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An Evaluation of the Current Use of Farmed vs Wild-Caught Ragworm Bait in Wales

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Crynodeb Gweithredol

Mae cynhyrchu abwyd i enweirwyr môr, trwy gasglu abwyd gwyllt neu ffermio, a'i werthu wedyn yn ddiwydiant gwerth uchel. Er enghraifft, amcangyfrifodd Monkman ac eraill (2015) fod genweirwyr Cymru wedi gwario tua £11.1 miliwn ar abwyd mewn un flwyddyn (2013). Mae'r gadwyn gyflenwi ar gyfer abwyd y môr yn seiliedig ar farchnad anffurfiol iawn sy'n cynnwys cyflenwadau o rywogaethau alltraeth wedi'u pecynnu, abwyd o fentrau dyframaethu penodol, a chasglu abwyd gwyllt rhynglanwol gan gasglwyr hamdden a chasglwyr masnachol. O ganlyniad, mae dealltwriaeth o'r maes hwn yn gyfyngedig. Ar hyn o bryd, mae casglu abwyd rhynglanwol, neu gasglu ar y draethlin, yng Nghymru yn bryder i Cyfoeth Naturiol Cymru (CNC) oherwydd yr effeithiau hysbys ar yr amgylchedd morol mewn rhai ardaloedd.

Nod yr adroddiad hwn yw gwerthuso'r defnydd presennol o abwyd melys sy'n cael eu ffermio o'u cymharu ag abwyd melys sy'n cael eu dal yn wyllt yng Nghymru, a nodi'r rhwystrau i ddefnyddio abwyd melys sy'n cael eu ffermio fel ffordd o atal stociau o abwyd melys gwyllt rhag cael eu hecsbloetio. Mae'n argymell nifer o fesurau y gellir eu cymryd i annog y defnydd o abwyd melys wedi'u ffermio er mwyn lleddfu'r pwysau ar yr amgylchedd morol. Er mwyn gwella dealltwriaeth o'r gadwyn cyflenwi abwyd, fe wnaethom ymgysylltu â'r holl randdeiliaid perthnasol yn y gymuned abwyd trwy gyfweliadau a holiaduron ar-lein, gyda chymysgedd o gwestiynau meintiol cymaradwy ac atebion pen agored manwl. Cyflwynir canfyddiadau genweirwyr, manwerthwyr (siopau a dosbarthwyr) a chyflenwyr (ffermydd a chasglwyr) i lenwi naw 'bwlch gwybodaeth'. Roedd anawsterau o ran ymgysylltu â chyfranogwyr wedi arwain at sampl o faint cymharol fach. Dylid ystyried yr adroddiad hwn felly fel un sy'n cyflwyno amrywiaeth o farnau dilys am y farchnad, yn hytrach na sampl gynhwysfawr neu gwbl gynrychioliadol. Mae'r drafodaeth yn cyflwyno golwg gytbwys o'r farchnad ac yn gwneud rhai argymhellion ar ddyfodol cyflenwi abwyd, yn benodol ffermio abwyd melys, i gwrdd â galw'r farchnad yng Nghymru.

Mae cyfweliadau â genweirwyr môr, perchnogion siopau abwyd, a ffermydd abwyd melys yn dangos y gall casglu abwyd melys gwyllt yng Nghymru fod ar 'drobwynt' naturiol, lle na all siopau stocio'r abwyd melys gwyllt sydd eu hangen arnynt i ateb y galw. Rhoddodd y cyfranogwyr lawer o resymau dros y cyflenwad cyfyngedig o abwyd melys gwyllt a allai ddwysáu a gwaethygu ei gilydd, gan gynnwys: bod y mwyafrif o'r casglwyr masnachol a chasglwyr hamdden yn mynd yn hen; mae'n well gan y genhedlaeth iau brynu abwyd; canfyddiad rhai unigolion bod y stociau gwyllt wedi gostwng; cost uchel tanwydd; tywydd anoddach ei ragweld; ac, yn y pen draw, llai o gloddwyr masnachol ar lannau Cymru nag yn y 2000au cynnar. O ganlyniad, mae siopau abwyd yn ei chael hi'n anodd dod o hyd i ddigon o abwyd melys ar gyfer eu cwsmeriaid, ac mae'r unig fferm abwyd melys yng Nghymru yn ei chael hi'n anodd cadw i fyny â'r galw presennol. Awgrymodd y cyfranogwyr, er mae'n bosibl bod llai o enweirwyr erbyn hyn o gymharu â diwedd y 1990au, bod galw siopau am abwyd o ffermydd ar gynnydd oherwydd yr argaeledd cyfyngedig o abwyd gwyllt. Datgelodd cyfweliadau â fferm abwyd melys yn yr Iseldiroedd fod y duedd hon yn y farchnad wedi digwydd mewn ffordd debyg yn y farchnad abwyd melys yn yr Iseldiroedd ar ddiwedd y 1980au. Dechreuodd cloddwyr masnachol ymddeol, a phan ddechreuodd y ffermydd abwyd melys gynnig treialon abwyd am ddim yn ystod y cyfnodau o alw mwyaf, fe wnaethon nhw ddarbwyllo siopau y gallen nhw ddarparu cyflenwad cyfleus a chyson o abwyd ac, wrth wneud hynny, gwnaethant atal cenhedlaeth newydd o gasglwyr abwyd melys gwyllt rhag cymryd y fantell.

Er gwaethaf rhywfaint o ganfyddiad bod abwyd melys sy'n cael eu ffermio o ansawdd gwaeth nag abwyd melys sy'n cael eu dal yn wyllt, datgelodd holiaduron fod y mwyafrif o'r genweirwyr môr yn fodlon defnyddio abwyd sydd wedi'u ffermio os nad oes abwyd gwyllt ar gael. Maent yn ystyried cynaliadwyedd y stociau yn flaenoriaeth uchel wrth wneud eu penderfyniadau prynu. Mae'r adroddiad yn archwilio ffactorau pwysig i'w hystyried wrth hysbysebu abwyd sydd wedi'u ffermio. Mae'n nodi, er bod genweirwyr môr weithiau'n gyndyn i ddewis abwyd sydd wedi'u ffermio, y maen nhw'n gallu cael eu darbwyllo i'w prynu os ydyn nhw'n gallu dibynnu ar ansawdd yr abwyd (yn enwedig yn ymwneud ag oes silff stociau byw o siopau) a chyflenwad cyson, ynghyd â gostyngiadau i'r pris neu dreialon am ddim. Roedd yn well gan y genweirwyr môr a holwyd gyflenwadau cynaliadwy ac abwydau lleol, ond mae angen ymchwil yn y maes hwn, gan nad oes asesu na labelu o ran cynaliadwyedd ar hyn o bryd ar gyfer ffermydd abwyd melys na stociau a ddaliwyd yn y gwyllt.

Mae'r dystiolaeth a gasglwyd drwy holiaduron a chyfweliadau â ffermydd abwyd melys yn awgrymu bod siopau abwyd yn ei chael hi'n anodd dod o hyd i ddigon o abwyd melys gwyllt, neu abwyd melys wedi'u ffermio'n lleol, ar gyfer eu cwsmeriaid. Mae hyn yn arbennig o wir yn ystod cyfnodau anarferol o braf, ar adegau brig o wyliau, ac yn ystod tymor bridio abwyd melys (mis Chwefror tan fis Mawrth). Pe bai siopau sy'n gwerthu abwyd melys gwyllt yn unig ar hyn o bryd yn newid i werthu abwyd melys sydd wedi'u ffermio, mae'n debygol y byddai mwy o brinder yn y cyflenwad i enweirwyr môr. Y rheswm am hyn yw bod yr unig fferm abwyd melys yng Nghymru eisoes yn ei chael hi'n anodd cadw i fyny â'r galw yn ystod y cyfnodau prysuraf, fel gwyliau cyhoeddus ac yn ystod tymor bridio abwyd melys. Gallai hyn beri'r risg y bydd prynwyr yn dod o hyd i abwyd melys gwyllt neu abwyd gwyllt eraill. Mae gan hyn y potensial i gyflwyno rhywogaethau abwyd estron, a symud cloddio i leoliadau newydd.

Mae'n debygol y bydd angen cyfuniad o gamau gweithredu tymor byr a thymor hir i symud y farchnad abwyd i ffwrdd o abwyd melys gwyllt. Yn seiliedig ar dystiolaeth gan ddefnyddwyr, gwerthwyr a chyflenwyr abwyd a holwyd yn ystod y prosiect hwn, mae nifer o opsiynau posibl yn codi:

- Mae cod ymddygiad newydd ar gyfer casglu abwyd a ddatblygwyd gan CNC mewn prosiect cyfochrog yn annog arferion casglu mwy cynaliadwy a defnyddio abwyd melys sydd wedi'u ffermio. Gellid hefyd ystyried ymgyrch addysgu ehangach, gan weithio gyda dylanwadwyr genweirio poblogaidd ar y cyfryngau cymdeithasol.

- Annog ffermwyr presennol a diweddar yng Nghymru a'r DU i dyfu eu cynhyrchiant i gadw i fyny â'r galw.

- Annog ffermydd abwyd melys i archwilio cynaliadwyedd, a gwella eu cynaladwyedd presennol, trwy ystyried deunyddiau pecynnu a deiet yr abwyd melys.

- Cefnogi astudiaethau dichonoldeb ar gyfer arallgyfeirio’r farchnad abwyd, gan gynnwys ymchwil i ddatblygu mathau eraill o abwyd byw ac nad ydynt yn fyw y gellid eu cynhyrchu a’u defnyddio yng Nghymru.

- Ymchwilio i gyfleoedd ar gyfer ffermio cydweithredol cymunedol, neu fentrau cymdeithasol, o bosibl yn defnyddio system amldroffig, neu fodelau economi gylchol.

- Annog datblygiad cymdeithas benodol ar gyfer y diwydiant abwyd, i hwyluso trafodaethau yn y dyfodol.

Mae angen buddsoddiad ar yr holl gamau gweithredu arfaethedig hyn, a bydd yn cymryd amser sylweddol i'w gwireddu. Yn y cyfamser, mae perygl i'r amgylchedd morol trwy or-gasglu abwyd melys gwyllt o ganlyniad i gyflenwad cyfyngedig o gynhyrchion fferm. Dylai camau gweithredu i wella cynaliadwyedd y stociau abwyd trwy ffermio fod o fudd i ecosystemau arfordirol ac, ar yr un pryd, cefnogi un o weithgareddau hamdden mwyaf y DU. Bydd hyn yn cefnogi llesiant cenedlaethau o enweirwyr môr y dyfodol yng Nghymru.

Executive summary

The production of bait for sea anglers, through wild collection or farming, and its subsequent sale is a high value industry. For example Monkman et al (2015) estimated that resident Welsh anglers spent approximately £11.1M on bait in a single year (2013). The sea bait supply chain is based on a very informal market comprising supplies of packaged offshore species, farmed baitworm from specific aquaculture ventures and intertidal collection of wild baits by recreational and commercial collectors. As a consequence, understanding of this area is limited. Intertidal, or shoreline bait collection in Wales is currently a concern for Natural Resources Wales (NRW) due to known impacts on the marine environment in some areas.

This report aims to evaluate the current use of farmed vs wild-caught ragworm bait in Wales and identify barriers to the use of farmed ragworm as a means to alleviate the exploitation of wild ragworm stocks. It recommends a number of measures that can be taken to encourage the use of farmed ragworm bait and hence alleviate pressure on the marine environment. To enhance understanding of the bait supply chain, we engaged with all relevant actors in the bait community through interviews and online questionnaires, with a mix of comparable quantitative questions and detailed open answers. The perceptions of anglers, retailers (shops and distributors) and suppliers (farms and collectors) are presented to fill nine 'knowledge gaps'. Difficulties engaging participants resulted in a relatively small sample size. This report should therefore be seen as presenting a range of valid opinions of the market, rather than an exhaustive or entirely representative sample. The discussion presents a balanced view of the market and makes some recommendations on the future of bait supply, specifically ragworm farming, to meet Welsh market demands.

Interviews with sea anglers, bait shop owners and ragworm farms show that the collection of wild ragworm in Wales may be at a natural 'turning point', whereby shops cannot stock the wild-captured ragworm that they require to meet demand. Participants gave many reasons for the limited availability of wild ragworm supplies that may both confound and compound each other, including: that most commercial and recreational collectors are ageing; the younger generation would rather buy bait; a perceived reduction in wild stocks by some; the high cost of fuel; more unpredictable weather, and ultimately fewer commercial diggers on Welsh shores than in the early 2000s. As a result, bait shops are struggling to source enough ragworm for their customers, and the only ragworm farm in Wales is struggling to keep up with current demand. Participants suggested that despite potentially lower numbers of anglers than in the late 1990s, shop demand from farms is in a phase of growth due to limited availability of wild baits. Interviews with a Dutch ragworm farm, revealed that this market trend occurred in a similar way in the ragworm market in Holland in the late 1980s: commercial diggers started retiring and when the ragworm farm started offering free bait trials in peak periods they convinced shops that they could provide a convenient and consistent supply of bait and in doing so halted the start of a new generation of wild ragworm collectors.

Despite some perception that farmed ragworm is inferior in quality to wild-captured ragworm, questionnaires revealed that most sea anglers are willing to use farmed bait if wild bait is unavailable. They consider sustainability of the stocks a high priority in their purchasing choices. The report explores important factors to consider when advertising farmed bait, identifying that although sea anglers are sometimes reluctant to choose farmed bait, they might be persuaded if they have guaranteed quality assurance (particularly relating to shelf life of live shop stocks), guaranteed consistency in supply, coupled with price discounts or free trials. Sea anglers questioned exhibited a preference for sustainable supplies and local baits, but research is needed in this area, as there is currently no sustainability assessment or labelling for ragworm farms or wild-caught stocks.

The evidence collected through questionnaires and interviews with ragworm farms suggest that bait shops are struggling to locally source enough wild or farmed ragworm for their customers, particularly in un-seasonally good weather, at peak holiday times and in ragworm breeding season (Feb-March). If shops currently stocking only wild-caught ragworm move from wild to farm suppliers, there would almost certainly be more shortages in ragworm supply for sea anglers since the only ragworm farm in Wales is struggling to keep up with current demand during peak times, such as public holidays and during the period of ragworm breeding. This could lead to the risk of buyers sourcing wild ragworm or other wild baits. This has the potential to introduce non-native bait species and to displace digging activity to new locations.

Shifting the bait market away from wild ragworm, is likely to require a combination of short and long term actions. Based on evidence from bait users, sellers and suppliers questioned during this project a number of potential options arise:

- A new code of conduct for bait collection developed by NRW in a parallel project encourages more sustainable collection practices and the use of farmed ragworm. A wider education campaign working with popular angling social media influencers could also be considered;

- Encouragement of existing and recent Welsh and UK farmers to grow their production to meet demand;

- Encouragement of ragworm farms to investigate and improve their sustainability through consideration of packaging materials and ragworm diet;

- Supporting feasibility studies for the diversification of the bait market, including research and development of alternative live and non-live baits that could be produced and used in Wales.

- Investigation of opportunities for community co-operative farming, or social enterprise, possibly feeding from within multitrophic system, or circular economy models;

- Encourage the development of a specific bait industry association, to establish a communication pathway for future dialogues.

These proposed actions all require investment and will take significant time to bring to fruition. In the meantime, there is risk to the marine environment through over-collection of wild ragworm owing to limited supply of farmed product. Actions to improve sustainability of bait stocks through farming should benefit coastal ecosystems whilst supporting one of the biggest UK leisure activities, thus supporting the well-being of future generations of sea anglers in Wales.

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Introduction

The production of bait for sea anglers, through wild collection or farming, and its subsequent sale is a high value industry. For example, Monkman et al (2015) estimated that resident Welsh anglers spent approximately £11.1M on bait in a single year (2013). A review of grey and published literature revealed limited information about sea angling bait supply chains in Wales, possibly as it is often a very informal market comprising the collection of wild shoreline species by recreational and commercial collectors, and baitworm aquaculture). There is an increasing body of evidence that the collection of bait can be detrimental to the habitats in which target species live (Morrell, 2009; Evans et al. 2015; Perrins et al. 2020). Despite this, recreational wild bait collection remains unregulated, and the law around commercial bait collection is complex and difficult to enforce (Bean & Appleby, 2014; Pombo et al. 2020; Morris-Webb, 2021).

Live ragworm is a popular live bait amongst recreational sea anglers across the UK, including Wales. There can be some confusion over the naming of species, not least because some of the Latin names have changed over time, and the common names are used differently among regions. British Sea Fishing https://britishseafishing.co.uk/ragworm-species-identification/ makes a useful attempt to clarify the situation:

King Ragworm (*Alitta virens*) '*The largest species of ragworm which is commonly used as bait in sea fishing. Can be up to 90cm long but is usually around 30cm. This species used to have the scientific name Nereis virens which is still commonly used, leading to confusion*'

Common 'Red' Ragworm (*Perinereis cultrifera*) '*A smaller species of ragworm, growing up to round 20cm in length, which is also commonly used as bait. Also known as red ragworm. This is a separate species, although many anglers and bait collectors may confuse this species with either small king ragworm or harbour ragworm, as they all live in the same habitat*'.

Harbour Ragworm (*Hediste diversicolor*) '*A much smaller species, usually growing to around 8-10cm. Identifiable by the red blood vessel running along its body this species is also known as mudworm, muddies, maddies, creeper rag and a range of other regional names. Confusion arises because the scientific name Nereis diversicolor has also been applied to this species, making people believe it is a separate species*.'

White Ragworm (*Nephtys* spp.) '*There are a number of species are classed as white ragworm by anglers, all of which are in the Nephtys genus. They include Nephtys caeca, Nephtys cirrosa, Nephtys kersivalensis and Nephtys assimili, but the most common is Nephtys hombergii. Since they are so similar (only marine biologists and other experts can tell them apart) they are considered as a single species by anglers and bait collectors. Most grow to 15cm in length, but some can be over 30cm. Colour varies from pale yellow to while, sometimes with a pinkish or reddish tinge*.'

Ragworm is dug from suitable habitats around the country by recreational sea anglers for their own use, and by commercial bait diggers to be sold in bait shops and informally, directly to anglers around the country. The ragworm market has significant value with Watson et al (2017) estimating the wild caught king ragworm (*A. virens)* market in the UK to be valued at £52 million per year. Three ragworm farms have supplied an unknown proportion of the UK ragworm market since the 1980s (Fowler 1999). Discussion with the angling trade industry, and specifically bait diggers, suggested that wild baits were becoming increasingly scarce on some shores in the late 1990s (Fowler 1999). However, in 2015 there was still a dependence on ragworm as a live bait, when a survey of 133 sea anglers in Wales found that 61% of respondents still used king ragworm, over 56% used harbour ragworm and approximately 25% used white or silver ragworm (Monkman et al. 2015). (NB It is worth noting the different interpretations of ragworm identification/naming outlined above in considering these data). The same survey found that between 10-21% of sea anglers surveyed collected their own ragworm, and it was hypothesised that this could be due to the lack of consistent availability of these baits in angling shops (Monkman et al. 2015).

Three aquaculture farms have been known to supply live ragworm bait to the UK: 1) Seabait Ltd., a small, research driven, University spin-out farm in northeast England which started production in 1984, reaching production of 30 tonnes per year with a retail value of £750K in the late 1990s (Fowler 1999); 2) Topsy Baits Ltd., a larger business venture which realised the gap in the market and started commercial production in the Netherlands in 1985 (Olive 1999, Pombo et al. 2020); 3) Dragon Baits Ltd., in Wales that opened in 2000 (Dragon Baits *pers. comm.*), reaching full production in 2004 (Barnett 2017). In other countries, live angling bait worm production has become a lucrative industry for the live angling bait and aquaculture feed markets, but the UK has struggled in maintaining farm production owing to various factors including the curtailing of warm water supply from a local power station to Seabait Ltd.

There has been growing concern that collection of wild ragworm compromises conservation objectives of the intertidal mudflat and sandflat feature within the Pembrokeshire Marine SAC. In 2007, one report extrapolated bait ragworm demand from 23 bait outlets in West Wales (Port Talbot to Newquay) to be approximately 194Kg, or 29,095 worms, per week, approximately a quarter of which, 49kg, was wild dug locally and mainly from the Gann (Morrel 2009). Although this data must be treated with caution as only 6 of the 23 shops were willing to give detail on their ragworm sales and supplies, it does demonstrate potential impacts ofintense localised collection. A locally co-produced voluntary management plan / no digging zone at the Gann was introduced but met with limited success owing to non-compliance (NRW 2020, unpublished).

Concern from NRW regarding the potential impact of bait digging in Wales is demonstrated by the commissioning of a number of pieces of work: 1) investigation of the location and intensity of bait digging in Wales (Perrins et al. 2020); 2) impacts of ragworm digging (Evans et al. 2015) and 3) future management options for NRW and Welsh Government (West et al. 2022). The review of management options by West et al (2022) made suggestions regarding the implementation and monitoring of voluntary measures which they considered can be a useful approach prior to implementation of hard legislation (that could lead to displacement of activities). West et al (2022) also suggested that new co-produced approaches to management should be tested to nurture some ownership, compliance and even self-policing of the management of the bait stock.

The current project engages the angling and bait community to provide evidence on the bait market in Wales and to explore opportunities for more farmed ragworm production. Specifically the project aims to: evaluate the current use of farmed vs wild-caught ragworm bait in Wales, identify any barriers to the use of farmed ragworm bait, and, with those barriers in mind, recommend measures that can be taken to encourage the use of farmed ragworm bait.

This report aims to inform NRW and the bait industry regarding the feasibility of increased farmed ragworm production as a means to alleviate the pressure on the environment due to wild collection methods. This research aims to inform long standing knowledge gaps in the following themes around the Welsh recreational sea angling bait market:

1. Perceived changes in bait collection
2. Supply and demand in the Welsh ragworm market in recent years;
3. Factors influencing where sea anglers buy ragworm;
4. Cost differences between wild caught and farmed ragworm;
5. The market for more farmed ragworm in Wales;
6. Sufficiency of farmed ragworm supplies to meet market demand;
7. Barriers limiting the growth of the Welsh farmed ragworm market;
8. Potential incentives to persuade sea anglers to choose farmed over wild ragworm;
9. Potential for co-operative ragworm farming in Wales.

The results of interviews and questionnaires are combined and presented under these nine themes, from the perceptions of the angler, bait retailer (all shops) and bait supplier (farms and collectors). The discussion brings these perspectives together and makes some recommendations on the future of bait production, and specifically ragworm, in Wales.

Methods

The sea angling bait industry is a ‘hidden’ market with very little commercial data on the size of the market or where bait comes from. Many people in the bait supply network, from the suppliers of bait to the individual angler (potential buyer), are widely dispersed individuals, often difficult to find and even more challenging to engage. It is the experience of the report authors of a long history of distrust around the network, especially externally with government and conservation agencies, but also with researchers, which is evident in the lack of successful survey attempts amongst the community. In 2012 it was estimated that there were 76,000 sea anglers resident in Wales (Armstrong et al. 2013), yet the most successful national survey which incentivised participation of sea anglers in 2013 only gleaned 141 responses from bait-using sea anglers, despite intensive advertising through magazines, Facebook pages, equipment retailers, bait shops and clubs (Monkman et al. 2015).

Other approaches to Welsh bait collectors, shops and sea anglers have included participatory mapping of fishing / collection grounds (FishMap Mon: Aron et al. 2014), targeted surveys of sea angling catch with anglers on beaches (Goudge & Morris, 2011), interviews regarding declining crab stocks (Morris et al., 2007) and specifically the Gann voluntary no-digging zone (NRW 2016). All have struggled to effectively engage with relevant parties for various reasons including unresolved conflict in dialogues, secrecy over well-guarded fishing behaviours or incomes, fear of licensing / prohibition, and even non-compliance with co-produced voluntary management areas. Surveyors have noted that approaching bait diggers on the beach can be seen as confrontational and resulted in lack of engagement (Watson et al. 2015), whilst approaching participants with ‘other than conservation’ or ‘self-gain’ narratives triggered by their own interest in the topic has proved more successful (Morris et al. 2007, Morris-Webb, 2021). Difficulties engaging with bait collectors and sea anglers has resulted in assumptions about the activities of bait collectors from observations (Morris et al. 2012), potentially feeding distrust in transparent management. Previous attempts to bring bait collectors together to create codes of conduct in workshops and focus groups have also struggled to involve the most relevant stakeholders, the bait collectors themselves. This may have resulted in bait collectors being ‘represented’ by angling clubs, angling governing bodies and recreational collectors, rather than by commercial bait collectors, specific bait collection bodies or shops. It is important to ensure a balance of all relevant knowledge in any co-creation dialogue.

Sampling Design

This project, named during the co-creation process by stakeholders as ‘Secure our Future Bait’ aimed to ensure inclusion of relevant members of the bait supply chain by avoiding a workshop setting and instead advertising the self-gain framing of participation through networks trusted by the target participants (bait collectors, bait retailers and sea anglers). As trust is important for any survey data to be accurate, we aimed to build trust through a three phase engagement process (Figure 1). Engagement initially involved the co-creation of a code of conduct with Angling Cymru and the piloting of the Code with key gatekeepers (respected and trusted members of the bait and angling community who could advertise the project to their networks) (not reported on here). This was followed by questionnaires to investigate bait supply and demand, delivered by semi-structured telephone interviews with ragworm farm owners, targeted face to face structured interviews with bait shops, and single submission online questionnaires of wider community (commercial bait collectors, recreational bait collectors and sea anglers). The strategic design aimed to ensure that the dissemination of final online questionnaires would snowball through the gatekeepers who were involved in development and piloting of the Code of Conduct, advertising through industry ‘champions’ (a respected member of the relevant community willing to ‘champion’ the project through advertising), and targeted mail shots to relevant angling and bait contacts. The advert sent to dissemination contacts was short and uniform to minimise introduction bias:

> *"Do you collect, buy or sell bait? The 'Secure our Future Bait' project aims to understand the bait market & has been co-creating a new code of conduct for bait collectors. Please take a look - it is important to get your opinions in this survey https<surveylink> ".*
>
> *“Do you collect, buy or sell bait? Then please click on the link below to take part in this survey. Angling Cymru has teamed up with Bangor Uni & Natural Resources Wales for the 'Secure our Future Bait' project. Everybody interested in bait has the right to contribute!”*

To avoid potential respondent bias from conservationists and ocean scientists, questionnaires were deliberately not advertised through NRW or Bangor University.

Phases 1 and 2 (see figure 1) are not presented in the results, as this report focuses on the consultation (or testing) of the co-created code of conduct in Phase 3. Methods and results that follow relate to Phase 3 alone.

This project was approved by Bangor University College of Environmental Sciences and Engineering Ethics and Governance Committee, Ref COSE2024LMWBait01A. All participants were given prior informed consents and opted into the survey. Participation in Phase 3 was anonymous. Shops, commercial collectors and bait farms were given additional information in their consents regarding the use and anonymisation of their commercial data.

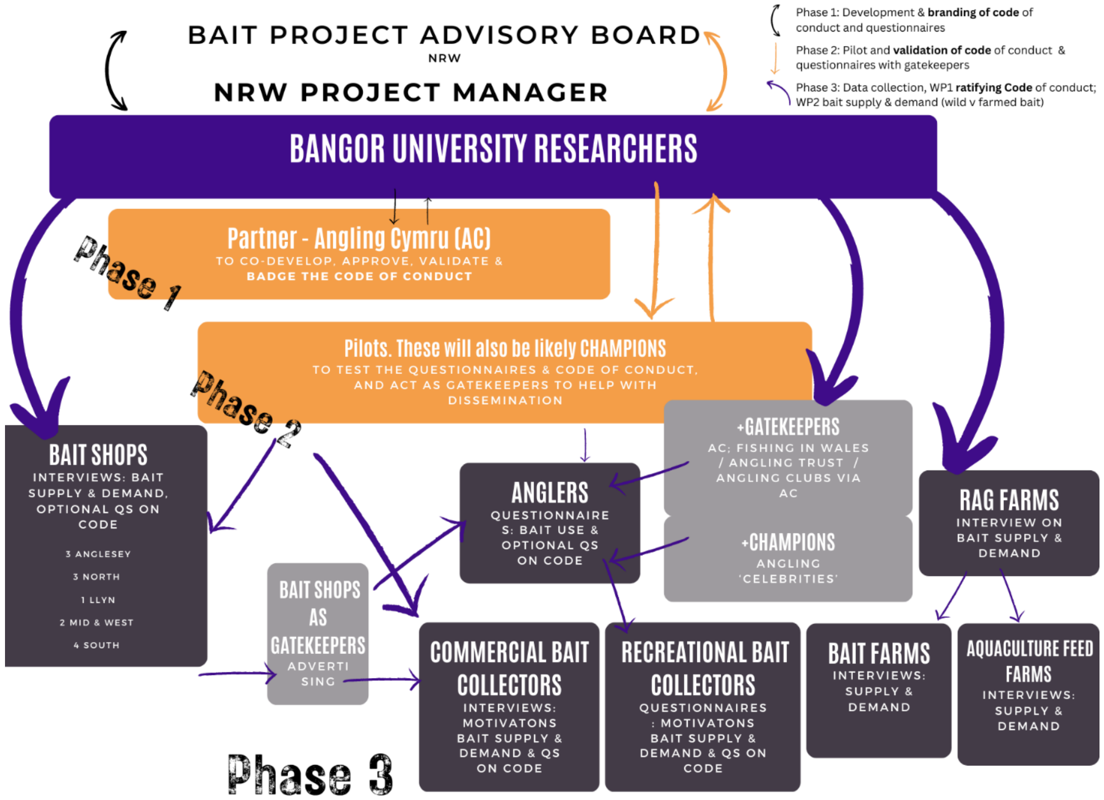

Figure 1 Three phase engagement process and sampling design for the Secure our Future Bait Project.

Questionnaires

Bilingual online questionnaires (hosted by KoboToolBox), available in English and Welsh, were programmed with complex routing to suit sea anglers, recreational bait collectors, commercial collectors and angling shops. Respondents were limited to one response per device, reducing potential bias from one person responding multiple times on a single device. Face to face structured interviews asked the same questionnaire specifically to bait shop managers/ owners and commercial collectors, and the interviewer submitted the data into a separate, multiple submission form on KoboToolBox.

Following a literature review and extensive discussion with the NRW project steering group, 74 questions were incorporated into the questionnaire (Supplementary Information 1: see items [B] and [C] in the Data Archive Appendix). The number of questions any respondent would be asked ranged from 9 questions for an angler who does not use ragworm bait, and does not collect bait themselves, to 61 questions for an angler or shop owner who uses and collects their own ragworm. The questions included a pilot of the co-created code of conduct developed during phase 1 of the project (Appendix 2).

Semi-structured interviews

Ragworm farm owners were telephone / online interviewed using a semi-structured interview topic guide (Supplementary Information 2: see item [D] in the Data Archive Appendix). Interviews discussed 67 questions, including describing the running of the farm, provide detail of barriers to farmed bait production, distribution, and past and future markets. Many questions were rich open answers, to draw answers around the nine research themes. Farm interview transcripts cannot be shared due to commercial sensitivity, but the data has been treated sensitively and presented as quotes and summarised in the results section where appropriate.

Questions per research theme

Of the 74 questions asked in the questionnaire, 16 questions were asked to provide a profile of the respondents. These included basic demographics (age, gender they identified as, and country of residence), questions regarding respondent type (angler, shop owner / distributor, bait collector), and if relevant, their years of experience of the bait market, and their live bait use. The nine research themes were explored throughout the flow of questionnaires and interviews and focused on 20 specific research questions:

Perceived changes in bait collection

RQ1. Have people noticed a change in bait collection activities?

Supply and Demand in the Welsh ragworm market in recent years

RQ2a. Has the bait market changed, and if so, how?

RQ2b. Where does ragworm come from and how big is the ragworm bait market in Wales?

RQ2c. Does the ragworm market fluctuate seasonally?

RQ2d. Are there sufficient supplies of ragworm?

Factors influencing where sea anglers buy ragworm

RQ3. What are the most important factors influencing where sea anglers buy ragworm?

Cost differences between wild caught and farmed ragworm

RQ4a. Is farmed ragworm more expensive for anglers?

RQ4b. Are sea anglers willing to pay more for farmed ragworm?

The market for more farmed ragworm in Wales

RQ5a. What proportion of ragworm sold in shops is wild vs farmed?

RQ5b. How much farmed ragworm would be required to meet Welsh bait market demands?

Sufficiency of farmed ragworm supplies to meet market demand

RQ6. Are there sufficient, willing suppliers of farmed ragworm in Wales to increase their bait production to meet demand?

Barriers limiting the growth of the Welsh farmed ragworm market

RQ7a. What are the perceived barriers to using farmed ragworm amongst sea anglers?

RQ7b. What barriers in market demand limit the growth of the farmed ragworm market?

RQ7c. What barriers at the point of sale limit the growth of the farmed ragworm market?

RQ7d. What barriers in farm production limit the growth of the farmed ragworm market?

RQ7e. What product distribution barriers limit the growth of the farmed ragworm market?

RQ7f. What other barriers are there?

Potential incentives to persuade sea anglers to choose farmed over wild ragworm

RQ8. What would incentivise sea anglers to choose farmed ragworm over wild bait ragworm?

Potential for co-operative ragworm farming in Wales

RQ9. Would commercial wild bait diggers be interested in co-operative ragworm farming, to replace their wild collection activity?

Individual questions are presented in Appendix 1, whilst the order the questions were presented in has been provided in Supplementary Information 1. Responses varied depending on the depth of answer required, and included a mix of categorical, scalar, numerical and open questions. Wherever possible the same question was asked of each participant type (angler, angling shop, bait collector and farm), although ragworm farmers had more open responses and additional questions (Supplementary Information 2).

Results

Following intensive advertising and liaison with 49 different champions and gatekeepers, online questionnaires and interviewing took place between May 28th and June 15th, 2024. Five of the 14 invited bait shop owners or managers were interviewed, using the questionnaire as interview guide. The survey period coincided with a Welsh school holiday and bank holiday, which may have affected participation. A more detailed summary of the dissemination plan, together with lessons learned, is provided in Appendix 3. Two bait farms were interviewed by telephone interview; one in March, and the second in March and April 2024 during multiple telephone calls to suit their availability. February and March was not a good time to interview due to breeding and stocking season.

In total 26 people took part in the questionnaires, and two ragworm farms were interviewed (Table 1). No participants chose to undertake questionnaires or interviews in Welsh. Low uptake of the survey may have resulted from a combination of the contentious topic, questionnaire deployment coinciding with a holiday, and lack of advance notification through angling magazines. Due to low numbers, data cannot claim to represent the whole bait community and cannot be statistically analysed, or presented as a proportion (or %) of the sampled population. Instead, the total number of responses to a specific question is marked as ‘N’, whilst the total number of responses to specific response categories are marked as ‘n’.

The majority of participants were males, over 55yrs of age, and resident in Wales. Seven of the 22 respondents, who identified as sea anglers, noted that they were resident in England but practiced their sea angling in Wales. No respondents were resident in Scotland or Northern Ireland. Most sea anglers had been sea angling for over 30 years (n=18 of N=22). When asked about which type of description best described their sea angling activities, only a few respondents were novice and casual sea anglers, whilst the majority identified as the higher experience levels who are probably more invested in the bait market, from active (n=11, *fish regularly throughout the year and have done so for many years. I am experienced in techniques to catch different species and might compete in occasional matches*) to specimen sea anglers (n=5, *target particular species and sizes of fish, sometimes at unusual locations*).

Of the 22 sea anglers who participated, seven completed the questionnaire to also represent recreational bait collectors, but later in the questionnaire 15 of the 22 answered yes to ‘*Do you collect bait for yourself or others*?’. One responded that they sell their bait. When asked which baits they collect, most collected peeler crab and lugworm, whilst 7 collected ragworm and other species listed were cockles, razor clams, hermit crabs, mussels and fish for bait.

The questionnaires also captured a range of shop owners through online and face to face interviews, from those new to the market to those who had been in the industry for over 30yrs. Of the seven shops that took part, six sell live bait including ragworm. Half of these stock farmed ragworm (one exclusively sold UK farmed rag, one exclusively sold farmed rag from abroad, and the third believed that they stocked farmed ragworm from both the UK and abroad).

Table 1 Summary of participants who took part in 'Secure our Future Bait' interviews and questionnaires. Columns present the 'group(s) participants selected their views to represent'. Numbers presented are the number of answers for each category. There was an option for people to declare 'other', but it was not selected by any respondents. n/a denotes groups not asked a question. The total number of responses, N = 28. $n^{!}$ Row sums to >28 as participants could select to represent multiple groups within the bait industry.

N=28	Ragworm farmer	Recreational Collector	Commercial Collector	Local Shop Manager / Owner	Angler
$n^{!}$	**2**	**7**	**3**	**7**	**22**
Interview (n)	2	1	2	5	4
Online (n)	0	6	1	2	18
Years supplying bait industry	25, 40	n/a	5-30	<5 to >30	n/a
Use (any) live bait	n/a	7	2	4	19
Buy (any) live bait	n/a	5	0	4	17
Sell (any) live bait	n/a	1	3	6	n/a
Use ragworm	n/a	6	2	3	18
Buy ragworm	n/a	5	0	3	15
Sell ragworm	n/a	0	n/a	6	1
Sell farmed ragworm	n/a	n/a	n/a	3	n/a
Collect (any) bait	0	7	3	2	15

How are the results presented and evidenced?

The aim of our mixed method approach was to use open answers and interview (qualitative) data to add context to something that is difficult to accurately assess using deductive reasoning, and / or closed, quantitative answers alone. “Context” can be defined as ‘*the circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood’.*

For each subheading of the results that follow, first any relevant quantitative data from questionnaires has been described (both online and from interview). Data from shop interviews and online questionnaires of anglers and bait distributors have been combined for presentation, as they followed identical formats and this presentation style ensures anonymity of those responding through interview. Where appropriate, data has been tabulated, but where there have been few responses the data has been described. To protect anonymity of some participants, some data is not displayed in its raw format but is instead discussed anonymously in the text.

Following this we provide a contextual summary. Concise quotes from questionnaire text responses have been provided where possible. However where informative viewpoints were provided within lengthy quotes, split across answers to several open questions, or could be derived from joining answers from different anglers, collectors or bait distributors, questionnaire responses (online and from structured interviews) have been summarised in subsequent descriptions.

All context provided in the results section below comes from text responses to questionnaires, with the exception of ragworm farmer contributions where explicitly stated, or within sections exclusively about farms.

Clearly labelled subsections provide information from interviews with ragworm farmers, but where farmer interview context adds to the questionnaire descriptions above, it has been noted. Again, in the farm specific sections, short quotes have been provided where-ever possible, but the often lengthy discussions have had to be summarised. These summaries aim to give richer context to broader issues. Ragworm farmers have consented to their businesses being identified in reporting.

Providing context is a re-iterative and reflexive process for the researcher, making links between quantitative and qualitative data, and across questionnaire responses or interview questions, where the researcher risks adding their own bias. Therefore, any results or recommendations state when the authors opinion of discussions is given through emergent themes.

The discussion section is the authors opinion given their reflections on the data presented combined with wider knowledge from the literature.

Perceived changes in bait collection

RQ1 Have people noticed a change in bait collection activities?

All sea anglers and bait collectors (not shops) were asked ‘Have you noticed a change in bait collection activity in recent years?’ as an open question. Of the 23 relevant respondents to this question, eleven said there had been no change, and two declined to comment.

Changes observed included that different bait is being collected now, with people travelling around the UK to collect it. One respondent has concerns that finding peeler crab is harder than it used to be, and put this down to a reduction in seaweed cover. Others were concerned with a depletion in wild beds, and mostly referring to the overharvesting of ragworm. Respondents noted increases in lugworm pumping (coupled with a decrease in lugworm digging).

Two respondents noted increases in commercial bait collection from roving (non-local) collectors, one specifying this applies to ragworm digging. Conversely, five respondents noted a decline in ‘digging’ with most referring directly to ragworm

Some participants offered suggestions as to why digging was decreasing, including:

> *“Decrease due to it being such hard work. Over harvested beds equals less of a yield. So less profit. Sometimes the prices get so silly it puts the buyer off.”*

> *“Personally, I have stopped collecting my own due to my age. Most anglers are in the older demographic, so if anything the sea anglers getting older is resulting in a reduction in bait collection. This probably applies to bait diggers, they are all getting older. It could be that because of increased age of anglers and collectors, that farmed baits may be taken on sooner than we think.”*

Two other respondents commented that there was less supply of local dug ragworm, and shops were either closing or moving to farmed baits.

Supply and demand in the Welsh ragworm market in recent years

RQ2a. Has the bait market changed, and if so, how?

Before focusing on ragworm and early in the survey, bait collectors and shops were all asked ‘Have you noticed a change in ‘real bait’ market in recent years? ‘Real bait’ includes live, frozen, dead and vacuumed baits, but excludes plastics etc.’. Respondents used this as an opportunity to present how the stocks have changed, rather than the market. The summary presented here combines answers to ‘Have you noticed a change in ‘real bait’ supplies or suppliers in recent years?’.

One bait collector stated that the real bait market is decreasing, whilst another said there was no change in the market. There was a general theme of real baits becoming less available from reliable suppliers for a variety of reasons. In addition to decreased supplies, one shop owner did make a valuable observation on the market, that there was a reduction in recreational collection with people preferring to buy baits:

“More demand: (people) want to buy it, people (are) not willing to collect it. People working, no time and tides restrict time. Easier for people to buy. Suppliers changed focus onto ragworm due to legislation. Becoming harder to collect shore crabs to use as bait.”

The respondent’s quote given above is unclear. They perceive a change in legislation, but do not detail this perceived change, and they may mean the co-produced voluntary management plan. They may refer to legislation in relation to shore crabs, suggesting that some clarification in the form of education or a code of conduct may be needed.

One shop praised Dragon Baits for the way they have worked to increase the shelf life of their farmed ragworm:

> *“The farmed bait from Dragon comes in peat which he believes improves the quality. He also makes sure that he keeps them damp but not wet to improve shelf-life. He changes newspaper morning and evening to manage the dampness of his product.”*

The same shop noted that getting a variety of baits from reliable suppliers is getting more difficult:

> “*A lot don't do the same products as they used to. Due to sand eels being harder to find. Am(m)o bait used to be a key supplier but often provide bait to aquariums now.” (sic)*

Other respondents gave answers on changes in the availability of different baits and how its changed in different areas:

Shore crab were mentioned again as harder to get by one shop owner (concurrent with observations on changes in bait collection activity, RQ1).

Sandeels are harder to source. A collector noted that “generally due to changes in the location of sand eels harder to get”, whilst a shop noted “because of legislation, sand eels are impossible to get, only allowed in Wales”.

Blow lug / Lugworms were noted to be both more available, and less available, which could be due to different locations, different perspectives or the shifting baseline of longevity / memory of the collectors and shop owners lived experience. A shop commented that its “easier to go out and collect lugworms etc than sand eels now”, whilst a collector noted that lugworms are cheaper than they were 20yrs ago. This contradicts a previous quote that lugworm supplies are scarcer “because of sea defence”, that is likely to be a place specific comment. One participant noted that they were buying farmed lugworm. To the author’s and farmers knowledge, there is nobody farming lugworm in Europe, although Dragon Baits and Topsy Baits both revealed in interview that they have explored the viability of lugworm farming as potentially feasible but less lucrative than ragworm. Dragon Baits imports wild dredged lugworm from the Netherlands, receiving a quarter of the supply that they used to. Dragon Baits and the Dutch lugworm supplier are worried that the size of imported worm is starting to decrease, showing signs of overexploitation, and in 2024, for the first year in 25yrs the supplier is taking a break of unknown duration from dredging, to allow the stock some recovery time. The lack of this import may add pressure to local lugworm supplies and beaches.

Black lugworm was also noted as available, but it’s not clear whether this is due to a change or the collecting shop owner becoming aware of it, “Best black lug in the country is in [location redacted] worth me travelling. to get it.” There may have been an increase in availability of black lugworm on the market as several anglers noted an increase in black lugworm pumping and lugworm activity (RQ1).

Pressures on **Wild Ragworm** stocks were also mentioned by several anglers when asked if they had observed changes in bait collection activity (RQ1). One angler and one shop commented that they believe there has been a decrease in wild ragworm stocks since the sewage treatment has been improved, so there may naturally be less worm, especially in estuaries, noting that “it’s getting harder to buy and sell ragworm”. This was the only time a shop mentioned difficulties in selling ragworms. Most shops rarely had a lack of demand. Perceptions of change are likely dependent on the responders lived experience, but most questionnaire respondents had 30+years of experience in the industry.

One respondent mentioned some **other British wild baits** that are not collected intertidally, but may be of interest and influence the pressures on bait shops and farms:

> *“Some baits are changing, eg: British mackerel has changed its season and is available later in the year, so this affects the market. The commercial kill of mackerel off Rockall is worrying, as the overall size of mackerel has come down and the mackerel are not being given time to grow. A lot of anglers feel that since we 'cleaned our seas up' some bait stocks have declined. Possibly this is detritus in mud and sand. The marine environment doesn't need to be totally clean - it likes nutrients. eg: the black lug in the NE declined in size and number when they turned off the sewage works. So this is probably affecting the stocks.”*

The same respondent noted in the additional comments:

> *"Angling and bait outlets are getting fewer and farther between. Bait supplies are getting harder to come by, which means more people will go online and more people will use frozen baits.”*

Perceived changes from ragworm farms

Dragon Baits, from Wales, reported a decline in wild stocks, but an increase in their own production. Dragon Baits has heard from wild diggers that sites where in the 1990s they could harvest 15-20lb of ragworm in a tide, are in 2023/4 only providing a 5lb harvest, concluding that the bed must host only 20-25% of the stock that it used to. It puts this down to potential overharvesting, less sewage for the worms to feed on, or other pollution (without specifying which pollutants) threatening the stock.

In terms of demand for bait, Dragon Baits reports that the peak time for fishing in their 30years of experience, was in the early to mid-2000s. Over the Christmas/ New Year period of 2004-2005, they sold 4 tonnes of worm in two weeks, compared to 0.5 tonnes in the same weeks in 2023-24. They went on to describe the recent changes in market in more detail:

> *"You could speculate why this is: Have lifestyle patterns changed (so people are wanting to spend more time with family)? Are there less anglers? The strange thing is that covid gave fishing a really, really big boost, at a time when angling was on the decline, but we had to ride the lock downs to survive until the shops could open. Fishing and golf came back on as regulations eased, and people felt safe doing it as they could be alone and enjoy being outside. In that 2yr period, we did decent on sales, and covered our costs, but now sales have levelled off to just above where it was before Covid, but not quite the same as peak period within Covid."*

Topsy Baits have 40yrs experience in the industry, and has seen a decline in the demand for ragworm as bait internationally over the last 20yrs, with a recent upturn in demand again this year. When they first started production, they supplied the UK, Spain, Belgium, France, Germany, Denmark and occasionally other countries such as Sweden and Norway. Demand for this Dutch farmed ragworm in the UK is less than half of what it was 20yrs ago. They used to supply top up supplies to Dragon Baits when it was in the set up phase in the early 2000s, when they also noted that the market was at its peak. They noted that "*There is a fluctuating market in the UK, bait demand is going down all the time. It depends if there are fish to be caught, so people give up angling.*

Topsy Baits believes that in other European countries, bait worm demand has been met for 30yrs by wild captured stocks of *Perinereis aibuhitensi* (known as Korean Worm) from China. Reportedly they export approximately 200tonnes per year of this wild captured worm to France, Spain, Italy and Greece. There is now a wild population in Normandy, France. Topsy Baits fills the gaps in this market when Chinese supplies are low. At the moment the authors cannot find any record of this being marketed in the UK.

RQ2b. Where does ragworm come from and how big is the ragworm bait market in Wales?

The Welsh bait industry is a passionate sector, with a complex and intertwined list of suppliers. Commercial diggers have traditionally supplied shops and are sometimes also shop owners or staff themselves. Ragworm farms have been supplying the sector since the 1990s, with one based in Wales and another based in the Netherlands. The Welsh farm employs ex-commercial diggers. Recreational diggers who responded to this survey were all anglers, who may occasionally sell their bait on the informal market to other anglers and shops (as declared by one collector). In this survey, shop owners and commercial diggers have often also identified as anglers. Most of the people involved are reluctant to engage in consultations or research about bait management. For these reasons, it is difficult to decipher a clear supply chain.

There are only two commercial ragworm farms currently supplying the UK bait market, one in Wales and the other in the Netherlands (NL) both of whom provided information that has been incorporated in this report with consent to be identified. Information related to a farm's experience has been provided in interviews by the farm owners, unless it is stated that it was someone else that perceived something about the farm or farmed bait.

It should be noted that two major sources of information were not successfully engaged in this project: Poole Harbour dredged ragworm industry and The Angling Trade Association. No Welsh distributors questioned mentioned using the 'bait dragged' ragworm sourced from Poole Harbour (England), although Dragon Baits noted in interview that byelaw restrictions on dredging in Poole Harbour has reduced supplies, increasing demand for farmed ragworm around the country.

Table 2 presents an overview of the supply and demand of ragworm in Wales from the survey data, showing the variability between individuals but also the difficulties in extrapolating from a small number of participants. As a result, figures displayed are indicative ranges and should not be extrapolated further or taken out of context. Also, it should be noted, as outlined above, the lack of consistency in the naming of the different ragworm species. This should be taken into consideration in the interpretation of information in table 2. Key outcomes (subject to these caveats) are as follows:

Anglers who were independent of the other roles in the supply chain on average spent £290 per annum on ragworm bait, although this number was highly variable between individuals.

Shops who contributed their annual sales data, sell on average 258kg of live ragworm per year to anglers.

Table 2 An overview of the ragworm supply and demand amongst the respondents to the Secure our Future Bait survey, 2024. To avoid confusion in interpretation of values, anglers who are also recreational collectors have been presented as 'recreational collectors. The row labelled 'Independent Anglers' contain only anglers who are not also collectors or shopkeepers. Annual yield[1] was derived from number of weeks / months digging, frequency per month / week and the number of worms collected per trip. Annual Sales[2] was derived from open answers to 'how much ragworm you sell weekly, monthly or annually'. Annual spend on ragworm[3] was derived from the number of months the shop stocks ragworm, the frequency of deliveries and the cost per delivery.

	Years experience	**Species collected / sold / bought**	**Annual yield[1] (collectors / bait farms)**	**Annual Sales[2] (anglers / shops)**	**Suppliers (worm sourced From. as % of total supplies)**	**Clients (as % of total clients)**	**Approx annual spend on ragworm[3]**	**Comments**
Recreational collector	10-20	King, Harbour	2.1-2.8kg / 150-200 worms	n/a	n/a	n/a	n/a	
Recreational collector	>30	Common, Harbour, White / Silver	4.2-8.5kg / 300-600 worms	n/a	n/a	n/a	n/a	
Recreational collector	>30	Common / Harbour	4.2-8.5kg / 300-600 worms	n/a	n/a	n/a	n/a	

	Years experience	Species collected / sold / bought	Annual yield[1] (collectors / bait farms)	Annual Sales[2] (anglers / shops)	Suppliers (worm sourced From. as % of total supplies)	Clients (as % of total clients)	Approx annual spend on ragworm[3]	Comments
Recreational collector	>30	King, Harbour, White / Silver	>28.5kg / >2000 worms	n/a	n/a	n/a	n/a	

	Years experience	Species collected / sold / bought	Annual yield[1] (collectors / bait farms)	Annual Sales[2] (anglers / shops)	Suppliers (worm sourced From. as % of total supplies)	Clients (as % of total clients)	Approx annual spend on ragworm[3]	Comments
Farm, Topsy Baits (NL)	>40	King	Annual supplies to UK ranging 1,950-4,225kg (~75kg per week in April 2024/ ~100-150kg per week in June 2024) (total bait production for international market incl. UK ~50 tonnes)	n/a	n/a	100% of supply to the UK is via a single bait wholesaler in England, who supplies bait shops only (not online traders) around the UK.	n/a	Total farm production 250 tonnes. 80% of this goes to aquaculture feeds. Pre Brexit UK supplies were 13000kg – 20,800kg per year.

	Years experience	Species collected / sold / bought	Annual yield[1] (collectors / bait farms)	Annual Sales[2] (anglers / shops)	Suppliers (worm sourced From. as % of total supplies)	Clients (as % of total clients)	Approx annual spend on ragworm[3]	Comments
Farm, Dragon Baits (Wales)	26	King	15 tonnes per year	n/a	n/a	5% Individual anglers (walk-ins); 95% shops. (45% Welsh shops; 45% English shops and <10% Scotland and Ireland)	n/a	Supplies at least 50 shops weekly, and 50 additional shops occasionally. Used to use wholesalers, but it is quicker and costs less to deliver live bait directly to shops using next day couriers. Won't sell to online shops to keep local shops alive, and to minimize black market sales.
Shop	<5	King, Harbour	n/a	109kg / 240lb (5lb/week per year, double in summer)	From a wholesaler; Direct from a ragworm farm; I dig my own	Declined	£572	

	Years experience	Species collected / sold / bought	Annual yield[1] (collectors / bait farms)	Annual Sales[2] (anglers / shops)	Suppliers (worm sourced From. as % of total supplies)	Clients (as % of total clients)	Approx annual spend on ragworm[3]	Comments
Shop	5-10	King, Harbour	n/a	Declined	50% bait wholesaler; 50% Farm abroad	Declined	Declined	
Shop	10-20	Declined to answer	n/a	312kg / annum Or average 6 kg / week (summer 8-10 kg / week, at its quietest around 4kg / wk)	From a wholesaler Direct from a ragworm farm I dig my own	100% Individual anglers	Declined	
Shop	20-30	King, Common, Harbour	n/a	~500kg (13.6kg (30lb) / week between April - October, less in Nov – March)	Dig my own (Apr-Oct) Direct from farm (Year round, but esp. Nov-March, to protect wild breeding stock)	100% Individual anglers	£4620 (subsidised by collecting bait for shop)	Can sell 2-10 packs of ragworm to an individual angler on a single visit

	Years experience	Species collected / sold / bought	Annual yield[1] (collectors / bait farms)	Annual Sales[2] (anglers / shops)	Suppliers (worm sourced From. as % of total supplies)	Clients (as % of total clients)	Approx annual spend on ragworm[3]	Comments
Shop	20-30	n/a	n/a	n/a	n/a	n/a	n/a	No longer sells ragworm due to sustainability concerns
Shop	>30	King, Harbour	n/a	109kg / 240lb (5-6lb per week, more in summer)	100% Farm	Declined	£4680	
Independent Anglers (n=12)	All >20	All	n/a	n/a	Local shops (n=10) Shops on route to mark (n=5) Direct from farm (n=3); Dig my own (n=2) Online (n=1) Wholesaler (n=1)	n/a	Average £290 (ranging from £50-1040 per angler)	

Recreational, or personal collectors, who declared that they never sell their bait, collect between 2 - 28.5kg of ragworm per person annually, usually targeting multiple species of ragworm.

Unfortunately, the annual yield (or supply) of the commercial collectors of wild ragworm who shared this information had to be redacted, to protect the anonymity of the single collector who shared their information.

Dragon Baits (farm in Wales) produces 15 tonnes per year for the UK market (2-3 million worms), with 45% going to Welsh shops. Topsy Baits (farm in Netherlands) supplies 1.9 – 4.2 tonnes per year (75-150kg per week) to a single English wholesaler for the UK market. This provides a total of 16.9 - 19.2 tonnes of farmed ragworm entering the UK market.

Ragworm Farms

There have been three ragworm farms in Europe supplying the bait market, two of which remain in business. The three are discussed below.

Seabait Ltd. was a research led polychaete farm that started operations in NE England in 1984 (Olive 1999). Unfortunately, the company did not return calls to contribute to this report. Dragon Baits (confirmed by Olive 1999 and Fowler 1999) summarised that Seabait was a market leader, supplying the first farmed ragworm in the UK, and helping to support and develop the international polychaete farming industry for the bait sector in the years that followed. It developed a niche in supplying harbour ragworm, *Hediste diversicolor*, which it then grew into shrimp broodstock (aquaculture feeds), trading as Sustainable Feeds Ltd. From interviews with the other farms, they stated that in 2023 the farm stopped production, after financial difficulties followed by several crashes in farm stocks after the power station water that supplied its water started using chlorine in its cooling system. Sustainable Feeds Ltd continues as an expert consultant on polychaete farming, but declined to be interviewed for this project.

Topsy Baits, owned by Delta Farms, is located in Zeeland, Netherlands. The founding Director, Bert Meijering, was interviewed and consented to the sharing of information in this report. The company started research, development and set up in 1983 and started selling ragworm in 1985, 40years ago, as a small family business aiming to fill a growing gap in wild ragworm as bait for the angling industry in the Netherlands. The owner was an environmental civil servant who noticed a gap in the market and the environmental problems associated with wild collection. He had no previous interest or experience in angling, bait or worm farming, making him a competitive and independent supplier to the industry. The business grew and collaborated with other companies in Wales, China and Portugal, all focusing on the bait industry. None of these collaborations worked – either due to the locations being unsuitable for the farmed species, or due to financial conflicts with partners. The farm specialises in king ragworm production (*Alitta virens*), which although relatively difficult to set up is easier to rear. This is done using modified carp feed that is mostly soy based. The farm has also tried farming harbour ragworm (*Hediste diversicolor*), lugworm (*Arenicola marina*) and bloodworm (*Marphisa sanguinea, previously Nereis sanguinea)*. Harbour ragworm was too difficult to farm for the bait market, as it will reproduce unpredictably and die before sale, producing lots of ragworm too small for the hook. Lugworm has a big market, but needs approximately x2.5 the size of a ragworm farm to reach same production levels. Bloodworm was too fragile and difficult to farm, but has a big market both in aquaculture and foreign baits. It is possible to farm lugworm but costs too much for the current market. Today, Topsy Baits is the largest supplier of farmed live ragworm bait in Europe. The farm comprises 38 hectares (95 acres) of outside pools with an indoor hatchery, with 20 local staff, producing 250 tonnes of king ragworm, 20% for the live bait market across Europe and 80% for frozen shrimp feed industry to 50 countries worldwide. They operate a policy that they supply to a single large wholesaler in each country, who then takes responsibility for local distribution. This growth has been facilitated by having physical space to grow in, and due to available capital to automate production processes, increasing efficiency.

Dragon Baits Ltd (also trading as Broodsafe Ltd) is a small family run ragworm farm based in Port Talbot in South Wales, started by the current owner's father who was an entrepreneur who would commercially dig for ragworm when he needed to fill financial gaps. The current owner, Chris Smith, was interviewed and consented to the sharing of his answers in this report. Dragon Baits Ltd liaised with Topsy Baits to start importing Dutch ragworm for the Welsh market, and decided to work with them to set up the first Welsh ragworm farm for the local market. The company secured a lease on an ex-industrial estate in November 1999, when it started developing with only three ponds, bringing its first stock to the market in summer 2000. By the mid-2000s they had grown the farm to 24 tanks, still importing Topsy Baits to meet market demand when necessary until it reached full operating capacity. At one point they attempted to move into the aquaculture feed market to develop pellet feeds, but this involved heavy investment to produce on a research and development scale big enough to reach commercial production levels. It has also worked to supply frozen ragworm to the South American shrimp farm aquaculture feed market, but constant high demands for supply started to compromise bait production. Dragon Baits sold those production pools, on another small site, to a dedicated supplier of different aquaculture feed species. The farm now focuses exclusively on the king ragworm (*Alitta virens*) market in Wales, fed on trout pellets that contain flour and fish meal. They currently supply exclusively to the Welsh and UK market, and no longer import or work with Topsy Baits. The farm is now 13 acres, with 24 outdoor tanks (each approximately 400,000 litres in volume) with 5 staff, producing approximately 15tonnes of ragworm (2-3million worms) per year for the UK bait market. Approximately 45% their production, or 6.75tonnes, is provided to the Welsh market. It is self-sufficient and it fertilizes from its own broodstock in 5-6 dedicated tanks. Dragon Baits also imports 'a few tonnes a year' of dredged, wild lugworm from the Netherlands and sell it on to their clients, generating 5-9% of their income as "*it's a superb bait for winter*".

RQ2c. Does the ragworm market fluctuate seasonally?

All relevant respondents in online questionnaires and interviews were asked when they dig, sell and use ragworm (Table 3). Very few respondents were willing to tell us their monthly collection and sale habits, so the data should be treated with caution. However, it does suggest that in winter, when ragworm are not feeding and breeding, and it is too cold to go digging for long, there may be a reduction in bait supply. The local bait farm operates at as low as 50% capacity during breeding season, when they need to sift out baiting worms from their stock and supply dredged lugworm (context from farm interviews).

The lack of winter stock was confirmed when shops were asked '*how does your demand for ragworm change through the year'*, the following points were made (summarised from both questionnaires and farm interviews):

- Winter can be quieter, but there is still demand and shops noted that it was hard to get enough stock.
- When it's cold, people don't want to collect their own so much, so there is increased demand.
- Shops relying on farmed ragworm detailed that meeting supply can be difficult during the breeding season, when the local bait farm operates at reduced capacity.
- Summer and holidays can be very busy, especially when the weather is good. The seasonal market is unpredictable and dependent on tourists and weather, and it can be difficult to meet demand.
- One shop noted that in the summer, they may have double their normal demand (and as a result they increase from receiving one delivery to receiving two deliveries per week).
- On rainy days, less ragworm is sold, but this is unpredictable and less season specific than previously.

In terms of supplies, Dragon Baits confirmed in interview that they harvest every day all year, but have reduced capacity during breeding months due to the need to sift out the breeding (green) worms, which are both undesirable baits (due to low longevity) but also needed by the farm to maintain production levels. Wherever possible they also sift out females, which reduces the number of worms harvested in a day both through time spent sifting and through the number of available worms. Topsy Baits confirmed that it is able to supply ragworm at consistent levels all year around.

*Table 3 Months where ragworm is in supply and demand in Wales. The data presented should be viewed with some caution since it is limited by a low number of respondents to questionnaires and interviews. RC = farm operating at reduced capacity during breeding season. * = months where demand may exceed local supplies.*

				*	*	*								*	*
			n	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Supply	Commercials dig wild ragworm		2	0	0	0	2	2	2	2	2	2	1	0	0
Supply	UK Farmed ragworm supply		1	1	RC	RC	1	1	1	1	1	1	1	1	1
Supply	NL Farmed ragworm supply		1	1	1	1	1	1	1	1	1	1	1	1	1
	Recreational ragworm digging		5	1	0	0	2	4	5	4	4	4	1	1	1
Demand	Shops stock ragworm		4	3	3	4	4	4	4	4	4	4	4	4	3
Demand	Anglers use ragworm		18	13	14	12	13	14	14	14	14	16	14	12	12

RQ2d. Are there sufficient supplies of ragworm?

In interview, Dragon Baits used their knowledge of the bait shops around the UK to extrapolate that they think the total UK ragworm market must need approximately 2 tonnes per week / 104 tonnes per year to meet demand. Currently Dragon Baits may supply up to 30% of this demand.

Throughout the questionnaire, anglers made several comments regarding the difficulties in getting bait, stating that shops were closing or asking them to pre-order ragworm (rather than walk in to buy it), making it more difficult to buy ragworm ‘on demand’, when they want it. There were also many comments along the theme of *“the people who gather the bait say it’s harder to acquire the amount of bait they need“* and limitations in supply during ragworm breeding season (Feb-March).

Questionnaires (both online and as structured interviews) asked shops *‘Is there more demand for ragworm bait than you can provide?’*. From the six shops that sell ragworm, only one said there was not more demand than they could supply. The other five responded that there are occasions when they can’t meet demand, with answers ranging from “*depends on the weather*”, to “*yes, constant demand*” and “*yes, almost weekly*”.

One shop that operates with preorder only on live bait commented that they rarely have too much demand for ragworm:

> *“Rarely (is there more demand than I can supply). In the past people used to book it regularly but they don't book it like they used to due to the weather being so changeable. In the past they used to have a diary of bait repeat orders as the demand was consistent.” (sic)*

However, the shop above does not sell ‘on demand’ so may not be the best judge of the ‘on demand’ market. Another shop commented that:

> *“for normal (ragworm), no (demand does not exceed supply), due to the supply from the farm. But for mud dried (wild), yes (there is more demand than we can supply)”. (sic)*

Insufficiency in supplies was mentioned in a questionnaire question about the seasonality of ragworm demand (RQ2c):

> *“In winter months the demand is there but I can't provide the rag, in summer the demand is also very high, its often gone within half a morning, so much more is needed. The demand is there throughout the year”*

When asked *'What limits your ability to meet bait market demands for ragworm?'*, answers were variable depending on whether the shop relied on farmed or wild ragworm. Limitations on meeting the demand for farmed stocks were shortages during breeding season, and if they need to increase the frequency or size of their deliveries last minute (due to good weather or increased demand). This was particularly pertinent in the holiday season, where the farm cannot always supply. For a detailed description of the farms ability to meet supplies see RQ5 below. Limitations on meeting the demand for wild stocks included weather, size of the tide and breeding season.

Two of the five shops mentioned that they can only get one worm delivery before the weekend, and the worms will die within a few days, so by early to mid-week they cannot stock ragworm. At least one of those shops was referring to farmed bait, claiming *"Almost half of the bait bought is thrown away (dead within 3 days)"*, which contradicts another shop's experience of the farmed bait having a better shelf life than wild (RQ2a). The longevity of live ragworm may depend on the supplier, but also how it is treated on arrival at the shop (comment from author).

Interestingly, when asked directly about the sufficiency of (any) ragworm supplies to meet demand, no shop mentioned difficulties in finding suppliers of wild bait, or a decrease in wild commercial collectors, although one shop quoted above did say that there was more demand for wild ragworm than they can supply. However, when specifically asked '*in your opinion, are there <u>sufficient suppliers</u> of wild ragworm in Wales to meet the demand?'*, all five shops answered 'no'. Comments included *"Sometimes no, when there is limited supply from farm, breeding season limits the supply. More demand than they can provide"* and *"there are a few, but they can't cope with the demand of new shops".* Lack of commercial collectors of wild bait was mentioned by shop owners in other places throughout the questionnaire, especially when discussing changes in the bait market where one shop mentioned that there "*More demand - want to buy it, people not willing to collect it (wild from the beach)" (sic).*

The authors note that the sufficiency of ragworm supplies, and variability of answers above, may depend on the shops location, the type of ragworm shops want to sell, whether they rely on consistent farmed stocks and unpredictable weather.

The conclusion here is that there may be a lack of supply:

- in peak holiday season (Christmas, Easter and summer, if the weather is good, evidenced in farm and shop interviews)
- during breeding season (Feb-March, especially in fair weather, as evidenced in Table 3 from farms, shops and angler responses)
- due to reliance on a single Welsh ragworm farm with no contingency or diversity in farmed supplies.

If demand for ragworm increases there would almost certainly be shortages in ragworm supply for anglers. This was confirmed by interviews with Dragon Baits, who informed us that they can definitely not keep up with current demand of the Welsh or UK market (see more detail in RQ6). Dragon Baits started supplying 20 new shops across the UK in the 6 (winter) months before being interviewed, and they are already having to refuse new customers to ensure consistency of supply to existing clients. In an independent interview, Topsy Baits also noted from its experience, that Wales can probably not meet its own live ragworm market needs (demand).

What changes or improvements would shops like to see in the ragworm supplies for Wales in the future?

These improvements only reflect the opinions of three shop owners, who suggested:

> *"More support"*
>
> *"Controls on wild digging, dig(ging) nursery beds destroys the nursing beds" (sic)*
>
> *"Biggest concern is if the farm closed there is no one else to provide a supply. The only alternative is Holland and that will only drive up the price. It would be cheaper to lob steaks out there soon."*

What happens if there's too much supply?

If farms increase production, what will happen to any surplus bait? We asked shops *"Do you ever have waste ragworm? If so, how much and what do you do with it?".* Five of six shops returning answers said very rarely do they have waste ragworm, one stating that they potentially have up to 10% waste or surplus. However, one of those shops also said that up to 50% of farmed ragworm can die over the weekend, but they did not specify where their supplies came from. If it looks like their ragworm stock is dying, shops stated that they sell it at a reduced price, or give it away, rather than waste it. Any dead waste ragworm was disposed of down the toilet, in compost, or frozen for crab bait. The sixth shop who claimed to never have waste was the shop taking live bait pre-orders only.

Factors influencing where anglers buy ragworm

RQ3. What are the most important factors influencing where anglers buy ragworm?

The quality of ragworm was unanimously found to be the most important factor influencing ragworm purchasing behaviour of anglers (Table 4), although the reliability of a supplier, convenience and loyalty to the supplier were all very important in the deciding where to buy ragworm. Surprisingly, the cost of ragworm was on average, not of high importance. Three respondents selected that 'something else' was important to them when deciding where to get their ragworm, but only one of these answers added information beyond convenience and quality of bait.

Table 4 Factors influencing ragworm procurement by anglers. Anglers responses to 'how important are the following factors when deciding where to get ragworm?' Scores for each statement are averaged from a 5 point Likert scale of 1, not at all important, to 5, very important. Low importance = scores of 1 or 2, not at all important or slightly important; high importance = scores of 4 or 5, fairly important or very important.

	Number of respondents who answered factor was of low importance	**Number of respondents who answered factor was of high importance**	**Average score* (n=19)**
Quality of rag	0	19	4.79
Reliability of supplier	3	12	4.56
Convenience (eg: location, opening times, etc)	2	15	4.16
Loyalty / Habit (eg: I always go to the same place)	1	14	3.84
Cost of rag	5	9	3.32
Recommendation from friends / social group	9	5	2.58
That the rag is wild	12	6	2.53
That the rag is farmed	13	3	1.95

* Maximum score attainable = 5

Preference for wild or farmed ragworm

Three of 19 ragworm users expressed a preference for farmed bait, whilst six expressed a preference for wild bait (Table 4).

When specifically asked *'Which (ragworm) bait do you believe is more effective for your / your customers' target species?'*, eight of the 19 believed wild ragworm is better than farmed; eight thought they were of equal effect; two were not sure which was more effective and one declined to answer. Nobody believed that farmed ragworm was better.

When asked '*Have you ever knowingly used / bought farmed ragworm*?', 16 out of 22 anglers responded 'yes'. Thirteen of these anglers (some of whom also owned shops) went on to answer *'How often do you choose to use farmed ragworm, and why?*'. One emergent theme from responses was that some shops prefer to sell farmed bait as they are the only formal suppliers that they are aware of, and / or for sustainability reasons (they may still use wild ragworm as a personal angling preference). The most common theme apparent in responses was that anglers and shops buy farmed ragworm when wild is not available, despite their preferences, as demonstrated by these quotes from questionnaires:

> *"I take whatever is available*"; *"I don't care either way"; "Most of the time due to cost" "My supplier only provides farmed rag"; "When wild rag unavailable"; "Only when wild is not available"*
> "*If I can't get wild rag, I'll get farmed. You can tell by colour and size what you're buying. Wild rag tends to be bigger than farmed, and a more uniform and vibrant colour. I'm not conscious of a shop trying to pass off farmed rag for wild rag. You*

don't usually buy farmed rag loose in my experience, it comes in packets, but you can buy wild rag wrapped in paper as individuals."

"*(I buy farmed rag) once a week for the shop, but for personal angling wild rag is mostly used"*

"The only bait (I use) due to Dragon being the only ragworm supplier, it is only farmed… but it is a good bait up there with squid."

"All the time" "Every time, convenience, and sustainability"

Cost differences between wild caught and farmed ragworm

On average, whether ragworm was wild or farmed was of low importance to anglers when choosing where to get their bait (Table 4).

RQ4a. Is farmed ragworm more expensive for anglers?

Only three of 19 ragworm users believed that farmed ragworm was more expensive than wild ragworm. Despite this, one of those three still prefers to buy farmed ragworm. Four respondents did not think it was more expensive and 12 did not know.

We validated these perceptions by asking shops how much they charge for half a kilogram of ragworm, or approximately 35 worms (which we were informed is a common sales pack). One shop returned feedback that they charge per ounce, so these have been converted at a rate of 35.27oz, or 2.2lb, per kg. Only two shops gave prices for wild ragworm, at between £32 per kg to £151.66 per kg (the latter for the shop charging £4.30 per ounce). This amount seems high to the reader, but was mentioned several times in their response. In 2017 the cost of wild ragworm to anglers was published to be £33 per kg (Watson et al. 2017), so the first of these prices show the price of wild ragworm hasn't increased much for at least some shops. Farmed ragworm cost between £44-50 per kg at the two shops who responded that only stock farmed ragworm, and £119.91 per kg at a shop who also stocks wild ragworm.

In interview, Dragon Baits told us that they used to supply worm to shops in 2000 at £17.60 per kg. By 2020 it was £22 per kg and since 2021 until 2024 the price has been £26.4 per kg. This is cheaper than the reported cost of the original UK ragworm farm, Seabait Ltd, who in 1999 sold the same species at a cost of £28 per kilo (Fowler 1999). Depending on the markup shops make, it is now likely comparable to wild ragworm, and Dragon Baits believes it is now selling at a cheaper or comparable price compared to wild collectors (they are informed the going rate is £28.60 per kg / £13 per lb for cash in hand, wild ragworm). Prices stayed the same for the first 10 yrs of production, as they had to maintain competition with wild collectors, selling on the informal market with limited overheads. However, the production costs have increased significantly since 2020 so another rise was necessary. The farm believes that the market has allowed a rise given that there are limited alternatives: limited availability from wild stocks, byelaw restrictions that limit harvesting by dredging in Poole Harbour, and the wild harvesters are harvesting less frequently (perceived by Dragon Baits to be partly due to age of diggers, price of fuel and loss of stocks, especially ragworm and lugworm). Combined, the farmer believes this means that the cost doesn't matter so much, as there is angler demand for farmed ragworm to replace lack of wild bait, corroborating evidence that anglers do not select their ragworm based on price (Table 4). They also believe digging is harder work than it used to be, due to weather and reduced availability of wild stocks, so recreational anglers are more likely to buy than to dig themselves.

Topsy Baits noted that it is inevitable that farmed ragworm should be more expensive than wild caught:

> "*I don't know how the wholesalers view wild worms, but to farm worm we need a lot of expenses and cost. But wild worms can not meet demand.*"

Despite this, Topsy Baits does not think anglers will pay more for farmed ragworm than wild.

RQ4b. Are anglers willing to pay more for farmed ragworm?

Of the seven shops interviewed, none believed that their customers would pay more for farmed bait, as the cost is already prohibitively high for some anglers. However, one of the shops that only stocks farmed bait commented that: *"(they have) no choice. That's all we sell."(sic)*

However, nine of the 19 ragworm customers said they would be willing to pay more for farmed ragworm than wild ragworm as bait, when asked *'Would you pay more for farmed ragworm than wild ragworm as bait? This may alleviate pressure on wild habitats in Wales.'* Five respondents were willing to pay up to 10% more than wild ragworm, one 11-20% more, two 21-30% more and one surprising respondent was willing to pay up to 70% more to alleviate pressure on wild stocks. The other ten ragworm users were not willing to pay more.

The market for more farmed ragworm in Wales

RQ5a. What proportion of ragworm sold in shops is wild vs farmed?

Shops selling live ragworm were asked what percentage of their ragworm supplies come from different sources. Of the seven shops questioned, most declined to respond to this question. Only three shops responded, all of whom claimed to solely buy from farms, two in the UK and the third who gained 100% of their supplies from a wholesaler selling farmed rag from abroad. Unfortunately, this is not enough data to conclude what proportion of ragworm sold is farmed or wild.

RQ5b. How much farmed ragworm would be required to meet Welsh bait market demands?

There was an insufficient number of willing respondents to answer this question in a robust way. RQs2b and 2d start to contribute the angler and shops perspectives on ragworm demand, with some data provided on what four of the shops require in terms of ragworm weight per annum. Unfortunately, this number cannot be fairly extrapolated up to provide the demand for ragworm from Welsh bait shops, as there was high variability in the shops answers and we do not know the number of shops selling live ragworm.

RQ6 uses interviews with ragworm farms to explore the farmers perspective of whether they believe they can meet what they perceive to be the market demand. In conclusion, Dragon Baits does not believe they can meet the current market demand if wild stock continues to become less available to shops. Topsy Baits perceived that they could increase production to meet demand, although via a single English distributor, but they acknowledged this may not be a sustainable long term option depending on future import legislation.

Sufficiency of farmed ragworm supplies to meet market demand

RQ2d focused on the angler and shop's perspectives of whether ragworm supplies in Wales are sufficient, and how they could be improved. From their perspective, there may be a decrease in the availability of wild stocks, but farmed bait is available most of the time for those who want to use it. However, there are times when farmed bait cannot meet demand, and if the whole Welsh market turned to farmed bait, could the farms cope with a long term increase in demand?

RQ6. Are there sufficient, willing suppliers of farmed ragworm in Wales to increase their bait production to meet demand?

An interview with the Dutch market leader in ragworm farming, Topsy Baits, confirmed that the Dutch ragworm market has moved to approximately 90% farmed baits, and 10% wild baits. In their experience from the Dutch market, shops were at first reluctant to stock the farmed bait, but Topsy convinced them to take free trials as a backup, or insurance, on busy weekends. Slowly, as the bait diggers started retiring, the outlets moved to farmed baits. The convenient and consistent availability of farmed baits to shops meant that there was no need for a new generation of diggers to start up.

In Wales, Dragon Baits has already started to see this effect:

> *"Once people come to us, even if its due to forced circumstances, they tend to come back and retention levels are pretty high"*

Dragon Baits has an ambition to dominate the Welsh market and absorb the gaps appearing in the market. At the moment they harvest every day, and can be quite reactive to demands with the busiest periods in holidays (Christmas, Easter, Summer). Currently, in those peak times and when the worms are breeding, they are unable to meet demands of new customers as they need to protect their stock and their reputation for consistent supply with their existing customers:

> "*We had 5 new shops contact us this week, but we had to turn them away as we don't have enough capacity. Probably had to turn down £6-7000 of sales this week. At the moment the worms aren't feeding and we need to protect our stock and not sell too much. We need more tanks." (March, during breeding season)*

However, Dragon Baits would like to increase production and are making small investments to increase productivity on their current site. They have just received a grant for a new harvesting machine, so will be able to increase production a small amount. Their biggest challenge is securing long term tenure or purchase of their site before investing heavily to grow the business. After the land is secured:

> *"Nets and pumps are expensive, and need repairing. We need six more nets to completely cover the tanks. Oxygenation would increase production, but need to save up for that."*

Although it is not a local supply, Topsy Baits claims they have capacity to easily increase production by extending the farm if and when there is a shortage of bait. In fact, between April and June 2024 their supplies to the UK doubled, but this is not unusual for the summer market. They are already growing their facility to almost double production in the coming years for the aquaculture market:

"If there was a market, I would grow the farm and supply more bait. We are about to buy another 13 hectares for aquaculture feed, totalling 130 acres for increased production, increasing production by another 150tonnes! Can buy out the neighbouring X(location)X, of another 100hectares. Local government is quite willing to help. We are lucky we have flat land."

However, Topsy Baits acknowledge that this may be a temporary solution:

"I think, in the long run, farming in the UK, will be cheaper (for the UK than sourcing bait from Europe). I don't see the UK coming back to Europe soon." (sic)

When asked about how ragworm farmers see the future of the farmed ragworm market, their answers were:

"Sunny! But mainly in Aquaculture feeds. The bait market will continue, but get less and less. Unless people get interested again. There are so many other big distractions!.. maybe we will also explore pet food markets".$_{TB}$

"I think the farm has a good future. Shops who use us like the reliability, consistency in supplies, and the wild beds are declining whilst wild costs increasing. There is scope to massively increase in the bait side in the UK, due to difficulties bringing worm into the country due to Brexit. We will come to the stage soon when the wild supply is running so low, we are going to be turning people away. What are the shops going to do then? If one shop closes, it just displaces the problem. Bait is key. Any increase in production would have to be done through us as there aren't any other quick options of people with the knowledge."$_{DB}$

Barriers limiting the growth of the Welsh farmed ragworm market

RQ7a. What are the perceived barriers to using farmed ragworm amongst anglers?

When asked about why anglers are willing to use farmed baits, one comment revealed that at least one angler believes *"farmed lasts longer as it has not been transported for as long and is cheaper",* whilst another angler commented they would not use farmed baits as they are *"inferior in every way".*

More negative perceptions of farmed ragworm appeared from several anglers during the questionnaires. Additional comments made elsewhere in the questionnaire clarified why some respondents do not like farmed baits, claiming:

"(farmed rag is of) poor quality, life expectancy of farmed rag less, farmed rag lasts 2-3 days, wild rag last 7 days"

"poorer quality than wilder rag, sometimes can look the same, farmed rag dies within 3 days, wild rag can be kept for 3 weeks, too expensive"

Two shops made comments that they believe their customers will not want to pay more for farmed ragworm:

"Because its rubbish, the quality is poor, doesn't look the same, doesn't last as long, can tell the difference"

"Customers prefer dug regardless of cost. They think it's more natural."

Topsy Baits offered their experience of changing perceptions about farmed ragworm being of inferior quality to wild:

"In the Netherlands, there was a good season for sole, and anglers started to use the farmed bait very successfully, so the myth was busted that wild bait was better."

RQ7b. What barriers in market demand limit the growth of the farmed ragworm market?

A running theme through interviews and questionnaires was that changes in the weather is affecting the market (likely due to climate change), so demand is less predictable than it used to be. This makes maintainingfarmed stocks difficult, especially for resource limited small farms. Topsy Baits noted that there has been declining demand for ragworm for bait over the last 20yrs, although both Topsy and Dragon Baits are starting to see increased market demand over the past four years. However, Dragon Baits noted:

"Even if participation in angling diminished, I don't think it will effect us due to loss of other bait sources."

RQ7c. What barriers at the point of sale limit the growth of the farmed ragworm market?

In questionnaires, three shops offered opinions why other shops choose not to stock farmed ragworm:

“Some people convinced wild is better, some shops dig there own”;
“Just the thought of it being farmed. More of a placebo effect that wild is better”;
“Habit”;
“Farmed rag doesn’t have the same scent and is not as effective, without a shadow of a doubt. Not as effective.”

Dragon Baits noted in interview that ‘quality’ is subjective:

> *“From a bait point of view the angler and the shop, quality means when they are given a tray of worms, the longer it lasts to sell = better quality. Dragon bait worms tend to last longer than wild worm, as they are used to the variability in temp etc. I think they will fish the same”.*

Dragon Baits also believe that some shops re-pack their farmed worm to make it look like wild stock, and would like points of sale to be honest about when they are selling farmed bait:

“*If shops were more honest then anglers would probably discount their superstitions.”*

However, some questionnaire respondents believed that farmed ragworm didn’t catch as well. One noted that it was because they were less fresh and stored longer than wild worm, so had lost their scent.

When farmers were asked if they had tested the quality of their ragworm compared to wild ragworm, neither farm had tested for feeding preference amongst the target fish. Dragon Baits has done pathogen, calatanoid and saturated fatty acid tests, which scored higher than other farmed and wild ragworm. Topsy Baits have tested their protein content for the aquaculture feed market, and this can be higher than wild baits. But this did not include pheromone / chemical tests or real life fish preference experiments with experienced anglers to see whether fish prefer it or catch with it.

Topsy Baits see price as a barrier to shops buying more farmed bait, although Dragon Baits believes that wild worm is now more expensive than their farmed worm.

Dragon Baits believes that some shops will continue stocking wild worm in loyalty to their long term suppliers, until those suppliers stop operating.

RQ7d. What barriers in farm production limit the growth of the farmed ragworm market?

Long set up times prior to production, and the high overheads associated with running a small farm that is reliant on the unpredictable bait market is a risk and potential barrier to growing the UK market. Topsy Baits noted that in 1985 there were 18 other farms who were largely unable to grow, which have now all closed. Dragon Baits noted that in 2023 SeaBait Ltd, who was the initial leader in ragworm farming and polychaete aquaculture, has eventually closed its doors after not being able to maintain consistent supplies of harbour ragworm, when the power station supplying their warm water supply started using chlorine in its cooling water. They were a small farm, limited geographically and subsidized by reduced overheads from warm water supplies from a local power station that meant their worms could feed all year. Interviews with Dragon Baits revealed concerns that small farms that cannot grow in size will not be able to provide bait at competitive prices.

The barriers related to farm production presented below are a summary of interviews with Dragon Baits and Topsy Baits.

Securing permanent tenure on their site, and increasing the size of the farm
Dragon Baits is keen to increase their production, but the biggest barrier to meeting Welsh ragworm demands is the tenure on their land, that expires in 11yrs. They have been trying to buy the land from Welsh Government, so they are loathe to invest heavily in farming until their site is secured permanently. They have been making small adjustments to increase ragworm supplies, but they need site security to be able to meet the ragworm demands for Wales.

Cash for increasing production
Ragworm farms, like many other farms, are economies of scale with big overheads. Small farms are not very viable as they are expensive to run, but the larger farms need more cash in the bank to cover their set up costs before production starts. Heavy investment is required for bespoke machinery to maximise efficiency and yields.

Dragon Baits said that they know how production can be increased a bit in the space they have, but it costs money:

> *“To produce an extra 3-5 tonne a year, we need to increase in size by 25%, but we need the outlay costs (£25K; pumps are £10K, harvesting machine is £25k to build), we could be predictable and start taking people on. Then the extra running costs would be relatively small in the longer term, £1500-2000 “*

They will be increasing production a little very soon, as they have received a grant for a new harvesting machine which will increase productivity with immediate effect.

Time

The reproductive biology and life cycle of ragworm means it takes time to reach production levels on any farm and development of new farms, or growth of existing farms will take time no matter how much investment there is. Worms need to be settled before fertilization in Feb-March. It takes three months to get from fertilisation to the point of harvesting ~1inch animals for moving into grow-out tanks. They then require 3-4 months feeding before reaching a saleable size. Worms do not feed in the colder months, November – Feb / March. In total, it takes 9-12 months to bring ragworm to a saleable size (approximately 8g).

When the Welsh farm set up, they subsidized their sales to ensure consistent market demand by buying in farmed worm from other farms.

Increasing overheads

Both Topsy Baits and Dragon Baits complained that all prices have gone up: labour, feed and energy, affecting both the running of the farm and their supply chain. But neither have transferred much of this on to their buyers.

Price competition with wild collectors

Farms feel that they are unable to increase prices to honestly reflect their recent inflated costs, as they are aware that they are constantly competing with wild collectors who have much lower overheads.

Increasing temperatures / environment

The tanks or pools have more temperature and salinity extremes than in the wild. Dragon Baits also noted that temperature can limit the growth and productivity of the worms – if it is too cold the worms don’t feed. But if it’s too warm for too long, oxygen levels will decline to a point that a whole tank will die. Topsy Baits noted that if the pools reach over 30^{o}C, the ragworm start to die off.

Staffing – *“Lack of a New generation: Need to find people that are willing to graft.”*$_{DB}$

Both farms have good staff retention and low staff turnover. Topsy Baits rely on staff between 35-60 (mostly 50+), with several of them now very skilled and experienced in worm farming after working for the company for 20+yrs. Dragon Baits has a smaller number of staff who have been with the farm for the last 5-6yrs. As a result they are vulnerable to pending staff changes, to a new workforce with less experience in the industry. Dragon Baits noted that in order to improve production they need at least one more staff member now, and to grow they will need 2-3 more people in the next few years. But the company is apprehensive, as they have previously advertised posts via word of mouth to people with an interest in the industry: ex-commercial diggers, fishers, bait shop owners and anglers, who make dedicated workers. They are particularly concerned about whether they will be able to find new staff willing to work the long, antisocial hours outdoors in the future through normal employment advertising channels.

Topsy Baits noted that

> "*Sometimes we advertise and have success. As long as they are willing to work, then that's ok. We don't have a problem getting people to work the hours in NL."*

Sustainability of ragworm feeds

Dragon Baits rely on a trout feed that is developed into 4 or 5 different pellets that contain fish meal. Topsy Baits similarly use a carp feed, largely soy based and probably also with fish meal. Neither were sure where the fish meal came from, but suspected somewhere in South America, and Dragon Baits thought this may be wild stocked. Authors note that marketing based on sustainability should require further investigation into ragworm feeds. See the discussion for suggestions regarding this.

RQ7e. What product distribution barriers limit the growth of the farmed ragworm market?

Keeping ragworm alive

In interview Dragon Baits said they have switched their distribution to British courier services, which are generally fast and efficient. However, they do have problems with some couriers unhappy to transport live worms.

In interview Topsy Baits claimed their worms will survive for four days during transport to the UK, and that once they are unpacked they can survive a couple of weeks if the shops take care of them. However, Topsy Baits mentioned that the heat of summer may affect survival during transport, and that it can't deliver to tropical countries.

Regulations of transporting live worms

Within Wales and the UK, Dragon Baits fear any further courier limitations on the transport of live animals. They already have problems with some couriers unhappy to transport the worms within the UK. They fear the impact of unclear and undefined Post Brexit regulations on the transport of live animals in the UK and on future export potential in the long term. They specifically fear changes in the 'non-harmonised product' status that worms currently have, which means animals do not require health certificates for transport within the UK.

Topsy Baits explained how exporting worms is also becoming more and more difficult due to paperwork, especially to the UK. At the time of interview, the UK currently has the same regulations as Europe for aquaculture feed and bait, but there is an increasing trend for more testing for viruses, antibiotics, pesticides before export. Topsy Baits has one person doing all the paperwork in relation to transport permits for the >50 countries supplied with frozen aquaculture feeds and live baits. Topsy

Baits is at a competitive advantage for international distribution, as it is close to four major shipping ports and two airports for easy, quick shipping. However, after Brexit importing to the UK has become more difficult and they also fear that legislation around transfer of live worms may become more stringent.

RQ7f. What other barriers are there?

Lack of Government Support

Dragon Baits feels that the sea angling, and specifically live and frozen sea angling bait industry, is little supported by government and often in conflict with environmental managers. The authors comment that it is an almost invisible market economy and support for more farms would help to increase visibility of the market, but also transparency of the stocks and help the environment and wild stock recover. This comment is inspired by interviews with Topsy Bait when recounting how farming became a welcome alternative to reduce environmental conflict in Holland. The researcher also notes the previous quotes from Dragon Baits regarding lack of governmental interest in the industry, which limits the company's ability to grow, whilst Topsy Bait commented that they have local governmental backing in the industry, enabling them to easily grow (RQs6 & 7d).

> *"If there was a market, I would grow the farm and supply more bait. … Local government is quite willing to help"* $_{TB}$

Dragon Baits noted several times that they feel the government is not taking the industry seriously, and ended their interview with the following quote:

> *"I'd like to think that this is still a strong industry, and one that needs to be seriously thought about, as fishing is a hugely, hugely participated past time and the supply of one of the key elements to sea fishing (bait), where the supply of bait in the not too distant future will start to become a problem. Unless, to be blunt, we are helped or able to keep pace with the reduction in wild stock and foreign supplies.*
>
> *If wild production stopped tomorrow (eg: dredging just stopped / the boats all broke / sudden enforcement of diggers on the south coast), we couldn't react. Shops would probably go bankrupt and close, and simply displace the problem. The other options (farms) are not infinite and not immediately available. It takes a year to start a farm. It's still a long, slow process to adapt and change. "* $_{DB}$

Reputation and Trust

In order to invest and meet the increasing overheads of making a small farm bigger, Dragon Baits needs to buy and ideally expand its well-established site . to continue to operate in the long term. It may also need funding and trust from banks and political support. Unfortunately, Dragon Baits was involved in a financial scandal almost 20 yrs ago. Despite hard work on the part of the new generation at Dragon Baits to rebuild its reputation with clients, interviews found that it still feels that it suffers from reputational damage. The passion displayed by Dragon Baits suggests they may be best placed to fill the hole in the market. They are open to demonstrating transparent operating practices to facilitate this, if they can gain financial and political backing.

> *"We have turned our reputation around. So now, to get Welsh Government to look positively on worms, and us (as we are the industry in the UK), and to potentially help, we may need fresh faces"* DB

Risk that bait farms move to supplying aquaculture feeds

Several farms have moved production to aquaculture feeds (specifically shrimp broodstock feeds). Put simply by Topsy Baits:

> "*(Aquaculture feed) is a bigger and easier market. All they have to do is freeze the worms. Easy distribution, less processing, bigger and constant demand."*

However, Topsy Baits notes that supplying to aquaculture feed markets is not for everybody, especially if you don't have the space to have a constant supply and equipment to freeze high volume worms. Dragon Baits sold their satellite farm in Pendine to a shrimp feed producer, farming harbour ragworm for aquaculture feed, as they considered it too small to be viable for king ragworm, as small farms are logistically challenging:

> *"For every 4-5 grow out tanks, you need at least 1 breeding tank, which could fail. So a small facility won't work. But small facilities could be grow out facilities."*

Dragon Baits told us that Seabait had warm water from a power station and could maintain feeding throughout the year, so they focussed on harbour ragworm, or maddies. Harbour ragworm reproduce so regularly that they would self-sustain / re-populated themselves, but they die shortly after. So harbour ragworm can be produced in the UK throughout the year, but are too erratic in their breeding patterns for the live bait market and so preferred as an easy breeder by frozen aquaculture feeds.

We asked the farms why they continue to supply to the bait market when aquaculture appears to be a more viable and consistent market:

“It’s history. We have a 30-40 tonne bait market, which is enough to continue. We charge more for bait than for aquaculture. Everything makes it more expensive to produce – eg: needs more packing, careful distribution.“ TB

“*It’s the most popular bait, it’s an all rounder. You can catch anything! It’s easy to keep, look after and to get to the shop alive. We fill the gap between wild stock and angling demand.” DB*

Potential incentives to persuade anglers to choose farmed over wild ragworm

RQ8. What would incentivise anglers to choose farmed ragworm over wild bait ragworm?

*Table 5 Potential factors that might incentivise more uptake of farmed ragworm in preference over wild ragworm. Anglers responses to 'What things would help persuade you to choose farmed ragworm over wild?' Scores for each statement are averaged from a Likert scale of 1, not at all important, to 5, very important. Low importance = scores of 1 or 2, not at all important or slightly important; high importance = scores of 4 or 5, fairly important or very important. * It was clear from the open answers to 'something else' that respondents misunderstood this category as they had no other ideas for incentives.*

	Reponses to Q (n)	Number of respondents who answered factor was of low importance	Number of respondents who answered factor was of high importance	Average score[!] (n=19)
Quality assurance	19	2	17	4.37
Guaranteed consistency of supply	19	2	16	4.26
Sustainability	19	2	16	4.11
Price discounts compared to wild ragworm	18	5	11	3.44
Local Produce (Welsh / UK farmed)	19	6	10	3.16
A free trial	19	8	9	3.00
Advertising of where farmed ragworm is available	17	10	7	2.65
Nothing, I don't want to use farmed bait	17	14	2	1.65
Something else*	3			1.67

[!] Maximum score attainable = 5

Of the 19 anglers who stated they use ragworm, 10 said they would be reluctant to buy farmed ragworm. Of these 10, 6 of the them said they would buy farmed ragworm if it cost the same or less than wild ragworm, 3 of the 10 said they would buy farmed ragworm if wild was not available, and only 1 of the 10 said that they would never use farmed ragworm. As one commented: "*I want **the best that's available** for me to maximise my chances in limited fishing time".*

All ragworm users (both shops and anglers) were asked to score nine different potential incentives to use farmed instead of wild ragworm (*Please score which things would help persuade you to choose farmed ragworm over wild?', from not at all important,1, to very important, 5*). Concurrent with anglers ragworm purchasing preferences (Table 4), quality assurance from the farm was considered of the highest importance as a potential incentive, followed by guaranteed consistency of supply, sustainability (Table 5). Although price discounts and free trials were important, they were less important than guaranteed quality and consistency of supply, or sustainability. Anglers also see local (Welsh or UK) farms as an important factor influencing whether they would buy farmed baits.

Although 'Advertising' of farmed baits only rated 'slightly important' to users, the authors note that advertising is the only way the market will increase awareness of any quality assurance schemes, guarantees of consistent supply or sustainability information.

Potential for co-operative ragworm farming in Wales

Eighteen questionnaire respondents opted to answer some additional questions at the end of the survey. They were given the below statement before being asked about their interest in co-operative farming.

"A community cooperative is an organisation that is owned and run jointly by its members. Members participation can range from capital investment to hands on help with day to day employment, or even paid employment. Members then share the profits or benefits. There is no plan or funding for a community bait farm in Wales, but there are some successful recent examples of community cooperatives in aquaculture in Wales and elsewhere."

Table 6 Interest in co-operative ragworm farming in Wales, from anglers, bait suppliers and bait sellers in Wales.

	Respondents (n)	Yes	No	Maybe
Believe a co-operative would be wanted in Wales	18	7	2	9

Believe a co-operative would be feasible in Wales	19	9	1	9
Would be interested in being part of a cooperative	19	5	12	2

There was some interest from collectors, farmers, anglers and shops in co-operative farming opportunities in Wales (Table 6). Respondents against the principle commented that more ragworm farming was unnecessary because Wales already has one farm, and one respondent considered ragworm farming was not viable (*"Ragworm farming has been tried before and failed"*). One experienced angler commented:

> *"Any way that will improve the availability of bait, the long-term sustainability of bait AND create jobs and growth has to be looked at. It would be stupid not to explore it. My participation would be age-defined. No concerns if it is done properly and achieves what it wants to, to sustain and protect the wild stocks."*

The same angler had earlier commented that they didn't like farmed ragworm, but reflected if it was the only option for a while to let wild stocks recover, they would have to accept the best available bait.

Dragon Baits had strong opinions in interview about the idea of developing satellite co-operative farms, and had previously considered something similar at their satellite in Pendine (that was sold to a shrimp feed producer). They concluded that the requirements of running a worm farm are very technical to learn and needs 24hr a day maintenance and high capital expenditure. For instance, the cost of feed is only 5% of the overheads of running a farm, and to be profitable with the current running costs any farm would need to produce at least 20 tonnes, so that has taken them 20+yrs and heavy investment to reach that level of production. However, they did say that smaller operatives could act as independent grow out facilities, which didn't rely on breeding their own brood stock. Grow out facilities have lower overheads and can be a smaller size in their opinion. If lots of locations were interested, an expert farm could act as the main brood facility and the co-operatives could host many grow out farms. This model is more akin to a shrimp farming model. If communities are interested in pursuing this option, Dragon Baits has offered to help train anybody who is interested, but they do not have capacity to supply grow out farms with their current resources, size or production levels.

RQ9. Would commercial wild bait diggers be interested in co-operative ragworm farming, to replace their wild collection activity?

Of those interested in becoming part of a co-operative bait farming initiative (Table 6), two were commercial collectors, one was a recreational collector, one was a shop owner and a recreational collector, and one was a shop owner (three of whom were also anglers). Two additional anglers may be interested, depending on what it involved.

Dragon Baits noted that commercial diggers who don’t want to dig any more make good employees, as they understand the species and don’t mind unusual working hours. If they grow, Dragon Baits will be looking for staff. So, bait farms may offer a good stable employment for some keen bait collectors.

Discussion

This project set out to evaluate the current use of farmed and wild-caught ragworm bait in Wales, identify barriers to the use of farmed ragworm bait and recommend measures that can be taken to alleviate pressures on the environment. We have analysed interviews and questionnaires from 28 people who are part of the bait supply chain in Wales: users (anglers), retailers (shops, outlets, buyers and sellers) and suppliers (commercial and recreational collectors and bait farms). The discussion brings these perspectives together in the context of the 9 identified knowledge gaps identified in the introduction. It makes some recommendations on the future of ragworm production in Wales.

Threats to the current ragworm market in Wales

This project has found that the ragworm market is threatened by fluctuations in ragworm demand and the availability of ragworm from both the wild and farmed sources.

Availability of wild ragworm supplies

Participants provided contradictory observations regarding the extent and intensity of wild ragworm digging. It is thus unclear from the results of our survey whether overall wild bait digging for ragworm is increasing or decreasing. Decreases in wild bait digging could be due to factors such as reduction in demand leading to regular diggers securing other employment, and reduction in bait angling competitions (not mentioned by participants, but suggested by NRW). Increases in wild bait digging could be due to roving collectors addressing a gap in the market (see questionnaire responses, related to limited shop supplies and Ammo baits providing less), localised high intensity digging, but also potentially displacement of digging activities. Contradictory reports of digging intensity indicate that managers should be cautious of assuming that wild harvesting is decreasing. It is possible that commercial digging could be quietly displaced to less known, or more remote / unmonitored beds, that might be vulnerable to roving collectors.

Despite the discourse around whether wild digging is increasing or decreasing, several shops complained that wild dug ragworm cannot meet the demand of their individual anglers, and Dragon Baits has said they are being approached by shops for regular supplies that they cannot meet. Many suggestions were given by participants as to why there is less availability of wild ragworm in shops including declining wild stocks, that digging is harder work than it used to be (due to less catch per unit effort with declining stocks, harsher weather, increased price of fuel and parking), an aging population of bait collectors and that a new (younger) generation of collectors either do not want to spend the physical effort on digging, or are not prioritising time to dig in their daily lives. Combining the general sense of responses from the survey participants, we suggest that less digging might be due to shifting social values or social norms in society, for instance from prioritising and valuing more family time, or that digging or informal income may not be as socially accepted as it was twenty years ago.

Availability of farmed ragworm supplies

Despite potentially lower numbers of sea anglers than twenty years ago, the reduction in the availability of wild bait means there is a perception from farmers (evidenced in recent increase in interest from new customers) that there a growing market for farmed bait. Questionnaires identified that some shops and most anglers are willing to try farmed ragworm if wild ragworm is not available. However, interviews with Dragon Baits from Wales identified that at times they could not meet demand, whilst Topsy Baits from the Netherlands could increase supplies to Wales. However, the pathway from the Netherlands to Wales is unclear, and there may be limitations in getting the Dutch bait to Wales, given they supply through a sole English distributor and it is likely there is no specific incentive to supply Welsh shops. Live bait supplies from Europe are also vulnerable to any post-Brexit changes in regulations on live transport or tariffs.

Fluctuating market demand

In interviews, ragworm farmers told us that they have seen a decline in overall farmed ragworm demand over the past 20yrs, but with a recent upturn in the market since a resurgence in popularity of the sport (or sea angling) during Covid. A basic comparison of the demands for shop bought ragworm from individual anglers has risen since 2009. In 2009 shops in Milford Haven identified anglers using shop bought ragworm bait were, on average, buying 8.4kg of ragworm per week (Morrell 2009), compared to those questioned around Wales in in the current project (2024), who were buying approximately 10.7kg per week. However, farmers tell us that their demand from shops is still less than their peak production in 2004, in their opinion due to fewer people choosing angling as a pastime overall. The authors note that there have been several periods of financial instability since the financial crash of 2008, which means the availability of disposable income may also be threatening the purchased live bait market (with anglers instead selecting reusable baits or collecting their own baits). Farmers believe that the increased demand they have experienced recently is due to a decline in wild bait stocks, a decline in the number of wild collectors, and the realisation of shops that farmed ragworm supplies can be more consistent and available than wild suppliers.

One angler highlighted a potential risk in their ‘additional comments’ that was not mentioned elsewhere:

> *“Perhaps there should be a ban on competitions in the estuaries or making competitions use other baits”.*

If angling clubs and associations decided to ban the use of live baits, or ragworm specifically, then there would inevitably be a drop in demand for baits. However, banning the use of certain baits in competition without consent from the industry may risk forcing a black market, discouraging participation in organised events or alienating anglers from their established groups. Established and respected social networks make behavioural change amongst social groups easier, so alienating people from these groups brings with it a risk of discommunicating individuals from key messages.

Reliance on a single farm

The Welsh ragworm market has a potential over-reliance on a single local farm. Although Topsy Baits does provide an unknown amount of ragworm to Wales, in 2017 the Independent claimed that 90% of UK commercial bait came from Holland, whilst in 2014 Dragon Baits claims to dominate the Welsh market. Although Topsy Baits Ltd has also moved most of its production to aquaculture feed production, it also says it will always honour the bait worm market wherever possible as it was their initial target market.

If new farms are required in Wales or the UK, they need time, space and heavy capital investment to set up. Dragon Baits estimate that it takes a minimum of nine months for a ragworm farm to reach production levels. According to ragworm farmers interviewed, farms benefit from an economy of scale and room to grow in the long term, but with bigger plants, farms risk moving into aquaculture feed production (see below).

Ragworm farms moving from bait to aquaculture feed production

The live bait market is lucrative, but logistically more challenging to give a high end market product than the same frozen product being sold for aquaculture feed. For this reason, there is a risk that large scale investors in live bait farms may decide to shift their products away from bait to aquaculture feeds in the long term.

Many polychaete farms move towards aquaculture feed production as it is lucrative and logistically easier (also concluded by Cole et al. 2018). Sustainable Feeds Ltd. moved its business to supply aquaculture feeds as a protein rich fish feed and for shrimp maturation (referred to as Shoreline Sustainable Feeds in Cole et al. 2018). However, interviews with Dragon Baits revealed that they understood that Sustainable Feeds has ceased farming operations in the UK as they could not maintain production after the power station water that supplied it started using chlorine in its system. Sustainable Feeds did not return calls to contribute to this report. It is also possible (speculation by report authors) that changes in the shrimp market in 2023 may have also contributed to the closure of the Sustainable Feeds plant. Topsy Baits Ltd has also moved to a higher proportion of aquaculture feed production, but says it will always honour the bait worm market wherever possible as it was their initial target market.

A report investigating viable aquaculture feeds in Norway identified only one global specialist in the production of polychaete-based pellet feeds for the salmon, trout and pet foods markets (Almås et al. 2020). This company, Prochaete Ltd. (www.prochaete.com), is based in the UK and the Almås et al. (2020) report claimed it was supplied by ragworm from Topsy Baits. There is also growing interest in the use of king ragworm in seabass feeds (Monteiro et al. 2024). It is possible that if production of polychaete based pellets for aquaculture and pet feeds continues in the UK, there may be significant risk that ragworm farms may move away from the bait market to this easier customer base.

Limited information on the wider ecological impact of farming

Conversations with ragworm farmers revealed that the farms rely on feeds of unknown source, which may comprise soy from unknown sources and South American fish meal from wild sources. One respondent believed that farmed ragworm is packed in peat, which is known to be of conservation concern. This current lack of understanding suggests there is a need to research the life cycle / ecological impact of the full farming venture.

Climate change

When forecasting the future of the angling and bait industry, we cannot ignore the increasing unpredictability in the seasonal weather as a result of climate change, and therefore unpredictability in the anglers demand. This was a theme that appeared throughout the survey, although respondents may not have directly attributed climate change, making it hard for shops to ensure they have enough live baits in stock when needed, especially during breeding season. Ragworm farmers perceived the overall falling numbers of recreational sea anglers to be a result of declining or changing target fish species and weather putting anglers off the sport, and causing unpredictable fluctuations in demand. Shops also noted that unpredictably hot weather, rain and storminess meant that angler demand is less predictable. The impact of increasingly unpredictable weather systems, due to the impacts of climate change, has been noted to affect many aspects of angling,including bait accessibility and fishing days (Townhill et al. 2019).

Although both farms noted that there has been an overall reduction in angler numbers, they also noted a resurgence in the popularity of the activity since the Covid pandemic. Dragon Baits did not consider falling angler numbers a risk to the demand for farmed bait, as they see farmed bait as the opportunity to meet the demands of a dwindling wild supply. However, aquaculture itself is also at risk to the impacts of climate change. Both Topsy Baits and Dragon Baits noted that it can be hard to maintain the correct temperature during extreme heatwaves, and that if pools overheat they can suffer from mass mortality of their stocks. Keeping tanks and farming adaptable and resilient to the changing climate must be fully considered prior to investment.

Availability of other bait species

Some shops made comments that vacuum packed real bait supplier, Ammo Baits, has reduced its supplies to the angling market whilst others noted an increase in lugworm demand and wild collection. Simultaneously, Dragon Baits said that their commercial imports of dredged lugworm from the Netherlands have reduced. A reduction in lugworm supply together with a recognised market need (particularly when farmed ragworm is breeding and less available) may increase demand for wild, farmed and imported stocks from other species or places. Topsy Baits also referenced Chinese importers of non-native worm baits as a potential threat to the market, as these suppliers have taken over many other European markets. The authors, farmers and shops are aware that there is an active online market for live and real sea angling baits. Both changes in availability of other wild stocks, and realisation that other baits may be importable from abroad, could be both an opportunity and a threat to the markets for ragworm and other baits.

Interestingly, one questionnaire respondent who was an experienced fisher offered an unexpected insight and suggestion to farmed and wild baits, which could be a threat to the ragworm market, in the ‘additional comments’ box at the end of the survey. Their claims or suggestions may justify some further research:

> "*Angling and bait outlets are getting fewer and farther between. Bait supplies are getting harder to come by, which means more people will go online and more people will use frozen baits. There is a commercial bait from the far east, a bit like an oily mackerel, which is wild, called 'bluey', which may come in via online shops. It's the principal bait in sustainable fishing practise and is now used in recreational fishing, available in most shops. Same as squid (which is usually Californian) and is also wild stocked…. If somebody could make a ‘sea fish boiley’, like a carp fishing boiley (a mixture of organics that are maybe krill or squid ingredients, many new ones are nut based, that you boil and can be moulded to your shape and size; 100% good for the carp for sea fishing different species, this would solve bait supply issues for Wales. There have been a few attempts: fish and strips was one attempt, that you cut into strips, and it did work. But it needed some serious honing to catch better and get them biting. It needs financing by a major company, usually its small company who try and run out of money. Between 1992-2003 / 1995-1996 there were some liquids to drop onto the baits and if you got the right one, they could enhance their catches. They were also commercial enhancers to stimulate feeding in fish farms. So they are under development, but maybe not enough marketing for angling community”.*

The authors note the opening of alternative markets might threaten the live bait market, but also questions the sustainability of ‘commercial enhancers to stimulate feeding’ if they contain artificial chemicals. Two respondents mentioned that the research and development of these baits are improving, stating that they had found effective artificial yet natural and / or chemically enhanced baits. The artificial bait and lure field may be rapidly developing. This question is beyond the scope of this report.

Opportunities for the ragworm market in Wales

Reports of the ragworm market from the farmers suggest that the angling economy peaked in 2004-2005, just before the global recession in 2008. The economy, and therefore people's disposable income, has since suffered several fluctuations but the evidence from this project is that there is now a growing demand for shop bought live baits that cannot be met by the current supply chain.

Evidence suggests that there are fewer wild diggers to meet demand resulting in a growing market for farmed bait despite potentially lower numbers of sea anglers than twenty years ago. Previous analysis of the Strengths, Weaknesses, Opportunities and Threats to the Welsh sea angling by key stakeholders identified that the industry is threatened by "reductions in localised bait availability (through overexploitation for example) or access to collect (e.g. black lugworm, peeler crab and sandeel) may reduce local sea angler numbers" (Monkman 2015). Evidence from the current project suggest that Monkman's concern may be misplaced, as shops and farmers while noting reductions in local bait collection activity and availability of wild stock, have also observed simultaneous rise in recent demand for farmed ragworm. Thus, reduction in the availability of local wild baits may not necessarily result in people leaving the sport. Instead, it may result in increased uptake of farmed or alternative baits.

A natural turning point to move away from wild stocks and look to farmed baits and alternative non-live baits

The evidence suggests that the ragworm industry is meeting a natural turning point whereby supplying shops from wild collectors is becoming harder. Questionnaires found that Welsh anglers were willing to buy farmed ragworm when wild stocks were not available, even when they believe farmed bait to be inferior to wild. As discussed in interviews with Topsy Baits, this is how they entered the Dutch bait market. This evidence presents a great opportunity to develop the ragworm industry with a focus on farming and research and investment in new farmed species, or non-live baits (such as fish feed based boileys or moulded feeds that contain naturally sourced ingredients).

Commercial collectors as bait farm workers

Dragon Baits noted that commercial diggers who don't want to dig any more can make good employees, as they understand the industry, species and don't mind unsociable working hours. Therefore, bait farms may offer a good stable employment for some keen bait collectors.

To address misconceptions

Increased pressure from sea anglers to stock farmed bait in the absence of wild bait may drive the market away from a reliance on less available wild stocks. However, to achieve this marketers may benefit from investment in trials and advertising, to address concerns amongst anglers to convince them that farmed ragworm is a viable alternative to wild ragworm (RQs7a-c), both in quality and in its commercial viability.

> *"Ragworm farming has been tried before and failed. I can't imagine the capital and revenue costs could ever make it viable."*

One good idea to improve the percieved quality of farmed ragworm came from one angler:

> *"Potentially a fully funded large match, where all sea anglers have to use the farmed bait provided. This may help alleviate superstitions."*

This is a good idea for marketing, which has been tried on small scales before. However, when farms were asked directly if they would fund a whole match they said this is highly unlikely. They would currently not be inclined to advertise or fund matches through donation of free ragworm due to financial losses that it would incur, the one off demand would compromise consistency in their usual shop supplies (when there may already be short supply) and finally Dragon Baits do not have capacity for more regular business at their current production levels. Financial incentives to supply on a one off event would ensure sufficient supplies and long term planning for such an event.

The farming industry may also offer training to shops in how to look after farmed bait once received from the supplier.

Beyond the concerns of anglers and shops that farmed ragworm is inferior to wild ragworm, some comments from participants revealed a need for education amongst sea anglers in other areas surrounding farmed baits:

> *"It also sounds like it would take business away from local tackle shops, which need all the help they can get."*

This comment could be correct, as farmed bait may cost more for shops who collect their own bait, or it could be a false perception, as the data collected here indicates that farming does keep shops stocked with live farmed ragworm when wild is less available

Research and improve farming feeds for sea angling baits

Conversations with ragworm farmers revealed that the farms rely on feeds of unknown source, which may comprise soy from unknown sources and South American fish meal from wild sources. This realisation also comes with an associated opportunity to research the life cycle / ecological impact of the full farming venture and improve the sustainability

To reduce ragworm farms reliance on soy and improve their sustainability, Norwegian researchers are already exploring the viability of using sugar kelp, *Saccharina latissima*, as feeds in ragworm aquaculture to reduce the requirement for potentially non-sustainable feeds (POLYKELP project, funded by SINTEF 2022). Although the POLYKELP project ultimately aims to improve the sustainability of salmon farming (with a seaweed-fed ragworm diet), if the concept is successful, there is also the opportunity to replace the soy and fish meal derived carp and trout feeds currently used by the UK ragworm for bait market.

(POLYKELP project: https://www.sintef.no/en/projects/2021/polykelp-seaweed-as-feed-source-for-protein-rich-polychaetes-aimed-for-salmon-feed/)

Availability of other bait species

Changes in availability of other wild stocks, and realisation that other baits may be importable from abroad, could be both an opportunity and a threat to the markets for ragworm and other baits (see comments in Threats, above).

There are opportunities to farm other bait species in Wales, although Dragon Baits and Topsy Baits both considered king ragworm (*Alitta virens*) the easiest and most viable species in the UK. One participant noted that a small Welsh research and development company was close to farming shore crab in South Wales, but that they ran out of funding. They elaborated that many attempts at farming are from small ventures, with low capital, and that investment from large industry partners may help boost development in this area (and the area of artificial alternative baits and lures). Any interested producers and researchers should be aware that there are producers of other polychaete species internationally, and patents for the aquacultural production of several species including *Arenicola* (lugworm), and packaging materials for polychaetes. Some of these are detailed in Almås et al. (2020).

Recommendations for non-legislative actions by stakeholders and regulators to alleviate pressures on environments arising from bait digging.

There are a number of ways, in both the short and long term, that the market for ragworm can shift from reliance on wild ragworm toward farmed supplies. This section lists a number of potential measures (in no particular order) which could be taken, both by stakeholders and NRW, to achieve these goals. These measures are based on the authors understanding of current status of the market gained from questionnaires with bait users, shops, distributors and collectors, and interviews with farmers, plus previous literature. The measures are listed for consideration by NRW, whilst accepting that the implementation of some of the recommended measures may be outside their control.

Following are recommendations for non-legislative actions to alleviate pressures on the environment, and to increase the environmental sustainability and resilience of the live ragworm bait market in Wales. Note all advertising and code of conduct related recommendations should be subject to regular media updates so they are not forgotten over time. Below, ‘Purpose’ gives reference to where in this report the evidence for the need for this action came from.

Actions Group A: Relieve Market Pressure

Action ID: RelieveMarketPressure_1
Action (what): Temporary sourcing of farmed native UK bait species from abroad.
Purpose (why): To meet market demands whilst there is reduced wild supplies (RQ6), during public holidays and over winter, where demand exceeds supply (RQ2d). This aims to mitigate risks associated with high demand forcing a resurgence in wild collection (see ‘threats’ in discussion).
Guidance (how): Suggest investigation into this by the organisations involved (there has been a recent rise in supply of farmed bait to the UK, but it is uncertain where this is delivered to within the UK).
Responsible Stakeholder (who): Angling Trade Association, Bait Farms, Shops, other Bait Distributors.
Term / Timescale (when): Short.

<u>Actions Group B: Advertised Farmed</u>

ActionID: AdvertisedFarmed_1
Action (what): Encourage angling influencers to use farmed ragworm.
Purpose (why): To change perceptions that farmed ragworm is inferior to wild (evidenced in questionnaires, RQ7a).
Guidance (how): Invite influencers to use some free farmed baits on their social media channels.
Responsible Stakeholder (who): Ragworm farms, shops who can't find wild suppliers, or shops who want to use more farmed bait.
Term / Timescale (when): Short (when there is an available farmed supply – not in winter).

ActionID: AdvertisedFarmed_2
Action (what): Trial of farmed vs wild ragworm.
Purpose (why): To change perceptions that farmed ragworm is inferior to wild (evidenced in questionnaires, specifically RQ7c). Neither farm have undertaken fish preference / choice experiments with farmed ragworm vs wild, or invited matches to use free bait.
Guidance (how): Test of the 'attractiveness' of farmed v wild ragworm to target species (for future advertising). This could be done in controlled lab trials for food preference, and / or at angling matches where competitors are provided free ragworm of unknown source (50% wild and 50%farmed). Angling influencers could also do free trials.
Responsible Stakeholder (who): Ragworm farms in conjunction with angling organisations / clubs / competitions / influencers. Scope for researchers.
Term / Timescale (when): Short.

ActionID: AdvertisedFarmed_3
Action (what): Test shelf life of farmed vs wild ragworm.
Purpose (why): To challenge perceptions that farmed ragworm has worse shelf life / longevity than wild ragworm (RQ2a).
Guidance (how): Controlled randomised trial of farmed vs commercially wild-caught ragworm. Advertising the results with social influencers.
Responsible Stakeholder (who): Any of the following: NRW, researchers, shops, Angling Trade Association, Angling Cymru, social media influencers.
Term / Timescale (when): Immediate.

ActionID: AdvertisedFarmed_4
Action (what): Improve reputation of farmed bait amongst competition anglers.
Purpose (why): Suggestion from angler: *"Potentially a fully funded large match, where all sea anglers have to use the farmed bait provided. This may help alleviate superstitions."*
Guidance (how): Could be done in conjunction with 'AdvertiseFarmed_2'. N.B.1: Only viable if farm has sufficient production levels. N.B.2: There was suggestion from NRW that this may have been done for a Welsh national boat qualifying match, and some international shore matches in the past. If it has been done, NRW should locate this information and use it in advertising campaigns (Code_5 or AdertiseFarmed_1-4).
Responsible Stakeholder (who): NRW, ragworm farms, Angling Cymru, angling clubs and associations.
Term / Timescale (when): Short.

ActionID: AdvertisedFarmed_5
Action (what): Marketing campaign that levers / addresses the sea anglers' farmed ragworm preferences.
Purpose (why): Evidence of sea anglers ragworm preferences (Tables 4 & 5).
Guidance (how): Following increased production of farmed ragworm, create an advertising campaign, with social media influencers, that levers the sea anglers farmed bait preferences for quality assurance, consistent supply, sustainability and locally farmed. Possibly combine with cost discounts or free trials Could be combined with Code_5.
Responsible Stakeholder (who): Angling Cymru and clubs? With help from NRW for accuracy on legislation?
Term / Timescale (when): Medium – Ongoing.

Actions Group C: Farm

ActionID: Farm_1
Action (what): Train shops in post-delivery care of farmed ragworm.
Purpose (why): Contradictory evidence from shops and anglers about the longevity of farmed ragworm. Advertising best practise to customers may improve longevity and confidence in the product.
Guidance (how): Training videos, available on farm websites, ideally delivered by real shop customers.
Responsible Stakeholder (who): Ragworm farms, with help from their shop customers.
Term / Timescale (when): Short.

ActionID: Farm_2
Action (what): Explore seaweed based feeds for more sustainable land based ragworm farming.
Purpose (why): Evidence suggests that sustainability is the third biggest incentive for anglers to prefer farmed ragworm over wild-caught (Table 5). However authors highlight concerns regarding the sustainability / environmental footprint of current ragworm feeds, which might be mitigated by seaweed alternatives (SINTEF 2022).
Guidance (how): Minimum: Follow up on SINTEF 2022 success of using feeds based on farmed sugar kelp. Alternatively: commission researchers to explore sustainability and alternative options. This could generate positive advertising, or labelling of sustainability credentials in line with other aquaculture ventures.
Responsible Stakeholder (who): Ragworm farms, researchers, UK Seafood Innovation Fund? NRW / WG?
Term / Timescale (when): Short.

ActionID: Farm_3
Action (what): Ensure peat is not used in farmed ragworm packing materials.
Purpose (why): One questionnaire respondent believed farmed ragworm is delivered in peat (RQ2a). Based on sustainability concerns over peat and its importance in carbon capture, in April 2024 UK Parliament announced a proposed Horticultural Peat (Prohibition of Sale) Bill. It is unclear whether this Bill will be passed, but the farmed ragworm industry should be cautious of sustainability concerns.
Guidance (how): If peat is used in packaging, ensure a more sustainable alternative is found. Note there is a patent on packaging materials for live polychaetes which may be useful to farmers (see information in Almås et al. 2020).
Responsible Stakeholder (who): Ragworm farms.
Term / Timescale (when): Immediate.

ActionID: Farm_4
Action (what): Impact / sustainability / life cycle assessment of ragworm (and other) bait farms, with potential for sustainability accreditation.
Purpose (why): Evidence from questionnaires and interviews that: farmed bait may be packed in peat and also utilise soy based carp feed from unknown sources of soy and trout pellets, comprising fish meal derived from wild fish from South America (RQ2a & b).
Guidance (how): A sustainable life-cycle assessment / impact assessment of ragworm farming (to ensure sustainable practice before future advertising). Not including financial sustainability.
Responsible Stakeholder (who): Ragworm farms.
Term / Timescale (when): Immediate.

ActionID: Farm_5
Action (what): Increase production of locally- based farmed ragworm.
Purpose (why): Currently the Welsh farm cannot meet market demands (RQ6). There are no other UK farms and only one other supplying the bait market in Europe. The mainland European market is flooded with Asian imports of non-native species (RQ2a). There is huge potential to grow the industry to cater for UK-wide bait industry (see threats and opportunities), and potentially into aquaculture feeds if resources were available.
Guidance (how): Growing the capacity of the existing bait farm in Wales, potentially encouraging recently closed farms to re-open to production of ragworm (and / or lugworm) baits. It will take some time to increase yield. This report may provide evidence they need to invest in production.
Responsible Stakeholder (who): Ragworm farms, recently closed aquaculture and ragworm farms, researchers, investors
Term / Timescale (when): Medium – Long.

ActionID: Farm_6
Action (what): Explore feasibility of local co-operative ragworm farming.
Purpose (why): Evidence suggests that there is interest in community co-operative farms from all parts of the bait supply chain (RQ9).
Guidance (how): Feasibility study to explore local community / co-operative farm development with bait shops, collectors and farms (have to be large to reach efficient production capacity). Identify viable sites, communities of interest, sources of broodstock, taking into account lead times from set up to point of sale (commercial viability). Look for other examples of community aquaculture, circular economy of multitrophic aquaculture and social enterprise models for advice. (e.g.: Car y Môr in South Wales). It is worth noting that Dragon Baits have serious concerns regarding set up costs and viability for self-sustaining, standalone farms with brood facilities but they did also offer to potentially help communities set up small facilities and supply brood stocks if required.
Responsible Stakeholder (who): Any members of the ragworm or bait supply chain interested in being part of an initiative. Ragworm farms, Aquaculture ventures, Researchers, The Angling Trade Association.
Term / Timescale (when): Long.

Actions Group D: Competitions

ActionID: Competitions_1
Action (what): Discourage use of wild bait.
Purpose (why): Suggestion from angler: *"Perhaps there should be a ban on competitions in the estuaries or making competitions use other baits".*
Guidance (how): There are already some bans / conditions in place in competitions for some bait, but it would be difficult to implement for recreational angling.
Responsible Stakeholder (who): Angling Cymru, Angling Clubs and Associations.
Term / Timescale (when): Ongoing.

Actions Group E: Horizon Scan

ActionID: HorizonScan_1
Action (what): Bait market supply chain analysis.
Purpose (why): Emergent suggestion from author: Respondents complained of the difficulty in getting sea bait, including commercial suppliers turning their backs on recreational bait market (see results to RA2a incl. diggers stopping, Ammo baits supplying less). In addition, there is no information on the size of the online bait market, or the source of their baits. These may both intensify pressure on wild stocks, or demand for non-native baits. This may also highlight potential invasive species to add to the Welsh watchlist.
Guidance (how): Commission a deeper analysis of the range of sea baits on the market, market threats and opportunities.
Responsible Stakeholder (who): The Angling Trade Association / Government?
Term / Timescale (when): Short – Medium.

ActionID: HorizonScan_2
Action (what): Monitor health of farmed vs wild ragworm.
Purpose (why): Emergent suggestion from author: one respondent asked: *“Could discarded farmed ragworm have an impact on wild ragworm stocks?".* Given the known risks from other aquaculture ventures to wild populations, there is potential for aquaculture stocks to host pathogens, disease and hybridise with native stocks. However, as farms avoid selling breeding worms, this risk would be minimal unless farmed species slipped off the anglers hook, or discarded after a fishing session, and survived in the wild.
Guidance (how): Suggest some research into whether the health of farmed vs wild ragworm should be monitored.
Responsible Stakeholder (who): NRW, Welsh Government.
Term / Timescale (when): Long.

Actions Group F: Diversify

ActionID: Diversify_1
Action (what): Research alternative non-live baits that are sustainable and natural product based.
Purpose (why): Evidence from anglers suggested that there are potential natural and chemical based alternatives under development internationally, or that have failed due to lack of capital investment (see Threats). Two anglers mentioned that they found some of these alternatives effective baits with some practice. Although the authors are aware that new baits are constantly under production, this is an author suggestion that environmental managers or funders may seek to better understand the emerging market to specifically address the replacement of ragworm.
Guidance (how): Review of alternative baits on the market, and their producers as potential investors, that could be adapted to replace ragworm in the sea angling market, such as fishing boilies or commercial enhancers. Requirement for impact / sustainability assessment (to ensure no unintended impact on the environment) and heavy investment. Bring this report to attention of current investors if possible.
Responsible Stakeholder (who): Feed producers and marketers, researchers, Angling Trade Association, large commercial investors (e.g.: aquaculture feed company or large tackle supplier), UK Seafood Innovation Fund? NRW / WG?
Term / Timescale (when): Suspect already ongoing.

ActionID: Diversify_2
Action (what): Assess viability to diversify farmed bait market to other bait species.
Purpose (why): Evidence from interviews and questionnaires that a range of common bait species are becoming increasingly difficult to purchase (lugworm, sand eel, peeler / shore crabs, RQs1 & 2). Literature suggests farming is viable for other polychaete species (Almås et al. 2022, Pombo. et al 2020) but ragworm farmers interviewed have investigated options, particularly for lugworm, and revealed challenges that made farming other species appear less viable than ragworm. One participant mentioned that a small company was close to farming shore crab in South Wales, which ran out of funding during research and development phase.
Guidance (how): Desk based review of the feasibility to diversifying the farmed bait market, both in species and location and / or number of farms (requiring significant investment and time); at the same time considering sustainable practice labelling. (CCW did commission similar research into the farming of shore crab many years ago, deeming it unfeasible, but the report reference is unknown at the time of writing. Since then, there has been a growing interest in polychaete aquaculture around the globe, so the technology may make it more feasible).
Responsible Stakeholder (who): Ragworm farms, aquaculture ventures, researchers, the Angling Trade Association, UK Seafood Innovation Fund?
Term / Timescale (when): Long.

Actions Group G: Collaborate

ActionID: Collaborate_1
Action (what): Co-creation of a bait collectors forum.
Purpose (why): Maine, USA, has an active wild bait worm fishery (Maine.gov 2024) which generated a revenue of $8.7mn in 2020. This was possible due to collaboration between collectors to form their own very active forum 'Independent Maine Marine Worm Harvesters Association'. This forum serves well as a communication pathway with policy makers (not dissimilar to many other fishing and cockle associations in the UK) and has worked well as a bottom up, trusted network, to negotiate and co-create best practise and permitting, and to communicate between each other and with decision makers.
Guidance (how): Speak with the Angling Trade Association and bait distributors to see if they consider a commercial bait collectors association important to Wales or the UK. This would need to be led by several trusted bait collectors or bait distributors.
Responsible Stakeholder (who): Angling Trade Association, NRW, A trusted lead in discussion with the Independent Maine Marine Worm Harvesters Association.
Term / Timescale (when): Short.

Limitations of the current project

The current project did not manage to engage with several key industry representatives, including the Angling Trade Association, online retailers and the first international ragworm farm owners, from Seabait / Sustainable Seafoods Ltd. In line with previous attempts at engaging sea anglers and bait collectors (presented in the introduction), and despite significant effort, the Secure Our Future Bait survey had low uptake. Incentives such as prize draws or vouchers for popular tackle providers may increase participation (as used by Monkman et al. 2015). Low response number meant data cannot claim to represent the whole bait community, but it does provide a range of views from independent sea anglers and bait shops of variable size spread across the country. Women, novice and new sea anglers, and sea anglers under 44 were not well represented, but this could reflect the demographic of the angling community. Despite efforts to avoid biasing the survey toward respondents with existing interests in sustainability or conservation, there are limits to the extent to which this could be reliably achieved. Further work might attempt proportional representation through use of specialist survey companies or survey marketplaces, using incentives to participate.

In order to build trust for future engagement our survey engaged with key members of the angling and bait community including YouTube influencers and closed Facebook groups. However, the limited duration of the project limits the extent to which trust can be gained beyond the short term. Towards the end of the survey period, we had a flurry of interest from unexpected places indicating our approach was beginning to bear fruit. Projects that require building a trusted network to disseminate surveys or engage key stakeholders need more budget, time and resources than those targeting established and trusted networks. Additional time is needed for surveys to ‘snowball’ (or gain momentum through recommendations).

Future surveys may be more effective if pathways of communication between stakeholders involved with the ragworm (or bait) supply chain and NRW/ WG are maintained. This might be achieved through development of a relationship with Angling Tackle Association or encouragement of the establishment of a bottom up driven bait collectors / bait industry association. The NRW Steering Group involved with this project has been improving links with the industry, and it is important that it keeps an ongoing ‘open door’ dialogue with sea anglers and bait shops to help build opportunities for future engagement. Breaks in communication may result in lost trust and slow future dialogues.

Conclusions

Interviews with sea anglers, bait shop owners and ragworm farms show that the collection of wild ragworm in Wales may be at a natural 'turning point', whereby shops cannot stock the wild-captured ragworm that they require to meet demand. Participants gave many reasons for the limited availability of wild ragworm supplies that may both confound and compound each other, including: that most commercial and recreational collectors are ageing; the younger generation would rather buy bait; a perceived reduction in wild stocks by some, making digging harder work; the high cost of fuel; more unpredictable weather, and ultimately fewer commercial diggers on Welsh shores. As a result, bait shops are struggling to source enough ragworm for their customers, and the only ragworm farm in Wales is struggling to keep up with current demand.

Most sea anglers who took part in questionnaire (both online and through interview) were willing to use farmed bait if wild was not available, and consider sustainability of the stocks a high priority in their purchasing choices. Therefore, the bait market has a good opportunity to move the market away from wild ragworm supplies through a combination of short and long term solutions (Recommendations List), including but not limited to:

- Promoting the new all-Wales code of conduct for bait collection (which includes promotion of the purchase of farmed bait) using strategic interactive and engaging advertising, and a wider education campaign working with popular angling social media influencers wherever possible;

- Encouragement of existing and recent Welsh and UK farmers to grow their production to meet demand;

- Encouragement of ragworm farms to investigate and improve their sustainability through consideration of packaging materials and ragworm diet;

- Supporting feasibility studies for the diversification of the bait market, including research and development of alternative live and natural non-live baits that could be produced and used in Wales.

- Investigation of opportunities for community co-operative farming, or social enterprise, possibly feeding from within multitrophic system, or circular economy models;

- Support the development of a specific bait industry association, to establish a communication pathway for future dialogues.

However, these options all require heavy investment and will take significant time to develop and advertise. In the meantime, the major risk to wild stocks is that the market is currently fragile due to heavy reliance on one ragworm farm, at a single location, that could not currently take on the total demand for ragworm in Wales. A second supplier, from an international farm currently supplies a small stock to the UK (an unknown proportion of which may go to Wales), via a single English distributor, and although they could increase their supplies to the UK, they are suffering from post-Brexit changes to importing live baits and are at risk from more changes to export/import legislation. They have developed a product that they can supply into the large aquaculture feed market which is logistically easier to supply, as it is not a live animal market. Other ragworm farms have closed, or have reached a large enough production capacity to move into the more lucrative and easier aquaculture feed market. If farmed ragworm bait supplies stop, the market could potentially open to a new generation of wild collectors or importers of wild stocks.

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Appendices

Appendix 1: ‘Secure our future bait’ questions asked to anglers, bait shops, bait collectors (online questionnaires and structured interviews) and ragworm farmers (semi-structured interviews) presented per reporting section

Questions presented here are not in the same order as they were presented in the questionnaire. The full questionnaires and interview schedules are presented in Supplementary Information 1-3.

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
HZ	66	RespondentProfile	All	Do you identify as: male, female, other	Categorical	Online/StructuredInterview
	F78	RespondentProfile	Farm	Do you identify as: male, female, other	Categorical	Semi-StructuredInterview
	F77	RespondentProfile	Farm	Which age bracket are you in?	Categorical	Semi-StructuredInterview
HY	65	RespondentProfile	All	Which age bracket are you in?	Categorical	Online/StructuredInterview
	F79	RespondentProfile	Farm	Do you live in Wales, England, Scotland, Somewhere else?	Categorical	Semi-StructuredInterview
IA	67	RespondentProfile	All	Do you live in Wales, England, Scotland, Somewhere else?	Categorical	Online/StructuredInterview
IB	67.1	RespondentProfile	All	if Somewhere else: Where do you live?	Other	Online/StructuredInterview
J	1	RespondentProfile	All	Which group/s of people do your views represent? Angler; Angling / tackle / bait shop; commercial bait collector; recreational bait collector; other.	Categorical	Online/StructuredInterview
AA	7	RespondentProfile	Shop	Which of the following best describes you? (local shop owner, online retailer, wholesaler, bait distributor)	Categorical	Online/StructuredInterview
W	3	RespondentProfile	Angler	Which of the following categories would best describe your fishing activity? (angler experience type)	Categorical	Online/StructuredInterview
V	2	RespondentProfile	Angler	How many years have you been sea-angling?	Categorical	Online/StructuredInterview
IK	74	RespondentProfile	Other	You have said that you are not an angler, shop owner or bait collector. Please tell me a bit about how you are involved with the recreational bait industry, and any comments you have about the bait market in Wales.	Open	Online/StructuredInterview
P	1.1	RespondentProfile	All	Regarding the bait market, and this questionnaire, who do you think your views represent best?	Other	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
AB	8	RespondentProfile	Angler	What is your involvement with the bait market, if any?	Open	Online/StructuredInterview
X	4	RespondentProfile	Angler	Do you use live bait?	Binary	Online/StructuredInterview
Y	5	RespondentProfile	Angler	Do you buy live bait?	Binary	Online/StructuredInterview
Z	6	RespondentProfile	Angler	Do you sell live bait?	Binary	Online/StructuredInterview
AG	11	RespondentProfile	Angler	Do you use live ragworm?	Binary	Online/StructuredInterview
AH	12	RespondentProfile	Angler / Shop	Do you buy live ragworm?	Binary	Online/StructuredInterview
AI	13	RespondentProfile	Seller	Do you sell live ragworm?	Binary	Online/StructuredInterview
AD		RespondentProfile	ComCol	How many years have you been involved with the bait market for?	Categorical	Online/StructuredInterview
AC	9	RespondentProfile	Shop	How many years have you been involved with the bait market for?	Categorical	Online/StructuredInterview
FK	50	RespondentProfile	all	Do you collect bait for your self or others?	Binary	Online/StructuredInterview
	F60	RespondentProfile	Farm	Do you collect bait yourself? (if so, ask commercial collector and code of conduct questions)	Open	Semi-StructuredInterview
	F24	RespondentProfile	Shop	Are you, personally, also a wild bait digger? if so, ask commercial collector and code of conduct questions)	Open	Semi-StructuredInterview
FJ	49	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	Have you noticed a change in bait collection activity in recent years? For example, an increase, decrease, or change in methods. Please explain, and tell us why do you think there has been a change.	Open	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
GR	58	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	Do you believe a code of conduct for the bait-collecting is necessary?	Categorical	Online/StructuredInterview
	F59	Perceived changes in bait collection and need for a code of conduct for bait collectors	Farm	Do you believe a code of conduct for the bait-collecting is necessary? at local level, Wales wide, Both, Not relevant.	Open	Semi-StructuredInterview
GS	58.1	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	You said that you think a code of conduct for bait collecting in Wales is not relevant. Why do you think it's not relevant?	Open	Online/StructuredInterview
GT	60	Perceived changes in bait collection and need for a code of conduct for bait collectors	Collectors	Do you follow a code of conduct for bait collectors?	Binary	Online/StructuredInterview
GU	61	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	Do you encourage your network (friends, colleagues, members, clubs etc) to follow any bait collector's codes?	Binary	Online/StructuredInterview
	F61-76	Perceived changes in bait collection and need for a code of conduct for bait collectors	Farm	Not asked as irrelevant, not bait collectors	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
GV	61.1	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	You said you don't currently encourage your network to follow a bait collector's code. Why not?	Open	Online/StructuredInterview
GX		Perceived changes in bait collection and need for a code of conduct for bait collectors		Present Draft Secure our Future Bait Code of Conduct. On the next pages we will show you a draft of a proposed new code of conduct for bait collectors in Wales, that has been co-developed with anglers, bait collectors and Angling Cymru. It is designed as a tri-fold leaflet. We are interested to hear what you think of this code.		Online/StructuredInterview
HA	62.1	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	This code is easy to understand	Scalar (1-5)	Online/StructuredInterview
HB	62.2	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	The guidance and terminology in this code applies to bait collectors in Wales	Scalar (1-5)	Online/StructuredInterview
HC	62.3	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	The guidance and terminology in this code of conduct applies to me	Scalar (1-5)	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
HD	62.4	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	I like the presentation and graphics of this code of conduct	Scalar (1-5)	Online/StructuredInterview
HF	62.5	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	I am satisfied that this code of conduct is fair	Scalar (1-5)	Online/StructuredInterview
HG	62.6	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	I would be willing to comply with this code of conduct	Scalar (1-5)	Online/StructuredInterview
HH	62.7	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	Other bait collectors I know or see are likely to comply with this code of conduct	Scalar (1-5)	Online/StructuredInterview
HI	63	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	What format of the code of conduct would be most useful to the bait collecting?/Animation/ Digital download (eg pdf) / digital online / leaflet / poster / other / video	Categorical	Online/StructuredInterview
HQ	63.1	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	What other formats would you like to see?	Other	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
HX	64.1	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	Where else would you like to see the code advertised?	Other	Online/StructuredInterview
HR	64	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	Where would you like to see the code of conduct advertised? Angling / Bait Shops / Angling Cymru website / NRW Website / Signs on the beach / other	Categorical	Online/StructuredInterview
IJ	73	Perceived changes in bait collection and need for a code of conduct for bait collectors	All	What do you think would encourage collectors to comply with a bait collectors code?	Open	Online/StructuredInterview
AE	10	Supply and Demand in the Welsh ragworm market in recent years	Angler	Have you noticed a change in 'real bait' market in recent years? 'Real bait' includes live, frozen, dead and vacuumed baits, but excludes plastics etc.	Open	Online/StructuredInterview
CX	27	Supply and Demand in the Welsh ragworm market in recent years	Buyer	How much do you think you spend on ragworm each year?		Online/StructuredInterview
CW	27	Supply and Demand in the Welsh ragworm market in recent years	Buyer	In these months, how much do you spend on ragworm per month, on average?		Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
CU	26	Supply and Demand in the Welsh ragworm market in recent years	Buyer	In these months, how often do you buy ragworm?	Categorical	Online/StructuredInterview
CV	27	Supply and Demand in the Welsh ragworm market in recent years	Buyer	In these weeks, how much do you spend on ragworm per week, on average?		Online/StructuredInterview
AJ	14	Supply and Demand in the Welsh ragworm market in recent years	Buyer	Where do you get your ragworm from?		Online/StructuredInterview
AU	14.1	Supply and Demand in the Welsh ragworm market in recent years	Buyer	You selected 'somewhere else'. Where do you get your ragworm?	Where	Online/StructuredInterview
GQ	57	Supply and Demand in the Welsh ragworm market in recent years	Collectors	How often do you sell your rag to other people, if at all?	Scalar	Online/StructuredInterview
GO	56	Supply and Demand in the Welsh ragworm market in recent years	Collectors	On average, how many ragworm would you collect in one session?		Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
GN	55	Supply and Demand in the Welsh ragworm market in recent years	Collectors	On average, in these months, how often do you collect ragworm?		Online/StructuredInterview
FL	51	Supply and Demand in the Welsh ragworm market in recent years	Collectors	Which live bait do you collect?	Categorical	Online/StructuredInterview
FZ	54	Supply and Demand in the Welsh ragworm market in recent years	Collectors	Which months do you usually dig for ragworm?	Categories	Online/StructuredInterview
FQ	51.1	Supply and Demand in the Welsh ragworm market in recent years	Collectors	Which other live baits to do you collect?	Other	Online/StructuredInterview
FX	52.1	Supply and Demand in the Welsh ragworm market in recent years	Collectors	Which other ragworm do you collect?	Other	Online/StructuredInterview
FR	52	Supply and Demand in the Welsh ragworm market in recent years	Collectors	Which ragworm do you collect?	Categorical	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
FY	53	Supply and Demand in the Welsh ragworm market in recent years	Collectors	Why do you choose to dig ragworm?	Open	Online/StructuredInterview
DF	30	Supply and Demand in the Welsh ragworm market in recent years	Comm_Coll	Have you noticed a change in ‘real bait’ supplies or suppliers in recent years?	Open	Online/StructuredInterview
CF	24	Supply and Demand in the Welsh ragworm market in recent years	CommColl	As a bait collector, are you:	Categorical	Online/StructuredInterview
	F1	Supply and Demand in the Welsh ragworm market in recent years	Farm	What is your Farm name	Open	Semi-StructuredInterview
	F2	RespondentProfile	Farm	Location (City/region):	Open	Semi-StructuredInterview
	F3	Supply and Demand in the Welsh ragworm market in recent years	Farm	How many years has your farm been in operation?	Numerical	Semi-StructuredInterview
	F4	Supply and Demand in the Welsh ragworm market in recent years	Farm	Is your farm family-owned, independently owned, or part of a larger corporation?	Categorical	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F5	Supply and Demand in the Welsh ragworm market in recent years	Farm	When and why did you or your company (whichever came first) start farming worms?	Open	Semi-StructuredInterview
	F6	Supply and Demand in the Welsh ragworm market in recent years	Farm	How does your farm operate now, compared to when it started?	Open	Semi-StructuredInterview
	F7	Supply and Demand in the Welsh ragworm market in recent years	Farm	What is the size of your farm? (in number of pools / volume of pools/ acres / square meters)	Open	Semi-StructuredInterview
	F8	Supply and Demand in the Welsh ragworm market in recent years	Farm	How many worms / tonnes of worm do you produce?	X	Semi-StructuredInterview
	F9	Supply and Demand in the Welsh ragworm market in recent years	Farm	Does production vary seasonally?	Open	Semi-StructuredInterview
	F10	Supply and Demand in the Welsh ragworm market in recent years	Farm	What species do you produce now?	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F11	Supply and Demand in the Welsh ragworm market in recent years	Farm	Which ragworm do you farm?	Categorical	Semi-StructuredInterview
	F13	Supply and Demand in the Welsh ragworm market in recent years	Farm	Have you ever farmed another species? If so, which?	Open	Semi-StructuredInterview
	F21	Supply and Demand in the Welsh ragworm market in recent years	Farm	Do your employees have a pre-existing interest in the bait market?	Open	Semi-StructuredInterview
	F22	Supply and Demand in the Welsh ragworm market in recent years	Farm	Is previous experience of bait digging essential for your employment considerations?	Open	Semi-StructuredInterview
	F23	Supply and Demand in the Welsh ragworm market in recent years	Farm	Would you consider employing commercial wild bait diggers on your farm?	Open	Semi-StructuredInterview
	F25	RespondentProfile	Farm	Have you observed any trends in the demand for farmed worms in different regions of the UK/Wales/internationally? How has this varied between bait and aquaculture? (Please discuss)	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F26	Supply and Demand in the Welsh ragworm market in recent years	Farm	Where do you distribute to (in the UK and globally)?	Open	Semi-StructuredInterview
	F27	Supply and Demand in the Welsh ragworm market in recent years	Farm	How many angling bait buyers (shops / outlets / wholesalers) do you supply in total?	Open	Semi-StructuredInterview
	F28	Supply and Demand in the Welsh ragworm market in recent years	Farm	Please describe your 'real bait' customer base giving an approximate percentage per type (real bait' includes live, frozen, dead and vacuumed baits, but excludes plastics etc):	Open	Semi-StructuredInterview
	F29	Supply and Demand in the Welsh ragworm market in recent years	Farm	Geographically, where are the bait shops you supply?	Open	Semi-StructuredInterview
	F30	Supply and Demand in the Welsh ragworm market in recent years	Farm	In Wales, how many bait / angling shops does your farm supply?	Open	Semi-StructuredInterview
	F30a	Supply and Demand in the Welsh ragworm market in recent years	Farm	How do you distribute to these shops?	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F31	Supply and Demand in the Welsh ragworm market in recent years	Farm	Elsewhere in the UK, how many bait / angling shops does your farm supply?	Open	Semi-StructuredInterview
	F31a	Supply and Demand in the Welsh ragworm market in recent years	Farm	How do you distribute to these shops?	Open	Semi-StructuredInterview
	F26	Supply and Demand in the Welsh ragworm market in recent years	Farm	Where do you distribute to (in the UK and globally)?	Open	Semi-StructuredInterview
	F27	Supply and Demand in the Welsh ragworm market in recent years	Farm	How many angling bait buyers (shops / outlets / wholesalers) do you supply in total?	Open	Semi-StructuredInterview
	F28	Supply and Demand in the Welsh ragworm market in recent years	Farm	Please describe your ‘real bait’ customer base giving an approximate percentage per type (real bait’ includes live, frozen, dead and vacuumed baits, but excludes plastics etc):	Open	Semi-StructuredInterview
	F29	Supply and Demand in the Welsh ragworm market in recent years	Farm	Geographically, where are the bait shops you supply?	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F30	Supply and Demand in the Welsh ragworm market in recent years	Farm	In Wales, how many bait / angling shops does your farm supply?	Open	Semi-StructuredInterview
	F30a	Supply and Demand in the Welsh ragworm market in recent years	Farm	How do you distribute to these shops?	Open	Semi-StructuredInterview
	F31	Supply and Demand in the Welsh ragworm market in recent years	Farm	Elsewhere in the UK, how many bait / angling shops does your farm supply?	Open	Semi-StructuredInterview
	F31a	Supply and Demand in the Welsh ragworm market in recent years	Farm	How do you distribute to these shops?	Open	Semi-StructuredInterview
	F32	Supply and Demand in the Welsh ragworm market in recent years	Farm	Internationally, how many bait / angling shops does your farm supply?	Open	Semi-StructuredInterview
	F32a	Supply and Demand in the Welsh ragworm market in recent years	Farm	How do you distribute to these shops?	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F36	Supply and Demand in the Welsh ragworm market in recent years	Farm	Is there more demand for ragworm bait than you can provide? Please discuss, in relation to whether this is consistent demand, or irregular.	Open	Semi-StructuredInterview
	F37	Supply and Demand in the Welsh ragworm market in recent years	Farm	Do you farm all the ragworm that you supply? In particular, do you also wild dig or buy in supplies from elsewhere to meet demand, and why.	Open	Semi-StructuredInterview
BC	16	Supply and Demand in the Welsh ragworm market in recent years	Seller	Do you have any idea how much ragworm you sell weekly, monthly or annually?		Online/StructuredInterview
BD	17	Supply and Demand in the Welsh ragworm market in recent years	Seller	What months do you typically buy / sell ragworms?	Months	Online/StructuredInterview
BR	18	Supply and Demand in the Welsh ragworm market in recent years	Seller	How does your demand for ragworm change through the year?	Open	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
BS	19	Supply and Demand in the Welsh ragworm market in recent years	Seller	Do you ever have waste ragworm? If so, how much and what do you do with it?	Open	Online/StructuredInterview
BT	20	Supply and Demand in the Welsh ragworm market in recent years	Seller	Is there more demand for ragworm bait than you can provide?	Open	Online/StructuredInterview
BU	21	Supply and Demand in the Welsh ragworm market in recent years	Seller	What limits your ability to meet bait market demands for ragworm?	Open	Online/StructuredInterview
BV	22	Supply and Demand in the Welsh ragworm market in recent years	Seller	In your opinion, are there sufficient suppliers of wild ragworm in Wales to meet the demand?	Open	Online/StructuredInterview
BW	23	Supply and Demand in the Welsh ragworm market in recent years	Seller	Where do your ragworm customers generally come from?	Open	Online/StructuredInterview
CE	23.1	Supply and Demand in the Welsh ragworm market in recent years	Seller	Please describe your 'other' ragworm customers	PercentCust_Other	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
CG	25	Supply and Demand in the Welsh ragworm market in recent years	User	What months do you typically use ragworms?	Months	Online/StructuredInterview
DB	28	Supply and Demand in the Welsh ragworm market in recent years	Shop	Or per month?	Numerical	Online/StructuredInterview
DA	28	Supply and Demand in the Welsh ragworm market in recent years	Shop	per week?	Numerical	Online/StructuredInterview
DC	29	Supply and Demand in the Welsh ragworm market in recent years	Shop	On average, how many ragworms, lbs or kg is one delivery of ragworm?		Online/StructuredInterview
DG	31	Supply and Demand in the Welsh ragworm market in recent years	Shop	Individual anglers	Anglers	Online/StructuredInterview
DP	31.1	Supply and Demand in the Welsh ragworm market in recent years	Shop	Please describe your 'other' ragworm suppliers	PercentSuppliers_Other	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
DQ	32	Supply and Demand in the Welsh ragworm market in recent years	Shop	In your opinion, are there sufficient suppliers of wild ragworm in Wales to meet the demand?	Open	Online/StructuredInterview
DR	33	Supply and Demand in the Welsh ragworm market in recent years	Shop	What changes or improvements would you like to see in the ragworm supplies for Wales in the future?	Open	Online/StructuredInterview
DU	34.1	Factors influencing where anglers buy ragworm	Angler	Reliability of supplier	Scalar (1-5)	Online/StructuredInterview
DV	34.2	Factors influencing where anglers buy ragworm	Angler	Loyalty / Habit (eg: I always go to the same place)	Scalar (1-5)	Online/StructuredInterview
DW	34.3	Factors influencing where anglers buy ragworm	Angler	Convenience (eg: location, opening times, etc)	Scalar (1-5)	Online/StructuredInterview
DX	34.4	Factors influencing where anglers buy ragworm	Angler	Recommendation from friends / social group	Scalar (1-5)	Online/StructuredInterview
DY	34.5	Factors influencing where anglers buy ragworm	Angler	Cost of rag	Scalar (1-5)	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
EB	34.6	Factors influencing where anglers buy ragworm	Angler	Quality of rag	Scalar (1-5)	Online/StructuredInterview
EC	34.7	Factors influencing where anglers buy ragworm	Angler	That the rag is wild	Scalar (1-5)	Online/StructuredInterview
ED	34.8	Factors influencing where anglers buy ragworm	Angler	That the rag is farmed	Scalar (1-5)	Online/StructuredInterview
EE	34.9	Factors influencing where anglers buy ragworm	Angler	Something else	Scalar (1-5)	Online/StructuredInterview
EF	34.9	Factors influencing where anglers buy ragworm	Angler	You said that 'something else' was an important factor when deciding where to buy your ragworm. Please tell us what 'something else' is.	Open	Online/StructuredInterview
AV	15	Cost differences between wild caught and farmed ragworm	Seller	Which ragworm do you buy / sell?	Categorical	Online/StructuredInterview
BB	15.1	Cost differences between wild caught and farmed ragworm	Seller	Which other ragworm do you buy / sell?	Which_Other	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
EM	41	Cost differences between wild caught and farmed ragworm	Angler	Do you think farmed ragworm is more expensive than wild ragworm?	Categorical	Online/StructuredInterview
EN	42	Cost differences between wild caught and farmed ragworm	Shop	In your shop, how much does half a kilo of WILD ragworm (approx. 35 worms) cost in £?	Numerical	Online/StructuredInterview
EO	43	Cost differences between wild caught and farmed ragworm	Shop	In your shop, how much does half a kilo of FARMED ragworm (approx. 35 worms) cost in £?	Numerical	Online/StructuredInterview
EP	44	Cost differences between wild caught and farmed ragworm	Shop	Do you think your customers would be willing to pay more for farmed ragworm?	Open	Online/StructuredInterview
EQ	45	Cost differences between wild caught and farmed ragworm	Angler	Would you pay more for farmed ragworm than wild rag as bait? This may alleviate pressure on wild habitats in Wales.	Binary	Online/StructuredInterview
ER	46	Cost differences between wild caught and farmed ragworm	Angler	How much more would you be willing to pay for farmed compared to wild rag? (expressed as % of wild cost)	Categorical	Online/StructuredInterview
	F42	Cost differences between wild caught and farmed ragworm	Farm	On a scale of 1 to 5, how do you perceive the cost of farmed bait compared to wild bait in your operation?	Scale	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F43	Cost differences between wild caught and farmed ragworm	Farm	If necessary, do you think anglers/distributors/wholesalers/retailers would be willing to pay more for farmed worm?	Open	Semi-StructuredInterview
AX		Cost differences between wild caught and farmed ragworm	Seller	Which ragworm do you buy / sell?/Common red rag (usually medium sized, and what is available in bait shops)	CommonRedRag	Online/StructuredInterview
AY		Cost differences between wild caught and farmed ragworm	Seller	Which ragworm do you buy / sell?/Harbour Rag / Maddies (small rag, usually thin and less than 2 inches long)	HarbourRag_Maddies	Online/StructuredInterview
AW		Cost differences between wild caught and farmed ragworm	Seller	Which ragworm do you buy / sell?/King Rag / Snakes (usually the bigger one, 18-24 inches long)	KingRag_Snakes	Online/StructuredInterview
BA		Cost differences between wild caught and farmed ragworm	Seller	Which ragworm do you buy / sell?/Other	Other	Online/StructuredInterview
AZ		Cost differences between wild caught and farmed ragworm	Seller	Which ragworm do you buy / sell?/White or Silver rag / Catworms	WhiteSilverRag_Cat	Online/StructuredInterview
	F44	The market for more farmed ragworm in Wales	Farm	In your opinion, what proportion of ragworm sold in shops is wild vs. farmed?	Open	Semi-StructuredInterview
	F39	Sufficiency of farmed ragworm supplies to meet market demand.	Farm	In your opinion, are there sufficient suppliers of farmed ragworm in Wales to meet the demand?	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F52	Sufficiency of farmed ragworm supplies to meet market demand.	Farm	Do you have any plans to expand your worm farming operation, and if so, where/how?	Open	Semi-StructuredInterview
	F54	Sufficiency of farmed ragworm supplies to meet market demand.	Farm	What strategic initiatives or adaptations are you planning to ensure future success in the worm market?	Open	Semi-StructuredInterview
EG	35	Barriers limiting the growth of the Welsh farmed ragworm market	Angler	Have you ever knowingly used / bought farmed ragworm?	Binary	Online/StructuredInterview
EH	36	Barriers limiting the growth of the Welsh farmed ragworm market	Angler	Would you use / buy farmed ragworm?	Binary	Online/StructuredInterview
EI	37	Barriers limiting the growth of the Welsh farmed ragworm market	Angler	You said you would not use / buy / sell farmed ragworm. Please tell us why:	Open	Online/StructuredInterview
EJ	38	Barriers limiting the growth of the Welsh farmed ragworm market	Shop	What do you think stops some shops from buying farmed ragworm?	Open	Online/StructuredInterview
EK	39	Barriers limiting the growth of the Welsh farmed ragworm market	Angler	How often do you choose to use farmed ragworm, and why?	Open	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
EL	40	Barriers limiting the growth of the Welsh farmed ragworm market	Angler Shop	Which bait do you believe is more effective for your / your customers' target species?	Categorical	Online/StructuredInterview
	F12	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	Have you ever tested the quality of your ragworm, compared to wild ragworm? If so, how?	Open	Semi-StructuredInterview
	F14	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	Why do you prefer to farm your current species?	Open	Semi-StructuredInterview
	F15	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	What is your ragworm feed?	Open	Semi-StructuredInterview
	F16	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	Where does your ragworm feed come from (geographical location, not company name)?	Open	Semi-StructuredInterview
	F17	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	Have you observed any changes / trends in the cost of production for farmed worms in different regions of the UK/Wales/internationally?	Open	Semi-StructuredInterview
	F18	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	How many workers do you employ on your farm and in what capacity?	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F19	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	Approximately how far do your employees live from your farm? (number of Km / miles)	Open	Semi-StructuredInterview
	F20	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	How did you recruit your employees?	Open	Semi-StructuredInterview
	F33	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	What do you think stops some shops from buying farmed ragworm?	Open	Semi-StructuredInterview
	F38	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	What limits your ability to meet bait market demands for ragworm?	Open	Semi-StructuredInterview
	F40	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	What do you see as the main barriers to the growth of the farmed ragworm market in Wales? Discuss lack of awareness, Regulatory issues, Quality Concerns, distribution challenges, Other.	Open	Semi-StructuredInterview
	F41	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	What do you see as the main barriers to the growth of the farmed ragworm market in Wales? Additional comments	Open	Semi-StructuredInterview
	F45	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	Why aquaculture feeds? (or why not?)	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F46-49	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	Farming for aquaculture feeds: Not asked as not relevant	Open	Semi-StructuredInterview
	F50	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	What factors make the aquaculture feed business more lucrative than bait buyers?	Open	Semi-StructuredInterview
	F51	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	How do you foresee the future of the farmed ragworm market?	Open	Semi-StructuredInterview
	F53	Barriers limiting the growth of the Welsh farmed ragworm market	Farm	Are there emerging trends or opportunities that you anticipate in the coming years?	Open	Semi-StructuredInterview
ES	47	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	Would you buy farmed ragworm if:	Categorical	Online/StructuredInterview
ET	47.1	Potential incentives to persuade anglers to choose farmed over wild rag	Angler Shop	You said there was another reason for you to buy farmed ragworm. What other reasons mean that you might buy farmed rag?	Open	Online/StructuredInterview
EW	48.1	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	Advertising of where farmed rag is available:	Scalar (1-5)	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
EX	48.2	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	Price discounts compared to wild rag:	Scalar (1-5)	Online/StructuredInterview
EY	48.3	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	Quality assurance:	Scalar (1-5)	Online/StructuredInterview
EZ	48.4	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	Guaranteed consistency of supply:	Scalar (1-5)	Online/StructuredInterview
FA	48.5	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	Sustainability:	Scalar (1-5)	Online/StructuredInterview
FD	48.6	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	Local Produce (Welsh / UK farmed):	Scalar (1-5)	Online/StructuredInterview
FE	48.7	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	A free trial:	Scalar (1-5)	Online/StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
FF	48.8	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	Nothing, I don't want to use farmed bait:	Scalar (1-5)	Online/StructuredInterview
FH	48.9	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	Something else	Scalar (1-5)	Online/StructuredInterview
FI	48.9	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	You said that 'something else' would help pursuade you to use farmed ragworm. Please tell us what 'something else' is.	Other	Online/StructuredInterview
FG	49.1	Potential incentives to persuade anglers to choose farmed over wild rag	Angler	Guaranteed consistency of supply:	Scalar (1-5)	Online/StructuredInterview
	F34	Potential incentives to persuade anglers to choose farmed over wild rag	Farm	Please tell us what you think would encourage shops to stock more farmed bait?	Open	Semi-StructuredInterview
	F35	Potential incentives to persuade anglers to choose farmed over wild rag	Farm	Please tell us what you think would encourage anglers to choose farmed ragworm over wild rag?	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
IF	69	Potential for co-operative ragworm farming in Wales	All	Do you think a cooperative ragworm farm would be wanted in Wales?	Categorical	Online/StructuredInterview
IG	70	Potential for co-operative ragworm farming in Wales	All	Do you think a cooperative ragworm farm would be feasible in Wales?	Categorical	Online/StructuredInterview
IH	71	Potential for co-operative ragworm farming in Wales	All	Would you be interested in being part of a cooperative ragworm farming initiative in Wales?	Categorical	Online/StructuredInterview
II	72	Potential for co-operative ragworm farming in Wales	All	Please tell us any additional concerns or comments regarding ragworm farming in Wales.	Open	Online/StructuredInterview
	F55	Potential for co-operative ragworm farming in Wales	Farm	Do you think a cooperative ragworm farm would be wanted in Wales? If so, by whom?	Open	Semi-StructuredInterview
	F56	Potential for co-operative ragworm farming in Wales	Farm	Do you think a cooperative ragworm farm would be feasible in Wales?	Open	Semi-StructuredInterview
	F57	Potential for co-operative ragworm farming in Wales	Farm	Would you be interested in being part of a cooperative ragworm farming initiative in Wales? If so, how would you see your role, and where do you think it should be based?	Open	Semi-StructuredInterview

DataCol	Q_No	ReportingSection	Perspective	Question	Response	DataCollectionType
	F58	Potential for co-operative ragworm farming in Wales	Farm	Please tell us any additional concerns or comments regarding ragworm farming in Wales.	Open	Semi-StructuredInterview
IE		Potential for co-operative ragworm farming in Wales		A community cooperative is an organisation that is owned and run jointly by its members. Members participation can range from capital investment to hands on help with day to day employment, or even paid employment. Members then share the profits or benefits. There is no plan or funding for a community bait farm in Wales, but there are some successful recent examples of community cooperatives in aquaculture in Wales and elsewhere.		Online/StructuredInterview
	F81	AdditionalInfo	Farm	Any additional comments on ragworm or the bait industry in Wales	Open	Semi-StructuredInterview

Appendix 2: Draft ‘Secure our future bait’ code of conduct for bait collectors in Wales, displayed to participants in online surveys and interviews. (note this is not the final code of conduct).

THE 5 KEY PRINCIPLES

1. Take Only What You Need

-**Sustainable collection:** Take only what you require.

-**Protect the breeding stock:** Don't take crabs with eggs, or under any minimum size (velvets, less than 65mm carapace length; edibles less than 140mm).

2. Leave As You Find

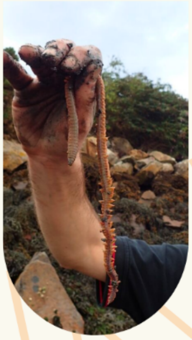
This ensures the future recruitment of bait to your collection ground.

-**Backfill for bait:** Fill any holes or trenches.

Bad practice vs. *Better practice*

-**Restore rocks as found:** Replace boulders the right way up, seaweed on the top. If you trap seaweed under rocks, it rots and spoils the habitat for crabs.

Bad practice vs. *Good practice*



3. Be a Shoreline Guardian

Your actions can make a big difference in helping our shores. Bait collectors can help by considering:

-**Check, Clean, Dry:** Check your gear for mud and marine life. Clean and Dry thoroughly before using again. Harmful species can survive up to two weeks if damp. It's best practice to dispose of natural packing and storage materials away from the shore.

– **Preserve fish habitats and nurseries** by not damaging fragile ecosystems, including seagrass, saltmarsh, muddy gravels and honeycomb tubeworm reef.

-**Considerate trapping:** Set crab traps thoughtfully and remember to retrieve your gear. Anything left behind may be mistaken for fly-tipping.

– **Beach clean as you go:** Try to take any litter you find home with you, along with your own litter.

– **Back the birds:** Avoid disturbing feeding, resting or nesting birds.

4. Be Legally Aware

– **Know the regs:** Research and obey the rules and any restrictions that apply.

– **Consider the landowner:** Obtain permission as required. This is necessary if collecting commercially. Access restrictions can apply to anybody.

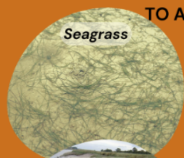
5. Be Smart, Stay Safe

– **Make safe for all:** Don't leave hazards such as holes or crab traps with sharp edges.

– **Don't dig near structures and moorings:** Ensure a harmonious coexistence with other beach users by not digging near their property.

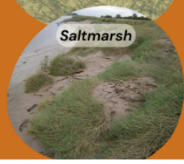
– **Safety is paramount:**
- **Check the tide.** If you don't know, don't go. If unsure, go before low.
- **Check the weather.** Be aware of disorientation in fog and leave the beach in lightning.
- **Carry** a whistle, a compass and a mobile phone in a dry bag/box.
- Make sure **somebody knows** where you are and your return time.
- **Beware** of mudflats and gullies. Even sandflats with gentle undulations can quickly fill behind you.

SENSITIVE FISH HABITATS & NURSERIES TO AVOID



Seagrass

Muddy gravels



Saltmarsh

Honeycomb reef

Appendix 3: Summary of bait survey dissemination plan.

A search of coastal angling, bait and fishing tackle shops advertised on Google Earth and Yell.com identified between 85 and 119 potential bait outlets around the Welsh coastline. However, upon checking some of these were permanently closed, so this is a rough estimate. We hoped to target a minimum of 10% of shops (9-12) evenly distributed around the country, two thirds of which would be small local shops, and one third would be large suppliers.

Of the 14 local angling / tackle shops contacted around the country, only five took part in face-to-face interviews at their shops in north, west and south Wales. An additional four shop owners committed to interviews after participant information was presented, but either were not at the shop at arranged times, or were too busy when the interviewer arrived. Resource limitations meant that they could not be substituted with another shop.

However, online questionnaires were disseminated through 49 different contacts and organisations on at least two occasions, whom together had a reach of approximately 20,000 individuals via their social media channels alone. Dissemination included: three large angling organisations following discussion; 15 shops, including those interviewed; three commercial bait collectors; three angling influencers / celebrities; two angling journalists; 15 boat charter companies; six angling clubs and two large Welsh sea angling Facebook groups. Despite significant effort, only 21 responses to online questionnaires were received (in addition to five interviews).

Data Archive Appendix

Data outputs associated with this project are archived in NRW's Document Management System on server-based storage at Natural Resources Wales.

The data archive contains:

[A] An Excel spreadsheet containing the questionnaire results (titled "DATA PACK Morris-Webb 2024_BaitQuestionnaireData") ADVI-448143571-863.

[B] A pdf file of online questions presented to respondents (titled "DATA PACK SuppInfo1a_OnlineQuestionnaires") ADVI-448143571-857.

[C] A pdf file of online questions presented to respondents (titled "DATA PACK SuppInfo1b_ShopInterviewQuestionnaires") ADVI-448143571-859.

[D] A pdf file of an interview guide used to conduct semi-structured interviews of ragworm farms (titled "DATA PACK SuppInfo2_RagfarmInterviewGuide") ADVI-448143571-856.

Metadata for this project is publicly accessible through Natural Resources Wales' Data Discovery Service https://metadata.naturalresources.wales/geonetwork/srv (English version) and https://metadata.cyfoethnaturiol.cymru/geonetwork/cym/ (Welsh version). The metadata is held as record no NRW_DS161352.

Further copies of this report are available from library@cyfoethnaturiolcymru.gov.uk