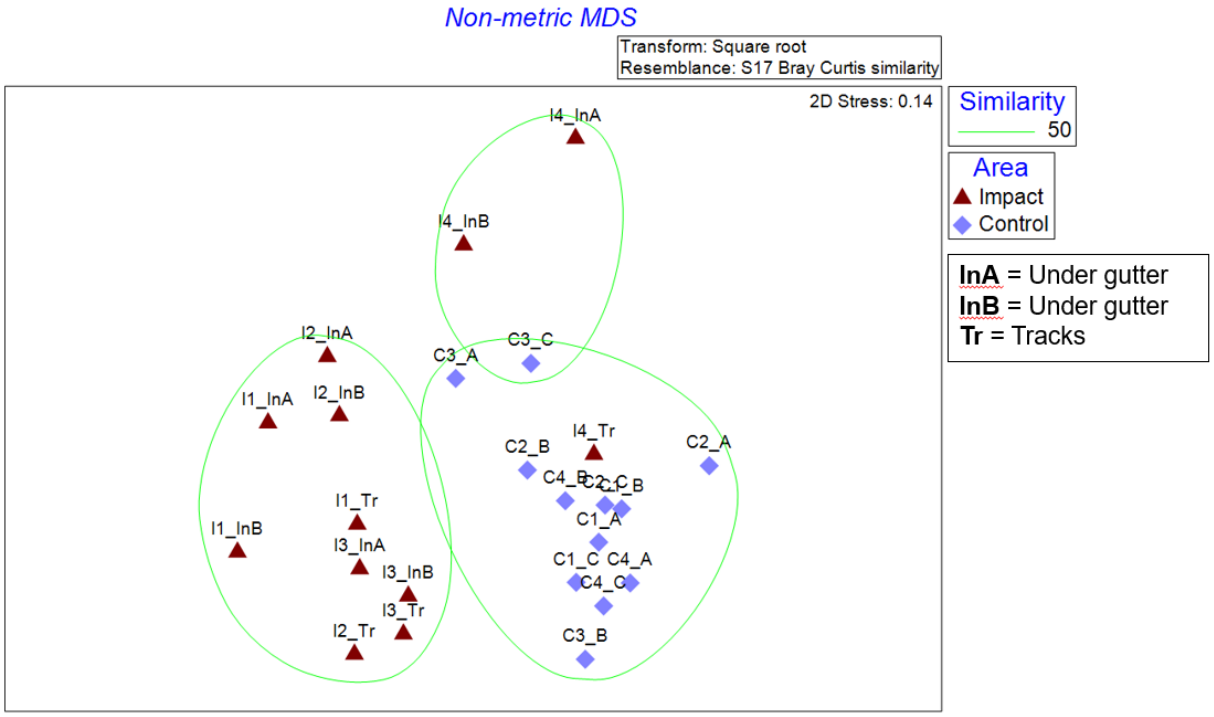


Table 37. The dominant taxa contributing to overall percentage similarity in control and impact areas at Deganwy, as per SIMPER routine on square-root transformed abundances (80% cut-off)

Species	AMBI EG Score	Mean Sqrt. Abundance	% Similarity	% Cumulative Contribution
Impact): *Group similarity 52.07*				
Tubificoides benedii	V	6.36	28.44	54.62
Nematoda	III	2.62	7.67	69.35
Corophium volutator	III	2.63	6.36	81.56
Control: *Group similarity 63.15*				
Tubificoides benedii	V	8.3	26.45	41.89
Peringia ulvae	III	6.11	17.71	69.93
Corophium volutator	III	3.23	6.16	79.69
Cerastoderma edule (juvenile)	III	1.85	5.17	87.88

Table 38. The dominant taxa contributing to overall percentage dissimilarity between control and impact areas at Deganwy, as per SIMPER routine on square-root transformed abundances. Average dissimilarity = 53.03%

Species	AMBI EG Score	Mean Abundance: Impact	Mean Abundance: Control	% Dissimilarity	% Cumulative Contribution
Peringia ulvae	III	1.07	6.11	11.08	20.9
Tubificoides benedii	V	6.36	8.3	6.36	32.88
Corophium volutator	III	2.63	3.23	6.19	44.55
Tubificoides pseudogaster	V	1.92	1.77	4.99	53.95
Nematoda	III	2.62	0.88	4.48	62.39
Cerastoderma edule (juvenile)	III	0.57	1.85	2.78	67.64
Crangon crangon	I	0.76	0.08	1.99	71.4
Collembola	Not listed	0	0.88	1.84	74.87
Scrobicularia plana (juvenile)	III	0.17	0.76	1.59	77.87
Tharyx Type A	IV	0	0.65	1.4	80.51

3.3.2.3 Megafaunal community composition

Six different taxa were recorded from 16 megafaunal surface samples taken at Deganwy (Figure 100). Three of the megafaunal samples had no megafauna within them. Characteristic taxa included a species of polychaete in the family Capitellidae, which were

only present in the impact area. *C. crangon* and *L. conchilega* were only encountered in the control area, and larger numbers of polychaete tubes were found in the control compared to the impacted area (Figure 100). It is worth noting, however, that overall abundance in the megafaunal samples was low.

The lugworm *Arenicola marina* was only found within two infaunal core samples (and not within the megafaunal samples) at Deganwy. Worm casts, which indicate the presence of the lugworm, were observed in relatively low numbers at Deganwy (Figure 101), however, casts were more abundant in the control area compared to the impact area (6.32 ± 1.7 per m^2 and 1.7 ± 0.6 per m^2 , respectively). This difference in worm casts was statistically significant (Kruskal-Wallis, $X^2(1) = 5.7$, $p = 0.02$).

Megafaunal communities showed a separation between the impact and control areas as shown in the nMDS plot (Figure 102). This separation is further supported by the results of an ANOSIM (R = 0.421, $p = 0.001$*)* which indicates a difference in species community composition between control and impact areas. However, this observation was only based on 4 samples, with the remaining samples containing either a single taxon or no megafauna present.

Figure 100. Mean (± SE) abundance of megafaunal taxa at Deganwy.

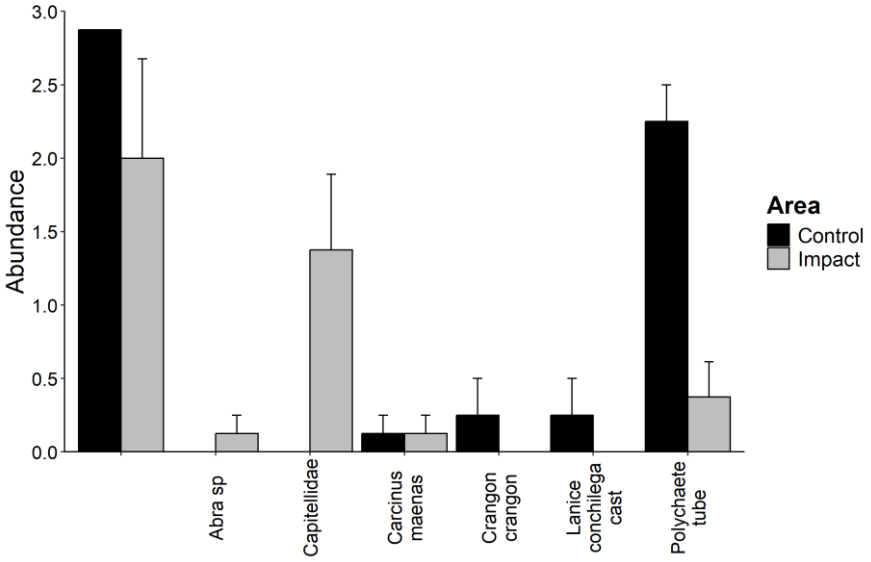


Figure 101. Mean (± SE) density per m² of worm cast counts at control and impact areas at Deganwy.

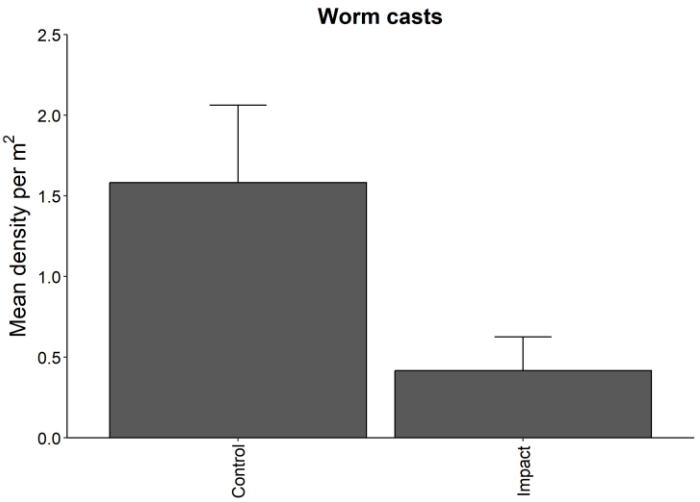
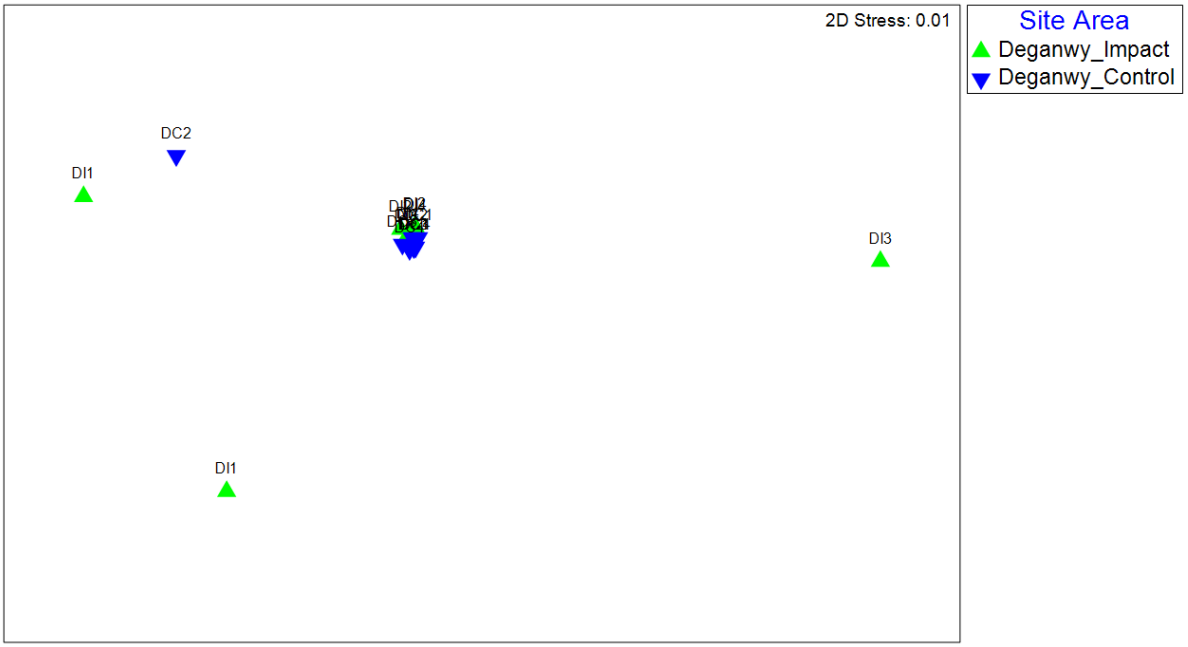


Figure 102. nMDS showing the relationship between the megafaunal communities in control and impact areas at Deganwy.



3.3.2.4 Epifaunal coverage

At Deganwy, the gutters showed low diversity in epifaunal coverage, with only ephemeral algae present, covering approximately 40% of the surface (Figure 103). No other epifauna were observed on the gutters. The low diversity of epifauna at Deganwy is likely the result of regular maintenance by a bait collector, who was observed on-site during the sampling.

Figure 103. Ephemeral algae present on gutters at Deganwy.



3.3.2.5 Anthropogenic disturbances

Trampling was observed at Deganwy, primarily due to the frequent maintenance of the gutters by the bait collector. No other recent bait collection from the gutters was observed. No public walking was observed on the site.

3.3.3 Historic comparison

No historical surveys were undertaken at Bangor Pier nor Deganwy. Therefore, historic comparisons with the 2024 samples were not carried out.

3.3.4 Discussion

3.3.4.1 Bangor Pier

Sediments at Bangor Pier were classified as sandy mud in both control and impact areas, with similar TOC levels. This similarity in habitat characteristics suggests a uniformity in sedimentary habitats and a stable environment. The differences in faunal communities between control and impact areas are unlikely to be a result of sediment differences, despite the results of the RELATE test suggesting otherwise. This is because the faunal composition was averaged per sampling block, which may not provide a true representation of the faunal composition in the control and impact areas.

Macrofaunal abundance and biomass were higher in the impact areas, although these differences were not statistically significant. The lack of significant differences in abundance and biomass between control and impact areas indicates that the disturbance

from tyres is having a minimal impact. This is further supported by the k-dominance plots, which show no dominance in the community in either area, indicating broad similarity.

In contrast, multivariate analyses, supported by ANOSIM and SIMPER, confirmed distinct community structures between control and impact areas. Opportunistic species such as *T. benedii and T. pseudogaster* were prominent in impact areas, while disturbance-tolerant species like *C. volutator, P. ulvae, and S. armiger* were more abundant in control areas. Despite the shift in communities, the species composition between the areas was similar, though at varying levels of abundance. Additionally, the AMBI scores indicate that these species are largely tolerant to disturbances in both areas, suggesting no discernible differences between the control and impact areas.

The non-native species *A. succinea* was identified at Bangor Pier. This is the first record of this species occurring within Wales.

Megafaunal communities were similar between control and impact areas, with no statistically significant differences observed. However, faunal abundance and diversity were low (4 taxa) at this site. Notably, *C. maenas* was relatively more abundant in the impact area, although this was not significant. This is expected, as moulting crabs seek refuge under shelters while they are most vulnerable to predation (Fowler, 1999). Epifaunal communities were diverse on the tyres, providing a suitable habitat for a variety of species. This may be due to the absence of bait collection activities, as these tyres seemed abandoned and not regularly checked.

Overall, the results suggest that sediment composition between the control and impact areas at Bangor Pier was stable and uniform, with no substantial changes in sediment structure due to the tyres. Benthic communities did not appear to be negatively impacted by the presence of tyres, as indicated by the shared species characteristics (i.e., AMBI scores) observed between control and impact areas. Bangor Pier exhibited substantial litter, indicating other types of disturbance.

3.3.4.2 Deganwy

The sediment classification and TOC levels at Deganwy were very similar with sediments predominantly classified as muddy sand. This indicates a stable, uniform sedimentary habitat.

Macrofaunal abundance and species richness was found to be significantly higher in the control compared to the impact area, despite the elevated abundance observed within the tracks. The low abundance and diversity of taxa in the impact area could be attributed to the gutters causing physical disruption to the subsurface sediment within the immediate area. This disruption likely creates localised areas void of fauna, which supports the elevated abundance observed within the tracks, as these areas experience a lower degree of physical disturbance. The similarity in Simpson’s diversity, coupled with the k-dominance plots indicating an even distribution of abundance among species in both areas, suggests that the overall community is not heavily impacted by the disturbance from gutters.

Multivariate analyses demonstrated shifts in community structure between control and impact areas but highlighted no discernible differences in fauna under the gutters and the tracks around the gutters. Despite the observed changes in infaunal communities between

control and impact areas, the presence of disturbance-tolerant and opportunistic species in both areas suggests no clear differences between control and impact areas. This indicates that the communities are resilient to this form of disturbance, with minimal impacts from the gutters.

The separation between control and impact areas in megafaunal community composition, with certain species only found in specific areas, indicates localised variations in habitat conditions. The higher abundance of *A. marina* worm casts in the control area suggests the presence of gutters in the impact area might be influencing their distribution. The low diversity of epifaunal coverage on gutters is likely due to regular maintenance checks, which can disrupt the establishment of diverse communities.

Overall, the sediment composition between the control and impact areas at Deganwy was stable and uniform, with no substantial changes in sediment structure from the gutters. The significantly lower macrofaunal abundance and species richness observed in the impact area are likely due to the gutters penetrating the subsurface sediment, creating localised areas void of fauna. However, wider site impacts were not observed, as the benthic communities at the control and impact areas were primarily classified as disturbance-tolerant and appear to be resilient to the level of disturbance exhibited at this site.

4 Conclusions

This study investigated the impact of various bait collection activities, including bait digging, boulder turning, and placement of crab shelters, on designated features of Welsh MPAs. While bait collection is a widespread practice across the UK, its potential long-term effects on faunal habitats have raised concerns.

4.1 Boulder turning

There were significant differences in the epifaunal community structure between the top and bottom of historically turned and not turned boulders at the west of Great Orme and Penmon-Beaumaris sites. These differences were also apparent at the wider site level between control and impact areas.

Both monitoring sites demonstrated long-term impacts on some faunal assemblages. Disturbance-sensitive mobile species, such as molluscs, showed characteristics of still recovering from historic boulder turning, while sessile barnacles showed resilience and faster recovery at both sites. Some taxa such as *N. lapillus* and their eggs appeared to have not shown any signs of impact as their presence was found to be evenly distributed between the control and impact areas at both monitoring sites. Recovery patterns varied depending on the species and environmental conditions at each monitoring site. It was suggested high wave and tidal energy at the west of Great Orme restricted algal growth, whereas at Penmon-Beaumaris, algae and seaweed thrived, potentially due to lower wave exposure. These findings were similarly observed in a previous boulder turning impact study (Mazik *et al.,* 2005).

In contrast to this current study, Mazik *et al.* (2005) reported no significant difference in the number of phyla between turned and unturned boulders, and found no differences at the broader site level. It was suggested that the level of impact was not detectable likely due to low number of turned boulder sampled in their study. Despite reporting different findings, Mazik *et al.* (2005) observed similar species typical of underboulder habitats, including the annelid *Spirorbinae*, bryozoans, molluscs (*N. lapillus*, *Gibbula* sp., and littorinids), as well as barnacles. While diversity may vary between different monitoring sites, these species and phyla are considered characteristic of underboulder communities (Connor *et al.,* 2004).

Fauna that prefer the top surfaces of boulders, like barnacles, recovered faster compared to those on the bottom surfaces, such as molluscs. Both sites exhibited moderate intensity of boulder turning and a low presence of recent boulder turning. The lack of recent disturbance likely facilitated the recovery of certain faunal assemblages, particularly those on the top surfaces. However, complete recovery of underboulder communities was not observed at either site.

4.2 Bait digging

The sediment analysis and faunal surveys at Angle Bay, Penmon-Beaumaris and Four Mile Bridge provided insights into the impacts of bait digging.

At Angle Bay direct physical habitat disturbance from bait digging activities was observed at the site with a number of bait diggers observed during the survey in the impact area. Despite that, during the 2023 survey there were no statistically significant differences between the faunal communities in control (undug) and impact (dug) areas at Angle Bay. Statistically significant decreases in seagrass density were observed between control and impact areas.

At Penmon-Beaumaris, the impact area exhibited higher macrofaunal abundance and biomass but lower diversity, indicating dominance by disturbance-tolerant species. This, coupled with signs of bait digging activities evident within the impact area, further suggests the area is regularly disturbed.

At Four Mile Bridge, the lack of a suitable control site and differences in sediment composition between control and impact areas posed challenges for assessing bait digging impacts. However, the impact area showed signs of disturbance, with high abundances of resilient, disturbance-tolerant species, which potentially suggests some level of impact from bait digging activities.

Collectively, the present survey has shown potential signs of macrofaunal benthic recovery from the long-term impacts of bait digging. Previous studies (Mosbahi *et al.* 2015, Watson *et al.* 2017) have reported decreases in macrofaunal abundance and changes in community structure in dug sediment compared to undisturbed habitats. However, these studies focused on the immediate short-term impacts of bait digging on intertidal habitats.

It is important to note that while macrofaunal abundance may have appeared to recover, the communities in previously disturbed environments differ from those in undisturbed (control) environments. This is indicated by the presence of disturbance-tolerant species regularly observed at the impact areas of both monitoring sites, suggesting a shift in community structure to possibly withstand ongoing disturbance in the area.

While this study has focused on the long-term impacts of bait digging on macrobenthic communities and sedimentary habitats, it is important to consider that bait digging could indirectly impact other fauna. Previous studies have highlighted that bait digging can alter prey abundance and diversity for birds and fish, influencing their foraging time and success (Clarke *et al.,* 2017, Watson *et al.,* 2017). However, recent research suggests that such disturbances do not significantly impact waders or wildfowl (Biermann 2020, Goss-Custard et al., 2020). Given the conflicting evidence, future studies on the long-term impacts of bait digging could potentially consider other factors, such as the effects on birds and fish.

4.3 Crab shelter provision

The provision of artificial crab shelters, designed to target crabs during their moulting process, showed minimal impacts at Deganwy and Bangor Pier monitoring sites. At Bangor Pier, the use of tyres as crab shelters did not impact sediment composition nor negatively impact benthic communities. This was likely attributed to the absence of bait collection activities, as the tyres sampled (i.e. a few hundred metres east of the main crab shelter site) appeared abandoned and not regularly checked.

At Deganwy, the significantly higher macrofaunal abundance and species richness in the control area, compared to the impact area, highlighted the physical disruption caused by gutters. These findings were supported by previous studies, which observed a rapid

decline in species richness and abundance of infauna beneath crab tiles compared to undisturbed habitats (Cook *et al.,* 2002, Sheehan 2007). It was suggested that the decrease in infauna may be due to the crab shelters increasing sediment penetrability, consequently creating an unsuitable environment (i.e. lower sediment stability) for infauna to inhabit (Warwick *et al.,* 1990).

Despite this, only localised impacts within the vicinity of the gutters were observed in the present study. Wider site impacts were not evident, as the benthic communities at the control and impact areas were primarily classified as disturbance-tolerant and appear to be resilient to other forms of disturbances at this site.
It has been previously noted that the presence of crab shelters can attract the settlement of species characteristic to the rocky shore, and potentially cause localised changes to the species composition on intertidal habitats (Cook *et al.,* 2002). Thus, it is possible that the faunal communities have adapted to the presence of crab shelters over time as the characteristic taxa were predominantly similar between the impact and control areas at both monitoring sites.

Overall, the study provides valuable insights into the varying impacts of different bait collection methods within Welsh MPAs. Notable impacts were observed for boulder turning and bait digging, while crab shelters were associated with minimal habitat disturbance, with effects largely localised to the immediate vicinity of the shelters. The study highlighted that infaunal recovery may be possible, as evidenced by some degree of recovery from boulder turning and the minimal impact of crab shelters, if bait collection activities are minimised over a period of time. These findings offer a broad understanding of the ecological effects of bait collection activities and can support the development of evidence-based management strategies within MPAs to mitigate their impacts.

4.4 Recommendations

This study has provided insights in assessing the impacts of bait collection activities on designated features of Welsh MPAs. However, some methodological constraints were identified which limited the conclusions which could be drawn. Therefore, in the context of future bait digging monitoring studies, it is recommended that suitable baseline/control sites are identified that share similar habitat characteristics to the impact sites to enable an appropriate comparison of potential impacts on benthic faunal composition.

Historical data comparisons within this study need to be interpreted with caution as the identification of faunal changes are constrained by differences in methodological approaches and lack of information. Historic data comparisons were therefore limited for multiple sites due to a lack of comparable data. As such, the development of a longer term, consistent sampling methodology is highly recommended to enable a better temporal comparison of bait collection impacts and to facilitate a more accurate assessment of long-term recovery. Any such developed methodology should look to ensure a consistent and replicable sampling approach, including standardising equipment (e.g. core size, quadrat size), species recording (abundance counts and percentage cover), sample processing (sieve size, biomass reporting), suitable sample replication and evenly distributed sampling between treatment groups to obtain more representative data. Careful consideration of sampling locations will also be required if any management measures are implemented in the future at the monitoring sites in response to bait collection activities.

To support the interpretation of bait collection impacts a broader assessment of potential impacts could be considered. For example, consideration of chemical leaching into sediments as a result of placement of tiles, gutters or tyres, the assessment of bait collection disturbance to waders or wildfowl influencing their foraging time and success, or the alteration of prey abundance and diversity for birds and fish, this could include measurements of infauna identified during sampling to assess if prey size availability is impacted.

Furthermore, a separate assessment of bait collection intensity at each site would be highly valuable to provide context to any results identified in bait collection studies and support the potential implementation of site management measures.

Future assessments undertaken at the sites reviewed in this project, should ensure consistency in methodologies to allow for accurate comparisons and to inform a better understanding of long-term ecological changes. By addressing these considerations, combined with ongoing review and observations of bait collection intensity at these sites, future studies can provide more robust and reliable insights into the effects of bait collection activities and inform effective management strategies.

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6 Abbreviations

AMBI	AZTI Marine Biotic Index
ANOSIM	Analysis of Similarity
ANOVA	Analysis of Variance
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System
ASCII	American Standard Code for Information Interchange
ASIN	Arcsine
ASML	Aquatic Survey and Monitoring Ltd
AZTI	AZTI-Tecnalia
CCW	Countryside Council for Wales
CI	Control-Impact
DIVERSE	Diversity Indices Calculation Component of PRIMER DIVERSITY
EG	Ecological Group
ESRI	Environmental Systems Research Institute, Inc.
GIS	Geographic Information System
GPS	Global Positioning System
HT	Historically Turned
IECS	Institute of Estuarine & Coastal Studies
IQI	Infaunal Quality Index
ISO	International Organization for Standardization
LMX	Littoral Mixed
LOI	Loss of Ignition
MDS	Multidimensional Scaling
MEDIN	Marine Environmental Data and Information Network
MESH	Mapping European Seabed Habitats
MNCR	Marine Nature Conservation Review
MPA	Marine Protected Area

MSBIAS	Marine Species of the British Isles and Adjacent Seas
NMBAQC	National Marine Biological Analytical Quality Control Scheme
nMDS	Non-metric Multidimensional Scaling
NRW	Natural Resources Wales
NT	Not Turned
PCA	Principal Component Analysis
PERMANOVA	Permutational Multivariate Analysis of Variance
PRIMER	Plymouth Routines In Multivariate Ecological Research
PSA	Particle Size Analysis
RStudio	An integrated development environment for R, a programming language for statistical computing and graphics
RT	Recently Turned
SAC	Special Area of Conservation
SACFOR	Superabundant, Abundant, Common, Frequent, Occasional, and Rare
SE	Standard Error
SIMPER	SIM- ilarity PERcentages
SS	Sum of Squares
SSSI	Site of Special Scientific Interest
TOC	Total Organic Carbon
UK	United Kingdom
VRT	Very Recently Turned
WoRMS	World Register of Marine Species

Appendices

Appendix A: Field Notes

Table A1. Field notes of boulders surveyed on each transect for boulder turning survey.

Site	Treatment	Date	Surveyor	Transect	Boulder no.	Boulder classification	Live barnacles	Dead barnacles	Spat
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	1	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	2	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	3	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	4	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	5	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	6	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	7	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	8	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	9	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	10	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	1	11	Recently turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	2	1	Recently turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	2	2	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	2	3	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	2	4	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	2	5	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	VAW	2	6	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	1	1	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	1	2	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	1	3	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	1	4	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	1	5	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	1	6	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	2	1	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	2	2	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	2	3	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	2	4	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	2	5	Not turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	2	6	Historically turned	NA	NA	NA
Penmon-Beaumaris	Impact	10/03/2024	KNG	2	7	Historically turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	VAW	1	1	Not turned	NA	NA	NA

Site	Treatment	Date	Surveyor	Transect	Boulder no.	Boulder classification	Live barnacles	Dead barnacles	Spat
Penmon-Beaumaris	Control	11/03/2024	VAW	1	2	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	VAW	1	3	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	VAW	2	1	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	VAW	2	2	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	VAW	2	3	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	VAW	2	4	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	VAW	2	5	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	VAW	2	6	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	1	1	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	1	2	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	1	3	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	1	4	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	1	5	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	1	6	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	2	1	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	2	2	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	2	3	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	2	4	Not turned	NA	NA	NA
Penmon-Beaumaris	Control	11/03/2024	KNG	2	5	Not turned	NA	NA	NA
Orme	Impact	12/03/2024	VAW	1	1	Not turned	12	1	0
Orme	Impact	12/03/2024	VAW	1	2	Not turned	9	13	0
Orme	Impact	12/03/2024	VAW	1	3	Not turned	16	12	1
Orme	Impact	12/03/2024	VAW	1	4	Historically turned	0	0	0
Orme	Impact	12/03/2024	VAW	1	5	Not turned	21	2	0
Orme	Impact	12/03/2024	VAW	1	6	Historically turned	1	0	0
Orme	Impact	12/03/2024	VAW	2	1	Not turned	21	0	0
Orme	Impact	12/03/2024	VAW	2	2	Not turned	7	2	0
Orme	Impact	12/03/2024	VAW	2	3	Historically turned	0	0	2
Orme	Impact	12/03/2024	VAW	2	4	Not turned	11	4	0
Orme	Impact	12/03/2024	VAW	2	5	Not turned	7	9	1
Orme	Impact	12/03/2024	VAW	2	6	Not turned	9	3	0
Orme	Impact	12/03/2024	KNG	1	1	Historically turned	0	0	0
Orme	Impact	12/03/2024	KNG	1	2	Historically turned	2	4	0
Orme	Impact	12/03/2024	KNG	1	3	Historically turned	1	8	0
Orme	Impact	12/03/2024	KNG	1	4	Historically turned	0	6	0
Orme	Impact	12/03/2024	KNG	1	5	Not turned	7	11	0
Orme	Impact	12/03/2024	KNG	1	6	Not turned	25	2	0
Orme	Impact	12/03/2024	KNG	1	7	Not turned	28	3	0

Site	Treatment	Date	Surveyor	Transect	Boulder no.	Boulder classification	Live barnacles	Dead barnacles	Spat
Orme	Impact	12/03/2024	KNG	1	8	Historically turned	3	18	0
Orme	Impact	12/03/2024	KNG	2	1	Not turned	15	0	0
Orme	Impact	12/03/2024	KNG	2	2	Not turned	8	4	0
Orme	Impact	12/03/2024	KNG	2	3	Historically turned	2	6	0
Orme	Control	13/03/2024	VAW	1	1	Not turned	4	1	0
Orme	Control	13/03/2024	VAW	1	2	Historically turned	0	0	0
Orme	Control	13/03/2024	VAW	1	3	Not turned	8	0	0
Orme	Control	13/03/2024	VAW	1	4	Not turned	0	0	0
Orme	Control	13/03/2024	VAW	1	5	Not turned	3	1	0
Orme	Control	13/03/2024	VAW	1	6	Not turned	8	0	2
Orme	Control	13/03/2024	VAW	1	7	Not turned	3	0	1
Orme	Control	13/03/2024	VAW	1	8	Not turned	0	0	0
Orme	Control	13/03/2024	VAW	1	9	Not turned	0	0	0
Orme	Control	13/03/2024	VAW	1	10	Not turned	0	0	0
Orme	Control	13/03/2024	VAW	2	1	Not turned	0	3	0
Orme	Control	13/03/2024	VAW	2	2	Not turned	0	0	0
Orme	Control	13/03/2024	VAW	2	3	Not turned	3	1	0
Orme	Control	13/03/2024	VAW	2	4	Not turned	21	4	0
Orme	Control	13/03/2024	VAW	2	5	Not turned	11	3	3
Orme	Control	13/03/2024	VAW	2	6	Not turned	6	2	0
Orme	Control	13/03/2024	VAW	2	7	Not turned	0	0	0
Orme	Control	13/03/2024	VAW	2	8	Not turned	5	0	0
Orme	Control	13/03/2024	VAW	2	9	Not turned	1	3	0
Orme	Control	13/03/2024	KNG	1	1	Not turned	4	0	0
Orme	Control	13/03/2024	KNG	1	2	Historically turned	0	0	0
Orme	Control	13/03/2024	KNG	1	3	Not turned	2	0	0
Orme	Control	13/03/2024	KNG	1	4	Not turned	8	1	0
Orme	Control	13/03/2024	KNG	1	5	Not turned	10	0	0
Orme	Control	13/03/2024	KNG	1	6	Not turned	6	0	0
Orme	Control	13/03/2024	KNG	1	7	Not turned	3	0	0
Orme	Control	13/03/2024	KNG	2	1	Not turned	7	0	0
Orme	Control	13/03/2024	KNG	2	2	Not turned	25	2	0
Orme	Control	13/03/2024	KNG	2	3	Not turned	12	0	0
Orme	Control	13/03/2024	KNG	2	4	Not turned	3	2	0
Orme	Control	13/03/2024	KNG	2	5	Not turned	10	0	0
Orme	Control	13/03/2024	KNG	2	6	Not turned	22	0	0
Orme	Control	13/03/2024	KNG	2	7	Not turned	9	0	0

Table A2. Field notes for quadrat stations sampled at Angle Bay

	Treatment	Block no.	Quadrat No.	Seagrass species	Seagrass (%)	Canopy height 1 (cm)	Canopy height 2 (cm)	Canopy height 3 (cm)	Seagrass condition	Algal (%)	Epiphyte (%)	Worm cast (count)
Angle Bay	Control	AC1	AC1.QA	Z. noltei	80	9	9	14	Good	0	0	4
Angle Bay	Control	AC1	AC1.QB	Z. noltei	90	9	8	10	Good	1	0	1
Angle Bay	Control	AC1	AC1.QC	Z. noltei	90	9	8	9	Good	0	0	5
Angle Bay	Control	AC2	AC2.QA	Z. noltei	75	9	7	11	Good	0	0	4
Angle Bay	Control	AC2	AC2.QB	Z. noltei	45	7	10	6	Good	0	0	2
Angle Bay	Control	AC2	AC2.QC	Z. noltei	95	9	8	8	Good	0	0	3
Angle Bay	Control	AC3	AC3.QA	Z. noltei	75	10	12	7	Good	0	0	5
Angle Bay	Control	AC3	AC3.QB	Z. noltei	45	7	8	10	Good	0	0	3
Angle Bay	Control	AC3	AC3.QC	Z. noltei	65	8	7	10	Good	0	0	3
Angle Bay	Control	AC4	AC4.QA	Z. noltei	40	26	10	30	Good	0	0	1
Angle Bay	Control	AC4	AC4.QB	Z. noltei	70	9	8	6	Good	0	0	5
Angle Bay	Control	AC4	AC4.QC	Z. noltei	80	11	10	9	Good	0	0	0
Angle Bay	Control	AC5	AC5.QA	Z. noltei	90	7	8	6	Good	0	0	0
Angle Bay	Control	AC5	AC5.QB	Z. noltei	95	11	10	10	Moderate	0	0	1
Angle Bay	Control	AC5	AC5.QC	Z. noltei	90	11	12	12	Good	0	0	1
Angle Bay	Control	AC6	AC6.QA	Z. noltei	85	11	10	10	Good	0	0	1
Angle Bay	Control	AC6	AC6.QB	Z. noltei	90	8	9	7	Good	0	0	0
Angle Bay	Control	AC6	AC6.QC	Z. noltei	95	6	9	14	Good	0	0	2
Angle Bay	Impact	AI1	AI1.QA	Z. noltei	30	22	7	9	Moderate	5	0	1
Angle Bay	Impact	AI1	AI1.QB	Z. noltei	60	6	9	9	Good	1	0	0
Angle Bay	Impact	AI1	AI1.QC	Z. noltei	20	10	8	7	Poor	25	0	1
Angle Bay	Impact	AI2	AI2.QA	Z. noltei	30	7	6	8	Moderate	0	0	1
Angle Bay	Impact	AI2	AI2.QB	Z. noltei	70	8	7	12	Good	0	0	2
Angle Bay	Impact	AI 2	AI2.QC	Z. noltei	15	5	8	5	Moderate	0	0	2
Angle Bay	Impact	AI 3	AI3.QA	Z. noltei	15	6	7	8	Good	0	0	0
Angle Bay	Impact	AI 3	AI3.QB	Z. noltei	10	7	5	5	Moderate	0	0	0
Angle Bay	Impact	AI 3	AI3.QC	Z. noltei	50	4	6	6	Good	0	0	0
Angle Bay	Impact	AI4	AI4.QA	Z. noltei	70	6	7	6	Good	0	0	1

Angle Bay	Impact	AI4	AI4.QB	Z. noltei	60	7	8	6	Moderate	0	0	0
Angle Bay	Impact	AI4	AI4.QC	Z. noltei	70	8	8	9	Good	0	0	2
Angle Bay	Impact	AI5	AI5.QA	Z. noltei	90	10	8	6	Good	0	0	4
Angle Bay	Impact	AI5	AI5.QB	Z. noltei	60	8	11	9	Good	0	0	2
Angle Bay	Impact	AI5	AI5.QC	Z. noltei	60	11	8	8	Good	0	0	5
Angle Bay	Impact	AI6	AI6.QA	Z. noltei	95	7	10	7	Good	0	0	1
Angle Bay	Impact	AI6	AI6.QB	Z. noltei	85	8	10	12	Good	14	0	0
Angle Bay	Impact	AI6	AI6.QC	Z. noltei	80	11	8	9	Good	0	0	1

Table A3. Field notes for core sample stations sampled for bait digging survey.

Site	Treatment	Block no.	Macrofauna core repl.	Sediment description	Core depth (cm)	Anoxic layer depth (cm)	Evidence of disturbance
Angle Bay	Control	AC1	AC1.C.A	Muddy Sand	15	15	None
Angle Bay	Control	AC1	AC1.C.B	Muddy Sand	15	4	None
Angle Bay	Control	AC1	AC1.C.C	Muddy Sand	15	4	None
Angle Bay	Control	AC2	AC2.C.A	Muddy Sand	15	2	None
Angle Bay	Control	AC2	AC2.C.B	Muddy Sand	15	2	None
Angle Bay	Control	AC2	AC2.C.C	Muddy Sand	15	2	None
Angle Bay	Control	AC3	AC3.C.A	Muddy Sand	15	2	None
Angle Bay	Control	AC3	AC3.C.B	Muddy Sand	15	3	None
Angle Bay	Control	AC3	AC3.C.C	Muddy Sand	15	4	None
Angle Bay	Control	AC4	AC4.C.A	Muddy Sand	15	2	None
Angle Bay	Control	AC4	AC4.C.B	Muddy Sand	15	3	None
Angle Bay	Control	AC4	AC4.C.C	Muddy Sand	15	4	None
Angle Bay	Control	AC5	AC5.C.A	Muddy Sand	15	2	None
Angle Bay	Control	AC5	AC5.C.B	Muddy Sand	15	2	Standing water
Angle Bay	Control	AC5	AC5.C.C	Muddy Sand	15	2	None
Angle Bay	Control	AC6	AC6.C.A	Muddy Sand	15	1	None
Angle Bay	Control	AC6	AC6.C.B	Muddy Sand	15	3	None
Angle Bay	Control	AC6	AC6.C.C	Muddy Sand	15	2	None

Site	Treatment	Block no.	Macrofauna core repl.	Sediment description	Core depth (cm)	Anoxic layer depth (cm)	Evidence of disturbance
Angle Bay	Impact	AI1	AI1.C.A	Muddy Sand	15	3	Disturbance in block
Angle Bay	Impact	AI1	AI2.C.B	Muddy Sand	15	3	Disturbance in block
Angle Bay	Impact	AI1	AI1.C.C	Muddy Sand	15	2	Disturbance in block
Angle Bay	Impact	AI2	AI2.C.A	Muddy Sand	15	0.5	Disturbance in block
Angle Bay	Impact	AI2	AI2.C.B	Muddy Sand	15	1	Disturbance in block
Angle Bay	Impact	AI 2	AI2.C.C	Gravelly Muddy Sand	15	1	None
Angle Bay	Impact	AI 3	AI3.C.A	Muddy Sand	15	0.5	Disturbance in block
Angle Bay	Impact	AI 3	AI3.C.B	Muddy Sand	15	0.5	Disturbance in block
Angle Bay	Impact	AI 3	AI3.C.C	Muddy Sand	15	1	Disturbance in block
Angle Bay	Impact	AI 4	AI4.C.A	Muddy Sand	15	0.5	Disturbance in block
Angle Bay	Impact	AI 4	AI4.C.B	Muddy Sand	15	0.5	Dig hole in corner (25%)
Angle Bay	Impact	AI 4	AI4.C.C	Muddy Sand	15	1	Disturbance in block
Angle Bay	Impact	AI 5	AI5.C.A	Muddy Sand	15	1	Evidence of historic backfilled holes
Angle Bay	Impact	AI 5	AI5.C.B	Muddy Sand	15	2	Evidence of historic backfilled holes

Site	Treatment	Block no.	Macrofauna core repl.	Sediment description	Core depth (cm)	Anoxic layer depth (cm)	Evidence of disturbance
Angle Bay	Impact	AI 5	AI5.C.C	Muddy Sand	15	2	Evidence of historic backfilled holes
Angle Bay	Impact	AI 6	AI6.C.A	Muddy Sand	15	2	None
Angle Bay	Impact	AI 6	AI6.C.B	Muddy Sand	15	2	None
Angle Bay	Impact	AI 6	AI6.C.C	Muddy Sand	15	2	None
Four Mile Bridge	Impact	1	FI1.A	Soft mud	10	2	Yes
Four Mile Bridge	Impact	1	FI1.B	Soft mud	15	1	Yes
Four Mile Bridge	Impact	1	FI1.C	Soft mud	15	2	Yes
Four Mile Bridge	Impact	2	FI2.A	Soft mud	15	2	Yes
Four Mile Bridge	Impact	2	FI2.B	Soft mud	15	2	Yes
Four Mile Bridge	Impact	2	FI2.C	Soft mud	15	2	Yes
Four Mile Bridge	Impact	3	FI3.A	Muddy gravel	15	1	Yes
Four Mile Bridge	Impact	3	FI3.B	Muddy gravel	15	1	Yes
Four Mile Bridge	Impact	3	FI3.C	Muddy gravel	15	1	Yes
Four Mile Bridge	Impact	4	FI4.A	Muddy gravel, rocks	15	1	Yes - old
Four Mile Bridge	Impact	4	FI4.B	Muddy gravel, rocks	15	1	Yes - old
Four Mile Bridge	Impact	4	FI4.C	Muddy gravel, rocks	15	1	Yes - old
Four Mile Bridge	Impact	5	FI5.A	Muddy, rocks	10	1	Yes - old
Four Mile Bridge	Impact	5	FI5.B	Muddy gravel	10	1	Yes - old
Four Mile Bridge	Impact	5	FI5.C	Muddy gravel	10	1	Yes - old
Four Mile Bridge	Impact	6	FI6.A	Muddy gravel	15	1	Yes - old
Four Mile Bridge	Impact	6	FI6.B	Muddy gravel	10	1	Yes - old
Four Mile Bridge	Impact	6	FI6.C	Muddy gravel	10	1	Yes - old
Four Mile Bridge	Control	1	FC1.A	Muddy sand	12	2	No
Four Mile Bridge	Control	1	FC1.B	Muddy sand	15	2	No
Four Mile Bridge	Control	1	FC1.C	Muddy sand	15	3	No
Four Mile Bridge	Control	2	FC2.A	Muddy sand	15	2	No
Four Mile Bridge	Control	2	FC2.B	Muddy sand	15	2	No
Four Mile Bridge	Control	2	FC2.C	Muddy sand	15	2	No
Four Mile Bridge	Control	3	FC3.A	Muddy sand	15	2	No
Four Mile Bridge	Control	3	FC3.B	Muddy sand	15	2	No
Four Mile Bridge	Control	3	FC3.C	Muddy sand	15	3	No
Four Mile Bridge	Control	4	FC4.A	Muddy sand	15	3	No
Four Mile Bridge	Control	4	FC4.B	Muddy sand	15	3	No
Four Mile Bridge	Control	4	FC4.C	Muddy sand	15	3	No

Site	Treatment	Block no.	Macrofauna core repl.	Sediment description	Core depth (cm)	Anoxic layer depth (cm)	Evidence of disturbance
Four Mile Bridge	Control	5	FC5.A	Muddy sand	12	2	No
Four Mile Bridge	Control	5	FC5.B	Muddy sand	12	2	No
Four Mile Bridge	Control	5	FC5.C	Muddy sand	12	3	No
Four Mile Bridge	Control	6	FC6.A	Muddy sand	15	2	No
Four Mile Bridge	Control	6	FC6.B	Muddy sand	15	2	No
Four Mile Bridge	Control	6	FC6.C	Muddy sand	10	2	No
Penmon-Beaumaris	Impact	1	PI1.A	Muddy sand	12	1	Yes
Penmon-Beaumaris	Impact	1	PI1.B	Muddy sand	12	1	Yes
Penmon-Beaumaris	Impact	1	PI1.C	Muddy sand	13	1	Yes
Penmon-Beaumaris	Impact	2	PI2.A	Muddy gravel	12	1	Yes
Penmon-Beaumaris	Impact	2	PI2.B	Muddy gravel	12	1	Yes
Penmon-Beaumaris	Impact	2	PI2.C	Muddy gravel	12	1	Yes
Penmon-Beaumaris	Impact	3	PI3.A	Muddy gravel	12	1	Yes
Penmon-Beaumaris	Impact	3	PI3.B	Muddy gravel	12	1	Yes
Penmon-Beaumaris	Impact	3	PI3.C	Muddy gravel	12	1	Yes
Penmon-Beaumaris	Impact	4	PI4.A	Muddy gravel	12	2	Yes
Penmon-Beaumaris	Impact	4	PI4.B	Muddy gravel	15	1	Yes
Penmon-Beaumaris	Impact	4	PI4.C	Muddy gravel	15	1	Yes
Penmon-Beaumaris	Impact	5	PI5.A	Muddy gravel, shells	12	1	Yes
Penmon-Beaumaris	Impact	5	PI5.B	Muddy gravel	13	1	Yes
Penmon-Beaumaris	Impact	5	PI5.C	Muddy gravel	15	1	Yes
Penmon-Beaumaris	Impact	6	PI6.A	Muddy gravel	15	<1	Yes
Penmon-Beaumaris	Impact	6	PI6.B	Muddy gravel	12	<1	Yes
Penmon-Beaumaris	Impact	6	PI6.C	Muddy gravel	12	<1	Yes
Penmon-Beaumaris	Impact	7	PI7.A	Muddy gravel	12	1	Yes
Penmon-Beaumaris	Impact	7	PI7.B	Muddy gravel	12	1	Yes
Penmon-Beaumaris	Impact	7	PI7.C	Muddy gravel	12	1	Yes
Penmon-Beaumaris	Impact	8	PI8.A	Muddy gravel	15	1	Yes
Penmon-Beaumaris	Impact	8	PI8.B	Muddy gravel	13	1	Yes
Penmon-Beaumaris	Impact	8	PI8.C	Muddy gravel	15	1	Yes
Penmon-Beaumaris	Control	1	PC1.A	Muddy gravel	12	1	No
Penmon-Beaumaris	Control	1	PC1.B	Muddy gravel	12	1	No
Penmon-Beaumaris	Control	1	PC1.C	Muddy gravel	12	1	No
Penmon-Beaumaris	Control	2	PC2.A	Muddy gravel	12	3	No
Penmon-Beaumaris	Control	2	PC2.B	Muddy gravel	12	3	No
Penmon-Beaumaris	Control	2	PC2.C	Muddy gravel	12	3	No
Penmon-Beaumaris	Control	3	PC3.A	Muddy sand gravel	15	3	No
Penmon-Beaumaris	Control	3	PC3.B	Muddy sand gravel	12	3	No

Site	Treatment	Block no.	Macrofauna core repl.	Sediment description	Core depth (cm)	Anoxic layer depth (cm)	Evidence of disturbance
Penmon-Beaumaris	Control	3	PC3.C	Muddy sand gravel	12	3	No
Penmon-Beaumaris	Control	4	PC4.A	Muddy sand gravel	12	3	No
Penmon-Beaumaris	Control	4	PC4.B	Muddy sand gravel	12	3	No
Penmon-Beaumaris	Control	4	PC4.C	Muddy sand gravel	12	3	No
Penmon-Beaumaris	Control	5	PC5.A	Muddy gravel	12	3	No
Penmon-Beaumaris	Control	5	PC5.B	Muddy gravel	12	3	No
Penmon-Beaumaris	Control	5	PC5.C	Muddy gravel	12	3	No
Penmon-Beaumaris	Control	6	PC6.A	Muddy gravel with rocks	12	4	No
Penmon-Beaumaris	Control	6	PC6.B	Muddy gravel with rocks	12	3	No
Penmon-Beaumaris	Control	6	PC6.C	Muddy gravel with rocks	12	3	No
Penmon-Beaumaris	Control	7	PC7.A	Muddy gravel	12	5	No
Penmon-Beaumaris	Control	7	PC7.B	Muddy gravel	12	4	No
Penmon-Beaumaris	Control	7	PC7.C	Muddy gravel	12	4	No
Penmon-Beaumaris	Control	8	PC8.A	Muddy gravel	12	3	No
Penmon-Beaumaris	Control	8	PC8.B	Muddy gravel	12	3	No
Penmon-Beaumaris	Control	8	PC8.C	Muddy gravel	12	3	No

Table A4. Field notes for quadrat stations sampled for crab sheltering survey.

Site	Treatment	Block no.	Macrofauna core repl.	Sediment description	Core depth (cm)	Anoxic layer depth (cm)	Evidence of disturbance
Deganwy	Impact	1	DI1.InA	Sandy mud	10	1	Gutters
Deganwy	Impact	1	DI1.InB	Sandy mud	10	1	Gutters
Deganwy	Impact	1	DI1.Tr	Sandy mud	10	1	Gutters
Deganwy	Impact	2	DI2.InA	Sandy mud	12	1	Bird tracks
Deganwy	Impact	2	DI2.InB	Sandy mud	12	1	Bird tracks
Deganwy	Impact	2	DI2.Tr	Sandy mud	12	1	Bird tracks
Deganwy	Impact	3	DI3.InA	Sandy mud	12	1	Bird tracks
Deganwy	Impact	3	DI3.InB	Sandy mud	12	1	Bird tracks
Deganwy	Impact	3	DI3.Tr	Sandy mud	12	1	Bird tracks
Deganwy	Impact	4	DI4.InA	Sandy mud	12	1	Gutters
Deganwy	Impact	4	DI4.InB	Sandy mud	12	1	Gutters
Deganwy	Impact	4	DI4.Tr	Sandy mud	12	1	Gutters
Deganwy	Control	1	DC1.A	Sandy mud	10	1	Bird tracks
Deganwy	Control	1	DC1.B	Sandy mud	12	1	Bird tracks
Deganwy	Control	1	DC1.C	Sandy mud	12	1	Bird tracks
Deganwy	Control	2	DC2.A	Sandy mud	12	1	None
Deganwy	Control	2	DC2.B	Sandy mud	12	1	None
Deganwy	Control	2	DC2.C	Sandy mud	12	1	None
Deganwy	Control	3	DC3.A	Sandy mud	12	1	None
Deganwy	Control	3	DC3.B	Sandy mud	12	1	None
Deganwy	Control	3	DC3.C	Sandy mud	12	1	None
Deganwy	Control	4	DC4.A	Sandy mud	12	1	None
Deganwy	Control	4	DC4.B	Sandy mud	12	1	None
Deganwy	Control	4	DC4.C	Sandy mud	12	1	None
Bangor	Impact	1	BI1.Cen	Mud	8	<1	Bird tracks
Bangor	Impact	1	BI1.InA	Mud	8	<1	Bird tracks
Bangor	Impact	1	BI1.InB	Mud	8	<1	Bird tracks
Bangor	Impact	2	BI2.Cen	Mud	8	<1	Bird tracks
Bangor	Impact	2	BI2.InA	Mud	8	<1	Bird tracks
Bangor	Impact	2	BI2.InB	Mud	8	<1	Bird tracks
Bangor	Impact	3	BI3.Cen	Mud	8	<1	Tyres, litter
Bangor	Impact	3	BI3.InA	Mud	8	<1	Tyres, litter
Bangor	Impact	3	BI3.InB	Mud	8	<1	Tyres, litter
Bangor	Impact	4	BI4.Cen	Mud	7	<1	Tyres
Bangor	Impact	4	BI4.InA	Mud	7	<1	Tyres
Bangor	Impact	4	BI4.InB	Mud	7	<1	Tyres

Site	Treatment	Block no.	Macrofauna core repl.	Sediment description	Core depth (cm)	Anoxic layer depth (cm)	Evidence of disturbance
Bangor	Control	1	BC1.A	Mud	8	<1	None
Bangor	Control	1	BC1.B	Mud	8	<1	None
Bangor	Control	1	BC1.C	Mud	8	<1	None
Bangor	Control	2	BC2.A	Mud	8	<1	None
Bangor	Control	2	BC2.B	Mud	8	<1	None
Bangor	Control	2	BC2.C	Mud	8	<1	None
Bangor	Control	3	BC3.A	Mud	7	<1	None
Bangor	Control	3	BC3.B	Mud	7	<1	None
Bangor	Control	3	BC3.C	Mud	7	<1	None
Bangor	Control	4	BC4.A	Mud	7	<1	Bird tracks
Bangor	Control	4	BC4.B	Mud	7	<1	Bird tracks
Bangor	Control	4	BC4.C	Mud	7	<1	Bird tracks

Appendix B: Station Photo Log

Table B1. Quadrat photo log for transects sampled for boulder turning.

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Penmon-Beaumaris	Impact	1	53.29243	-4.06395	1	Recently turned		
Penmon-Beaumaris	Impact	1	53.29242	-4.06397	2	Not turned		
Penmon-Beaumaris	Impact	1	53.29243	-4.06396	3	Historically turned		
Penmon-Beaumaris	Impact	1	53.29243	-4.06396	4	Very recently turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Penmon-Beaumaris	Impact	1	53.29023	-4.06779	5	Historically turned		
Penmon-Beaumaris	Impact	2	53.29016	-4.06763	1	Not turned		
Penmon-Beaumaris	Impact	2	53.29017	-4.06758	2	Historically turned		
Penmon-Beaumaris	Impact	2	53.2902	-4.06754	3	Not turned		
Penmon-Beaumaris	Impact	2	53.29022	-4.06755	4	Historically turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Penmon-Beaumaris	Impact	2	53.29022	-4.06755	5	Historically turned		
Penmon-Beaumaris	Impact	3	53.2929	-4.0636	1	Recently turned		
Penmon-Beaumaris	Impact	3	53.29284	-4.06371	2	Historically turned		
Penmon-Beaumaris	Impact	3	53.2929	-4.06356	3	Historically turned		
Penmon-Beaumaris	Impact	3	53.29296	-4.06364	4	Historically turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Penmon-Beaumaris	Impact	3	53.29281	-4.06367	5	Historically turned		
Penmon-Beaumaris	Impact	4	53.29244	-4.06386	1	Historically turned		
Penmon-Beaumaris	Impact	4	53.29239	-4.06396	2	Historically turned		
Penmon-Beaumaris	Impact	4	53.29243	-4.06395	3	Historically turned		No Image
Penmon-Beaumaris	Impact	4	53.29242	-4.06397	4	Historically turned	No Image	No Image
Penmon-Beaumaris	Impact	4	53.29243	-4.06396	5	Historically turned	No Image	No Image

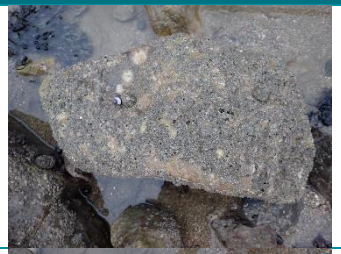
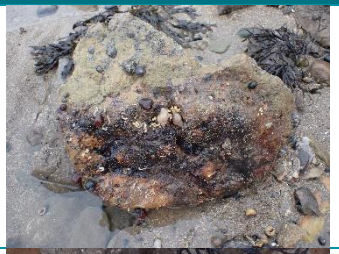
Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Penmon-Beaumaris	Control	1	53.28963	-4.06673	1	Not turned		
Penmon-Beaumaris	Control	1	53.2897	-4.06645	2	Not turned		
Penmon-Beaumaris	Control	1	53.28965	-4.06666	3	Not turned		
Penmon-Beaumaris	Control	1	53.28966	-4.06661	4	Not turned		
Penmon-Beaumaris	Control	1	53.28967	-4.06655	5	Not turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Penmon-Beaumaris	Control	2	53.32727	-3.8623	1	Recently turned		
Penmon-Beaumaris	Control	2	53.32738	-3.86243	2	Recently turned		
Penmon-Beaumaris	Control	2	53.32736	-3.86239	3	Recently turned		
Penmon-Beaumaris	Control	2	53.32731	-3.86229	4	Recently turned		
Penmon-Beaumaris	Control	2	53.32732	-3.86231	5	Not turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Penmon-Beaumaris	Control	3	53.29023	-4.06779	1	Not turned		
Penmon-Beaumaris	Control	3	53.29016	-4.06763	2	Not turned		
Penmon-Beaumaris	Control	3	53.29017	-4.06758	3	Not turned		
Penmon-Beaumaris	Control	3	53.2902	-4.06754	4	Not turned		
Penmon-Beaumaris	Control	3	53.29024	-4.06752	5	Not turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Penmon-Beaumaris	Control	4	53.28965	-4.06666	1	Not turned		
Penmon-Beaumaris	Control	4	53.28966	-4.06661	2	Not turned		
Penmon-Beaumaris	Control	4	53.28967	-4.06655	3	Not turned		
Penmon-Beaumaris	Control	4	53.28968	-4.06648	4	Not turned		
Penmon-Beaumaris	Control	4	53.28963	-4.06666	5	Not turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Orme	Impact	1	53.32766	-3.86233	1	Not turned		
Orme	Impact	1	53.32768	-3.86232	2	Not turned		
Orme	Impact	1	53.32753	-3.86222	3	Historically turned		
Orme	Impact	1	53.3276	-3.86227	4	Historically turned		
Orme	Impact	1	53.32758	-3.86224	5	Historically turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Orme	Impact	2	53.32767	-3.86231	1	Not turned		
Orme	Impact	2	53.32767	-3.86231	2	Not turned		
Orme	Impact	2	53.32905	-3.86759	3	Not turned		
Orme	Impact	2	53.32899	-3.86764	4	Not turned		
Orme	Impact	2	53.32897	-3.86764	5	Not turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Orme	Impact	3	53.32736	-3.86239	1	Historically turned		
Orme	Impact	3	53.32731	-3.86229	2	Historically turned		
Orme	Impact	3	53.32732	-3.86231	3	Historically turned		
Orme	Impact	3	53.32721	-3.86253	4	Historically turned		
Orme	Impact	3	53.32729	-3.86228	5	Historically turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Orme	Impact	4	53.3276	-3.86227	1	Historically turned		
Orme	Impact	4	53.32758	-3.86224	2	Historically turned		
Orme	Impact	4	53.32766	-3.8623	3	Not turned		
Orme	Impact	4	53.32767	-3.86231	4	Historically turned		
Orme	Impact	4	53.32903	-3.86777	5	Historically turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Orme	Control	1	53.32899	-3.86766	1	Not turned		
Orme	Control	1	53.32899	-3.86766	2	Not turned		
Orme	Control	1	53.32901	-3.86741	3	Not turned		
Orme	Control	1	53.32891	-3.86714	4	Not turned		
Orme	Control	1	53.32901	-3.86729	5	Not turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Orme	Control	2	53.32895	-3.86718	1	Not turned		
Orme	Control	2	53.32894	-3.86715	2	Not turned		
Orme	Control	2	53.32893	-3.86715	3	Not turned		
Orme	Control	2	53.32893	-3.86715	4	Not turned		
Orme	Control	2	53.32893	-3.86715	5	Not turned		

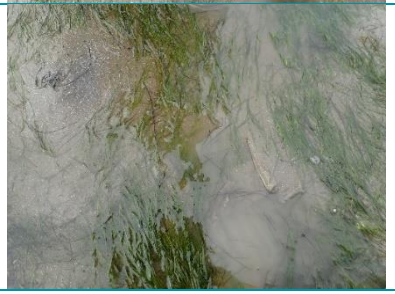
Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Orme	Control	3	53.32899	-3.86764	1	Not turned		
Orme	Control	3	53.32895	-3.86761	2	Not turned		
Orme	Control	3	53.32897	-3.86764	3	Not turned		
Orme	Control	3	53.32903	-3.86777	4	Not turned		
Orme	Control	3	53.32899	-3.86771	5	Not turned		

Site	Treatment	Transect	Latitude	Longitude	Boulder replicate	Boulder Classification	Top photo	Bottom photo
Orme	Control	4	53.32901	-3.86729	1	Not turned		
Orme	Control	4	53.32899	-3.86724	2	Not turned		
Orme	Control	4	53.32895	-3.86718	3	Not turned		
Orme	Control	4	53.32894	-3.86715	4	Not turned		
Orme	Control	4	53.32893	-3.86715	5	Not turned		

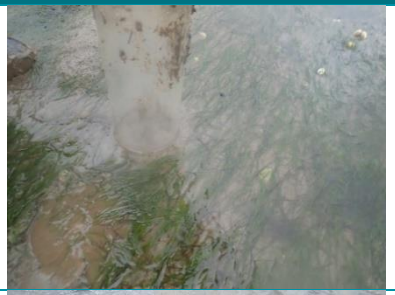
Table B2. Quadrat photo log for stations sampled for bait digging survey.

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Angle Bay	Control	AC1	Seagrass	A	51.677686	-5.046628		
Angle Bay	Control	AC1	Seagrass	B	51.677685	-5.046662		
Angle Bay	Control	AC1	Seagrass	C	51.677629	-5.046727		No image
Angle Bay	Control	AC2	Seagrass	A	51.677552	-5.046675		

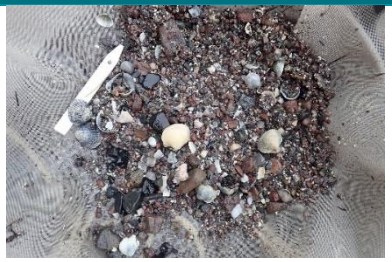
Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Angle Bay	Control	AC2	Seagrass	B	51.677533	-5.046643		
Angle Bay	Control	AC2	Seagrass	C	51.677523	-5.046643		No image
Angle Bay	Control	AC3	Seagrass	A	51.677552	-5.04648		
Angle Bay	Control	AC3	Seagrass	B	51.677545	-5.046434		

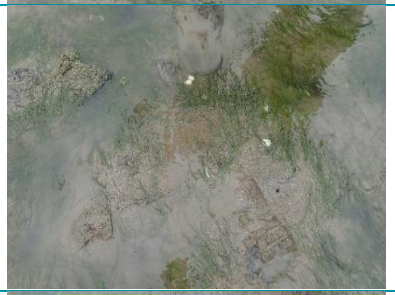
Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Angle Bay	Control	AC3	Seagrass	C	51.677513	-5.046446		
Angle Bay	Control	AC4	Seagrass	A	51.677737	-5.04713		
Angle Bay	Control	AC4	Seagrass	B	51.677702	-5.047164		
Angle Bay	Control	AC4	Seagrass	C	51.677704	-5.047205		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Angle Bay	Control	AC5	Seagrass	A	51.678115	-5.048226		
Angle Bay	Control	AC5	Seagrass	B	51.678061	-5.048239		
Angle Bay	Control	AC5	Seagrass	C	51.678046	-5.048269		
Angle Bay	Control	AC6	Seagrass	A	51.678118	-5.048535		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Angle Bay	Control	AC6	Seagrass	B	51.67812	-5.048533		
Angle Bay	Control	AC6	Seagrass	C	51.678081	-5.048573		
Angle Bay	Impact	AI1	Seagrass	A	51.678862	-5.045475		
Angle Bay	Impact	AI1	Seagrass	B	51.678879	-5.045482		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Angle Bay	Impact	AI1	Seagrass	C	51.678881	-5.045582		
Angle Bay	Impact	AI2	Seagrass	A	51.678861	-5.045434		
Angle Bay	Impact	AI2	Seagrass	B	51.678983	-5.045481		
Angle Bay	Impact	AI2	Seagrass	C	51.678985	-5.045516		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Angle Bay	Impact	AI3	Seagrass	A	51.679132	-5.04565		
Angle Bay	Impact	AI3	Seagrass	B	51.679125	-5.045628		
Angle Bay	Impact	AI3	Seagrass	C	51.679168	-5.045625		
Angle Bay	Impact	AI4	Seagrass	A	51.679303	-5.045753	No image	No image
Angle Bay	Impact	AI4	Seagrass	B	51.679309	-5.045806	No image	

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Angle Bay	Impact	AI4	Seagrass	C	51.67931	-5.045807	No image	
Angle Bay	Impact	AI5	Seagrass	A	51.678827	-5.04666		
Angle Bay	Impact	AI5	Seagrass	B	51.678843	-5.046713		
Angle Bay	Impact	AI5	Seagrass	C	51.678818	-5.046716		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Angle Bay	Impact	AI6	Seagrass	A	51.678913	-5.047128		
Angle Bay	Impact	AI6	Seagrass	B	51.678882	-5.047157		
Angle Bay	Impact	AI6	Seagrass	C	51.678901	-5.047159		
Four Mile Bridge	Impact	FI1	Muddy Sand	A	53.27355	-4.579839		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Four Mile Bridge	Impact	FI1	Muddy Sand	B	53.2736	-4.579795		
Four Mile Bridge	Impact	FI1	Muddy Sand	C	53.273625	-4.579794		
Four Mile Bridge	Impact	FI2	Muddy Sand	A	53.2736	-4.579607		No image
Four Mile Bridge	Impact	FI2	Muddy Sand	B	53.273651	-4.579543		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Four Mile Bridge	Impact	FI2	Muddy Sand	C	53.273633	-4.579572		
Four Mile Bridge	Impact	FI3	Gravelly Muddy Sand	A	53.273847	-4.579066		
Four Mile Bridge	Impact	FI3	Gravelly Muddy Sand	B	53.273808	-4.579037		
Four Mile Bridge	Impact	FI3	Gravelly Muddy Sand	C	53.27381	-4.579028		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Four Mile Bridge	Impact	FI4	Muddy Sand	A	53.274411	-4.579708		
Four Mile Bridge	Impact	FI4	Muddy Sand	B	53.27438	-4.579691		
Four Mile Bridge	Impact	FI4	Muddy Sand	C	53.274399	-4.579722		
Four Mile Bridge	Impact	FI5	Gravelly Muddy Sand	A	53.274184	-4.578725		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Four Mile Bridge	Impact	FI5	Gravelly Muddy Sand	B	53.274166	-4.578729		
Four Mile Bridge	Impact	FI5	Gravelly Muddy Sand	C	53.274184	-4.578789		No image
Four Mile Bridge	Impact	FI6	Muddy Sand	A	53.274229	-4.579025		
Four Mile Bridge	Impact	FI6	Muddy Sand	B	53.274232	-4.579046		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Four Mile Bridge	Impact	FI6	Muddy Sand	C	53.274243	-4.579091		
Four Mile Bridge	Control	FC1	Sand	A	53.295362	-4.566471		
Four Mile Bridge	Control	FC1	Sand	B	53.295366	-4.566469		
Four Mile Bridge	Control	FC1	Sand	C	53.295363	-4.56643		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Four Mile Bridge	Control	FC2	Sand	A	53.29553	-4.566283		
Four Mile Bridge	Control	FC2	Sand	B	53.295549	-4.56631		
Four Mile Bridge	Control	FC2	Sand	C	53.295579	-4.56628		
Four Mile Bridge	Control	FC3	Sand	A	53.295603	-4.56603		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Four Mile Bridge	Control	FC3	Sand	B	53.29565	-4.56603		
Four Mile Bridge	Control	FC3	Sand	C	53.295659	-4.566058		
Four Mile Bridge	Control	FC4	Sand	A	53.295819	-4.565773		
Four Mile Bridge	Control	FC4	Sand	B	53.295812	-4.56571		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Four Mile Bridge	Control	FC4	Sand	C	53.295852	-4.565763		
Four Mile Bridge	Control	FC5	Sand	A	53.295977	-4.565702		
Four Mile Bridge	Control	FC5	Sand	B	53.295971	-4.565744		
Four Mile Bridge	Control	FC5	Sand	C	53.295972	-4.565798		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Four Mile Bridge	Control	FC6	Sand	A	53.296204	-4.565505		
Four Mile Bridge	Control	FC6	Sand	B	53.296241	-4.565488		
Four Mile Bridge	Control	FC6	Sand	C	53.296245	-4.565525		
Penmon-Beaumaris	Impact	PI1	Gravelly Muddy Sand	A	53.27653	-4.080606		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Impact	PI1	Gravelly Muddy Sand	B	53.276535	-4.080583		
Penmon-Beaumaris	Impact	PI1	Gravelly Muddy Sand	C	53.276499	-4.080517		
Penmon-Beaumaris	Impact	PI2	Gravelly Muddy Sand	A	53.276442	-4.080353		
Penmon-Beaumaris	Impact	PI2	Gravelly Muddy Sand	B	53.276414	-4.080324	No image	

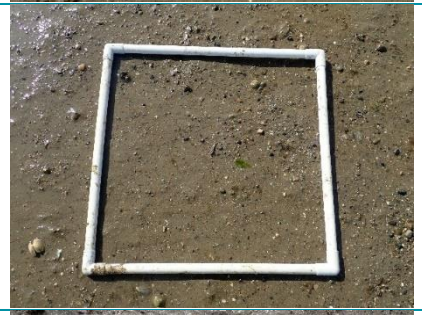
Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Impact	PI2	Gravelly Muddy Sand	C	53.276405	-4.080306		
Penmon-Beaumaris	Impact	PI3	Slightly Gravelly Muddy Sand	A	53.276415	-4.080073		
Penmon-Beaumaris	Impact	PI3	Slightly Gravelly Muddy Sand	B	53.276385	-4.080062		
Penmon-Beaumaris	Impact	PI3	Slightly Gravelly Muddy Sand	C	53.276373	-4.080133	No image	

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Impact	PI4	Gravelly Muddy Sand	A	53.276488	-4.079861		No image
Penmon-Beaumaris	Impact	PI4	Gravelly Muddy Sand	B	53.276508	-4.079819		
Penmon-Beaumaris	Impact	PI4	Gravelly Muddy Sand	C	53.276483	-4.079797		
Penmon-Beaumaris	Impact	PI5	Gravelly Muddy Sand	A	53.276292	-4.08025		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Impact	PI5	Gravelly Muddy Sand	B	53.276283	-4.080311		
Penmon-Beaumaris	Impact	PI5	Gravelly Muddy Sand	C	53.276261	-4.080286		
Penmon-Beaumaris	Impact	PI6	Gravelly Muddy Sand	A	53.276236	-4.080009		
Penmon-Beaumaris	Impact	PI6	Gravelly Muddy Sand	B	53.276223	-4.079978		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Impact	PI6	Gravelly Muddy Sand	C	53.276213	-4.080041		No image
Penmon-Beaumaris	Impact	PI7	Gravelly Muddy Sand	A	53.276062	-4.079959		
Penmon-Beaumaris	Impact	PI7	Gravelly Muddy Sand	B	53.276035	-4.079959		
Penmon-Beaumaris	Impact	PI7	Gravelly Muddy Sand	C	53.276035	-4.080042		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Impact	PI8	Gravelly Muddy Sand	A	53.275908	-4.080145		No image
Penmon-Beaumaris	Impact	PI8	Gravelly Muddy Sand	B	53.275898	-4.080076		
Penmon-Beaumaris	Impact	PI8	Gravelly Muddy Sand	C	53.275911	-4.08018		
Penmon-Beaumaris	Control	PC1	Gravelly Muddy Sand	A	53.288498	-4.066226		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Control	PC1	Gravelly Muddy Sand	B	53.288500	-4.066259		
Penmon-Beaumaris	Control	PC1	Gravelly Muddy Sand	C	53.288514	-4.066334		
Penmon-Beaumaris	Control	PC2	Gravelly Muddy Sand	A	53.288079	-4.065895		
Penmon-Beaumaris	Control	PC2	Gravelly Muddy Sand	B	53.288116	-4.065975		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Control	PC2	Gravelly Muddy Sand	C	53.288085	-4.065999		
Penmon-Beaumaris	Control	PC3	Slightly Gravelly Muddy Sand	A	53.288116	-4.066445		
Penmon-Beaumaris	Control	PC3	Slightly Gravelly Muddy Sand	B	53.288088	-4.066508		
Penmon-Beaumaris	Control	PC3	Slightly Gravelly Muddy Sand	C	53.288048	-4.066478		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Control	PC4	Gravelly Sand	A	53.288235	-4.066376		
Penmon-Beaumaris	Control	PC4	Gravelly Sand	B	53.288252	-4.066322		
Penmon-Beaumaris	Control	PC4	Gravelly Sand	C	53.288257	-4.066373		No image
Penmon-Beaumaris	Control	PC5	Gravelly Muddy Sand	A	53.288481	-4.067131		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Control	PC5	Gravelly Muddy Sand	B	53.288478	-4.067176		
Penmon-Beaumaris	Control	PC5	Gravelly Muddy Sand	C	53.288492	-4.067223	No image	
Penmon-Beaumaris	Control	PC6	Gravelly Muddy Sand	A	53.287390	-4.067137		
Penmon-Beaumaris	Control	PC6	Gravelly Muddy Sand	B	53.287409	-4.067129		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Control	PC6	Gravelly Muddy Sand	C	53.287434	-4.067174		
Penmon-Beaumaris	Control	PC7	Slightly Gravelly Sand	A	53.287278	-4.066733		
Penmon-Beaumaris	Control	PC7	Slightly Gravelly Sand	B	53.287313	-4.066764		
Penmon-Beaumaris	Control	PC7	Slightly Gravelly Sand	C	53.287318	-4.066817		

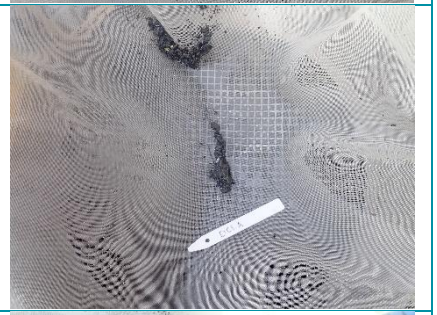
Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Penmon-Beaumaris	Control	PC8	Gravelly Muddy Sand	A	53.287828	-4.066776		
Penmon-Beaumaris	Control	PC8	Gravelly Muddy Sand	B	53.287829	-4.066711		
Penmon-Beaumaris	Control	PC8	Gravelly Muddy Sand	C	53.287877	-4.066683		

Table B3. Quadrat photo log for stations sampled for crab sheltering survey.

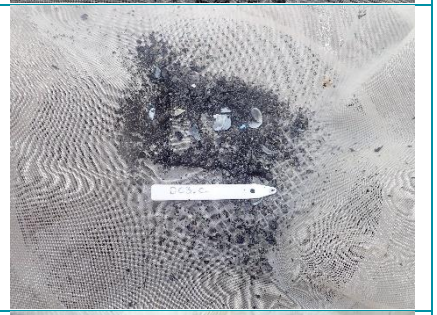
Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Deganwy	Impact	1	Muddy Sand	DI1.InA	53.29353	-3.83213		
Deganwy	Impact	1	Muddy Sand	DI1.InB	53.29353	-3.83215		
Deganwy	Impact	1	Muddy Sand	DI1.Tr	53.29355	-3.83218		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Deganwy	Impact	2	Muddy Sand	DI2.InA	53.29361	-3.83224		
Deganwy	Impact	2	Muddy Sand	DI2.InB	53.29362	-3.83221		
Deganwy	Impact	2	Muddy Sand	DI2.Tr	53.29361	-3.83223		
Deganwy	Impact	3	Muddy Sand	DI3.InA	53.29369	-3.83238		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Deganwy	Impact	3	Muddy Sand	DI3.InB	53.2937	-3.83235		
Deganwy	Impact	3	Muddy Sand	DI3.Tr	53.2937	-3.83236		
Deganwy	Impact	4	Muddy Sand	DI4.InA	53.29385	-3.83262		
Deganwy	Impact	4	Muddy Sand	DI4.InB	53.29386	-3.83261		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Deganwy	Impact	4	Muddy Sand	DI4.Tr	53.29387	-3.83264		
Deganwy	Control	1	Muddy Sand	DC1.A	53.29312	-3.83126		
Deganwy	Control	1	Muddy Sand	DC1.B	53.29313	-3.83119		
Deganwy	Control	1	Muddy Sand	DC1.C	53.29307	-3.83122		

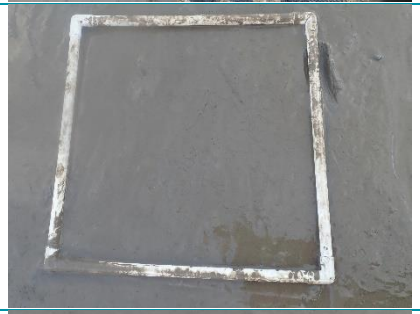
Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Deganwy	Control	2	Muddy Sand	DC2.A	53.29321	-3.83143		
Deganwy	Control	2	Muddy Sand	DC2.B	53.29323	-3.83136		
Deganwy	Control	2	Muddy Sand	DC2.C	53.2932	-3.83135		
Deganwy	Control	3	Sandy Mud	DC3.A	53.29337	-3.83174		

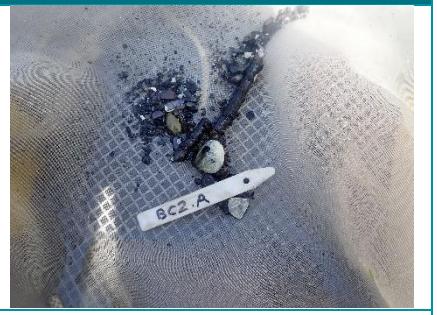
Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Deganwy	Control	3	Sandy Mud	DC3.B	53.29338	-3.83168		
Deganwy	Control	3	Sandy Mud	DC3.C	53.2933	-3.83175		
Deganwy	Control	4	Sandy Mud	DC4.A	53.29356	-3.83209		
Deganwy	Control	4	Sandy Mud	DC4.B	53.29353	-3.832		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Deganwy	Control	4	Sandy Mud	DC4.C	53.29355	-3.83193		
Bangor	Impact	1	Sandy Mud	BI1.Cen	53.23591	-4.12902		
Bangor	Impact	1	Sandy Mud	BI1.InA	53.23575	-4.12885		
Bangor	Impact	1	Sandy Mud	BI1.InB	53.23572	-4.12886		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Bangor	Impact	2	Sandy Mud	BI2.Cen	53.23573	-4.12894		
Bangor	Impact	2	Sandy Mud	BI2.InA	53.23572	-4.12894		
Bangor	Impact	2	Sandy Mud	BI2.InB	53.23574	-4.12896		
Bangor	Impact	3	Sandy Mud	BI3.Cen	53.23571	-4.129		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Bangor	Impact	3	Sandy Mud	BI3.InA	53.23571	-4.129		
Bangor	Impact	3	Sandy Mud	BI3.InB	53.2357	-4.12899		
Bangor	Impact	4	Sandy Mud	BI4.Cen	53.23561	-4.12891		
Bangor	Impact	4	Sandy Mud	BI4.InA	53.23566	-4.1289		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Bangor	Impact	4	Sandy Mud	BI4.InB	53.23565	-4.12893		
Bangor	Control	1	Sandy Mud	BC1.A	53.23575	-4.12871		
Bangor	Control	1	Sandy Mud	BC1.B	53.23577	-4.12871		
Bangor	Control	1	Sandy Mud	BC1.C	53.23585	-4.12883		

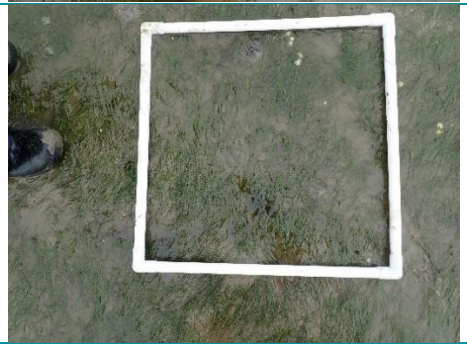
Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Bangor	Control	2	Sandy Mud	BC2.A	53.23582	-4.12867		
Bangor	Control	2	Sandy Mud	BC2.B	53.23586	-4.12863		No Image
Bangor	Control	2	Sandy Mud	BC2.C	53.2358	-4.12867		
Bangor	Control	3	Sandy Mud	BC3.A	53.23591	-4.12856		

Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Bangor	Control	3	Sandy Mud	BC3.B	53.23589	-4.12859		
Bangor	Control	3	Sandy Mud	BC3.C	53.23589	-4.12864		
Bangor	Control	4	Sandy Mud	BC4.A	53.23587	-4.12891		
Bangor	Control	4	Sandy Mud	BC4.B	53.23587	-4.12891		

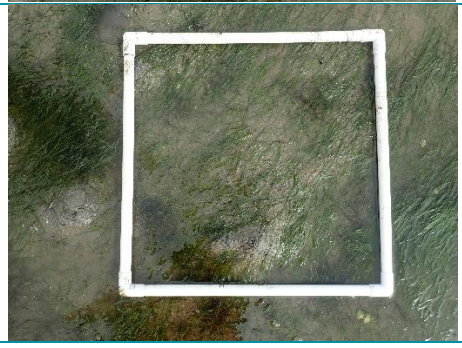
Site	Area	Block	Sediment	Core No.	Latitude	Longitude	Core Photo	Post sieve photo
Bangor	Control	4	Sandy Mud	BC4.C	53.23589	-4.12891		

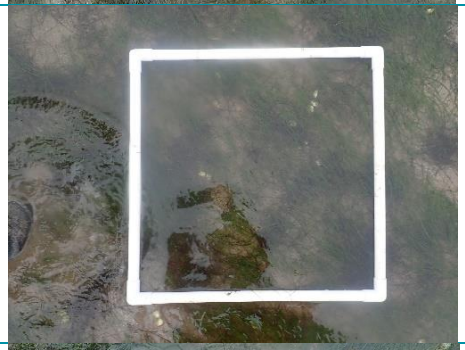
Table B4. Quadrat photo log for stations sampled at Angle Bay

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC1	Seagrass	Muddy Sand	1Q	51.677682	-5.046695	
Control	AC1	Seagrass	Muddy sand	2Q	51.677664	-5.046683	
Control	AC1	Seagrass	Muddy sand	3Q	51.67766	-5.046676	

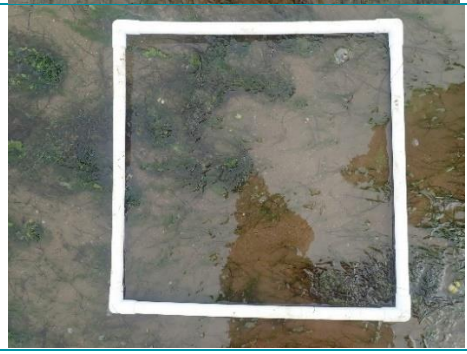
Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC2	Seagrass	Muddy sand	1Q	51.677576	-5.046706	
Control	AC2	Seagrass	Muddy sand	2Q	51.677547	-5.04671	
Control	AC2	Seagrass	Muddy sand	3Q	51.677517	-5.046699	

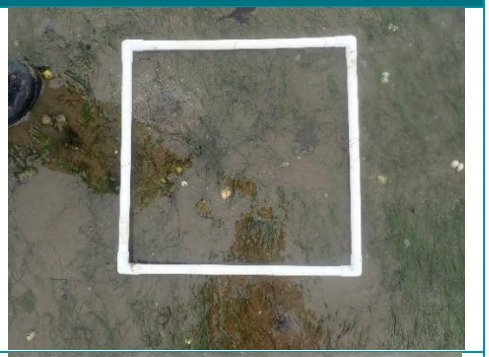
Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC3	Seagrass	Muddy sand	1Q	51.677549	-5.046509	
Control	AC3	Seagrass	Muddy sand	2Q	51.677517	-5.046505	
Control	AC3	Seagrass	Muddy sand	3Q	51.677496	-5.046477	

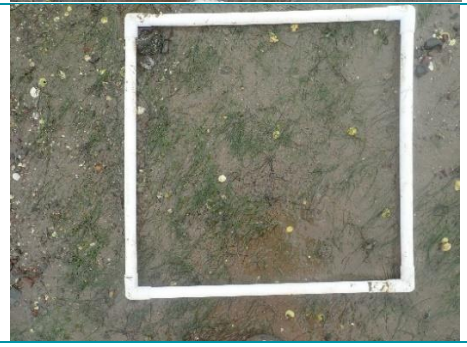
Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC4	Seagrass	Muddy sand	1Q	51.67776	-5.047216	
Control	AC4	Seagrass	Muddy sand	2Q	51.677748	-5.047191	
Control	AC4	Seagrass	Muddy sand	3Q	51.677736	-5.047165	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC5	Seagrass	Muddy sand	1Q	51.67813	-5.048284	
Control	AC5	Seagrass	Muddy sand	2Q	51.678122	-5.048276	
Control	AC5	Seagrass	Muddy sand	3Q	51.678069	-5.048263	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC6	Seagrass	Muddy sand	1Q	51.678132	-5.048604	
Control	AC6	Seagrass	Muddy sand	2Q	51.678122	-5.048602	
Control	AC6	Seagrass	Muddy sand	3Q	51.678127	-5.048549	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI1	Seagrass	Muddy sand	1Q	51.678862	-5.045438	
Impact	AI1	Seagrass	Muddy sand	2Q	51.678869	-5.045435	
Impact	AI1	Seagrass	Muddy sand	3Q	51.678836	-5.045475	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI2	Seagrass	Muddy sand	1Q	51.679011	-5.045492	
Impact	AI2	Seagrass	Muddy sand	2Q	51.679	-5.0455	
Impact	AI2	Seagrass	Gravelly muddy sand	3Q	51.678973	-5.045505	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI3	Seagrass	Muddy sand	1Q	51.679177	-5.045633	
Impact	AI3	Seagrass	Muddy sand	2Q	51.679137	-5.045615	
Impact	AI3	Seagrass	Muddy sand	3Q	51.679148	-5.045632	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI4	Seagrass	Muddy sand	1Q	51.679341	-5.045777	
Impact	AI4	Seagrass	Muddy sand	2Q	51.679323	-5.045752	
Impact	AI4	Seagrass	Muddy sand	3Q	51.679303	-5.045789	

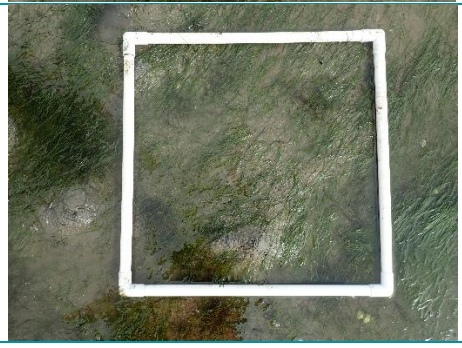
Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI5	Seagrass	Muddy sand	1Q	51.678607	-5.046503	
Impact	AI5	Seagrass	Muddy sand	2Q	51.678828	-5.046665	
Impact	AI5	Seagrass	Muddy sand	3Q	51.678809	-5.046698	

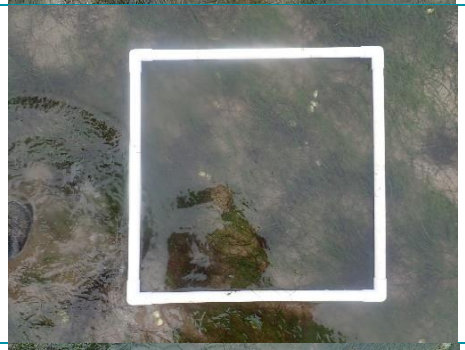
Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI6	Seagrass	Muddy sand	1Q	51.67894	-5.047144	
Impact	AI6	Seagrass	Muddy sand	2Q	51.678929	-5.047138	
Impact	AI6	Seagrass	Muddy sand	3Q	51.678903	-5.047139	
Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC1	Seagrass	Muddy Sand	1Q	51.677682	-5.046695	
Control	AC1	Seagrass	Muddy sand	2Q	51.677664	-5.046683	
Control	AC1	Seagrass	Muddy sand	3Q	51.67766	-5.046676	

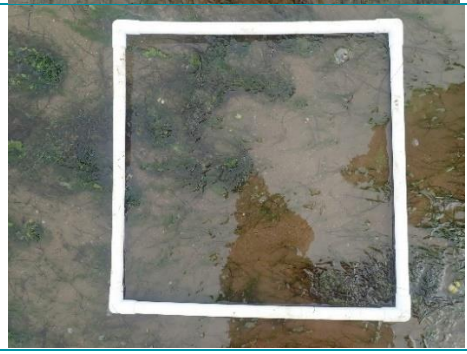
Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC2	Seagrass	Muddy sand	1Q	51.677576	-5.046706	
Control	AC2	Seagrass	Muddy sand	2Q	51.677547	-5.04671	
Control	AC2	Seagrass	Muddy sand	3Q	51.677517	-5.046699	

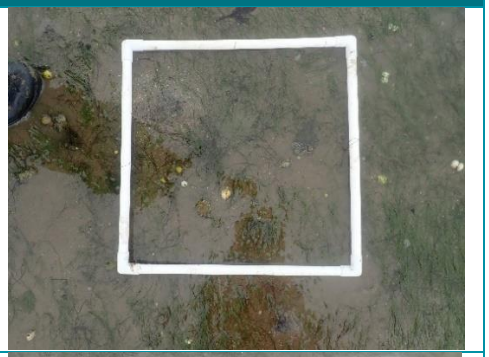
Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC3	Seagrass	Muddy sand	1Q	51.677549	-5.046509	
Control	AC3	Seagrass	Muddy sand	2Q	51.677517	-5.046505	
Control	AC3	Seagrass	Muddy sand	3Q	51.677496	-5.046477	

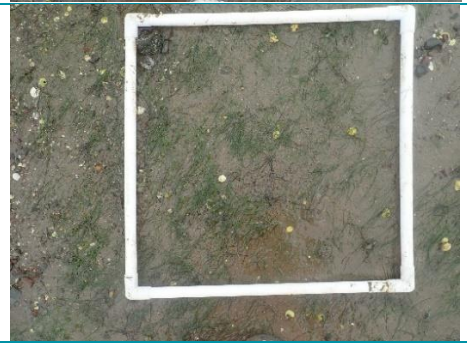
Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC4	Seagrass	Muddy sand	1Q	51.67776	-5.047216	
Control	AC4	Seagrass	Muddy sand	2Q	51.677748	-5.047191	
Control	AC4	Seagrass	Muddy sand	3Q	51.677736	-5.047165	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC5	Seagrass	Muddy sand	1Q	51.67813	-5.048284	
Control	AC5	Seagrass	Muddy sand	2Q	51.678122	-5.048276	
Control	AC5	Seagrass	Muddy sand	3Q	51.678069	-5.048263	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Control	AC6	Seagrass	Muddy sand	1Q	51.678132	-5.048604	
Control	AC6	Seagrass	Muddy sand	2Q	51.678122	-5.048602	
Control	AC6	Seagrass	Muddy sand	3Q	51.678127	-5.048549	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI1	Seagrass	Muddy sand	1Q	51.678862	-5.045438	
Impact	AI1	Seagrass	Muddy sand	2Q	51.678869	-5.045435	
Impact	AI1	Seagrass	Muddy sand	3Q	51.678836	-5.045475	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI2	Seagrass	Muddy sand	1Q	51.679011	-5.045492	
Impact	AI2	Seagrass	Muddy sand	2Q	51.679	-5.0455	
Impact	AI2	Seagrass	Gravelly muddy sand	3Q	51.678973	-5.045505	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI3	Seagrass	Muddy sand	1Q	51.679177	-5.045633	
Impact	AI3	Seagrass	Muddy sand	2Q	51.679137	-5.045615	
Impact	AI3	Seagrass	Muddy sand	3Q	51.679148	-5.045632	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI4	Seagrass	Muddy sand	1Q	51.679341	-5.045777	
Impact	AI4	Seagrass	Muddy sand	2Q	51.679323	-5.045752	
Impact	AI4	Seagrass	Muddy sand	3Q	51.679303	-5.045789	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI5	Seagrass	Muddy sand	1Q	51.678607	-5.046503	
Impact	AI5	Seagrass	Muddy sand	2Q	51.678828	-5.046665	
Impact	AI5	Seagrass	Muddy sand	3Q	51.678809	-5.046698	

Area	Block No.	Target habitat	Sediment type	Quadrat No.	Latitude	Longitude	Quadrat Photo
Impact	AI6	Seagrass	Muddy sand	1Q	51.67894	-5.047144	
Impact	AI6	Seagrass	Muddy sand	2Q	51.678929	-5.047138	
Impact	AI6	Seagrass	Muddy sand	3Q	51.678903	-5.047139	

Appendix C: Faunal Data

Table C1. Transect sampling abundance and percentage cover data from boulder top surfaces.

Species	PI1.1	PI1.2	PI1.3	PI1.4	PI1.5	PI2.1	PI2.2	PI2.3	PI2.4	PI2.5	PI3.1	PI3.2	PI3.3	PI3.4	PI3.5	PI4.1	PI4.2	PI4.3	PI4.4	PI4.5
Porifera %	<1			2																
Live adult barnacles %	<1	40	<1		30	60	45	60		45	20	30		30			20	15	10	20
Dead barnacles %	<1	4	<1		10	10	40	5		45	60	40	70	10		30	30	60	20	40
Juv barnacles %		1			<1	1	1	5							10					
Red algal turf %	<1			2		<1														
Green algal turf %		50																10		
Red / brown crust %			2			2														
Fucoid sporelings %	1		85	1	50	2	2	1	1		1									
Fucus vesiculosus %						10	3	5	10											
Fucus serratus %										2	5	2	15	2	10	10	5	20	15	30
Corallinacea enc. %	15		3						<1							5				
Spirorbinae %	25		2	3				<1	25											
Spirobranchus % (fanworm)	20		2					<1	5											
Austrominius modest. %	<1	10	<1		15	30	10	10				10				20				
Balanus balanus %							10					5	10							
Balanus crenatus %													10				5			
Semibalanus balanoides %		30			15	30	25	50			80	15	50	50	30	10	60	80	20	35
Chthamalus %																				
Porcellana platychel.																				
Polydora sp. tubes %																				
Littorina littorea			1		3	2	1				1								2	
Littorina obt./mar.			1			1			1											

Species	PI1.1	PI1.2	PI1.3	PI1.4	PI1.5	PI2.1	PI2.2	PI2.3	PI2.4	PI2.5	PI3.1	PI3.2	PI3.3	PI3.4	PI3.5	PI4.1	PI4.2	PI4.3	PI4.4	PI4.5
Littorina saxatilis																				
Nucella lapillus	1		1	1													1			3
Nucella lapillus eggs (%)				1																
Patella vulgata					2	1	3			4				3		1	1	1	1	2
Gibbula sp			4	5		1											1			
Anomiidae (saddle oyst.																				
Amphipholis squamata					4															
Ophiothrix fragilis					1															
Sabellaria									20											
Hymeniacidon perle.																				
Ophlitaspongia papilla					1															
Orange sponge	<1				<1															
Mastocarpus stellatus	<1					<1														

Species	PC1.1	PC1.2	PC1.3	PC1.4	PC1.5	PC2.1	PC2.2	PC2.3	PC2.4	PC2.5	PC3.1	PC3.2	PC3.3	PC3.4	PC3.5	PC4.1	PC4.2	PC4.3	PC4.4	PC4.5
Porifera %																				
Live adult barnacles %	60	20	<1	30	50	35	80	60	60	80	60	70		40	70				5	10
Dead barnacles %	20	<1	<1	35	15	35	10	30	5	10	10					20	2	5		
Juv barnacles %	10	60	2	30	10	2	<1	2	2	<1	5	10	2	3	2	30	40	30		10
Red algal turf %				<1		<1														
Green algal turf %																				
Red / brown crust %																				
Fucoid sporelings %																				
Fucus vesiculosus %																				
Fucus serratus %																				
Corallinacea enc. %			20	20																
Spirorbinae %																				
Spirobranchus % (fanworm)			10												<1		5			

Species	PC1.1	PC1.2	PC1.3	PC1.4	PC1.5	PC2.1	PC2.2	PC2.3	PC2.4	PC2.5	PC3.1	PC3.2	PC3.3	PC3.4	PC3.5	PC4.1	PC4.2	PC4.3	PC4.4	PC4.5
Austrominius modest. %	10	60	<1	45	45	25	50	40	33	40	20	50	<1	20	10	20	30	25	<1	5
Balanus balanus %																				
Balanus crenatus %																				
Semibalanus balanoides %	30	20	<1	15	13	5	30	15	20	40	60	30	<1	15	60	10	20	5	5	15
Chthamalus %	20		<1		2	5		5	7											
Porcellana platychel.																				
Polydora sp. tubes %				5	7	10		10					<1							
Littorina littorea	5	6	1	8	14	34	19	6	10	11	3	7	4	7	4	15		7	8	
Littorina obt./mar.																				
Littorina saxatilis	8					4	3		2		7	1			1					
Nucella lapillus			1	1	16							1		2				1		
Nucella lapillus eggs (%)																				
Patella vulgata			1		2	1	1	1	2				1					2		
Gibbula sp																				
Anomiidae (saddle oyst.																				1
Amphipholis squamata																				
Ophiothrix fragilis																				
Sabellaria																				
Hymeniacidon perle.													5							
Ophlitaspongia papilla																				
Orange sponge																				
Mastocarpus stellatus				<1															5	20

Species	OI1.1	OI1.2	OI1.3	OI1.4	OI1.5	OI2.1	OI2.2	OI2.3	OI2.4	OI2.5	OI3.1	OI3.2	OI3.3	OI3.4	OI3.5	OI4.1	OI4.2	OI4.3	OI4.4	OI4.5
Porifera %																				
Live adult barnacles %	20	80	10	40	50	25	60	60	80	73	70	80	10	10	50	50	10	45	<1	<1
Dead barnacles %	50	10	<1	10	20	25	5	10	10	7	10	15	5	15	10	10	2	20		
Juv barnacles %	<1	5		3	<1	<1						<1		<1	<1	2				<1

Species	OI1.1	OI1.2	OI1.3	OI1.4	OI1.5	OI2.1	OI2.2	OI2.3	OI2.4	OI2.5	OI3.1	OI3.2	OI3.3	OI3.4	OI3.5	OI4.1	OI4.2	OI4.3	OI4.4	OI4.5
Red algal turf %																				
Green algal turf %																				2
Red / brown crust %																				
Fucoid sporelings %		<1						<1	<1									<1		
Fucus vesiculosus %																				
Fucus serratus %											15	20	2	20	5	15	5		5	2
Corallinacea enc. %																				
Spirorbinae %																			<1	
Spirobranchus % (fanworm)																				
Austrominius modest. %	10	40	3			15	24	20	20	13		1	10	<1	40	10	10	2	<1	<1
Balanus balanus %																				
Balanus crenatus %																				
Semibalanus balanoides %	10	35	7			10	45	40	60	60	70	80	<1	10	20	40	<1	60		
Chthamalus %		5					1													
Porcellana platychel.																				
Polydora sp. tubes %																				
Littorina littorea	1	3			2			1		1	1			1		1	1			
Littorina obt./mar.																				
Littorina saxatilis	2	3		1		7		2	4	6	1									
Nucella lapillus																				
Nucella lapillus eggs (%)																				
Patella vulgata		2		1	1	2									1			2		
Gibbula sp						1						1				3				
Anomiidae (saddle oyst.																				
Amphipholis squamata																				
Ophiothrix fragilis																				
Sabellaria																				

Species	OI1.1	OI1.2	OI1.3	OI1.4	OI1.5	OI2.1	OI2.2	OI2.3	OI2.4	OI2.5	OI3.1	OI3.2	OI3.3	OI3.4	OI3.5	OI4.1	OI4.2	OI4.3	OI4.4	OI4.5
Hymeniacidon perle.																				
Ophlitaspongia papilla																				
Orange sponge																				
Mastocarpus stellatus												<1								

Species	OC1.1	OC1.2	OC1.3	OC1.4	OC1.5	OC2.1	OC2.2	OC2.3	OC2.4	OC2.5	OC3.1	OC3.2	OC3.3	OC3.4	OC3.5	OC4.1	OC4.2	OC4.3	OC4.4	OC4.5
Porifera %																				
Live adult barnacles %		1	2	2	5	35	15	30	60	70	2	10	15	20	10	15	50	15	20	35
Dead barnacles %		<1	<1	<1	<1	15	5	10	15	20	<1		<1			10	3	5	2	5
Juv barnacles %	<1	2	<1	<1	<1	<1		<1		<1	<1	<1		<1	<1					<1
Red algal turf %					<1									2						
Green algal turf %											20									
Red / brown crust %																				
Fucoid sporelings %	1		1				<1							<1		1				
Fucus vesiculosus %		3	2	2			5			1										
Fucus serratus %											<1	<1	<1		<1					
Corallinacea enc. %					20	<1	70	15												
Spirorbinae %																				
Spirobranchus % (fanworm)																				
Austrominius modest. %		1		<1	1	15	5	22	35	40	2	5	10	5	2	12	30	20	15	20
Balanus balanus %																				
Balanus crenatus %																				
Semibalanus balanoides %		1	2	2	4	20	10	8	25	30		5	5	15	8	5	10	<1	2	10
Chthamalus %																				
Porcellana platychel.														2						
Polydora sp. tubes %									5											
Littorina littorea			1			1	2		2		1									
Littorina obt./mar.		1																		

Species	OC1.1	OC1.2	OC1.3	OC1.4	OC1.5	OC2.1	OC2.2	OC2.3	OC2.4	OC2.5	OC3.1	OC3.2	OC3.3	OC3.4	OC3.5	OC4.1	OC4.2	OC4.3	OC4.4	OC4.5
Littorina saxatilis						2				1							6			3
Nucella lapillus				1		1					1					1	1	1		
Nucella lapillus eggs (%)																				
Patella vulgata	3	2	1	1	4	2	1		4		1			1						
Gibbula sp					5	4	7		4	2			1				2			
Anomiidae (saddle oyst.																				
Amphipholis squamata																				
Ophiothrix fragilis																				
Sabellaria																				
Hymeniacidon perle.																				
Ophlitaspongia papilla																				
Orange sponge																				
Mastocarpus stellatus					<1															

Table C2. Transect sampling abundance and percentage cover data from boulder bottom surfaces.

Species	PI1.1	PI1.2	PI1.3	PI1.4	PI1.5	PI2.1	PI2.2	PI2.3	PI2.4	PI2.5	PI3.1	PI3.2	PI3.3	PI3.4	PI3.5	PI4.1	PI4.2	PI4.3	PI4.4	PI4.5
Porifera %		2																		
Live adult barnacles %		1	<1	45	<1	55		2	<1	45										
Dead barnacles %	<1	3	2	35	1	5	10	50	5	40	5	<1	2	10	10		20	30	5	
Juv barnacles %			<1	<1		<1				1										
Red algal turf %							<1													
Red / brown crust %						4														
Fucus vesiculosus %	10	1		1		2			3											
Ascidians solitary %	<1																			
Enc. calc. bryozoa %		15	1		1	2	10									5				
Corallinacea enc. %	5	1	5	1	0															
Spirorbinae %	3	30	2		10	<1	15	45	15	10	2	5	40	20	25	2	30		40	20
Spirobranchus % (fanworm)						1														
Austrominius modes. %		1	1	5	<1	20		1		20										
Balanus crenatus %				10												5				
Semibalanus balanoi %			1	30		35		1	<1	20						2				
Verruca stroemia %																				
Nucella lapillus			8		1					1							1			
Nucella lapillus eggs (%)		5	3		<1						5	15	5					2		
Spiny nucella (juvenile)																				
Anomiidae		4			1		3													
Patella vulgata			2	2					3											
Gibbula sp		5	7				5		1		1			1			4	2		1
Littorina littorea		4	1		1		3			2										
Littorina saxatilis		1	1																	
Buccinum					1															
Phorcus lineatus																				

Species	PI1.1	PI1.2	PI1.3	PI1.4	PI1.5	PI2.1	PI2.2	PI2.3	PI2.4	PI2.5	PI3.1	PI3.2	PI3.3	PI3.4	PI3.5	PI4.1	PI4.2	PI4.3	PI4.4	PI4.5
Porcellana platychel.	1	2																		
Carcinus																				
Carcinus (juvenile)		1	1																	
Xantho																				
Mytilus edulis (juvenile)			1																	
Sea lemon		1																		
Nudibranch	P																			
Actinia						1											2	1		
Asterias rubens			1		1		1													
Amphipholis squam.																				
Sabellaria																				
Sandy tubes																				
Sand worm																				
Annelida eggs																				
Annelida sp 1																				
Annelida sp 2																				
Annelida sp 3																				
Polydora sp																				
Eulalia sp																				
Eulalia eggs																				
Hymeniacidon perle.																				
Halisarca dujardin. (snot		1																		
Grantia compressa		1																		
Ophlita. papilla (orange																				
Dynam. pumila (%)	1	1	<1				5													
Sea urchin					1															
Amphipoda					10		2	1				1		1	2					

Species	PI1.1	PI1.2	PI1.3	PI1.4	PI1.5	PI2.1	PI2.2	PI2.3	PI2.4	PI2.5	PI3.1	PI3.2	PI3.3	PI3.4	PI3.5	PI4.1	PI4.2	PI4.3	PI4.4	PI4.5
Mastocarpus stellatus																				
Lipophrys pholis																				
Goby																				
Chiton																				
Red algal (small and filamentous)																				
Isopoda																				

Species	PC1.1	PC1.2	PC1.3	PC1.4	PC1.5	PC2.1	PC2.2	PC2.3	PC2.4	PC2.5	PC3.1	PC3.2	PC3.3	PC3.4	PC3.5	PC4.1	PC4.2	PC4.3	PC4.4	PC4.5
Porifera %																				
Live adult barnacles %						<1	5	7	2	4				<1			10			
Dead barnacles %		30	1	<1	<1	<1	10	3	5	10	30	20	30	<1			30	20	5	15
Juv barnacles %			<1		<1		<1	<1	<1	2							20			
Red algal turf %				1		1														
Red / brown crust %																				
Fucus vesiculosus %																				
Ascidians solitary %																				
Enc. calc. bryozoa %				10		20	30	0	40	5	5	2		<1	<1			1	1	
Corallinacea enc. %			40	1		<1														
Spirorbinae %																	10			<1
Spirobranchus % (fanworm)				7		1	5	1	10	1	20	30	2	<1	1	<1		20	10	1
Austrominius modes. %			<1	<1		<1	4	4	1	5				<1			20			
Balanus crenatus %						<1	<1	3	1	1										
Semibalanus balanoi %												20	30				40			
Verruca stroemia %							<1													
Nucella lapillus						2	1	1	2	3				4						1
Nucella lapillus eggs (%)	<1	<1	20	5	50	<1			<1			5	45	40	20		10		5	2
Spiny nucella (juvenile)						2	1		4	1					2			2	1	

Species	PC1.1	PC1.2	PC1.3	PC1.4	PC1.5	PC2.1	PC2.2	PC2.3	PC2.4	PC2.5	PC3.1	PC3.2	PC3.3	PC3.4	PC3.5	PC4.1	PC4.2	PC4.3	PC4.4	PC4.5
Anomiidae		1	14		38		4	2	30	43			6					3	1	1
Patella vulgata					4	2	1						1	1	3		1			
Gibbula sp	1	3	12	1	23	6	9	3	3	4	1	2	3	14	25		9	3		1
Littorina littorea	1		1		3	2	4	1	2	4										3
Littorina saxatilis													1	2	4	1		1		
Buccinum																				
Phorcus lineatus			3		4					2										
Porcellana platychel.									1											
Carcinus																				
Carcinus (juvenile)			3		3															
Xantho				1																
Mytilus edulis (juvenile)																				
Sea lemon																				
Nudibranch																				
Actinia																				
Asterias rubens																				
Amphipholis squam.																				
Sabellaria																				
Sandy tubes																				
Sand worm																				
Annelida eggs	1				1															
Annelida sp 1		1							1									1		
Annelida sp 2																				
Annelida sp 3																				
Polydora sp			30			5														
Eulalia sp		1																		
Eulalia eggs			1																	

Species	PC1.1	PC1.2	PC1.3	PC1.4	PC1.5	PC2.1	PC2.2	PC2.3	PC2.4	PC2.5	PC3.1	PC3.2	PC3.3	PC3.4	PC3.5	PC4.1	PC4.2	PC4.3	PC4.4	PC4.5
Hymeniacidon perle.																				
Halisarca dujardin. (snot					<1							2								
Grantia compressa																				
Ophlita. papilla (orange																				
Dynam. pumila (%)			<1		<1															
Sea urchin																				
Amphipoda			1	30			4		1	19		1		1			20		10	2
Mastocarpus stellatus				1		1														
Lipophrys pholis																				
Goby					2															
Chiton							1	1				1								
Red algal (small and filamentous)														<1						
Isopoda																				

Species	OI1.1	OI1.2	OI1.3	OI1.4	OI1.5	OI2.1	OI2.2	OI2.3	OI2.4	OI2.5	OI3.1	OI3.2	OI3.3	OI3.4	OI3.5	OI4.1	OI4.2	OI4.3	OI4.4	OI4.5
Porifera %																				
Live adult barnacles %	10	15	5	70	5	1	1	2	6	4	25	1	5	3	20	<1	<1	5		3
Dead barnacles %	2	1	<1	15	50	4	5	3	2	2	2			2		5		<1	2	<1
Juv barnacles %	<1		<1	<1														<1		
Red algal turf %	5	<1																		
Red / brown crust %						3				<1										
Fucus vesiculosus %																				
Ascidians solitary %																				
Enc. calc. bryozoa %	5	3	2		5	10						1				<1		10		5
Corallinacea enc. %	30			2		2														
Spirorbinae %						3	15											2	<1	
Spirobranchus % (fanworm)	5		<1		<1	2	<1		<1	<1		15	<1							15

Species	OI1.1	OI1.2	OI1.3	OI1.4	OI1.5	OI2.1	OI2.2	OI2.3	OI2.4	OI2.5	OI3.1	OI3.2	OI3.3	OI3.4	OI3.5	OI4.1	OI4.2	OI4.3	OI4.4	OI4.5
Austrominius modes. %	8	7	5	60	5	1	1	2	2	2	20	<1	5	3	15		<1	5	1	2
Balanus crenatus %																				
Semibalanus balanoi %	2	8		10				1	4	2	5	<1				<1		<1	<1	<1
Verruca stroemia %																				
Nucella lapillus		1		5		2			2	4										
Nucella lapillus eggs (%)						1														
Spiny nucella (juvenile)											1									
Anomiidae			1			2	1							1			2		1	
Patella vulgata	2	1	1	1		12	4		3	6	1	2						5		
Gibbula sp	5	3	7	5	7	7		5	2	9	3			2	1		3	3	1	
Littorina littorea		2	1				3	1	1	4										
Littorina saxatilis						3	1	4	1						1			2		
Buccinum																				
Phorcus lineatus	1					1		1												
Porcellana platychel.						1														
Carcinus						1														
Carcinus (juvenile)		1				1														
Xantho																				
Mytilus edulis (juvenile)																				
Sea lemon																				
Nudibranch																				
Actinia	4	1	2	3	1	8	2	2	3	3	1	1	1				5	7	2	7
Asterias rubens																				
Amphipholis squam.																				
Sabellaria		2			1															
Sandy tubes			2		2							1			1			4		
Sand worm																				

Species	OI1.1	OI1.2	OI1.3	OI1.4	OI1.5	OI2.1	OI2.2	OI2.3	OI2.4	OI2.5	OI3.1	OI3.2	OI3.3	OI3.4	OI3.5	OI4.1	OI4.2	OI4.3	OI4.4	OI4.5
Annelida eggs																				
Annelida sp 1																				
Annelida sp 2																				
Annelida sp 3																				
Polydora sp																				
Eulalia sp																				
Eulalia eggs																				
Hymeniacidon perle.																				
Halisarca dujardin. (snot	1				<1															
Grantia compressa																				
Ophlita. papilla (orange	1																			
Dynam. pumila (%)				<1		<1														
Sea urchin																				
Amphipoda			27			23	15	47	13	9	3			2						
Mastocarpus stellatus	5	<1																		
Lipophrys pholis																				
Goby																				
Chiton						2						1		4					1	1
Red algal (small and filamentous)																				
Isopoda																				

Species	OC1.1	OC1.2	OC1.3	OC1.4	OC1.5	OC2.1	OC2.2	OC2.3	OC2.4	OC2.5	OC3.1	OC3.2	OC3.3	OC3.4	OC3.5	OC4.1	OC4.2	OC4.3	OC4.4	OC4.5
Porifera %														5			5			
Live adult barnacles %	<1		<1	<1	<1	<1	4	10	1	10	<1	<1		<1	<1	<1		<1	<1	3
Dead barnacles %	<1	<1	<1	<1	<1	60	1	<1	<1	40	<1	<1	<1						1	<1
Juv barnacles %	<1	<1			<1			<1	<1	<1		<1								
Red algal turf %																				
Red / brown crust %																				

Species	OC1.1	OC1.2	OC1.3	OC1.4	OC1.5	OC2.1	OC2.2	OC2.3	OC2.4	OC2.5	OC3.1	OC3.2	OC3.3	OC3.4	OC3.5	OC4.1	OC4.2	OC4.3	OC4.4	OC4.5
Fucus vesiculosus %																				
Ascidians solitary %																				
Enc. calc. bryozoa %	1		<1		20		10		1	2		5	20		2	<1	15		<1	
Corallinacea enc. %					4				1	<1										
Spirorbinae %		5	15	2		<1	10		4		<1		35	2			10		<1	2
Spirobranchus % (fanworm)				<1	<1															
Austrominius modes. %			<1		<1	<1		6	<1	8	2	<1	<1	<1	<1	<1		<1	<1	2
Balanus crenatus %																				
Semibalanus balanoi %	<1				<1	<1		4	<1	2									<1	<1
Verruca stroemia %																				
Nucella lapillus	1			1		2	1		1	1			1	2		1	2			2
Nucella lapillus eggs (%)										<1				3						
Spiny nucella (juvenile)													2				2		3	1
Anomiidae		1			1								1							
Patella vulgata	4	5	1	3	2	4	11	5	10	5	1	6	3	10	1	6	7	3	5	1
Gibbula sp	1	5	3	5	6	2	6	3	4	5	7	2	5	1		5	22	1	5	12
Littorina littorea		1		7			1	2			2	2							1	
Littorina saxatilis						5					1	1				1	4		1	8
Buccinum																				
Phorcus lineatus																				
Porcellana platychel.												1		7			2	2		
Carcinus		1																		
Carcinus (juvenile)										1									1	
Xantho																				
Mytilus edulis (juvenile)																				
Sea lemon																				
Nudibranch													1							

Species	OC1.1	OC1.2	OC1.3	OC1.4	OC1.5	OC2.1	OC2.2	OC2.3	OC2.4	OC2.5	OC3.1	OC3.2	OC3.3	OC3.4	OC3.5	OC4.1	OC4.2	OC4.3	OC4.4	OC4.5
Actinia									1	2				1						
Asterias rubens																				
Amphipholis squam.						1														
Sabellaria																				
Sandy tubes												1								
Sand worm					1															
Annelida eggs												<1				5				
Annelida sp 1																1				
Annelida sp 2			3																	
Annelida sp 3										1										
Polydora sp																				
Eulalia sp																				
Eulalia eggs																				
Hymeniacidon perle.										2										
Halisarca dujardin. (snot																				
Grantia compressa																				
Ophlita. papilla (orange																				
Dynam. pumila (%)			<1				<1		<1	<1										
Sea urchin												1	15							
Amphipoda	16	21			4											8	6	5	4	8
Mastocarpus stellatus																				
Lipophrys pholis				1					1											
Goby																				
Chiton																				
Red algal (small and filamentous)																				
Isopoda																	1			

Table C3. Macrofaunal core sample abundance data from bait digging survey at Penmon-Beaumaris and Four Mile Bridge.

Species	Qualifier	FI1.A	FI1.B	FI1.C	FI2.A	FI2.B	FI2.C	FI3.A	FI3.B	FI3.C	FI4.A	FI4.B	FI4.C	FI5.A	FI5.B	FI5.C	FI6.A	FI6.B	FI6.C	FC1.A	FC1.B	FC1.C
Animalia	eggs	P		P	P	P		P	P		P	P										
Porifera									P													
Dynamena pumila																						
Sertularia																						
Campanulariidae																						
Clytia hemisphaerica																						
Obelia bidentata																						
Obelia dichotoma																						
Platyhelminthes																	1					
Nemertea			1							1	1											
Nemertea	fragment	P										P										
Cerebratulus										1		2					1					
Nematoda		333	13	58	114	304	66	144	47	120	129	510	1249	32	11	24	36	76	129	19	15	5
Sipuncula	juvenile																					
Annelida	fragment									P		P										
Gattyana cirrhosa																						
Pholoe inornata																						
Eteone longa	aggregate																					
Phyllodoce groenlandica																						
Phyllodoce mucosa													1									
Eumida bahusiensis																						
Paranaitis kosteriensis																						
Paranaitis kosteriensis	fragment																					
Glycera tridactyla										1					1							
Goniada maculata	fragment																					
Podarkeopsis capensis																						
Microphthalmus																						
Parexogone hebes				1						1												
Myrianida																						

Species	Qualifier	FI1.A	FI1.B	FI1.C	FI2.A	FI2.B	FI2.C	FI3.A	FI3.B	FI3.C	FI4.A	FI4.B	FI4.C	FI5.A	FI5.B	FI5.C	FI6.A	FI6.B	FI6.C	FC1.A	FC1.B	FC1.C
Myrianida	epitoke																					
Nereididae	fragment																					
Hediste diversicolor																	4		2			
Alitta virens		1		4				1							1	2						
Alitta virens	fragment										P											
Eunereis longissima																						
Eunereis longissima	fragment																					
Nephtys	juvenile																					
Nephtys caeca	fragment																					
Nephtys cirrosa																						
Nephtys cirrosa	fragment																					
Nephtys hombergii																						
Nephtys hombergii	fragment																					
Scoloplos armiger					7	2	1		4	1	8	35	9	3	2						1	2
Scoloplos armiger	fragment																					
Aricidea (Aricidea) minuta																						
Poecilochaetus serpens																						
Poecilochaetus serpens	fragment																					
Spionidae	fragment	P					P															
Aonides oxycephala																						
Dipolydora caulleryi	fragment																					
Pseudopolydora pulchra																						
Pseudopolydora pulchra	fragment																					
Pygospio elegans				3						1							2					2
Pygospio elegans	fragment																				P	
Scolelepis (Scolelepis) squamata																						
Scolelepis (Scolelepis) squamata	fragment																					
Streblospio shrubsolii				2								1							2			
Magelona filiformis																						
Magelona johnstoni																						

Species	Qualifier	FI1.A	FI1.B	FI1.C	FI2.A	FI2.B	FI2.C	FI3.A	FI3.B	FI3.C	FI4.A	FI4.B	FI4.C	FI5.A	FI5.B	FI5.C	FI6.A	FI6.B	FI6.C	FC1.A	FC1.B	FC1.C
Cirratulidae	sp. indet.																					
Chaetozone gibber																						
Tharyx	A	1		136	18		9			18					2		1	4	32			
Capitellidae	fragment																					
Capitella		3		1	40	4	6			4	6	35	8	1		1				2	3	
Heteromastus filiformis																						
Mediomastus fragilis										1												
Notomastus														10					1		1	
Arenicola marina			1					1											1			
Euclymene oerstedii	aggregate																					
Euclymene oerstedii	aggregate/fragment																					
Scalibregma inflatum																						
Galathowenia oculata																						
Galathowenia oculata	fragment																					
Owenia																						
Owenia	fragment																					
Lagis koreni																						
Melinna palmata																						
Ampharete	sp. indet.						2															
Ampharete cf. acutifrons		1			2			2		10	4	14	28	19	5	10	10	4	4		1	
Lanice conchilega																						
Fabricia stellaris						3				2	3	4										
Manayunkia aestuarina		22		3	2	3	4	5	2	2	12	43	58	1		2		1	9		1	
Baltidrilus costatus					2					1	7	35										
Tubificoides benedii		15	38	51	154	58	56	2	13	21	92	647	255	31	2	3	5	17	65	3	1	
Tubificoides pseudogaster	aggregate		2	1								5										
Tubificoides pseudogaster	aggregate/fragment																					
Enchytraeidae			1					2				1							1			1
Achelia echinata	aggregate																					
Ammothella longipes																						

Species	Qualifier	FI1.A	FI1.B	FI1.C	FI2.A	FI2.B	FI2.C	FI3.A	FI3.B	FI3.C	FI4.A	FI4.B	FI4.C	FI5.A	FI5.B	FI5.C	FI6.A	FI6.B	FI6.C	FC1.A	FC1.B	FC1.C
Anoplodactylus petiolatus																						
Acari																						
Balanomorpha	juvenile																					
Copepoda		1											2									
Leucothoe incisa																						
Ampelisca brevicornis																						
Ampelisca brevicornis	fragment																					
Bathyporeia	fragment																					
Bathyporeia pilosa																					16	1
Bathyporeia sarsi																				1	1	1
Haustorius arenarius																						
Gammarus	fragment																					
Corophium arenarium																						
Corophium volutator		1	1	7	3		2	20	21	10	18	64	44	20	14	9	9	63	88			
Pariambus typicus																						
Pariambus typicus	fragment																					
Phtisica marina																						
Gnathiidae	praniza																					
Cyathura carinata																						
Decapoda	fragment																					
Decapoda	megalopa				1																	
Crangon crangon																						
Crangon crangon	fragment																					
Paguridae	juvenile																					
Polybius	juvenile																					
Carcinus maenas	juvenile																					
Lepidochitona cinerea																						
Obtusella intersecta																						
Peringia ulvae		146	8	3	27	50	3	4	1	30	13	52	91					1		1		
Tragula fenestrata																						
Retusa obtusa																						

Species	Qualifier	FI1.A	FI1.B	FI1.C	FI2.A	FI2.B	FI2.C	FI3.A	FI3.B	FI3.C	FI4.A	FI4.B	FI4.C	FI5.A	FI5.B	FI5.C	FI6.A	FI6.B	FI6.C	FC1.A	FC1.B	FC1.C
Alderia modesta											1											
Bivalvia	sp. indet.																					
Bivalvia	fragment		P																			
Nuculidae	juvenile																					
Mytilus edulis	juvenile																					
Modiolula phaseolina																						
Pectinidae	juvenile																					
Thyasira flexuosa																						
Kurtiella bidentata																						
Cerastoderma edule														1								
Cerastoderma edule	juvenile																					
Spisula	juvenile																					
Ensis	juvenile																					
Tellinoidea	juvenile										2											
Macomangulus tenuis																						
Abra alba						3							1						1			
Abra alba	fragment																					
Abra tenuis										1	5	9										
Scrobicularia plana		2			3	1																
Scrobicularia plana	juvenile		1		1							1										
Timoclea ovata																						
Venerupis corrugata															1							
Venerupis corrugata	juvenile																					
Mya	juvenile																					
Varicorbula gibba																						
Crisia																						
Walkeria uva					P																	
Conopeum reticulum																						
Electra pilosa																						
Celleporella hyalina																						
Cryptosula pallasiana																						

Species	Qualifier	FI1.A	FI1.B	FI1.C	FI2.A	FI2.B	FI2.C	FI3.A	FI3.B	FI3.C	FI4.A	FI4.B	FI4.C	FI5.A	FI5.B	FI5.C	FI6.A	FI6.B	FI6.C	FC1.A	FC1.B	FC1.C
Phoronis																						
Phoronis	fragment																					
Amphiuridae	fragment			P																		
Actinopterygii	egg			1		3																
Rhodophyta																						
Audouinella					P																	
Hildenbrandiaceae																						
Corallina			P																			
Chondracanthus acicularis																						
Gracilariaceae		P			P																	
Plocamium											P											
Callithamniaceae																						
Ceramium												P										
Ceramium echionotum																						
Ceramium gaditanum																						
Plumaria plumosa																						
Pterothamnion plumula																						
Spermothamnion																						
Dasysiphonia japonica																						
Hypoglossum hypoglossoides																						
Phycodrys rubens																						
Vertebrata byssoides																						
Leptosiphonia brodiei																						
Vertebrata fucoides																						
Vertebrata																						
Polysiphonia stricta																						
Pterosiphonieae																						
Phaeophyceae	encrusting																					
Ectocarpus	aggregate																					
Spongonema tomentosum																						

Species	Qualifier	FI1.A	FI1.B	FI1.C	FI2.A	FI2.B	FI2.C	FI3.A	FI3.B	FI3.C	FI4.A	FI4.B	FI4.C	FI5.A	FI5.B	FI5.C	FI6.A	FI6.B	FI6.C	FC1.A	FC1.B	FC1.C
Sphacelaria																						
Desmarestia aculeata																						
Fucus												P										
Ulva compressa		P	P	P	P	P	P		P		P	P		P								
Ulva intestinalis	aggregate										P	P		P								
Ulva fenestrata																						
Chaetomorpha					P				P			P			P							
Cladophora				P																		
Collembola												1					1					
Chironomidae	larva						1	1			2	1	4									
Dolichopodidae	larva							1														
Bacillariophyceae																						
Zostera noltei					P							P										
Lemna				P		P					P			P								
Rubus	seed		2																			

Species	Qualifier	FC2.A	FC2.B	FC2.C	FC3.A	FC3.B	FC3.C	FC4.A	FC4.B	FC4.C	FC5.A	FC5.B	FC5.C	FC6.A	FC6.B	FC6.C	PI1.A	PI1.B	PI1.C	PI2.A	PI2.B	PI2.C
Animalia	eggs																					P
Porifera																						
Dynamena pumila																						
Sertularia																						
Campanulariidae																						
Clytia hemisphaerica																						
Obelia bidentata																						
Obelia dichotoma																						
Platyhelminthes																						
Nemertea																						
Nemertea	fragment																					
Cerebratulus																						
Nematoda		21	4	3	2	3	4	19	8	5	1	10	1	15	23	17	13	95	21	42	114	62
Sipuncula	juvenile																					

Species	Qualifier	FC2 .A	FC2 .B	FC2 .C	FC3 .A	FC3 .B	FC3 .C	FC4 .A	FC4 .B	FC4 .C	FC5 .A	FC5 .B	FC5 .C	FC6 .A	FC6 .B	FC6 .C	PI1 .A	PI1 .B	PI1 .C	PI2 .A	PI2 .B	PI2 .C
Annelida	fragment																					
Gattyana cirrhosa																						
Pholoe inornata																						
Eteone longa	aggregate								1	1								1				
Phyllodoce groenlandica																						
Phyllodoce mucosa																						
Eumida bahusiensis																						
Paranaitis kosteriensis																						
Paranaitis kosteriensis	fragment																					
Glycera tridactyla																						1
Goniada maculata	fragment																					
Podarkeopsis capensis																		1				
Microphthalmus																						
Parexogone hebes											1			1								1
Myrianida																						
Myrianida	epitoke																					
Nereididae	fragment																					
Hediste diversicolor																						
Alitta virens																	7	6	6		5	1
Alitta virens	fragment																					
Eunereis longissima																					1	
Eunereis longissima	fragment																P					
Nephtys	juvenile																					
Nephtys caeca	fragment																					
Nephtys cirrosa																						
Nephtys cirrosa	fragment																					
Nephtys hombergii																						
Nephtys hombergii	fragment																					
Scoloplos armiger						2	1		2	4	1		2				3	2	1	2	2	
Scoloplos armiger	fragment				P																	

Species	Qualifier	FC2.A	FC2.B	FC2.C	FC3.A	FC3.B	FC3.C	FC4.A	FC4.B	FC4.C	FC5.A	FC5.B	FC5.C	FC6.A	FC6.B	FC6.C	PI1.A	PI1.B	PI1.C	PI2.A	PI2.B	PI2.C
Aricidea (Aricidea) minuta																						
Poecilochaetus serpens																						
Poecilochaetus serpens	fragment																					
Spionidae	fragment															P						
Aonides oxycephala																						
Dipolydora caulleryi	fragment																					
Pseudopolydora pulchra																						
Pseudopolydora pulchra	fragment																					
Pygospio elegans		2		5				5						1								
Pygospio elegans	fragment																					
Scolelepis (Scolelepis) squamata															1							
Scolelepis (Scolelepis) squamata	fragment	P																				
Streblospio shrubsolii				1										3								
Magelona filiformis																						
Magelona johnstoni																						
Cirratulidae	sp. indet.																	13	4			2
Chaetozone gibber																	7	6	3	5	2	2
Tharyx	A								1										1			
Capitellidae	fragment																					
Capitella									1			1	1	5	1	3				1		
Heteromastus filiformis															2	1						
Mediomastus fragilis																	5	6	6			10
Notomastus																						2
Arenicola marina									2						1							
Euclymene oerstedii	aggregate																					
Euclymene oerstedii	aggregate/fragment																					
Scalibregma inflatum																		1	1			
Galathowenia oculata																						
Galathowenia oculata	fragment																					

Species	Qualifier	FC2.A	FC2.B	FC2.C	FC3.A	FC3.B	FC3.C	FC4.A	FC4.B	FC4.C	FC5.A	FC5.B	FC5.C	FC6.A	FC6.B	FC6.C	PI1.A	PI1.B	PI1.C	PI2.A	PI2.B	PI2.C
Owenia																						
Owenia	fragment																					
Lagis koreni																	2	2		1	3	
Melinna palmata																	3	7	1		1	
Ampharete	sp. indet.																					
Ampharete cf. acutifrons																	3	6		1		
Lanice conchilega																						
Fabricia stellaris																						
Manayunkia aestuarina																						
Baltidrilus costatus																						
Tubificoides benedii									1	1	2				16	1	28	49	22	6	3	10
Tubificoides pseudogaster	aggregate											2		4	5	1						
Tubificoides pseudogaster	aggregate/fragment																					
Enchytraeidae																						
Achelia echinata	aggregate																					
Ammothella longipes																						
Anoplodactylus petiolatus																						
Acari				1																		
Balanomorpha	juvenile																					
Copepoda		1																				
Leucothoe incisa																						
Ampelisca brevicornis																						1
Ampelisca brevicornis	fragment																					
Bathyporeia	fragment					P																
Bathyporeia pilosa		2						6						1	1	1						
Bathyporeia sarsi		3		1	1				4	2												
Haustorius arenarius								1														
Gammarus	fragment															P						
Corophium arenarium								1	1	3		1		3	3	2						

Species	Qualifier	FC2 .A	FC2 .B	FC2 .C	FC3 .A	FC3 .B	FC3 .C	FC4 .A	FC4 .B	FC4 .C	FC5 .A	FC5 .B	FC5 .C	FC6 .A	FC6 .B	FC6 .C	PI1 .A	PI1 .B	PI1 .C	PI2 .A	PI2 .B	PI2 .C
Corophium volutator		1															2					
Pariambus typicus																						
Pariambus typicus	fragment																					
Phtisica marina																						
Gnathiidae	praniza															1						
Cyathura carinata																			1			
Decapoda	fragment																					P
Decapoda	megalopa																					
Crangon crangon																						
Crangon crangon	fragment																				P	
Paguridae	juvenile																					
Polybius	juvenile																					
Carcinus maenas	juvenile																	1	3		1	
Lepidochitona cinerea																						
Obtusella intersecta																						
Peringia ulvae																	4	11	24	1	7	1
Tragula fenestrata																						
Retusa obtusa																						
Alderia modesta																						
Bivalvia	sp. indet.																		1			
Bivalvia	fragment																					
Nuculidae	juvenile																					
Mytilus edulis	juvenile																			1	2	1
Modiolula phaseolina																						
Pectinidae	juvenile																					
Thyasira flexuosa																						
Kurtiella bidentata																	1		4	1	2	
Cerastoderma edule											1											
Cerastoderma edule	juvenile																5	25	5	8	17	2
Spisula	juvenile																					
Ensis	juvenile																					

Species	Qualifier	FC2 .A	FC2 .B	FC2 .C	FC3 .A	FC3 .B	FC3 .C	FC4 .A	FC4 .B	FC4 .C	FC5 .A	FC5 .B	FC5 .C	FC6 .A	FC6 .B	FC6 .C	PI1 .A	PI1 .B	PI1 .C	PI2 .A	PI2 .B	PI2 .C
Tellinoidea	juvenile																					
Macomangulus tenuis																						
Abra alba																		1	1			1
Abra alba	fragment																					
Abra tenuis																						
Scrobicularia plana																						
Scrobicularia plana	juvenile																					
Timoclea ovata																						
Venerupis corrugata																						
Venerupis corrugata	juvenile																					
Mya	juvenile																1	2	1	1	1	
Varicorbula gibba																						
Crisia																						
Walkeria uva																						
Conopeum reticulum																						
Electra pilosa																						
Celleporella hyalina																						
Cryptosula pallasiana																						
Phoronis																						
Phoronis	fragment																					
Amphiuridae	fragment																					
Actinopterygii	egg																					
Rhodophyta																						
Audouinella																						
Hildenbrandiaceae																						
Corallina																						
Chondracanthus acicularis																						
Gracilariaceae																	P		P		P	
Plocamium																					P	
Callithamniaceae																						
Ceramium																					P	

Species	Qualifier	FC2 .A	FC2 .B	FC2 .C	FC3 .A	FC3 .B	FC3 .C	FC4 .A	FC4 .B	FC4 .C	FC5 .A	FC5 .B	FC5 .C	FC6 .A	FC6 .B	FC6 .C	PI1 .A	PI1 .B	PI1 .C	PI2 .A	PI2 .B	PI2 .C
Ceramium echionotum														P					P			
Ceramium gaditanum																						
Plumaria plumosa																						
Pterothamnion plumula																						
Spermothamnion																						
Dasysiphonia japonica																						
Hypoglossum hypoglossoides																						
Phycodrys rubens																						
Vertebrata byssoides																						
Leptosiphonia brodiei																						
Vertebrata fucoides																						
Vertebrata																	P					
Polysiphonia stricta																						
Pterosiphonieae																						
Phaeophyceae	encrusting																					
Ectocarpus	aggregate																					
Spongonema tomentosum															P							
Sphacelaria				P													P					
Desmarestia aculeata																						
Fucus																						
Ulva compressa				P					P													
Ulva intestinalis	aggregate				P																	
Ulva fenestrata																						
Chaetomorpha																					P	
Cladophora				P																		
Collembola																						
Chironomidae	larva																					
Dolichopodidae	larva																					
Bacillariophyceae																						
Zostera noltei																						

Species	Qualifier	FC2.A	FC2.B	FC2.C	FC3.A	FC3.B	FC3.C	FC4.A	FC4.B	FC4.C	FC5.A	FC5.B	FC5.C	FC6.A	FC6.B	FC6.C	PI1.A	PI1.B	PI1.C	PI2.A	PI2.B	PI2.C
Lemna																						
Rubus	seed																					

Species	Qualifier	PI3.A	PI3.B	PI3.C	PI4.A	PI4.B	PI4.C	PI5.A	PI5.B	PI5.C	PI6.A	PI6.B	PI6.C	PI7.A	PI7.B	PI7.C	PI8.A	PI8.B	PI8.C	PC1.A	PC1.B	PC1.C
Animalia	eggs					1																
Porifera																						
Dynamena pumila																						
Sertularia					P																	
Campanulariidae																						
Clytia hemisphaerica											P											
Obelia bidentata																						
Obelia dichotoma																						
Platyhelminthes																						
Nemertea					1	1															1	
Nemertea	fragment														P					P		
Cerebratulus																					1	
Nematoda		157	298	154	118	143	72	228	99	18	216	335	117	79	377	67	45	135	117	37	32	10
Sipuncula	juvenile																					
Annelida	fragment				P			P	P	P			P	P	P	P	P	P	P			
Gattyana cirrhosa														1								
Pholoe inornata																						
Eteone longa	aggregate			1							1	1		2	1				1		1	
Phyllodoce groenlandica															1							
Phyllodoce mucosa																						
Eumida bahusiensis																						
Paranaitis kosteriensis																		1				1
Paranaitis kosteriensis	fragment						P										P					
Glycera tridactyla				1											1						1	
Goniada maculata	fragment																			P		
Podarkeopsis capensis																						
Microphthalmus																			1		1	

Species	Qualifier	PI3.A	PI3.B	PI3.C	PI4.A	PI4.B	PI4.C	PI5.A	PI5.B	PI5.C	PI6.A	PI6.B	PI6.C	PI7.A	PI7.B	PI7.C	PI8.A	PI8.B	PI8.C	PC1.A	PC1.B	PC1.C
Parexogone hebes				1		2			4		2	1	1		12			3				1
Myrianida																						
Myrianida	epitoke																					
Nereididae	fragment										P											
Hediste diversicolor																						
Alitta virens		1	1	1	2	1	3			2					1	2		2	1			
Alitta virens	fragment							P														
Eunereis longissima																						
Eunereis longissima	fragment																					
Nephtys	juvenile											1			1			2	1	1		
Nephtys caeca	fragment																					
Nephtys cirrosa																			1			
Nephtys cirrosa	fragment																					
Nephtys hombergii					1													1				
Nephtys hombergii	fragment																					
Scoloplos armiger		3	4	3	3	6	4	2	2		1	1	3		2	2	3	3	2		1	
Scoloplos armiger	fragment																					
Aricidea (Aricidea) minuta																						
Poecilochaetus serpens																				1	1	
Poecilochaetus serpens	fragment				P																	
Spionidae	fragment																			P		
Aonides oxycephala								1														
Dipolydora caulleryi	fragment																					
Pseudopolydora pulchra																						
Pseudopolydora pulchra	fragment																P					
Pygospio elegans																						
Pygospio elegans	fragment																					
Scolelepis (Scolelepis) squamata																						
Scolelepis (Scolelepis) squamata	fragment																					

Species	Qualifier	PI3.A	PI3.B	PI3.C	PI4.A	PI4.B	PI4.C	PI5.A	PI5.B	PI5.C	PI6.A	PI6.B	PI6.C	PI7.A	PI7.B	PI7.C	PI8.A	PI8.B	PI8.C	PC1.A	PC1.B	PC1.C
Streblospio shrubsolii																						
Magelona filiformis																						2
Magelona johnstoni																						1
Cirratulidae	sp. indet.				4	3					2	1			34			13				
Chaetozone gibber			4	1	2	1		11	1		9	1	6	1	8	3	10	7	2			
Tharyx	A			12			8	31	7				5									
Capitellidae	fragment						P			P										P		
Capitella																						
Heteromastus filiformis																						
Mediomastus fragilis		10		26	11	17	30	30	17	12	22	28	19	13	17	10	8	22	7		3	1
Notomastus		2	2	3	1	1		2	2		1	1	1	3	2	1	1	1	1		1	2
Arenicola marina															1							
Euclymene oerstedii	aggregate				1																1	4
Euclymene oerstedii	aggregate/fragment																			P		
Scalibregma inflatum					3	2	2	3	1	2		1	1	1	2	1	2	2	1		1	
Galathowenia oculata						1														1		1
Galathowenia oculata	fragment								P				P		P						P	
Owenia		1																				
Owenia	fragment																					
Lagis koreni			2		2	1	8		2		1	1	1	2	2		1	7	1	2	4	2
Melinna palmata		3	2	1	5	2	2	1	1		5	3	1	2	2	1		1				1
Ampharete	sp. indet.																					
Ampharete cf. acutifrons			3		1						4			3	1			5				
Lanice conchilega				1										1	4			2	1	5		2
Fabricia stellaris																						
Manayunkia aestuarina																						
Baltidrilus costatus																						
Tubificoides benedii		2	7	10	10	10	13	8	4	1	11	7	5	1	9	1	4	18	9		1	
Tubificoides pseudogaster	aggregate			4		9	10	5	10	1			4		5		3	7	11		1	
Tubificoides pseudogaster	aggregate/fragment																					

Species	Qualifier	PI3.A	PI3.B	PI3.C	PI4.A	PI4.B	PI4.C	PI5.A	PI5.B	PI5.C	PI6.A	PI6.B	PI6.C	PI7.A	PI7.B	PI7.C	PI8.A	PI8.B	PI8.C	PC1.A	PC1.B	PC1.C
Enchytraeidae																						
Achelia echinata	aggregate																					
Ammothella longipes																						
Anoplodactylus petiolatus																						
Acari																						
Balanomorpha	juvenile																			1		
Copepoda																						
Leucothoe incisa															1							
Ampelisca brevicornis											1											
Ampelisca brevicornis	fragment																		P			
Bathyporeia	fragment																					
Bathyporeia pilosa																						
Bathyporeia sarsi																						
Haustorius arenarius																						
Gammarus	fragment																					
Corophium arenarium						1																
Corophium volutator					1																	
Pariambus typicus																			1			
Pariambus typicus	fragment																	P				
Phtisica marina		1																				
Gnathiidae	praniza																					
Cyathura carinata				2					1													
Decapoda	fragment																					
Decapoda	megalopa																					
Crangon crangon				2																	1	3
Crangon crangon	fragment	P	P			P		P		P				P				P		P		
Paguridae	juvenile													2								
Polybius	juvenile													1	1							
Carcinus maenas	juvenile											1								1		
Lepidochitona cinerea																						
Obtusella intersecta																						

Species	Qualifier	PI3.A	PI3.B	PI3.C	PI4.A	PI4.B	PI4.C	PI5.A	PI5.B	PI5.C	PI6.A	PI6.B	PI6.C	PI7.A	PI7.B	PI7.C	PI8.A	PI8.B	PI8.C	PC1.A	PC1.B	PC1.C
Peringia ulvae		2	4	4	9	2	1	2	1		1	2	1	3	2	4				2		
Tragula fenestrata																	1					
Retusa obtusa														1								
Alderia modesta																						
Bivalvia	sp. indet.									1		1	1	1								
Bivalvia	fragment																					
Nuculidae	juvenile																					
Mytilus edulis	juvenile		1	2		1		2	1				1			1		1	1		1	
Modiolula phaseolina																						
Pectinidae	juvenile																					
Thyasira flexuosa			1			1																
Kurtiella bidentata			1	2	1		2	1		1						1						
Cerastoderma edule																						
Cerastoderma edule	juvenile	9	7	8	7	1	4	3	3	3	1	3	2	4	2	1	6	2	1	6	7	18
Spisula	juvenile		1																			
Ensis	juvenile																					
Tellinoidea	juvenile																					
Macomangulus tenuis				1																		
Abra alba					1									1	3		2	2				
Abra alba	fragment															P			P			
Abra tenuis																						
Scrobicularia plana																						
Scrobicularia plana	juvenile																					
Timoclea ovata																						
Venerupis corrugata																						
Venerupis corrugata	juvenile																					
Mya	juvenile			1				1									2	1				
Varicorbula gibba						1					1											
Crisia																						
Walkeria uva																						
Conopeum reticulum														P								P

Species	Qualifier	PI3.A	PI3.B	PI3.C	PI4.A	PI4.B	PI4.C	PI5.A	PI5.B	PI5.C	PI6.A	PI6.B	PI6.C	PI7.A	PI7.B	PI7.C	PI8.A	PI8.B	PI8.C	PC1.A	PC1.B	PC1.C
Electra pilosa																						
Celleporella hyalina														P								
Cryptosula pallasiana															P							
Phoronis																						
Phoronis	fragment																					
Amphiuridae	fragment																					
Actinopterygii	egg				1					1												
Rhodophyta								P														
Audouinella																						
Hildenbrandiaceae								P														
Corallina																						
Chondracanthus acicularis											P											
Gracilariaceae		P			P		P						P	P	P		P			P	P	P
Plocamium							P	P					P	P			P					P
Callithamniaceae																				P		
Ceramium		P										P			P					P		
Ceramium echionotum																						
Ceramium gaditanum																				P		
Plumaria plumosa																						P
Pterothamnion plumula																						
Spermothamnion																						
Dasysiphonia japonica						P																
Hypoglossum hypoglossoides		P																				
Phycodrys rubens																						
Vertebrata byssoides														P	P							
Leptosiphonia brodiei														P	P							
Vertebrata fucoides																						
Vertebrata																						
Polysiphonia stricta																				P		
Pterosiphonieae								P										P				

Species	Qualifier	PI3.A	PI3.B	PI3.C	PI4.A	PI4.B	PI4.C	PI5.A	PI5.B	PI5.C	PI6.A	PI6.B	PI6.C	PI7.A	PI7.B	PI7.C	PI8.A	PI8.B	PI8.C	PC1.A	PC1.B	PC1.C
Phaeophyceae	encrusting						P							P	P						P	P
Ectocarpus	aggregate																					
Spongonema tomentosum																						
Sphacelaria					P								P				P	P	P	P		P
Desmarestia aculeata																	P					
Fucus																						
Ulva compressa				P														P	P	9		
Ulva intestinalis	aggregate				P		P															
Ulva fenestrata																				P		
Chaetomorpha							P							P	P				P		P	
Cladophora						P							P	P	P		P		P			
Collembola						1			1													
Chironomidae	larva																					
Dolichopodidae	larva																					
Bacillariophyceae															P					P		
Zostera noltei																						
Lemna																						
Rubus	seed				1								1									

Species	Qualifier	PC2.A	PC2.B	PC2.C	PC3.A	PC3.B	PC3.C	PC4.A	PC4.B	PC4.C	PC5.A	PC5.B	PC5.C	PC6.A	PC6.B	PC6.C	PC7.A	PC7.B	PC7.C	PC8.A	PC8.B	PC8.C
Animalia	eggs			P																		
Porifera																						
Dynamena pumila						P		P														
Sertularia														P								
Campanulariidae																						P
Clytia hemisphaerica																						
Obelia bidentata						P																
Obelia dichotoma						P																P
Platyhelminthes																						
Nemertea					1			1					1									
Nemertea	fragment						P		P							P		P				

Species	Qualifier	PC2 .A	PC2 .B	PC2 .C	PC3 .A	PC3 .B	PC3 .C	PC4 .A	PC4 .B	PC4 .C	PC5 .A	PC5 .B	PC5 .C	PC6 .A	PC6 .B	PC6 .C	PC7 .A	PC7 .B	PC7 .C	PC8 .A	PC8 .B	PC8 .C
Cerebratulus					2			2						1								
Nematoda		5	4	16	41	14	37	33	20	29	17	7		13	27	74	28	32	32	45	55	23
Sipuncula	juvenile							1														
Annelida	fragment										P		P	P	P	P	P	P	P			
Gattyana cirrhosa																						
Pholoe inornata		1						1														
Eteone longa	aggregate			1			1						1									
Phyllodoce groenlandica																						
Phyllodoce mucosa																						
Eumida bahusiensis								1														
Paranaitis kosteriensis			1	2		1				1												1
Paranaitis kosteriensis	fragment																					
Glycera tridactyla																						
Goniada maculata	fragment																					
Podarkeopsis capensis																						
Microphthalmus																				2	1	
Parexogone hebes						1	1			1											1	
Myrianida								1														
Myrianida	epitoke							2														
Nereididae	fragment							P				P										
Hediste diversicolor																						
Alitta virens																						1
Alitta virens	fragment																					
Eunereis longissima												1			1							
Eunereis longissima	fragment																					
Nephtys	juvenile											1	3		1	1				2		
Nephtys caeca	fragment							P														
Nephtys cirrosa			1							1												1
Nephtys cirrosa	fragment				P	P																
Nephtys hombergii																						

Species	Qualifier	PC2 .A	PC2 .B	PC2 .C	PC3 .A	PC3 .B	PC3 .C	PC4 .A	PC4 .B	PC4 .C	PC5 .A	PC5 .B	PC5 .C	PC6 .A	PC6 .B	PC6 .C	PC7 .A	PC7 .B	PC7 .C	PC8 .A	PC8 .B	PC8 .C
Nephtys hombergii	fragment															P						
Scoloplos armiger			1	1	1		1	1						1	2	1						2
Scoloplos armiger	fragment																					
Aricidea (Aricidea) minuta																				1		
Poecilochaetus serpens		1			1																	
Poecilochaetus serpens	fragment					P																
Spionidae	fragment									P												
Aonides oxycephala							2															
Dipolydora caulleryi	fragment																P					
Pseudopolydora pulchra						1																
Pseudopolydora pulchra	fragment																					
Pygospio elegans															1	1						
Pygospio elegans	fragment																					
Scolelepis (Scolelepis) squamata																						
Scolelepis (Scolelepis) squamata	fragment																					
Streblospio shrubsolii																						
Magelona filiformis				1	2											1						
Magelona johnstoni																						
Cirratulidae	sp. indet.						4			1						1	1					
Chaetozone gibber				1	1	1		2												3	1	
Tharyx	A																					
Capitellidae	fragment																					
Capitella													6		1							
Heteromastus filiformis																						
Mediomastus fragilis		9		4	4		9	2						4	2	1		6		3	4	2
Notomastus			3		3	2	1	1	1	1				7	4	1		1		4	2	1
Arenicola marina												1	4									

Species	Qualifier	PC2.A	PC2.B	PC2.C	PC3.A	PC3.B	PC3.C	PC4.A	PC4.B	PC4.C	PC5.A	PC5.B	PC5.C	PC6.A	PC6.B	PC6.C	PC7.A	PC7.B	PC7.C	PC8.A	PC8.B	PC8.C
Euclymene oerstedii	aggregate	1	1		1	1	3	1	1	2											1	1
Euclymene oerstedii	aggregate/fragment			P																		
Scalibregma inflatum			1															1				1
Galathowenia oculata				1			2															
Galathowenia oculata	fragment													P	P	P		P		P	P	P
Owenia		1				1	1															
Owenia	fragment															P						
Lagis koreni			1	3	3	1	1						1				1	8	1	2	2	2
Melinna palmata		1		1	1									1							1	
Ampharete	sp. indet.												2								1	1
Ampharete cf. acutifrons															1	1						
Lanice conchilega		2		2	3	5	4		1	2	2	1	1					2	2	4	1	1
Fabricia stellaris																						
Manayunkia aestuarina																						
Baltidrilus costatus																						
Tubificoides benedii		1			4	3	1	2					3	4	2	12	1	1		4	1	3
Tubificoides pseudogaster	aggregate	1			6	1		1		2			1		2	7				1	2	1
Tubificoides pseudogaster	aggregate/fragment										P											
Enchytraeidae																						
Achelia echinata	aggregate									1												
Ammothella longipes								1														
Anoplodactylus petiolatus					1																	
Acari																						
Balanomorpha	juvenile																					
Copepoda																						
Leucothoe incisa																						
Ampelisca brevicornis					2		1															
Ampelisca brevicornis	fragment					P																
Bathyporeia	fragment																					

Species	Qualifier	PC2 .A	PC2 .B	PC2 .C	PC3 .A	PC3 .B	PC3 .C	PC4 .A	PC4 .B	PC4 .C	PC5 .A	PC5 .B	PC5 .C	PC6 .A	PC6 .B	PC6 .C	PC7 .A	PC7 .B	PC7 .C	PC8 .A	PC8 .B	PC8 .C
Bathyporeia pilosa																						
Bathyporeia sarsi																						
Haustorius arenarius																						
Gammarus	fragment																					
Corophium arenarium																						
Corophium volutator													1									
Pariambus typicus						1														1		
Pariambus typicus	fragment																					
Phtisica marina																						
Gnathiidae	praniza																					
Cyathura carinata																						
Decapoda	fragment																					
Decapoda	megalopa							1													1	
Crangon crangon					1			1										1				
Crangon crangon	fragment																		P			P
Paguridae	juvenile							1														
Polybius	juvenile																					
Carcinus maenas	juvenile				1			1														
Lepidochitona cinerea																		1				
Obtusella intersecta					1																	
Peringia ulvae							1				3	1								1		1
Tragula fenestrata																						
Retusa obtusa																				1		
Alderia modesta																						
Bivalvia	sp. indet.																				1	
Bivalvia	fragment											P										P
Nuculidae	juvenile						1															
Mytilus edulis	juvenile	2	1		1			1	1	2	2	2	3					4		2		1
Modiolula phaseolina											1	1										
Pectinidae	juvenile			1					1											3		
Thyasira flexuosa																						

Species	Qualifier	PC2.A	PC2.B	PC2.C	PC3.A	PC3.B	PC3.C	PC4.A	PC4.B	PC4.C	PC5.A	PC5.B	PC5.C	PC6.A	PC6.B	PC6.C	PC7.A	PC7.B	PC7.C	PC8.A	PC8.B	PC8.C
Kurtiella bidentata															1	1			1			
Cerastoderma edule																						
Cerastoderma edule	juvenile	3	9	7	14	10	10	6	10	4	13	20	14	12	7	1	4	19	4	16	8	10
Spisula	juvenile				1									1								
Ensis	juvenile					1																
Tellinoidea	juvenile																					
Macomangulus tenuis																						1
Abra alba												1							1			
Abra alba	fragment																					
Abra tenuis																						
Scrobicularia plana																						
Scrobicularia plana	juvenile																					
Timoclea ovata						1																
Venerupis corrugata																						
Venerupis corrugata	juvenile							1														
Mya	juvenile			1																	1	2
Varicorbula gibba																					1	1
Crisia					P																	
Walkeria uva																						
Conopeum reticulum		P		P	P	P	P						P			P		P				
Electra pilosa											P			P								
Celleporella hyalina																						
Cryptosula pallasiana																				P		
Phoronis															1							
Phoronis	fragment															P						
Amphiuridae	fragment																					
Actinopterygii	egg											1						1				
Rhodophyta														P				P				
Audouinella				P	P											P						
Hildenbrandiaceae														P					P			
Corallina																						

Species	Qualifier	PC2.A	PC2.B	PC2.C	PC3.A	PC3.B	PC3.C	PC4.A	PC4.B	PC4.C	PC5.A	PC5.B	PC5.C	PC6.A	PC6.B	PC6.C	PC7.A	PC7.B	PC7.C	PC8.A	PC8.B	PC8.C
Chondracanthus acicularis								P														
Gracilariaceae		P	P	P	P	P	P		P	P	P	P		P		P	P	P	P	P	P	P
Plocamium		P		P	P	P			P					P				P		P	P	P
Callithamniaceae																						
Ceramium		P			P	P		P						P						P		
Ceramium echionotum																						
Ceramium gaditanum																						
Plumaria plumosa														P			P					P
Pterothamnion plumula					P				P											P		
Spermothamnion								P														
Dasysiphonia japonica														P								
Hypoglossum hypoglossoides									P													
Phycodrys rubens																		P				
Vertebrata byssoides								P														
Leptosiphonia brodiei					P	P																
Vertebrata fucoides												P					P	P				
Vertebrata								P														
Polysiphonia stricta																						P
Pterosiphonieae														P	P	P		P				P
Phaeophyceae	encrusting	P	P		P	P	P		P	P				P		P	P	P	P	P	P	P
Ectocarpus	aggregate									P												
Spongonema tomentosum																						
Sphacelaria			P		P	P		P						P				P	P	P		P
Desmarestia aculeata																						
Fucus																						
Ulva compressa		P			P	P		P	P		P			P	P	P		P		P		P
Ulva intestinalis	aggregate			P		P				P	P	P		P	P					P		
Ulva fenestrata						P																
Chaetomorpha			P		P		P		P		P			P		P	P	P	P	P		P

Species	Qualifier	PC2 .A	PC2 .B	PC2 .C	PC3 .A	PC3 .B	PC3 .C	PC4 .A	PC4 .B	PC4 .C	PC5 .A	PC5 .B	PC5 .C	PC6 .A	PC6 .B	PC6 .C	PC7 .A	PC7 .B	PC7 .C	PC8 .A	PC8 .B	PC8 .C
Cladophora			P		P	P	P		P									P				P
Collembola															1			1				
Chironomidae	larva																					
Dolichopodidae	larva									1												
Bacillariophyceae					P	P		P									P			P		P
Zostera noltei																						
Lemna																						
Rubus	seed											1										

Table C4. Macrofaunal core sample abundance data for bait digging at Angle Bay.

Species	Qualifier	AC1.A	AC1.B	AC1.C	AC2.A	AC2.B	AC2.C	AC3.A	AC3.B	AC3.C	AC4.A	AC4.B	AC4.C	AC5.A	AC5.B	A
Animalia	eggs		P							P	P			P	P	
Nematoda		5		1	22	2		21	3	4	1	24			11	
Golfingia (Golfingia) elongata				1												
Phyllodoce mucosa										1		2				
Glycera tridactyla				1												
Glycera tridactyla	fragment															
Microphthalmus																
Nephtys	juvenile						1									
Nephtys hombergii						2		1	1	2		1		1	1	
Polydora cornuta				1												
Pygospio elegans					1			1								
Pygospio elegans	fragment								P							
Streblospio shrubsolii							3									
Capitella																
Heteromastus filiformis		1			3							1	1			
Heteromastus filiformis	fragment						P									
Arenicolidae	juvenile			1												
Arenicola marina	fragment															
Melinna palmata								2	1					1		
Ampharete cf. acutifrons														1		
Spirobranchus lamarcki							1									
Tubificoides benedii										1						
Tubificoides benedii	fragments															
Tubificoides pseudogaster	aggregate			1			2									
Austrominius modestus											1					
Gammarus	sp. indet.															
Idotea	juvenile													1		
Idotea chelipes									1							
Crangonidae	fragment															
Crangon crangon									1							

Carcinus maenas	juvenile							1								
Lepidochitona cinerea																
Littorina littorea																
Littorina saxatilis			1					2	5			1		2		
Peringia ulvae		118	64	146	186	87	85	144	137	120	103	118	76	97	48	1
Tragula fenestrata																
Retusa obtusa											1			1		
Bivalvia	fragment					P										
Cerastoderma edule		1	1	2	2	2	2	2	1	1		2			1	
Cerastoderma edule	juvenile			1	1		1	1	1	1	1			1		1
Cerastoderma edule	fragment												P			
Abra tenuis					1	1		1	1	1	3		2	2		
Scrobicularia plana							1	1								
Mya arenaria											1					
Callithamniaceae					P											
Ceramium										P		P				
Ulva intestinalis	aggregate															
Chaetomorpha										P						P
Cladophora																
Chironomidae	larva								1							
Dolichopodidae	larva	1														
Cyanophyceae				P		P	P	P	P	P	P	P				
Nanozostera noltei		P	P	P	P	P	P	P	P	P	P	P		P	P	P
Species	**Qualifier**	**AI1.A**	**AI1.B**	**AI1.C**	**AI2.A**	**AI2.B**	**AI2.C**	**AI3.A**	**AI3.B**	**AI3.C**	**AI4.A**	**AI4.B**	**AI4.C**	**AI5.A**	**AI5.B**	**A**
Animalia	eggs									P						
Nematoda					1	39				1	18		1	9	28	1
Golfingia (Golfingia) elongata																
Phyllodoce mucosa		1					1		1							
Glycera tridactyla					1											
Glycera tridactyla	fragment		P													
Microphthalmus					2						1					
Nephtys	juvenile															

Nephtys hombergii		1		1			1	1	2						1	1
Polydora cornuta																
Pygospio elegans		1	1			5	4					2		1		
Pygospio elegans	fragment															
Streblospio shrubsolii							7									
Capitella		2			14	2		4			4	2				1
Heteromastus filiformis						2	1							1		1
Heteromastus filiformis	fragment															
Arenicolidae	juvenile															
Arenicola marina	fragment					P										
Melinna palmata																
Ampharete cf. acutifrons																
Spirobranchus lamarcki																
Tubificoides benedii		4	4	4		2	31						7			1
Tubificoides benedii	fragments									P						
Tubificoides pseudogaster	aggregate	8	1	2	2	12	7									
Austrominius modestus										59						
Gammarus	sp. indet.			1												
Idotea	juvenile															
Idotea chelipes			1	1											2	
Crangonidae	fragment															
Crangon crangon				1			2									
Carcinus maenas	juvenile		1													
Lepidochitona cinerea																
Littorina littorea																
Littorina saxatilis				1	1				2			1				
Peringia ulvae		31	46	127	148	61	105	125	88	164	58	73	39	130	79	8
Tragula fenestrata																
Retusa obtusa																
Bivalvia	fragment															
Cerastoderma edule		1								2	2	1	3	2	2	2
Cerastoderma edule	juvenile						2		2		1		1		2	

Cerastoderma edule	fragment															
Abra tenuis												3	1			2
Scrobicularia plana							1									
Mya arenaria																
Callithamniaceae																
Ceramium																
Ulva intestinalis	aggregate		P	P						P						
Chaetomorpha			P	P												
Cladophora			P													
Chironomidae	larva															
Dolichopodidae	larva															
Cyanophyceae																
Nanozostera noltei		P	P	P	P		P	P		P	P	P		P	P	P

Table C5. Macrofaunal core sample biomass data from bait digging survey at Penmon-Beaumaris and Four Mile Bridge

Species	FI1.A	FI1.B	FI1.C	FI2.A	FI2.B	FI2.C	FI3.A	FI3.B	FI3.C	FI4.A	FI4.B	FI4.C
Annelida	0.0136	0.0297	0.046	0.1156	0.0285	0.0179	0.0439	0.0051	0.1275	0.0399	0.4131	0.1789
Crustacea	0.0001	0.0001	0.0018	0.0007	0.5726	0.0001	0.011	0.0048	0.0014	0.0047	0.0176	0.0216
Mollusca	6.7072	0.0116	0.0007	0.7017	0	0.2859	0.0013	0.0079	0.0109	0.016	0.0589	0.0772
Echinodermata	0	0	0.0001	0	0	0	0	0	0	0	0	0
Other	0.0022	0.0001	0.0017	0.0021	0.0032	0.0008	0.0119	0.0007	0.0099	0.0245	0.0367	0.0178
Species	**FI5.A**	**FI5.B**	**FI5.C**	**FI6.A**	**FI6.B**	**FI6.C**	**FC1.A**	**FC1.B**	**FC1.C**	**FC2.A**	**FC2.B**	**FC2.C**
Annelida	0.0665	0.0581	0.0361	0.0296	0.0175	0.0638	0.0025	0.0041	0.0372	0.0227	0	0.0029
Crustacea	0.0115	0.0039	0.0041	0.0017	0.0115	0.0278	0.0001	0.0023	0.0008	0.0007	0	0.0001
Mollusca	0.1316	0.2089	0	0	0.0001	0.0003	0.0001	0	0	0	0	0
Echinodermata	0	0	0	0	0	0	0	0	0	0	0	0
Other	0.0008	0.0001	0.0007	0.0187	0.0027	0.0043	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Species	**FC3.A**	**FC3.B**	**FC3.C**	**FC4.A**	**FC4.B**	**FC4.C**	**FC5.A**	**FC5.B**	**FC5.C**	**FC6.A**	**FC6.B**	**FC6.C**
Annelida	0.0019	0.0046	0.0094	0.0061	0.6256	0.0351	0.0022	0.0004	0.0094	0.0025	0.2144	0.008
Crustacea	0.0001	0.0001	0	0.0236	0.0018	0.0001	0	0.0001	0	0.0002	0.0008	0.0006
Mollusca	0	0	0	0	0	0	7.5508	0	0	0	0	0
Echinodermata	0	0	0	0	0	0	0	0	0	0	0	0
Other	0.0001	0.0001	0.0001	0.0004	0.0004	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
Species	**PI1.A**	**PI1.B**	**PI1.C**	**PI2.A**	**PI2.B**	**PI2.C**	**PI3.A**	**PI3.B**	**PI3.C**	**PI4.A**	**PI4.B**	**PI4.C**
Annelida	0.0765	0.0776	0.5909	0.0058	0.0949	0.0094	0.0732	0.0377	0.1063	0.2486	0.0704	0.1481
Crustacea	0.0002	0.0011	0.0058	0	0.0025	0.4484	0.021	0.0055	0.0808	0.005	0.0231	0
Mollusca	0.0048	0.0346	0.0227	0.0064	0.0099	0.0021	0.0016	0.0278	0.018	0.0162	0.1011	0.0035
Echinodermata	0	0	0	0	0	0	0	0	0	0	0	0
Other	0.0001	0.0005	0.0001	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0044	0.0011	0.0001
Species	**PI5.A**	**PI5.B**	**PI5.C**	**PI6.A**	**PI6.B**	**PI6.C**	**PI7.A**	**PI7.B**	**PI7.C**	**PI8.A**	**PI8.B**	**PI8.C**
Annelida	0.2078	0.0244	0.0117	0.0449	0.0269	0.0382	0.0763	0.2712	0.0236	0.0587	1.1092	0.1002
Crustacea	0.0181	0.0008	0.0127	0.0001	0.0012	0	0.0511	0.013	0	0	0.0228	0.0001
Mollusca	0.0067	0.0019	0.0034	0.005	0.0022	0.0021	0.0033	0.017	0.0038	0.0168	0.0071	0.0019
Echinodermata	0	0	0	0	0	0	0	0	0	0	0	0
Other	0.0005	0.0001	0.0002	0.0005	0.0009	0.0001	0.0001	0.0038	0.0001	0.0001	0.0002	0.0001
Species	**PC1.A**	**PC1.B**	**PC1.C**	**PC2.A**	**PC2.B**	**PC2.C**	**PC3.A**	**PC3.B**	**PC3.C**	**PC4.A**	**PC4.B**	**PC4.C**
Annelida	0.1424	0.0525	0.0452	0.1324	0.0337	0.0239	0.1077	0.1178	0.387	0.0657	0.024	0.027
Crustacea	0.0001	0.0072	0.0025	0	0	0	0.0037	0.0001	0.0001	0.0018	0	0
Mollusca	0.0026	0.0032	0.0062	0.0016	0.002	0.0021	0.0065	0.0026	0.0029	0.0492	0.0036	0.0001
Echinodermata	0	0	0	0	0	0	0	0	0	0	0	0
Other	0.0016	0.1391	0.0001	0.0001	0.0001	0.0001	0.0028	0.0001	0.0024	0.0056	0.0019	0.0001
Species	**PC5.A**	**PC5.B**	**PC5.C**	**PC6.A**	**PC6.B**	**PC6.C**	**PC7.A**	**PC7.B**	**PC7.C**	**PC8.A**	**PC8.B**	**PC8.C**
Annelida	0.01	0.0073	0.0156	0.0961	0.0648	0.0515	0.0001	0.0191	0.0009	0.0155	0.0442	0.0612
Crustacea	0	0	0.0009	0	0.0001	0	0	0.0001	0.0014	0.0001	0.0001	0.0001
Mollusca	0.0048	0.0057	0.0031	0.0032	0.0028	0.0024	0.0007	0.0157	0.0038	0.0059	0.0206	0.0128
Echinodermata	0	0	0	0	0	0	0	0	0	0	0	0
Other	0.0001	0.0001	0.001	0.0001	0.0427	0.0427	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001

Table C6. Macrofaunal core sample biomass data from bait digging survey at Angle Bay

	AC1.A	AC1.B	AC1.C	AC2.A	AC2.B	AC2.C	AC3.A	AC3.B	AC3.C
Annelida	0.0016	0	0.0005	0.0023	0.0132	0.0012	0.019	0.0073	0.007
Crustacea	0	0	0	0	0	0	0.0676	0.0194	0
Mollusca	2.2342	2.6739	1.1097	2.4443	4.6535	5.2449	4.0632	2.3075	5.6432
Echinodermata	0	0	0	0	0	0	0	0	0
Other	0.0002	0	0.0001	0.0001	0.0001	0	0.0001	0.0002	0.0001
	AC4.A	**AC4.B**	**AC4.C**	**AC5.A**	**AC5.B**	**AC5.C**	**AC6.A**	**AC6.B**	**AC6.C**
Annelida	0	0.0159	0.0001	0.02	0.0016	0	0.0346	0.0199	0.0046
Crustacea	0	0	0	0.0001	0	0	0.0001	0.0056	0.004
Mollusca	21.8868	3.7097	0.3826	0.8104	0.4097	0.7876	4.5676	0.8298	4.8927
Echinodermata	0	0	0	0	0	0	0	0	0
Other	0.0001	0.0001	0	0	0.0001	0	0.0001	0	0.0001
	AI1.A	**AI1.B**	**AI1.C**	**AI2.A**	**AI2.B**	**AI2.C**	**AI3.A**	**AI3.B**	**AI3.C**
Annelida	0.0097	0.0961	0.018	0.0216	1.2522	0.0637	0.0072	0.0131	0.0001
Crustacea	0	0.0021	0.022	0	0	0.0429	0	0	0
Mollusca	0.3629	0.2359	0.7153	0.7439	0.3507	2.3027	0.4652	0.5114	1.6471
Echinodermata	0	0	0	0	0	0	0	0	0
Other	0	0	0	0.0001	0.0001	0	0	0	0.0001
	AI4.A	**AI4.B**	**AI4.C**	**AI5.A**	**AI5.B**	**AI5.C**	**AI6.A**	**AI6.B**	**AI6.C**
Annelida	0.0009	0.0002	0.0013	0.0033	0.0033	0.0327	0.0226	0.0352	0.0299
Crustacea	0	0	0	0	0.0005	0	0	0.0001	0
Mollusca	2.6929	1.5692	8.6011	3.7295	2.0526	2.9888	0.524	1.2541	3.9998
Echinodermata	0	0	0	0	0	0	0	0	0
Other	0.0001	0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0

Table C7. Megafaunal sample in-situ identification abundance data from bait digging survey at Penmon-Beaumaris and Four Mile Bridge.

Sample	FI.1.M1	F1.1.M2	FI.2.M1	FI.2.M2	FI.3.M1	FI.3.M2	FI.4.M1	FI.4.M2	FI.5.M1	FI.5.M2	FI.6.M1	FI.6.M2	FC.1.M1	FC.1.M2
Anoxic layer depth (cm)	1	1	2	2	3	3	1	1	1	1	2	2	3	3
Carcinus maenas					2				1	1				
Cerastoderma edule	1	1			1	1		1		3	2	3		
Crangon crangon														
Littorina littorea														
Nepthtys (ragworm)														
Sand mason cast														
Polychaete tube			1				6	5	1		1	1	2	1
Amphipod														
Polychaete sp														
Tritia reticulata														
Red algae														
Glycerindae														
Polychaete sp a														
Polychaete sp b														
Buccinum andatum														
worm tubes														
Chiton														
Tittorina littorina														
Sample	**FC.2.M1**	**FC.2.M2**	**FC.3.M1**	**FC.3.M2**	**FC.4.M1**	**FC.4.M2**	**FC.5.M1**	**FC.5.M2**	**FC.6.M1**	**FC.6.M2**	**PI.1.M1**	**PI.1.M2**	**PI.2.M1**	**PI.2.M2**
Anoxic layer depth (cm)	2	2	2	2	2	2	2	2	3	2	1	1	1	1
Carcinus maenas												1	2	
Cerastoderma edule									1					
Crangon crangon														
Littorina littorea														
Nepthtys (ragworm)			1								1			
Sand mason cast											3	3	8	4
Polychaete tube			3	4							1			1
Amphipod						2								
Polychaete sp												1		
Tritia reticulata														
Red algae														
Glycerindae														
Polychaete sp a														
Polychaete sp b														
Buccinum andatum														
worm tubes														
Chiton														
Tittorina littorina														

Sample name	PI.3.M1	PI.3.M2	PI.4.M1	PI.4.M2	PI.5.M1	PI.5.M2	PI.6.M1	PI.6.M2	PI.7.M1	PI.7.M2	PI.8.M1	PI.8.M2	PC.1.M1	PC.1.M2
Anoxic layer depth (cm)	1	1	1	1	1	1	1	1	1	1	1	1	3	4
Carcinus maenas								1						1
Cerastoderma edule									1					
Crangon crangon	1			1	2	2	1	2	1	1		7		
Littorina littorea														
Nepthtys (ragworm)			1											
Sand mason cast	2	5	7	4	2	3	3	3	6	4		2	9	10
Polychaete tube	1				5	4	3	4		2	3	2		
Amphipod														
Polychaete sp		1												
Tritia reticulata											1			
Red algae						1								
Glycerindae											1			
Polychaete sp a														4
Polychaete sp b														1
Buccinum andatum													1	
worm tubes														
Chiton														
Tittorina littorina														
Sample name	**PC.2.M1**	**PC.2.M2**	**PC.3.M1**	**PC.3.M2**	**PC.4.M1**	**PC.4.M2**	**PC.5.M1**	**PC.5.M2**	**PC.6.M1**	**PC.6.M2**	**PC.7.M1**	**PC.7.M2**	**PC.8.M1**	**PC.8.M2**
Anoxic layer depth (cm)	3	3	4	4	3	3	3	3	3	3	3	3	2	2
Carcinus maenas	1			1									1	
Cerastoderma edule														
Crangon crangon							1				1		1	
Littorina littorea							1							
Nepthtys (ragworm)								1						
Sand mason cast	5	8	6	25	4	5		6	7	11		2	11	6
Polychaete tube														
Amphipod														
Polychaete sp														
Tritia reticulata			1											
Red algae														
Glycerindae														
Polychaete sp a	1		1		1	1								
Polychaete sp b							1	2						
Buccinum andatum														
worm tubes									3	4	1	2		
Chiton										1				
Tittorina littorina														1

Table C8. Megafaunal sample in-situ identification abundance data from bait digging survey at Angle Bay

Treatment	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control	Control
Block no	1	1	2	2	3	3	4	4	5	5	6	6
Sample name	AC1.M1	AC1.M2	AC2.M1	AC2.M2	AC3.M1	AC3.M2	AC4.M1	AC4.M2	AC5.M1	AC5.M2	AC6.M1	AC6.M2
Anoxic layer depth (cm)	4	3	2	2	3	3	4	3	2	2	2	2
Animalia_eggs			1									
Acanthocardia aculeata_juvenile												
Acanthocardia echinate												
Amphipoda										1		
Arenicola defodiens												
Arenicola marina	1											
Cancer pagurus												
Carcinus maenas	1			3	1	1		2				1
Cerastoderma edule	26	15	38	36	17	19	29	26	32	34	39	36
Crangon crangon	1			1			1	2	1	1		
Diadumene lineata	1											
Echinocardium chordatum												
Ensis ensis												
Ensis magnus												
Ensis siliqua												
Lanice conchilega							1					
Littorina littorea			3	3	1				9		4	3
Macoma balthica	2		1	5			1	1	1	2	2	1
Nepthtys sp.	1		2	5	1			2	1	2	5	1
Notomastus											1	
Ostrea edulis												
Pagurus benhardus												
Pisida longicornis												

Porecellana platycheles												
Pygospio elegans tubes									6	4	7	2
Sipunculida (Golfingia)												
Ruditapes philippinarum			1				1	1				
Ruditapes philippinarum_juvenile	5	1	1					1	1			
Turritella communis												
Velutinoidea_cowrie								1	1			
Xantho sp.												
Treatment	**Impact**	**Impact**	**Impact**	**Impact**	**Impact**	**Impact**	**Impact**	**Impact**	**Impact**	**Impact**	**Impact**	**Impact**
Block no	1	1	2	2	3	3	4	4	5	5	6	6
Sample name	AI1.M1	AI1.M2	AI2.M1	AI2.M2	AI3.M1	AI3.M2	AI4.M1	AI4.M2	AI5.M1	AI5.M2	AI6.M1	AI6.M2
Anoxic layer depth (cm)	1	3	2	2	1	1	1	1	1	1	1	1
Animalia_eggs												
Acanthocardia aculeata_juvenile												
Acanthocardia echinate												
Amphipoda												
Arenicola defodiens												
Arenicola marina												
Cancer pagurus												
Carcinus maenas	1		5	1		1	1				1	1
Cerastoderma edule	25	4	21	17	21	23	9	32	57	25	23	37
Crangon crangon		3	2		1				1			3
Diadumene lineata											1	
Echinocardium chordatum												
Ensis ensis												
Ensis magnus												
Ensis siliqua												
Lanice conchilega												

Littorina littorea			2	2			1		4	4		5
Macoma balthica				1					3	2	1	4
Nepthtys sp.	2		2	2	5	1		3	2		3	3
Notomastus												
Ostrea edulis												
Pagurus benhardus												
Pisida longicornis												
Porecellana platycheles												
Pygospio elegans tubes											3	8
Sipunculida (Golfingia)												
Ruditapes philippinarum			1							1		
Ruditapes philippinarum_juvenile	5	1	1					1	1			
Turritella communis												
Velutinoidea_cowrie								1	1			
Xantho sp.												

Table C9. Macrofaunal core sample abundance data from crab sheltering survey.

Species	Qualifier	DI1_InA	DI1_InB	DI1_Tr	DI2_InA	DI2_InB	DI2_Tr	DI3_InA	DI3_InB	DI3_Tr	DI4_InA	DI4_InB	DI4_Tr
Animalia	eggs								P				
Campanulariidae													
Fecampia erythrocephala	egg capsule												
Nemertea													
Cerebratulus													
Nematoda		3	6	4	14	6	32	4	20	30			2
Gattyana cirrhosa													
Pholoe inornata													
Eteone longa	aggregate												
Nereididae	fragment												
Nereididae	juvenile												
Hediste diversicolor													
Alitta succinea													
Alitta virens													
Nephtys	juvenile												
Nephtys hombergii													
Nephtys hombergii	fragment												
Scoloplos armiger					1								
Polydora ciliata	aggregate												
Polydora cornuta													
Dipolydora saintjosephi	aggregate												
Spiophanes bombyx		1											
Streblospio shrubsolii								1	1			1	
Aphelochaeta marioni													
Chaetozone gibber													
Tharyx	Type A												
Capitella									2				
Arenicolidae	fragment		P										
Arenicola marina		1								1			
Scalibregma inflatum													

Species	Qualifier	DI1_InA	DI1_InB	DI1_Tr	DI2_InA	DI2_InB	DI2_Tr	DI3_InA	DI3_InB	DI3_Tr	DI4_InA	DI4_InB	DI4_Tr
Manayunkia aestuarina													
Baltidrilus costatus			4				9	3		1			
Tubificoides benedii		19	44	67	31	38	74	66	74	60	4	30	24
Tubificoides pseudogaster	aggregate	11	22	3			15	4	18	10			
Enchytraeidae			1				1						
Acari													
Balanus crenatus													
Copepoda													
Gammarus locusta													
Melita palmata													
Corophium volutator		2		2	2	2	34	6	10	59	1		34
Decapoda	fragment										P		
Decapoda	megalopa												
Crangonidae	sp. indet.					1							
Crangonidae	fragment			P									
Crangon crangon		2	1		2						6	8	
Portunoidea	juvenile/sp. indet												
Carcinus maenas					1								
Carcinus maenas	juvenile												
Littorina littorea													
Peringia ulvae					1				1	3	6	2	27
Retusa obtusa													
Bivalvia													
Nuculidae	juvenile												
Mytilus edulis	juvenile						1						
Kurtiella bidentata													
Cerastoderma edule	juvenile	2				1			2		1	1	1
Macoma balthica													
Scrobicularia plana									1				
Scrobicularia plana	juvenile			1									1
Mya arenaria	juvenile							1					

Species	Qualifier	DI1_InA	DI1_InB	DI1_Tr	DI2_InA	DI2_InB	DI2_Tr	DI3_InA	DI3_InB	DI3_Tr	DI4_InA	DI4_InB	DI4_Tr
Amathia								P					
Corallinaceae													
Cystoclonium purpureum											P		
Gracilariaceae													
Gracilaria													
Plocamium		P	P			P	P	P	P	P	P	P	
Ceramium													
Compsothamnion thuyoides													
Halurus flosculosus										P			
Heterosiphonia plumosa													
Hypoglossum hypoglossoides			P										
Vertebrata byssoides											P		
Vertebrata lanosa													
Vertebrata nigra			P										
Xiphosiphonia pennata								P	P			P	
Ectocarpus	aggregate				P	P		P			P		
Elachista													
Sphacelaria													
Laminaria					P								
Ulva compressa									P				
Ulva intestinalis	aggregate												
Ulva rigida													
Chaetomorpha													
Cladophora									P				
Collembola													
Chironomidae	larva												
Rubus	Seed				1								

Species	Qualifier	DC1_A	DC1_B	DC1_C	DC2_A	DC2_B	DC2_C	DC3_A	DC3_B	DC3_C	DC4_A	DC4_B	DC4_C
Animalia	eggs												
Campanulariidae													
Fecampia erythrocephala	egg capsule												

Species	Qualifier	DC1_A	DC1_B	DC1_C	DC2_A	DC2_B	DC2_C	DC3_A	DC3_B	DC3_C	DC4_A	DC4_B	DC4_C
Nemertea											1		
Cerebratulus													
Nematoda		4	1			1		1	3		2	2	1
Gattyana cirrhosa													
Pholoe inornata													
Eteone longa	aggregate				1						1	1	
Nereididae	fragment												
Nereididae	juvenile								1				
Hediste diversicolor													
Alitta succinea													
Alitta virens													
Nephtys	juvenile												1
Nephtys hombergii					1						2		
Nephtys hombergii	fragment		P			P							
Scoloplos armiger						1							
Polydora ciliata	aggregate												
Polydora cornuta													
Dipolydora saintjosephi	aggregate												
Spiophanes bombyx													
Streblospio shrubsolii				2				1	3		1	1	1
Aphelochaeta marioni													
Chaetozone gibber													
Tharyx	Type A	1		4				1	2			2	1
Capitella													
Arenicolidae	fragment											P	
Arenicola marina													
Scalibregma inflatum													
Manayunkia aestuarina													
Baltidrilus costatus													
Tubificoides benedii		86	51	94	19	60	84	25	111	70	74	56	151
Tubificoides pseudogaster	aggregate			7		1		16	103		3		3

Species	Qualifier	DC1_A	DC1_B	DC1_C	DC2_A	DC2_B	DC2_C	DC3_A	DC3_B	DC3_C	DC4_A	DC4_B	DC4_C
Enchytraeidae													
Acari					1								
Balanus crenatus													
Copepoda													
Gammarus locusta													
Melita palmata													
Corophium volutator		19	17		12	4	20		10		39	12	56
Decapoda	fragment												
Decapoda	megalopa							1					
Crangonidae	sp. indet.												
Crangonidae	fragment												
Crangon crangon								1					
Portunoidea	juvenile/sp. indet												
Carcinus maenas													
Carcinus maenas	juvenile								1			1	
Littorina littorea													
Peringia ulvae		64	41	46	43	27	20	17	68	5	97	21	48
Retusa obtusa					1								
Bivalvia		1											
Nuculidae	juvenile		1						1				
Mytilus edulis	juvenile					1							
Kurtiella bidentata													
Cerastoderma edule	juvenile	3	1	2	7	1	3	1	5	2	8	3	12
Macoma balthica								1			1		
Scrobicularia plana							1		1				
Scrobicularia plana	juvenile		1	2	2		2		2		2	1	
Mya arenaria	juvenile		1								1		
Amathia													
Corallinaceae													
Cystoclonium purpureum													
Gracilariaceae										P			

Species	Qualifier	DC1_A	DC1_B	DC1_C	DC2_A	DC2_B	DC2_C	DC3_A	DC3_B	DC3_C	DC4_A	DC4_B	DC4_C
Gracilaria													
Plocamium				P		P	P	P	P	P	P	P	P
Ceramium													
Compsothamnion thuyoides													
Halurus flosculosus				P									
Heterosiphonia plumosa						P							
Hypoglossum hypoglossoides													
Vertebrata byssoides													
Vertebrata lanosa													
Vertebrata nigra													
Xiphosiphonia pennata													
Ectocarpus	aggregate					P							
Elachista													
Sphacelaria												P	
Laminaria													
Ulva compressa													
Ulva intestinalis	aggregate												
Ulva rigida													
Chaetomorpha													
Cladophora										P			
Collembola		6	5		1		2		1		1		2
Chironomidae	larva					1							
Rubus	Seed												

Species	Qualifier	BI1_InA	BI1_InB	BI1_Cen	BI2_InA	BI2_InB	BI2_Cen	BI3_InA	BI3_InB	BI3_Cen	BI4_InA	BI4_InB	BI4_Cen
Animalia	eggs												
Campanulariidae		P											
Fecampia erythrocephala	egg capsule					P				P	P		
Nemertea													
Cerebratulus					1								
Nematoda		56		1			2			6		2	14
Gattyana cirrhosa													1

Species	Qualifier	BI1_InA	BI1_InB	BI1_Cen	BI2_InA	BI2_InB	BI2_Cen	BI3_InA	BI3_InB	BI3_Cen	BI4_InA	BI4_InB	BI4_Cen
Pholoe inornata										1			
Eteone longa	aggregate											1	
Nereididae	fragment			P									
Nereididae	juvenile												
Hediste diversicolor			2			4	1	6	2			1	1
Alitta succinea													
Alitta virens		4				1					1	1	
Nephtys	juvenile												
Nephtys hombergii													
Nephtys hombergii	fragment												
Scoloplos armiger					2	3					1	1	1
Polydora ciliata	aggregate												45
Polydora cornuta													
Dipolydora saintjosephi	aggregate												1
Spiophanes bombyx													
Streblospio shrubsolii													
Aphelochaeta marioni									1	2		2	
Chaetozone gibber													
Tharyx	Type A									3			1
Capitella		2				2		4		1			
Arenicolidae	fragment												
Arenicola marina													
Scalibregma inflatum		1											
Manayunkia aestuarina						1						2	
Baltidrilus costatus													
Tubificoides benedii		37	12	11	7	21	3	10	18	8	35	13	5
Tubificoides pseudogaster	aggregate	70		13	1	2	7	5		3	1	1	
Enchytraeidae													
Acari													1
Balanus crenatus													15
Copepoda		1											

Species	Qualifier	BI1_InA	BI1_InB	BI1_Cen	BI2_InA	BI2_InB	BI2_Cen	BI3_InA	BI3_InB	BI3_Cen	BI4_InA	BI4_InB	BI4_Cen
Gammarus locusta		2											2
Melita palmata													
Corophium volutator				1			1				7	10	1
Decapoda	fragment												P
Decapoda	megalopa												
Crangonidae	sp. indet.												
Crangonidae	fragment												
Crangon crangon													
Portunoidea	juvenile/sp. indet												1
Carcinus maenas													
Carcinus maenas	juvenile										1		
Littorina littorea			1										
Peringia ulvae		8	1	2	4	9	4	6	5	3	1	8	2
Retusa obtusa					1	1							
Bivalvia													
Nuculidae	juvenile												
Mytilus edulis	juvenile												
Kurtiella bidentata					1								
Cerastoderma edule	juvenile												
Macoma balthica													
Scrobicularia plana													
Scrobicularia plana	juvenile				1	1							
Mya arenaria	juvenile												
Amathia													
Corallinaceae													P
Cystoclonium purpureum													
Gracilariaceae													
Gracilaria		P											
Plocamium								P					
Ceramium		P				P						P	
Compsothamnion thuyoides		P											

Species	Qualifier	BI1_InA	BI1_InB	BI1_Cen	BI2_InA	BI2_InB	BI2_Cen	BI3_InA	BI3_InB	BI3_Cen	BI4_InA	BI4_InB	BI4_Cen
Halurus flosculosus													
Heterosiphonia plumosa													P
Hypoglossum hypoglossoides													
Vertebrata byssoides													
Vertebrata lanosa													
Vertebrata nigra								P					
Xiphosiphonia pennata													
Ectocarpus	aggregate												
Elachista													
Sphacelaria													
Laminaria													
Ulva compressa		P		P	P				P		P		
Ulva intestinalis	aggregate					P	P	P		P			P
Ulva rigida							P						
Chaetomorpha								P					
Cladophora													
Collembola			1	1			1			3		1	
Chironomidae	larva												
Rubus	Seed								1				

Species	Qualifier	BC1_A	BC1_B	BC1_C	BC2_A	BC2_B	BC2_C	BC3_A	BC3_B	BC3_C	BC4_A	BC4_B	BC4_C
Animalia	eggs							P					
Campanulariidae													
Fecampia erythrocephala	egg capsule												
Nemertea													
Cerebratulus													
Nematoda				1	13		2	2	7	2			
Gattyana cirrhosa													
Pholoe inornata													
Eteone longa	aggregate												
Nereididae	fragment												
Nereididae	juvenile												

Species	Qualifier	BC1_A	BC1_B	BC1_C	BC2_A	BC2_B	BC2_C	BC3_A	BC3_B	BC3_C	BC4_A	BC4_B	BC4_C
Hediste diversicolor		4	2	3	4	2	3		3	2	4	1	3
Alitta succinea									1				
Alitta virens		1	1	2	2		1		2	1			2
Nephtys	juvenile												
Nephtys hombergii													
Nephtys hombergii	fragment												
Scoloplos armiger		4	2	2	4	1	8	13	5	5	2	8	
Polydora ciliata	aggregate												
Polydora cornuta				1									
Dipolydora saintjosephi	aggregate												
Spiophanes bombyx													
Streblospio shrubsolii													
Aphelochaeta marioni				1	2	2	2	2	1				2
Chaetozone gibber						1							1
Tharyx	Type A												
Capitella				4	3	2	2	5		6		1	
Arenicolidae	fragment												
Arenicola marina													
Scalibregma inflatum										1			
Manayunkia aestuarina		1	1	2	1		2				1		
Baltidrilus costatus													
Tubificoides benedii		1		1	2	1	3		1		1		
Tubificoides pseudogaster	aggregate	1		4	1	1							4
Enchytraeidae													
Acari													
Balanus crenatus													
Copepoda													
Gammarus locusta						2							
Melita palmata									1				
Corophium volutator		7	9	3	9	9	11	2	8	8	7		3
Decapoda	fragment												

Species	Qualifier	BC1_A	BC1_B	BC1_C	BC2_A	BC2_B	BC2_C	BC3_A	BC3_B	BC3_C	BC4_A	BC4_B	BC4_C
Decapoda	megalopa												
Crangonidae	sp. indet.												
Crangonidae	fragment												
Crangon crangon													
Portunoidea	juvenile/sp. indet												
Carcinus maenas													
Carcinus maenas	juvenile												
Littorina littorea													
Peringia ulvae		14	12	15	23	9	30	10	11	13	7	8	12
Retusa obtusa				1			2			2		2	
Bivalvia													
Nuculidae	juvenile												
Mytilus edulis	juvenile												
Kurtiella bidentata					1								
Cerastoderma edule	juvenile								1			2	
Macoma balthica													
Scrobicularia plana													
Scrobicularia plana	juvenile												
Mya arenaria	juvenile												
Amathia													
Corallinaceae													
Cystoclonium purpureum													
Gracilariaceae													
Gracilaria													
Plocamium													
Ceramium													
Compsothamnion thuyoides													
Halurus flosculosus													
Heterosiphonia plumosa													
Hypoglossum hypoglossoides													
Vertebrata byssoides													

Species	Qualifier	BC1_A	BC1_B	BC1_C	BC2_A	BC2_B	BC2_C	BC3_A	BC3_B	BC3_C	BC4_A	BC4_B	BC4_C
Vertebrata lanosa											P		
Vertebrata nigra													
Xiphosiphonia pennata													
Ectocarpus	aggregate												
Elachista				P									
Sphacelaria													
Laminaria													
Ulva compressa						P	P	P			P		
Ulva intestinalis	aggregate			P	P		P						P
Ulva rigida													
Chaetomorpha			P					P					
Cladophora													
Collembola													
Chironomidae	larva												
Rubus	Seed												

Table C10. Macrofaunal core sample biomass data from crab sheltering survey

Species	DI1_InA	DI1_InB	DI1_Tr	DI2_InA	DI2_InB	DI2_Tr	DI3_InA	DI3_InB	DI3_Tr	DI4_InA	DI4_InB	DI4_Tr
Annelida	0.3101	0.1456	0.0417	0.0129	0.017	0.0644	0.0414	0.0525	0.2889	0.0005	0.0136	0.0152
Crustacea	0.0019	0.0001	0.0002	1.5916	0.0018	0.0343	0.002	0.0044	0.0203	0.1969	0.0239	0.0126
Mollusca	0.0009	0	0.012	0.0001	0.0001	0.0001	0.0009	1.8931	0.0031	0.001	0.0012	0.0332
Other	0.3131	0.1458	0.054	1.6048	0.019	0.1005	0.0444	1.951	0.313	0.1984	0.0387	0.0611
Species	**DC1_A**	**DC1_B**	**DC1_C**	**DC2_A**	**DC2_B**	**DC2_C**	**DC3_A**	**DC3_B**	**DC3_C**	**DC4_A**	**DC4_B**	**DC4_C**
Annelida	0.0515	0.2449	0.0656	0.1658	0.0833	0.0415	0.0205	0.134	0.0667	0.2744	0.353	0.1653
Crustacea	0.0109	0.0132	0	0.0094	0.0011	0.0115	0.0067	0.0086	0	0.0098	0.0116	0.0281
Mollusca	0.0119	0.017	0.0731	0.0539	0.0072	0.2219	0.0234	7.8833	0.0036	0.129	0.0084	0.0149
Other	0.0745	0.2753	0.1387	0.2295	0.0918	0.275	0.0507	8.0261	0.0703	0.4146	0.3731	0.2085
Species	**BI1_InA**	**BI1_InB**	**BI1_Cen**	**BI2_InA**	**BI2_InB**	**BI2_Cen**	**BI3_InA**	**BI3_InB**	**BI3_Cen**	**BI4_InA**	**BI4_InB**	**BI4_Cen**
Annelida	1.8421	0.0505	0.0148	0.0061	0.7678	0.0042	0.0562	0.1304	0.0065	0.0863	0.2919	0.0477
Crustacea	0.0059	0	0.0001	0	0	0.0014	0	0	0	0.0899	0.0387	0.1178
Mollusca	0.0148	4.5217	0.0043	0.0237	0.0205	0.0125	0.0099	0.0099	0.0049	0.0018	0.0254	0.0024
Other	1.8629	4.5723	0.0194	0.0571	0.7883	0.0189	0.0661	0.1403	0.0121	0.178	0.3562	0.1681
Species	**BC1_A**	**BC1_B**	**BC1_C**	**BC2_A**	**BC2_B**	**BC2_C**	**BC3_A**	**BC3_B**	**BC3_C**	**BC4_A**	**BC4_B**	**BC4_C**
Annelida	0.5869	0.1882	0.1781	0.5333	0.087	1.1826	0.0157	0.1745	0.5815	0.4042	0.1874	0.8211
Crustacea	0.0205	0.0193	0.0031	0.0243	0.0502	0.0316	0.0142	0.0198	0.0218	0.0161	0	0.0075
Mollusca	0.0165	0.0099	0.014	0.0268	0.0179	0.0452	0.003	0.0052	0.0142	0.0072	0.0127	0.0191
Other	0.6239	0.2174	0.1953	0.5845	0.1551	1.2595	0.033	0.1996	0.6176	0.4275	0.2001	0.8477

Table C11. Megafaunal sample in-situ identification abundance data from crab sheltering survey.

Sample	DI1.M1	DI1.M2	DI2.M1	DI2.M2	DI3.M1	DI3.M2	DI4.M1	DI4.M2
Anoxic layer depth (cm)	1	1	1	1	1	1	1	1
Carcinus maenas								1
Crangon crangon								
Nepthtys (ragworm)								
Sand mason cast								
worm tubes					1			2
Polychaete sp A			4	1	3		1	2
Abra sp						1		
Polychaete sp B								
Sample	**DC1.M1**	**DC1.M2**	**DC2.M1**	**DC2.M2**	**DC3.M1**	**DC3.M2**	**DC4.M1**	**DC4.M2**
Anoxic layer depth (cm)	1	1	1	1	1	1	1	1
Carcinus maenas					1			
Crangon crangon	2							
Nepthtys (ragworm)								
Sand mason cast					2			
worm tubes	3	2	5		3	2	1	2
Polychaete sp A								
Abra sp								
Polychaete sp B								
Sample	**BC1.M1**	**BC1.M2**	**BC2.M1**	**BC2.M2**	**BC3.M1**	**BC3.M2**	**BC4.M1**	**BC4.M2**
Anoxic layer depth (cm)	<1	<1	<1	<1	<1	<1	<1	<1
Carcinus maenas							2	1
Crangon crangon								
Nepthtys (ragworm)								
Sand mason cast								
worm tubes		1						
Polychaete sp A								
Abra sp								
Polychaete sp B		1				2		

Sample	BI1.M1	BI1.M2	BI2.M1	BI2.M2	BI3.M1	BI3.M2	BI4.M1	BI4.M2
Anoxic layer depth (cm)	<1	<1	<1	<1	<1	<1	<1	<1
Carcinus maenas	1	3				1		1
Crangon crangon								
Nepthtys (ragworm)		1						
Sand mason cast								
worm tubes		2			2	1		
Polychaete sp A								
Abra sp								
Polychaete sp B		1	1		1			

Appendix D: Sediment Data

Table D1. Particle Size Analysis (PSA) data from bait digging survey at Penmon-Beaumaris and Four Mile Bridge.

Station	Textural Group	% GRAVEL	% SAND	% MUD	% V COARSE GRAVEL	% COARSE GRAVEL	% MEDIUM GRAVEL	% FINE GRAVEL	% V FINE GRAVEL	% V COARSE SAND	% COARSE SAND	% MEDIUM SAND	% FINE SAND	% V FINE SAND	% V COARSE SILT	% COARSE SILT	% MEDIUM SILT	% FINE SILT	% V FINE SILT	% CLAY
FI	Muddy Sand	0.00	81.10	18.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.70	42.90	21.60	2.30	5.20	5.30	3.90	2.10	0.20
FI2	Muddy Sand	0.00	76.40	23.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.70	41.10	23.60	2.80	5.50	6.60	5.40	3.10	0.30
FI3	Gravelly Muddy Sand	10.80	67.30	21.90	0.00	2.40	3.00	2.50	2.90	1.90	3.30	15.90	29.40	16.90	6.30	6.40	4.10	2.90	1.90	0.40
FI4	Muddy Sand	0.00	59.80	40.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.50	27.30	25.90	12.00	9.30	8.50	6.60	3.30	0.40
FI5	Gravelly Muddy Sand	15.50	56.00	28.50	0.00	1.70	5.60	4.30	3.90	2.10	1.20	5.60	22.60	24.50	12.00	7.20	4.30	3.00	1.70	0.40
FI6	Muddy Sand	0.00	69.30	30.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.90	33.20	28.20	8.50	6.70	6.80	5.40	2.90	0.40
FC1	Sand	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.10	71.60	15.30	0.00	0.00	0.00	0.00	0.00	0.00
FC2	Sand	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.60	69.00	13.40	0.00	0.00	0.00	0.00	0.00	0.00
FC3	Sand	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.90	68.80	12.40	0.00	0.00	0.00	0.00	0.00	0.00
FC4	Sand	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.40	67.00	10.50	0.00	0.00	0.00	0.00	0.00	0.00
FC5	Sand	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.00	68.70	13.30	0.00	0.00	0.00	0.00	0.00	0.00
FC6	Sand	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.90	71.70	14.40	0.00	0.00	0.00	0.00	0.00	0.00
PI	Gravelly Muddy Sand	22.00	48.70	29.30	0.00	1.80	9.40	6.20	4.60	4.50	7.60	10.90	10.00	15.80	12.10	7.00	4.50	3.30	1.90	0.50
PI2	Gravelly Muddy Sand	9.20	73.40	17.40	0.00	0.00	0.80	3.80	4.70	11.70	22.00	22.30	9.70	7.70	5.90	3.90	3.10	2.50	1.60	0.40
PI3	Slightly Gravelly Muddy Sand	4.80	84.30	10.90	0.00	0.00	3.50	1.30	0.00	19.80	25.10	26.60	8.70	4.20	4.10	2.50	1.90	1.50	0.80	0.10
PI4	Gravelly Muddy Sand	8.20	73.80	18.00	0.00	0.00	1.60	3.20	3.50	5.30	17.30	29.20	13.30	8.80	6.70	4.00	3.00	2.40	1.50	0.30
PI5	Gravelly Muddy Sand	12.20	72.00	15.80	0.00	0.00	2.00	4.80	5.40	7.40	19.30	27.70	11.00	6.70	5.90	3.60	2.70	2.10	1.20	0.20

Station	Textural Group	% GRAVEL	% SAND	% MUD	% V COARSE GRAVEL	% COARSE GRAVEL	% MEDIUM GRAVEL	% FINE GRAVEL	% V FINE GRAVEL	% V COARSE SAND	% COARSE SAND	% MEDIUM SAND	% FINE SAND	% V FINE SAND	% V COARSE SILT	% COARSE SILT	% MEDIUM SILT	% FINE SILT	% V FINE SILT	% CLAY
PI6	Gravelly Muddy Sand	8.80	79.60	11.60	0.00	0.00	1.60	3.40	3.80	8.10	24.10	32.90	10.80	3.80	3.90	2.40	2.20	1.80	1.10	0.20
PI7	Gravelly Muddy Sand	6.30	81.60	12.20	0.00	0.00	0.90	2.50	2.90	11.00	26.00	32.20	9.30	3.00	4.20	2.90	2.20	1.70	1.00	0.20
PI8	Gravelly Muddy Sand	8.00	77.60	14.40	0.00	0.00	0.60	3.30	4.10	13.20	20.80	27.10	10.20	6.30	5.80	3.40	2.30	1.70	1.00	0.20
PC1	Gravelly Muddy Sand	13.90	74.60	11.40	0.00	0.00	1.10	5.70	7.10	10.70	12.80	25.40	18.40	7.40	3.50	2.70	2.10	1.70	1.10	0.20
PC2	Gravelly Muddy Sand	14.90	74.10	11.00	0.00	0.00	2.30	5.80	6.70	14.10	14.50	24.30	14.10	7.20	4.00	2.50	1.90	1.50	0.90	0.20
PC3	Slightly Gravelly Muddy Sand	3.50	85.70	10.80	0.00	0.00	0.20	1.40	1.90	12.00	22.10	30.40	14.60	6.50	3.80	2.40	1.90	1.60	1.00	0.20
PC4	Gravelly Sand	6.90	85.20	7.90	0.00	0.00	0.30	2.90	3.70	15.60	23.70	30.20	12.00	3.60	2.60	1.70	1.50	1.30	0.80	0.10
PC5	Gravelly Muddy Sand	14.80	45.20	40.00	0.00	1.60	5.30	4.20	3.80	0.90	3.00	8.30	14.20	18.80	15.50	10.20	6.20	4.50	2.80	0.80
PC6	Gravelly Muddy Sand	19.30	71.30	9.50	0.00	0.00	3.60	7.40	8.20	7.80	14.80	27.30	16.50	4.90	2.80	2.30	1.80	1.50	0.90	0.10
PC7	Slightly Gravelly Sand	3.30	87.90	8.90	0.00	0.00	0.00	1.40	1.90	16.90	24.90	29.10	12.50	4.40	3.20	2.10	1.50	1.20	0.70	0.10
PC8	Gravelly Muddy Sand	12.10	74.60	13.30	0.00	0.00	1.00	5.00	6.20	17.00	17.20	18.20	12.10	10.00	5.70	3.00	2.00	1.50	0.90	0.20

Table D2. Particle Size Analysis (PSA) data from bait digging survey at Angle Bay

	AC1	AC2	AC3	AC4	AC5	AC6	AI1	AI2	AI3	AI4	AI5	AI6
TEXTURAL GROUP:	Muddy Sand	Muddy Sand	Muddy Sand	Muddy Sand	Muddy Sand	Muddy Sand	Muddy Sand	Muddy Sand	Sand	Sand	Muddy Sand	Muddy Sand
% GRAVEL:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% SAND:	66.8	72.2	57.3	79.8	64.4	65.8	89.0	81.3	90.9	98.7	87.9	77.9
% MUD:	33.2	27.8	42.7	20.2	35.6	34.2	11.0	18.7	9.1	1.3	12.1	22.1
% V COARSE GRAVEL:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% COARSE GRAVEL:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

% MEDIUM GRAVEL:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% FINE GRAVEL:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% V FINE GRAVEL:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% V COARSE SAND:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% COARSE SAND:	3.5	6.2	3.8	4.2	3.9	3.5	3.2	7.6	6.9	3.0	4.5	5.0
% MEDIUM SAND:	30.6	37.7	26.7	44.3	33.0	34.6	46.9	46.3	58.9	55.2	46.1	48.3
% FINE SAND:	27.2	25.9	21.9	30.4	23.7	24.4	37.4	26.5	25.0	39.7	35.5	23.8
% V FINE SAND:	5.6	2.4	4.9	0.9	3.8	3.4	1.5	0.9	0.1	0.8	1.7	0.9
% V COARSE SILT:	4.9	3.5	5.1	2.0	5.2	5.1	1.6	3.5	1.4	0.0	0.1	0.0
% COARSE SILT:	7.5	5.5	8.8	4.2	7.4	6.3	3.2	4.9	2.1	0.0	0.2	0.0
% MEDIUM SILT:	9.1	7.4	12.0	5.5	9.5	8.3	2.7	4.9	2.2	0.0	2.2	0.2
% FINE SILT:	7.8	7.3	10.9	5.4	8.8	8.9	2.3	3.8	2.3	0.2	6.0	5.1
% V FINE SILT:	3.6	3.7	5.2	2.7	4.3	4.9	1.1	1.6	1.1	0.6	3.3	12.7
% CLAY:	0.4	0.5	0.7	0.3	0.5	0.8	0.0	0.1	0.0	0.5	0.3	4.2

Table D3. Total Organic Carbon (TOC) data from bait digging survey.

Sample No.	FI	FI2	FI3	FI4	FI5	FI6	FC1	FC2	FC3	FC4	FC5	FC6
TOC (% Volume LOI)	1.37	1.78	1.39	1.93	2.27	1.99	0.64	0.70	0.81	0.70	0.77	0.63

Sample No.	PI	PI2	PI3	PI4	PI5	PI6	PI7	PI8	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
TOC (% Volume LOI)	1.80	1.36	1.37	1.07	1.07	1.09	1.31	1.45	0.67	1.33	0.99	0.89	2.68	1.41	0.98	0.91

Sample No.	AC1	AC2	AC3	AC4	AC5	AC6	AI1	AI2	AI3	AI4	AI5	AI6
TOC (% Volume LOI)	1.074	1.804	1.503	1.449	1.778	1.947	0.670	1.054	0.952	0.865	1.0412	2.023

Table D4. Particle Size Analysis (PSA) data from crab sheltering survey.

Station	Textural Group	% GRAVEL	% SAND	% MUD	% V COARSE GRAVEL	% COARSE GRAVEL	% MEDIUM GRAVEL	% FINE GRAVEL	% V FINE GRAVEL	% V COARSE SAND	% COARSE SAND	% MEDIUM SAND	% FINE SAND	% V FINE SAND	% V COARSE SILT	% COARSE SILT	% MEDIUM SILT	% FINE SILT	% V FINE SILT	% CLAY
DI	Muddy Sand	0.00	87.30	12.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.60	49.70	10.00	1.60	3.50	3.20	2.70	1.60	0.10
DI2	Muddy Sand	0.00	73.00	27.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	24.30	35.90	12.90	5.10	6.70	6.80	5.30	2.80	0.30
DI3	Muddy Sand	0.00	34.40	65.60	0.00	0.00	0.00	0.00	0.00	0.00	0.80	3.00	9.30	21.30	18.60	13.80	13.90	11.80	6.60	1.00
DI4	Muddy Sand	0.00	36.40	63.60	0.00	0.00	0.00	0.00	0.00	0.00	0.40	2.50	10.40	23.00	18.80	13.90	13.40	10.80	5.80	0.90
DC1	Muddy Sand	0.00	87.30	12.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.60	49.70	10.00	1.60	3.50	3.20	2.70	1.60	0.10
DC2	Muddy Sand	0.00	73.00	27.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	24.30	35.90	12.90	5.10	6.70	6.80	5.30	2.80	0.30
DC3	Sandy Mud	0.00	34.40	65.60	0.00	0.00	0.00	0.00	0.00	0.00	0.80	3.00	9.30	21.30	18.60	13.80	13.90	11.80	6.60	1.00
DC4	Sandy Mud	0.00	36.40	63.60	0.00	0.00	0.00	0.00	0.00	0.00	0.40	2.50	10.40	23.00	18.80	13.90	13.40	10.80	5.80	0.90
BI	Sandy Mud	0.00	40.70	59.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	13.70	23.30	17.30	11.50	12.10	10.90	6.60	1.00
BI2	Sandy Mud	0.00	38.50	61.50	0.00	0.00	0.00	0.00	0.00	0.00	0.20	2.20	9.90	26.10	20.40	12.00	11.70	10.40	6.00	0.90
BI3	Sandy Mud	0.00	39.20	60.80	0.00	0.00	0.00	0.00	0.00	0.00	0.80	2.60	10.60	25.20	19.80	12.50	12.00	10.10	5.50	0.90
BI4	Sandy Mud	0.00	40.30	59.70	0.00	0.00	0.00	0.00	0.00	0.00	1.80	4.50	10.50	23.50	19.40	12.80	11.90	9.70	5.20	0.80
BC1	Sandy Mud	0.00	36.40	63.60	0.00	0.00	0.00	0.00	0.00	0.00	0.80	2.80	9.80	23.00	19.10	13.10	13.00	11.20	6.40	1.00
BC2	Sandy Mud	0.00	28.90	71.10	0.00	0.00	0.00	0.00	0.00	0.00	0.40	1.90	7.40	19.20	19.80	16.60	15.40	12.10	6.30	0.90
BC3	Sandy Mud	0.00	34.40	65.60	0.00	0.00	0.00	0.00	0.00	0.00	0.80	3.00	9.30	21.30	18.60	13.80	13.90	11.80	6.60	1.00
BC4	Sandy Mud	0.00	36.40	63.60	0.00	0.00	0.00	0.00	0.00	0.00	0.40	2.50	10.40	23.00	18.80	13.90	13.40	10.80	5.80	0.90

Table D5. Total Organic Carbon (TOC) data from crab sheltering survey.

Sample No.	DI	DI2	DI3	DI4	DC1	DC2	DC3	DC4
TOC (% Volume LOI)	1.1	1.36	1.42	1.53	1.66	1.41	1.42	1.71
Sample No.	**BI**	**BI2**	**BI3**	**BI4**	**BC1**	**BC2**	**BC3**	**BC4**
TOC (% Volume LOI)	4.04	4.51	4.01	3.80	4.22	4.06	3.76	4.36

Appendix E: Infaunal metrics

Table E1. Number of species and total abundance from quadrat counts from boulder top surfaces sampled for boulder turning survey.

Sample	PI1.1	PI1.2	PI1.3	PI1.4	PI1.5	PI2.1	PI2.2	PI2.3	PI2.4	PI2.5	PI3.1	PI3.2	PI3.3	PI3.4	PI3.5	PI4.1	PI4.2	PI4.3	PI4.4	PI4.5
Abundance	1	0	7	6	10	5	4	0	21	4	1	0	0	3	0	1	3	1	3	5
No. of taxa	1	0	4	2	4	4	2	0	2	1	1	0	0	1	0	1	3	1	2	2
Sample	**PC1.A**	**PC1.B**	**PC1.C**	**PC1.D**	**PC1.E**	**PC2.A**	**PC2.B**	**PC2.C**	**PC2.D**	**PC2.E**	**PC3.A**	**PC3.B**	**PC3.C**	**PC3.D**	**PC3.E**	**PC4.A**	**PC4.B**	**PC4.C**	**PC4.D**	**PC4.E**
Abundance	13	6	3	9	32	39	23	7	14	11	10	9	5	9	5	15	0	10	8	1
No. of taxa	2	1	3	2	3	3	3	2	3	1	2	3	2	2	2	1	0	3	1	1
Sample	**OI1.A**	**OI1.B**	**OI1.C**	**OI1.D**	**OI1.E**	**OI2.A**	**OI2.B**	**OI2.C**	**OI2.D**	**OI2.E**	**OI3.A**	**OI3.B**	**OI3.C**	**OI3.D**	**OI3.E**	**OI4.A**	**OI4.B**	**OI4.C**	**OI4.D**	**OI4.E**
Abundance	3	8	0	2	3	10	0	3	4	7	2	1	0	1	1	4	1	2	0	0
No. of taxa	2	3	0	2	2	3	0	2	1	2	2	1	0	1	1	2	1	1	0	0
Sample	**OC1.A**	**OC1.B**	**OC1.C**	**OC1.D**	**OC1.E**	**OC2.A**	**OC2.B**	**OC2.C**	**OC2.D**	**OC2.E**	**OC3.A**	**OC3.B**	**OC3.C**	**OC3.D**	**OC3.E**	**OC4.A**	**OC4.B**	**OC4.C**	**OC4.D**	**OC4.E**
Abundance	3	3	2	2	9	10	10	0	10	3	3	0	1	3	0	1	9	1	0	3
No. of taxa	1	2	2	2	2	5	3	0	3	2	3	0	1	2	0	1	3	1	0	1

Table E2. Total number of species and abundance from quadrat counts from boulder bottom surfaces sampled for boulder turning survey.

Sample	PI1.1	PI1.2	PI1.3	PI1.4	PI1.5	PI2.1	PI2.2	PI2.3	PI2.4	PI2.5	PI3.1	PI3.2	PI3.3	PI3.4	PI3.5	PI4.1	PI4.2	PI4.3	PI4.4	PI4.5
Abundance	2	18	22	2	16	1	14	1	4	3	1	1	0	2	2	0	7	3	0	1
No. of taxa	2	7	8	1	7	1	5	1	2	2	1	1	0	2	1	0	3	2	0	1
Sample	**PC1.A**	**PC1.B**	**PC1.C**	**PC1.D**	**PC1.E**	**PC2.A**	**PC2.B**	**PC2.C**	**PC2.D**	**PC2.E**	**PC3.A**	**PC3.B**	**PC3.C**	**PC3.D**	**PC3.E**	**PC4.A**	**PC4.B**	**PC4.C**	**PC4.D**	**PC4.E**
Abundance	2	6	64	32	77	19	25	8	44	76	1	4	11	22	34	1	30	10	12	8
No. of taxa	2	4	7	3	7	6	8	5	8	7	1	3	4	5	4	1	3	5	3	5
Sample	**OI1.A**	**OI1.B**	**OI1.C**	**OI1.D**	**OI1.E**	**OI2.A**	**OI2.B**	**OI2.C**	**OI2.D**	**OI2.E**	**OI3.A**	**OI3.B**	**OI3.C**	**OI3.D**	**OI3.E**	**OI4.A**	**OI4.B**	**OI4.C**	**OI4.D**	**OI4.E**
Abundance	3	8	0	2	3	10	0	3	4	7	2	1	0	1	1	4	1	2	0	0
No. of taxa	2	3	0	2	2	3	0	2	1	2	2	1	0	1	1	2	1	1	0	0
Sample	**OC1.A**	**OC1.B**	**OC1.C**	**OC1.D**	**OC1.E**	**OC2.A**	**OC2.B**	**OC2.C**	**OC2.D**	**OC2.E**	**OC3.A**	**OC3.B**	**OC3.C**	**OC3.D**	**OC3.E**	**OC4.A**	**OC4.B**	**OC4.C**	**OC4.D**	**OC4.E**
Abundance	3	3	2	2	9	10	10	0	10	3	3	0	1	3	0	1	9	1	0	3
No. of taxa	1	2	2	2	2	5	3	0	3	2	3	0	1	2	0	1	3	1	0	1

Table E3. Total number of species, abundance, Simpson's diversity and biomass for core samples collected from bait digging survey at Penmon-Beaumaris and Four Mile Bridge.

Sample	FI1.A	FI1.B	FI1.C	FI2.A	FI2.B	FI2.C	FI3.A	FI3.B	FI3.C	FI4.A	FI4.B	FI4.C	FI5.A	FI5.B
Abundance	529	67	273	375	432	151	184	90	227	305	1462	1750	118	39
No. of taxa	14	10	15	13	11	11	12	8	19	17	20	12	9	9
Diversity	0.525	0.624	0.670	0.719	0.473	0.665	0.374	0.649	0.684	0.721	0.677	0.465	0.795	0.765
Biomass	6.723	0.042	0.050	0.820	0.604	0.305	0.068	0.019	0.150	0.085	0.526	0.296	0.210	0.271
Sample	**FI5.C**	**FI6.A**	**FI6.B**	**FI6.C**	**FC1.A**	**FC1.B**	**FC1.C**	**FC2.A**	**FC2.B**	**FC2.C**	**FC3.A**	**FC3.B**	**FC3.C**	**FC4.A**
Abundance	51	69	166	335	26	41	12	31	4	11	4	6	5	32
No. of taxa	7	9	7	12	5	10	6	7	1	5	3	3	2	5
Diversity	0.702	0.680	0.635	0.735	0.444	0.704	0.750	0.520	0.000	0.694	0.625	0.611	0.320	0.586
Biomass	0.041	0.050	0.032	0.096	0.003	0.007	0.038	0.024	0.000	0.003	0.002	0.005	0.010	0.030
Sample	**FC4.B**	**FC4.C**	**FC5.A**	**FC5.B**	**FC5.C**	**FC6.A**	**FC6.B**	**FC6.C**	**PI1.A**	**PI1.B**	**PI1.C**	**PI2.A**	**PI2.B**	**PI2.C**
Abundance	21	16	6	14	4	33	53	29	85	235	106	70	162	99
No. of taxa	9	6	5	4	3	8	9	10	15	18	18	12	15	16
Diversity	0.789	0.781	0.778	0.459	0.625	0.736	0.706	0.633	0.840	0.773	0.853	0.612	0.489	0.585
Biomass	0.628	0.035	7.553	0.001	0.010	0.003	0.215	0.009	0.082	0.114	0.620	0.012	0.108	0.460
Sample	**PI3.A**	**PI3.B**	**PI3.C**	**PI4.A**	**PI4.B**	**PI4.C**	**PI5.A**	**PI5.B**	**PI5.C**	**PI6.A**	**PI6.B**	**PI6.C**	**PI7.A**	**PI7.B**
Abundance	192	339	241	188	209	161	334	158	45	281	389	171	124	495
No. of taxa	12	16	22	24	23	15	19	18	13	18	17	18	21	28
Diversity	0.326	0.226	0.573	0.594	0.519	0.748	0.515	0.587	0.757	0.400	0.253	0.515	0.579	0.412
Biomass	0.096	0.071	0.205	0.274	0.196	0.152	0.233	0.027	0.028	0.051	0.031	0.040	0.131	0.305
Sample	**PI7.C**	**PI8.A**	**PI8.B**	**PI8.C**	**PC1.A**	**PC1.B**	**PC1.C**	**PC2.A**	**PC2.B**	**PC2.C**	**PC3.A**	**PC3.B**	**PC3.C**	**PC4.A**
Abundance	97	91	241	163	63	61	49	28	23	44	97	51	82	68
No. of taxa	15	16	25	21	16	19	14	12	10	16	24	22	19	25
Diversity	0.508	0.725	0.666	0.474	0.635	0.701	0.804	0.834	0.786	0.820	0.788	0.865	0.761	0.747
Biomass	0.028	0.076	1.139	0.102	0.147	0.202	0.054	0.134	0.036	0.026	0.121	0.121	0.392	0.122
Sample	**PC4.B**	**PC4.C**	**PC5.A**	**PC5.B**	**PC5.C**	**PC6.A**	**PC6.B**	**PC6.C**	**PC7.A**	**PC7.B**	**PC7.C**	**PC8.A**	**PC8.B**	**PC8.C**
Abundance	36	49	40	39	42	47	55	109	37	80	43	96	86	62
No. of taxa	8	14	8	13	14	12	16	19	7	15	8	18	19	25
Diversity	0.610	0.633	0.701	0.696	0.838	0.818	0.729	0.522	0.412	0.763	0.433	0.742	0.577	0.825
Biomass	0.030	0.027	0.015	0.013	0.021	0.099	0.110	0.097	0.001	0.035	0.006	0.022	0.065	0.074

Table E4. Total number of species, abundance, Simpson's diversity and biomass for core samples collected from bait digging survey at Angle Bay

Sample No.	AC1.A	AC1.B	AC1.C	AC2.A	AC2.B	AC2.C	AC3.A	AC3.B	AC3.C
Abundance (no. of individuals)	125	67	155	216	95	97	177	153	132
No. of taxa	4	4	9	7	6	9	11	11	9
Diversity (1-λ)	0.108	0.088	0.113	0.249	0.161	0.232	0.325	0.198	0.173
Biomass	2.236	2.674	1.11	2.447	4.667	5.246	4.15	2.334	5.65
Sample No.	**AC4.A**	**AC4.B**	**AC4.C**	**AC5.A**	**AC5.B**	**AC5.C**	**AC6.A**	**AC6.B**	**AC6.C**
Abundance (no. of individuals)	112	149	80	108	62	109	214	116	134
No. of taxa	8	7	4	10	5	2	10	5	11
Diversity (1-λ)	0.154	0.349	0.098	0.194	0.374	0.018	0.545	0.085	0.522
Biomass	21.89	3.726	0.383	0.831	0.411	0.788	4.602	0.855	4.901
Sample No.	**AI1.A**	**AI1.B**	**AI1.C**	**AI2.A**	**AI2.B**	**AI2.C**	**AI3.A**	**AI3.B**	**AI3.C**
Abundance (no. of individuals)	49	55	138	169	124	162	130	95	228
No. of taxa	8	7	8	7	8	11	3	5	6
Diversity (1-λ)	0.575	0.299	0.153	0.227	0.653	0.542	0.075	0.142	0.417
Biomass	0.373	0.334	0.755	0.766	1.603	2.409	0.472	0.525	1.647
Sample No.	**AI4.A**	**AI4.B**	**AI4.C**	**AI5.A**	**AI5.B**	**AI5.C**	**AI6.A**	**AI6.B**	**AI6.C**
Abundance (no. of individuals)	84	82	52	143	114	112	138	109	140
No. of taxa	6	6	6	5	6	8	5	8	5
Diversity (1-λ)	0.48	0.207	0.423	0.17	0.463	0.457	0.529	0.254	0.07
Biomass	2.694	1.569	8.603	3.733	2.057	3.022	0.547	1.29	4.03

Table E5. Total number of species, abundance, Simpson's diversity and biomass for core samples collected from crab sheltering survey.

Sample	DI1_InA	DI1_InB	DI1_Tr	DI2_InA	DI2_InB	DI2_Tr	DI3_InA	DI3_InB	DI3_Tr	DI4_InA	DI4_InB	DI4_Tr
Abundance	41	79	78	52	48	166	85	130	164	19	42	89
No. of taxa	8	7	6	7	5	7	7	10	7	6	5	6
Diversity	0.700	0.603	0.257	0.568	0.355	0.711	0.386	0.627	0.699	0.748	0.450	0.689
Biomass	0.626	0.292	0.108	3.209	0.038	0.199	0.089	3.901	0.625	0.397	0.077	0.122

Sample	DC1_A	DC1_B	DC1_C	DC2_A	DC2_B	DC2_C	DC3_A	DC3_B	DC3_C	DC4_A	DC4_B	DC4_C
Abundance	184	120	157	88	97	132	65	312	77	233	101	276
No. of taxa	8	10	7	10	9	7	10	14	3	14	11	10
Diversity	0.648	0.680	0.553	0.689	0.538	0.548	0.721	0.715	0.169	0.696	0.633	0.627
Biomass	0.149	0.550	0.277	0.459	0.183	0.550	0.101	16.052	0.141	0.828	0.746	0.417
Sample	**BI1_InA**	**BI1_InB**	**BI1_Cen**	**BI2_InA**	**BI2_InB**	**BI2_Cen**	**BI3_InA**	**BI3_InB**	**BI3_Cen**	**BI4_InA**	**BI4_InB**	**BI4_Cen**
Abundance	181	17	30	18	46	19	31	26	31	48	43	92
No. of taxa	9	5	7	8	11	7	5	4	10	8	12	15
Diversity	0.710	0.478	0.669	0.772	0.735	0.776	0.778	0.476	0.851	0.444	0.810	0.706
Biomass	3.726	9.145	0.039	0.087	1.577	0.037	0.132	0.281	0.024	0.356	0.712	0.336
Sample	**BC1_A**	**BC1_B**	**BC1_C**	**BC2_A**	**BC2_B**	**BC2_C**	**BC3_A**	**BC3_B**	**BC3_C**	**BC4_A**	**BC4_B**	**BC4_C**
Abundance	33	27	40	65	30	66	35	41	40	22	22	27
No. of taxa	8	6	13	12	10	11	7	11	9	6	6	7
Diversity	0.742	0.678	0.818	0.802	0.798	0.742	0.749	0.835	0.808	0.752	0.715	0.743
Biomass	1.248	0.435	0.391	1.169	0.310	2.519	0.066	0.399	1.235	0.855	0.400	1.695

Appendix F: Historic Data Descriptions

Table F1. Description of historic datasets used to assess changes in infaunal community composition from the 2024 bait digging survey at Penmon-Beaumaris.

Survey Name	Copyright	Project Contract	Description	References
1997 MNCR east Anglesey littoral survey	Joint Nature Conservation Committee 1999	ISB: 1 86107 466 2	The surveys of Cardigan Bay and north Wales were initiated by The Marine Nature Conservation Review (MNCR), as part of its general survey programme of the coast of Britain, to provide more comprehensive coverage of the coast in MNCR Sector 10 (between Cwm-yr-Eglwys in Pembrokeshire, and Rhos Point in Conwy). The data from these surveys have been used to describe the biology of each section of coast thus enabling assessment of their natural heritage importance. Survey protocol followed standard MNCR recording and infaunal sampling techniques (Connor & Hiscock 1996). The samples were obtained by means of a 0.0083m2 core or a 0.1m2 Day grab for biological and sediment particle size. These were combined and sieved over a 0.5 mm mesh sieve. Material retained on the sieve was preserved in seawater-formalin for subsequent identification and enumeration of the species present. A separate sediment sample was taken for particle-size analysis.	Brazier, D.P., Holt, R.H.F., Murray, E., & Nichols, D.M. 1999. Marine Nature Conservation Review Sector JO. Cardigan Bay and north Wales: area summaries. Peterborough, Joint Nature Conservation Committee. (Coasts and seas of the United Kingdom. MNCR series.)
2002 CCW Marine mud and muddy gravel characterisation in the Menai Strait	Countryside Council for Wales	FC 73-02-221	This survey was undertaken to characterise the intertidal communities with the Menai Strait and Conwy Bay SACs. Species lists for these habitats within the Menai Strait have not been compiled since 1982. Intertidal core sampling was undertaken during August 2002 using MNCR Phase 2 sampling methodologies	Barnes. 2003. Marine mud and muddy gravel characterisation in the Menai Strait. CCW Contract Science Report No 564

Survey Name	Copyright	Project Contract	Description	References
			and recording forms (Hebog Environmental), and a total of 21 samples were collected, for both macrofaunal and granulomametric analysis, at 7 sites along the Anglesey coastline of the Menai Strait, from Lleiniog at the northern end of the Strait to Barras at the southern end. At each sample point, 8 cores of diameter 10.3cm, depth 20cm, were taken for macrofaunal analysis using a stainless steel hand corer. These 8 cores were combined and placed in a 25 litre plastic bucket for convenient transportation off the shore. No sample processing was undertaken on-site. A further sample of sediment was taken for granulometric analysis using a 5cm diameter corer to a depth of 15cm. Macrofaunal samples were initially processed using a Wilson Autosiever and a 0.5mm sieve mesh. Sieved samples were preserved in 4% (or greater) buffered saline formalin (buffered with hexamethylene tetramine) and stained with Rose Bengal (4g/l of 40% formaldehyde).	
2004 CCW / IECS Menai Strait & Conwy Bay SAC muddy gravel (LMX) epibiota monitoring	Countryside Council for Wales	FC 73-02-291	The Institute of Estuarine and Coastal Studies (IECS) was commissioned by the Countryside Council for Wales (CCW) to carry out an intertidal survey in order to establish the extent and quality of muddy gravel biotopes as well as characterise the infaunal community. Intertidal core sampling was undertaken in August 2004 by IECS using the same MNCR Phase 2 sampling methodologies (i.e. 0.01m2 corer and sieved over a 0.5mm mesh). Five core replicates were taken in each area of muddy gravel along with a particle size analysis (PSA) sample to identify infaunal biomass and sediment characteristics respectively. These were taken at sites previously sampled for comparability.	Allen, J.H., Boyes, S. & F. Burlinson. 2008 Intertidal Monitoring of muddy gravels in Menai Strait and Conwy Bay SAC. CCW Marine Monitoring report No 45.

Survey Name	Copyright	Project Contract	Description	References
2013 NRW/ASML Menai Strait and Conwy Bay SAC muddy gravel survey	Natural Resources Wales	Aquatic Survey and Monitoring Ltd. 330 MFG 11 / WDM002	The survey formed part of the Menai Strait and Conwy Bay SAC intertidal monitoring programme. The overriding objective of the survey was to establish the reference condition for the Menai Strait and Conwy Bay SAC, using established monitoring stations to describe natural and unnatural changes in the communities. Five 0.01 m2 core sample are taken from each station and sieved through a 0.5 mm mesh. Each sample was transferred to a bag or pot, and individually labelled. A sample of sediment was also collected from each station for granulometry analysis. The samples were preserved in formalin and transported to an accredited laboratory for analysis of the infauna and the sediment granulometry.	Moore, J. 2018. Menai Strait and Conwy Bay SAC intertidal monitoring summary, 2010 to 2017. NRW Evidence Report No. 301, 50+ix pp, Natural Resources Wales, Bangor

Table F2. Description of historic datasets used to assess changes in infaunal community composition from the 2024 bait digging survey at Angle Bay

Survey Name	Copyright	Project Contract	Description	References
1982 Rostron PMSA -Milford Haven sediment survey	Institute of Petroleum	PMSA (Pembrokeshire Marine Species Atlas)	This survey was collated as part of the Pembrokeshire Marine Species Atlas project by SubSea Survey. The samples were obtained by means of a 0.1 m² Day grab, for biological, sediment particle size, trace metal and hydrocarbon analyses. Infaunal samples were sieved over a 1 mm sieve. The objectives of the 1982 benthic survey were to make a thorough investigation of the distribution of species and communities in relation to environmental factors, and also to note possible effects of industrial activity within the survey area.	Rostron (1983) Biological survey of sediments within Milford Haven Estuary, April 1982.
1996-97 Rostron PMSA -Sea Empress oil spill sediment shore impact assessment	Countryside Council for Wales	PMSA	This survey was collated as part of the Pembrokeshire Marine Species Atlas project by SubSea Survey. The work was carried out under contract to CCW in response to the Sea Empress Oil Spill. Therefore, the copyright for the collation rests with CCW, however, the IPR of the individual surveys remains with the person/organisation named in the copyright field. OLIB Metadata URI: 24328 / 110337	Rostron (1998) Sea Empress oil spill sediment shore impact assessment. The infauna of heavily oiled shores in Milford Haven and Carmarthen Bay. CCW Sea Empress Report 244.
2008 CCW / ASML Pembrokeshire	Countryside Council for Wales	FC 73-02-342	The Habitats Directive establishes that the management of Special Areas of Conservation (SACs) should aim to achieve the favourable	Bunker (2012) Intertidal SAC monitoring *Zostera*

Survey Name	Copyright	Project Contract	Description	References
Marine SAC Zostera noltii Monitoring			conservation status of habitat and species features. In the case of SACs, the features are the habitats and/or species listed in Annex I and Annex II of the Habitats Directive for which the individual site has been selected. CCW developed a programme of intertidal monitoring work across Wales during 2004 and 2005. These surveys were managed and implemented for CCW by the Institute of Estuarine and Coastal Studies (University of Hull). These projects focused on a wide range of sensitive habitats such as Zostera, muddy gravels, caves, rock pools, algal dominated rocky shores, Sabellaria reefs, under-boulders, and various rare habitats and species. Aquatic Survey & Monitoring Ltd. (ASML) have been contracted by CCW to continue development and management of the intertidal monitoring programme for each marine SAC for the period 2006 to 2011; working as a team with CCW HQ and CCW Regional staff. Pembrokeshire Marine SAC was selected for eight Habitats Directive Annex I habitat types and five Annex II species. The aim of this survey was to initiate eelgrass *Zostera noltii* monitoring at Angle Bay in Milford Haven. The boundary of the eelgrass bed was defined using a GPS in tracking mode. Quadrat sampling was carried out on a grid approach, across the denser area of the bed, recording, in addition to eelgrass cover, other valuable parameters such as water cover, substratum type and other species observed within the quadrat. Metadata record: 115176	*noltii* in Angle Bay, Pembrokeshire Marine SAC 2008. CCW Marine Monitoring Report No: 74

Data Archive Appendix

Data outputs associated with this project are archived in Marine Recorder Online on server–based storage at Natural Resources Wales.

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] Raw Survey Data in Excel Format.

[C] Bait Digging Survey data held in Marine Recorder.

Metadata for this project is publicly accessible by emailing EvidenceReportsandSubscriptions@cyfoethnaturiolcymru.gov.uk. The metadata is held as record NRW_DS161356.

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