Isle of Man crab and lobster fishery consultation evidence document (4)

A 5-year scientific research plan for the Isle of Man crab and lobster fishery (2020-2025)

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Introduction

Since the closure of the Port Erin marine laboratory in 2007, the Isle of Man Government Department of Environment, Food and Agriculture (DEFA) has contracted an independent body to provide fisheries science research, advice and recommendations to support the Department in the management of locally important and emerging fisheries.

In 2020, Bangor University successfully tendered for the provision of independent fisheries science advice, effectively securing a continuation of services following the previous science contract (2015-2020) until 2025. The agreement centres on the provision of an "accurate understanding of commercial fishery stock status from which to base appropriate levels of fishing effort, whilst also maintaining stocks within safe biological limits". The 2020-2025 independent science contract has a specification to "develop and deliver monitoring and related research programmes for … crab [and] lobster, to improve understanding of stock status, better understand biology and advise on future management measures".

In addition, DEFA will to build upon 'Future Fisheries' (FF), which is a strategy that was unanimously passed by Tynwald in 2015 and underpins the sustainable management of the Isle of Man's sea fisheries over the period 2016-2021. It is expected that the next strategy will include and develop the vision set out in FF, including aims to;

- Safeguard the long-term viability of the Manx sea fisheries industry with regionally relevant management;
- Develop sustainable fisheries to ensure reliable seafood production;
- Obtain and apply basic fisheries science data to enable sustainable management;
- Apply an effective range of fisheries management measures within the territorial sea, and
- Secure sustainability by appropriate management of fishing effort across all fishery sectors.

Our understanding of static-gear fisheries (and target species) in Isle of Man waters has steadily increased over the previous contract but it is acknowledged that the evidence status of static-gear fisheries remains relatively poor in comparison to mobile gear fisheries which may be considered data-rich. There are certain aspects of 'standard' data monitoring (e.g. spatial data (VMS) and accurate landings and effort data) in the static gear sector which require substantial improvement in order to develop robust management. Many of the subsequent research proposals (e.g. spatial management, fisheries-dependent reference points/EERS, and landings sampling/size-based indicators) are dependent upon improvements to the statutory reporting mechanisms required in the static-gear fisheries, particularly spatial reporting.

In the absence of a clear methodological approach to fisheries independent stock surveys and assessments for baited trap crab and lobster fisheries, and where stock boundaries and connectivity has not yet been determined for these species, it will be vital to develop fishery reference points (e.g. LPUE, sex-ratio, size-based trends). Understanding how such reference points are driven by the environment (e.g. temperature, habitat) and at what scale management should be considered (e.g. Irish-sea, Isle of Man territorial waters or specific sub-areas) is essential. Understanding spatial scales for fisheries management can be informed using mark-recapture experimental data, which can also shed light on aspects of species life history such as size-at-age, growth, and spawning patterns. There are additional research opportunities to identify fishery enhancement and conservation opportunities including spatial management, artificial reef designs, and gear-design modifications.

This document highlights several research opportunities for the 2020-2025 contract. It can be viewed as a basis for discussion within the crab and lobster consultation, and Bangor University are seeking views on any and/or all the research proposals.

1. Development of fishery reference points using 'Enhanced Electronic Reporting Systems' (EERS) and Gear-in gear-out (GIGO) technology

Fisheries that use baited pots to target species often record highly variable landings-per-unit-effort (LPUE), which is typically described as the weight (kg) of catch per pot hauled. The variability in LPUE is driven by season and location as well as more complex environmental interactions between the baited pot and the target species. Although abundance of target species in the vicinity of the pot will affect LPUE, LPUE is not always directly correlated with stock abundance. Variables such as temperature, habitat, bait-type, soak time, tidal cycle and depth have, either separately or together, been shown to have significant effects on LPUE in a number of pot fisheries. Therefore, fisheries management advice has limited accuracy if it assumes fisheries-dependent records of LPUE (i.e. catch returns / logbooks) is a direct reflection of population abundance without accounting for these compounding effects. This has resulted in a general absence of management of pot fisheries throughout the British Isles, except for technical measures such as minimum conservation reference size (MCRS) restrictions on catch that are based on maturity estimates.

In the past, on-board observer data has been used to try and explain how environmental variables effect LPUE. Scientific on-board observer programmes are however often short-term (interrupted by funding and/or staffing constraints) and thus only present 'snapshots' of fishery dynamics and processes in terms of time and space (e.g. limited to a specific area over a single season). Onboard observer programmes can hinder standard operating procedures on vessels (slow operations down) as well as raise legitimate safety concerns for the skipper, particularly on smaller vessels, which represent the majority of active fishing vessels in the Isle of Man. Rather than attempt to implement an on-board observer programme, Bangor University propose to collaborate with static-gear fisheries in the Isle of Man to develop and maintain an automated system of data collection.

Figure 1. Zebra-tech equipment; decklogger (left) and wet-tag (right).

Electronic logbook and gear-in gear-out (GIGO) technology has been developed by Zebra-Tech© in New Zealand where the rock lobster industry had significant input into hardware design. DEFA acquired several Zebra-Tech 'decklogger' devices, which have been trialled in the Isle of Man crab, lobster and whelk fisheries from 2017-2019. Integrating Gear-in Gear-out (GIGO; small devices that are attached to pots) and the Decklogger (which is equipped with mobile technologies in tough, portable hardware) means that vessels can easily report enhanced logbook data in a system that is straight-forward and efficient. The system is designed to report each haul's catch and effort and automatically synchronises these data against time, latitude, longitude, depth, soak-time, temperature and tidal-coefficient. Using statistical modelling techniques, it is possible to determine whether these variables have an effect on LPUE, how they interact and how much 'certainty' is captured in the models ability to predict LPUE.

Bangor University has already trialled this approach with a small number of vessels. Below are the data collected during the trial, which highlighted some significant effects on LPUE during the 2018/19 crab fishery. These included location (left), sea-bottom-temperature (centre) and lobster bycatch (right), which all have a quantifiable effect on crab LPUE (see Figure 2). Using data from only 2 vessels the model was able to explain a high proportion (68%) of the deviance in the data. Clearly there is more work to be done in capturing additional variables (e.g. bait-type, pot-type), but it is promising that the results are in line with what might be expected, including:

- Pots are more likely to catch crab in the west;
- Temperatures below 13°C have a negative effect on crab catches, and temperatures above 15 °C increase the quantity of crab caught per pot by 1 kg compared to pots in the same area at 13 °C.
- As the quantity of lobster bycatch increase, the quantity of crab decreases.

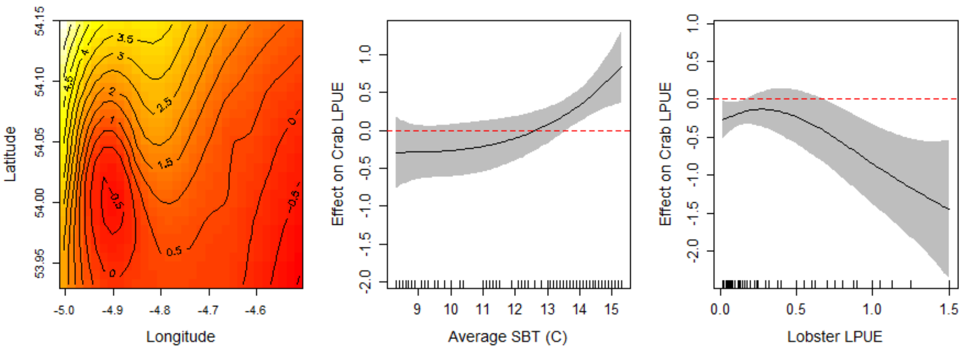

Figure 2. The significant drivers of crab landings-per-unit-effort in the 2018/19 Isle of Man southwest crab fishery.

The next 5-years present an opportunity to expand the use of this technology in order to develop a robust baseline of catch-data, which is reported alongside parameters that are known (or expected) to have an effect on catch rates. In this way there is the clear potential to use commercial catch-rates (LPUE) as an index of stock abundance. This way, fisheries can be assessed against data from the fishery as opposed to relying exclusively on a scientific potting survey that may be limited in terms of where, when and how sampling can take place due to logistical and resource limitations. Encouraging a sentinel fleet of commercial vessels to use this enhanced system may fill the knowledge gaps required to take the fishery out of a 'data-poor' scenario, notwithstanding the fundamental requirement to require accurate electronic spatial (VMS), landings and effort data from all vessels.

As well as developing catch models, a high-resolution spatial record of activity will be absolutely fundamental in the coming years for marine spatial planning (e.g. seismic surveys, wind farm leasing rounds, marine nature reserves and increased participation/co-benefits in spatial management decisions in mobile-gear fisheries). This enhanced electronic reporting system attaches haul-specific catch rates to latitude and longitude records. These data would belong to the skipper (with a data-sharing agreement with DEFA and Bangor University) and would provide the most robust evidence of specific areas representing value to individual fishers whilst ensuring commercially sensitive data are protected. EERS would be in addition to spatial data (VMS) requirements throughout the fleet, with the exception of very small open vessels, which is considered a pre-requisite to spatial management approaches in fisheries. Note that the use of EERS within a sentinel fleet does not negate the requirement for basic spatial data reporting (e.g. iVMS) for the crab and lobster fisheries.

Aim

- Increase the EERS coverage in Isle of Man static-gear fisheries using a 'sentinel fleet'.
- Develop the EERS firmware so that it captures all of the significant variables that have an effect on LPUE that can be quantitatively recorded.
- Develop modelling capabilities for crab and lobster LPUE ('standardised LPUE').
- Develop area-based approaches for management of effort and harvests in crab and lobster fisheries.

Specific proposals

- Draft a data-sharing agreement with industry, DEFA and Bangor University.
- Require spatial reporting and improved logbook data for all vessels, with the possible exception of very small (< 6 m) open vessels.
- Seek options for consideration with respect to mandatory requirement and/or incentive scheme for industry enrolment in EERS scheme.

Deliverables

- Personalised vessel-specific annual reports to skippers in the sentinel fleet.
- Aggregated annual reports and presentation to sector-specific subgroups with commercially sensitive data redacted.
- Within the limits of a data-sharing agreement, use spatial data to inform marine spatial planning and as evidence of commercial fishing activity if offshore developments occur.
- Use EERS data and co-management framework to develop management approaches for the fishery (weekly reports, as per QSC fishery), following standardisation of commercial data with appropriate reference points (e.g. 5-year average).

2. Landings sampling and development of size-based indices

A regular sampling programme of commercial landings which records population data (including sex, size, weight and condition of animals, e.g. Figure 3) can be used to develop an index of population health, which can be incorporated into the approach outlined in the previous section. For example, some data-limited approaches are now recommending using change in L_{90} as a proxy for fishing mortality (*F*), where L_{90} is the average size of the largest 10% of animals that are harvested (L_{95} would = the average size of the largest 5% of individuals). If L_{90} or L_{95} decreases over time (over a season, and/or overall several years), this can mean that fewer animals are surviving long enough to reach older (larger) length categories which can be an indication that *F* is high, assuming growth rates remain relatively constant. Other approaches track changes in L_{cap} (e.g. the average size of captured lobster) relative to estimates of L_{50} (the average size at maturity) to detect whether the fishery is tending towards recruit overfishing, although L_{cap} is sensitive to pulses of recruits within the fishery (i.e. a large portion of small animals around the size of MLS being landed as a results of good recruitment). If the size-distribution of landed lobster becomes increasingly truncated around the MCRS, or the L_{50} estimate, then this can also be an indication of overfishing. There are many other length-based and condition-based indices that can be used to inform management, for a full summary see Miethe et al. (2016).

It is likely that size-based indices will have to be area-specific, i.e. tracking trends within discrete fishing grounds in Isle of Man territorial waters, because of local-scale variation in population structure of crab and lobster. Spatial data (iVMS) is therefore essential so that catch sampled at processors, which can usually traced to a specific vessel, can be assigned to a particular fishing ground or area.

It may be possible to develop technological solutions to collect this data, for example using camera technology and automised image recognition analysis (machine learning, stereo-video imaging). This has been attempted previously on-board vessels by Bangor University in both Wales and the Isle of Man. It is expected that developing the technology for use onshore in processors would not encounter the same issues as with the offshore trials (e.g. battery life, accuracy, time-limitations, durability etc.). This technology would be designed and developed in collaboration with processors. Whilst it is being developed, scientific staff would record the data in person.

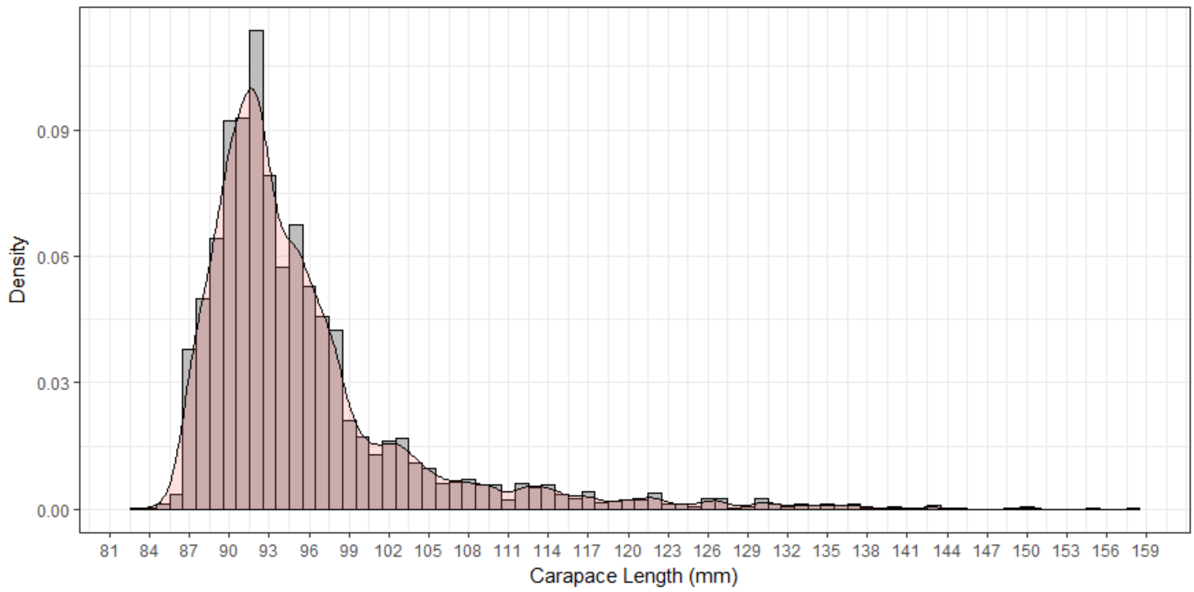

Figure 3. Size data collected from commercial landings of European lobster (2017-2019).

Aim

- Build a commercial sampling dataset and look to develop area-specific indicators based on population metrics for both crab and lobster.
- Build consensus on what indices are important specifically for crab and lobster and what trends mean in relation to stock management for crab and lobster (in collaboration with ICES Working Group on the Life History of Crab and Lobster, Bangor University EMFF research group, Isle of Man industry working groups).

Specific proposals:

- Monthly sampling at processors and/or quayside (where catch leaves island directly) for all main static gear species, including crab and lobster.
- Where there is opportunity to do so, develop methods of automating data collection using camera technology and AI/Machine Learning (Bangor/Aberystwyth EMFF project link-up).

Deliverables:

- Combination of size-based data, and agreed size-based indices, into management advice together with the standardised LPUE thresholds (see previous section).
- Real-time, short-term and long-term perspectives on changing crab and lobster populations, presented in annual reports.

3. Crab & Lobster Recruitment Index surveys

Developing an index of recruitment for crab (*C. pagurus*) and lobster (*H. gammarus*) is important for detecting any future issues in the respective stocks and for understanding the factors that drive both exceptional and poor recruitment. Being able to anticipate population abundance several years in advance is important for long-term fisheries management and sustainable business management in the catching and processing sectors.

A useful example of approaches to monitoring recruitment in successful crustacean fisheries is that adopted by the Wahle laboratory in the USA for the American lobster (*H. americanus*). The so called 'settlement index' is a large scale monitoring programme that monitors a single count of the number of newly recruited young-of-year lobsters at the end of autumn each year. The American lobster settlement index (ALSI) [1]has employed several methodologies since it was developed in the early 1990s, including visual surveys (diver and intertidal), diver-based suction sampling and vessel-deployed passive collectors (cobble filled cage), which together have opened a window on the relationship between larval supply, post-larval settlement success, benthic recruitment and the mechanisms that drive them, such as sea surface temperature anomalies and prevailing winds.

Little work has been undertaken in Europe on this aspect of crustacean stock monitoring and surveys in search of recently settled young-of-year European lobster have been unsuccessful. The difficulty in sampling young-of-year lobster in Europe has been explained by the very low density of populations compared to its American cousin, meaning the probability of detection is significantly reduced. However, in the Isle of Man, there has been some success in previous studies attempting to detect pre-recruit crustacean species. The inter-tidal study by Anderson (2012) identified areas of coastline that are potentially important to the sustainability and maintenance of the Isle of Man crab fishery (Figure 4). The shoreline monitoring methodology alongside a number of others trial methods could form the basis for regular recruitment surveys with clear potential to potentially inform management.

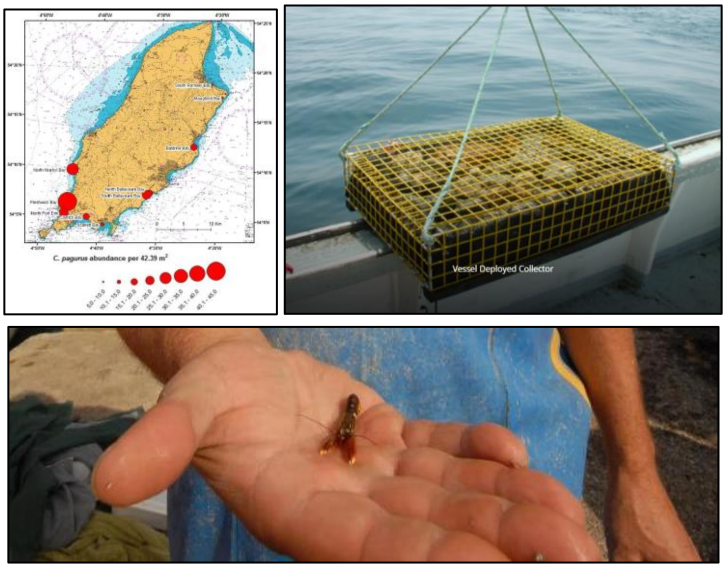

Figure 4. Previous inter-tidal recruitment work undertaken in 2012 (topleft), a cobble-filled lobster settlement device (top-right) and juvenile European lobster (bottom).

[1] https://umaine.edu/wahlelab/american-lobster-settlement-index-alsi/

Aim

- Trial methodologies to develop an IOM Crab and Lobster Settlement & Recruitment Index.
- To develop a long-term perspective and forward planning of management for both crab and lobster fisheries.

Specific proposals

- Literature review to establish best methodologies and survey design, likely to include;
    - the deployment of fine-mesh *Nephrops* creels in known juvenile lobster 'hot spots' around the island;
    - timed-searches of inter-tidal areas and;
    - vessel deployed cobble-filled passive collectors (see above image) in the near-shore area within MNRs (see Wahle et al. (2009). Explore options for this work to be undertaken in collaboration with industry.
- Development of annual index of recruitment.
- Medium-to-long-term forecasting of fishery recruitment
- Modelling of recruit index against environmental parameters (e.g. Sea surface temperature, north Atlantic oscillation…)

Deliverables

- Report on how successful different methods are for capturing pre-recruit and young-of-year for both crab and lobster.
- Develop further proposals to expand on most viable methods using industry knowledge and particle tracking models to determine where recruitment surveys should be undertaken.
- Long-term modelling of IOM Crab and Lobster SRI against environmental factors

4. Lobster Habitat Enhancement project

The establishment of a network of inshore Marine Nature Reserves (MNRs) in the Isle of Man 0-3 NM in 2018 means that 52% of the 0-3 NM is not fished with mobile fishing gear (including Ramsey Bay, which allows a limited fishery in the Fishery Management Zone). The MNR network provides an opportunity to conduct long-term research in crab/lobster population ecology and spatial management/enhancement of static-gear fisheries.

All of the MNRs are already fished for lobster and crab and support inshore fishing vessels. However the yield from some of certain parts of MNR areas could possibly be improved through habitat enhancement. ‘Population bottleneck’ is a term used to describe an environmental effect that significantly limits the abundance of a wild population by reducing the amount of individuals that survive beyond a certain size. For shelter-dwelling crustaceans such as lobster, population bottlenecks are thought to be primarily driven by predation during the larval and early benthic settlement life-stages until they recruit into the fishery. Predation during the post-settlement life-stages is linked to habitat availability; shelter-dwelling crustaceans rely on size-specific shelter availability as they grow and a bottleneck will occur in lobster populations if all the available sheltering habitat in an area is occupied, leaving a proportion of the population vulnerable to predation. In theory, this could ultimately, constrain the amount of individuals that eventually recruit into the fishery.

Improving larval survivability (the amount of individuals surviving the larval stage) has been attempted in several ‘stock enhancement’ projects that have looked to bolster population abundance by rearing lobster eggs in hatchery programmes and releasing them at stage VI/VII (several weeks old). However, as yet, the benefits of such programmes are unproven and do not seem to be economically viable at any significant scale. Moreover, increasing the number of individuals surviving the larval stage in an attempt to increase adult population abundance may be ineffective if the population bottleneck is more significantly constrained by post-settlement habitat availability, i.e. adult population abundance may be more correlated to the degree of habitat availability rather than the number of larval survivors. This is where ‘stock enhancement’ and ‘habitat enhancement’ are fundamentally different in approach; the former looks to artificially increase the number of individuals that reach the seabed whilst the latter looks to modify the seabed to support greater numbers.

Bearing in mind that the Isle of Man already enforces a prohibition on landing egg-bearing females, stock egg-production can be considered safeguarded and developing a hatchery programme is likely to have limited marginal benefits for the fishery. A more cost-effective management measure that could be considered for improving egg-production is introducing a maximum landing size (MaxLS) for both female and male lobster (e.g. in Scotland, female lobster are protected with a MaxLS = 145 mm CL).

The next 5-years presents an opportunity to conduct a proof-of-concept ‘habitat enhancement’ trial within an MNR. Also known as ‘fake holes’, structures could be placed on the seabed to create artificial habitat designed to provide additional shelter for lobster in areas that were previously considered to be relatively poor in terms of lobster habitat. Monitoring of settlement, recruitment and occupancy of the area by lobster would be undertaken with trapping (scientific pots), tagging and potentially dive surveys (subject to consent).

Similar trials have been undertaken in the US, where before an 'artificial reef' was built few lobsters were found on the soft habitat within an area of Narragansett Bay, Rhode Island. Within 3 months vagrant lobster had moved in. After the first year, lobster density on the reef was equal to or greater than nearby natural areas. Tagged lobsters were recaptured numerous times on the reef suggesting a long residence time by some individuals. Post-larval settlement on the reef compared favourably to settlement density in natural beds nearby.

These 'enhancement areas' would necessarily be closed to commercial fishing for the duration of the scientific research (effectively becoming a temporary no-take-zone) but would be designed in consultation with the fishing industry and be located within naturally 'poor' lobster habitat (minimising opportunity cost to vessels).

As an example of the type of structure that could be used, Reef-cubes® are part of an eco-engineering solution supplied by ARC Marine, based in Brixham Environmental Laboratory. Reef-cubes are designed with the purpose of restoring complex marine habitats whilst protecting subsea assets such as monopoles, cables, foundations and pipelines. They are made from recycled material (90% less carbon emissions compared to cement) and is reported to enhance sequestration of carbon from the marine environment.

Additional funding and/or collaboration with third-parties would be required in order to pilot an experimental reef-enhancement programme for crustacean fishery benefits within Isle of Man MNRs.

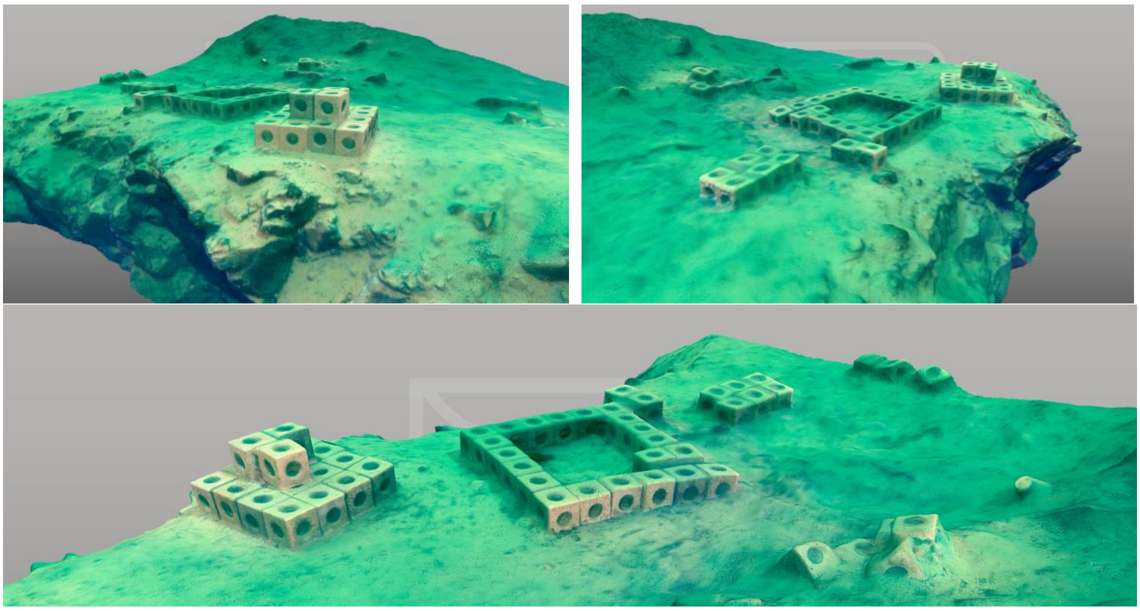

Figure 5. Computer generated image of an artificial reef formed from Reef-cubes©. Source: ARC Marine.

Aim

- Using a controlled experimental design, evaluate the efficacy of habitat enhancement for increasing lobster abundance within the Isle of Man's inshore MNRs.

Specific proposals

- Explore existing literature and resources to develop the likely most appropriate design of 'fake holes' for *H. gammarus*.
- Evaluate costs of setting up a reef-enhancement monitoring programme.
- Work with industry to design a temporary experimental no-take-zone in an area of 'poor' lobster habitat, but within relatively close proximity to natural lobster habitat (~ 1km). Conduct 'before' monitoring to establish existing habitat availability and abundance of lobster within area (12 months).
- Develop a monitoring programme, employing trapping, tagging and diver based surveys to monitor occupancy and residence of the reef over time relative to prior and control surveys.
- Integrate the crab & lobster recruitment and settlement index survey (RSI) to determine whether artificial reef habitat are suitable for post-larval settlement.
- If successful, explore how to open the area to commercial fishing with appropriate harvest regimes (effort controls) to ensure sustained economic benefits.
- If successful, use fisher-knowledge and habitat maps to explore where additional habitat enhancement might yield similar results.
- If successful, use data to inform marine infrastructure developments in the future.

Deliverables

- Annual progress reports.
- Development of management advice for re-opening areas to commercial fishing after effect of closure and habitat enhancement has been quantitatively understood.

5. Crab & Lobster mark-recapture surveys

A preliminary lobster mark-recapture study was undertaken in the south of the island during 2017 and 2018. The data has provided significant insight on growth and movement of lobster in the Baie ny Carrickey MNR. However, since this was an industry-led project, sampling was limited to lobsters with no commercial value (undersize individuals or egg-bearing females over MLS only). Using government owned 'scientific' pots (no escape panels), the mark-recapture survey can continue under a science-led approach supported by industry efforts where possible. The project will continue to rely on recapture reports from industry. Please see the lobster mark-recapture report for justification and existing understanding (Garratt et. al, 2019).

Aim

- To continue to develop an understanding of the movement and connectivity of European lobster in the inshore grounds of the Isle of Man.

Specific proposals

- To expand the mark-recapture sampling programme to the west coast and northeast (Ramsey Bay).
- Monitor returns for evidence of spatial variation in growth rates / moult timing.
- Monitor data to identify any broad-scale connectivity between geographical areas.

Deliverables

- Annual updates.

By contrast, there has been limited research into brown crab movement and growth using mark-recapture experiments in the Isle of Man. Some initial work was undertaken to assess whether tagging using t-bar tags induces mortality and there is reason to further explore this in further trials. Alternatively, non-invasive cable-tie tags can be applied to brown crabs, a method which has been adopted in the Regional Inshore Fisheries Groups (RIFGs) in Scotland. However these tags are not retained through moulting unlike t-bar tags.

It is known that brown crab, particularly female populations, are highly migratory and have been observed travelling 100s of kms. Data from Scotland show that widely dispersed populations are actually connected and thus could be argued to form a single stock unit, yet continue to be monitored, assessed and managed within smaller jurisdictional limits. For example, crabs that were tagged in Shetland have been recovered in Orkney. Likewise, crabs from Orkney have been recovered in the Hebrides. Western Isles and Scottish West coast crabs have been recovered in the Atlantic fishing grounds north of Northern Ireland as well as in the Republic of Irelands near Malin Head (Figure 6). The evidence suggests a counter-clockwise migration of these populations that link several assessment units. Data also suggest that crab migrate westward in the English Channel and around the Lizard peninsula. What is less clear is whether the Isle of Man and Irish Sea populations are also connected to these populations through the North Channel of the Irish Sea, or whether populations in the northern Irish Sea are more likely to migrate and mix with populations in Wales and SW England, or both.

Developing an understanding of stock connectivity is important for conservation and management of fisheries, particularly where there is clear evidence that stocks extend beyond the jurisdictional boundaries of fisheries administrations. In such situations, international agreement and co-operation is typically required in order to implement effective management to ensure sustainable exploitation.

Aim

- Develop a greater understanding of stock-boundaries, connectivity and movement ecology of brown crab populations targeted in the northern Irish Sea, within the context of the wider North Atlantic.

Specific proposals

- Liaise with RIFGs to co-ordinate tagging efforts on the Isle of Man so that they adopt a similar methodology.
- Continue to investigate t-bar tag induced mortality.
- Tag 5,000 individuals over 5 years (1,000 per year). Each RIFG in Scotland aims to tag 10,000.

Deliverables

- Annual updates.

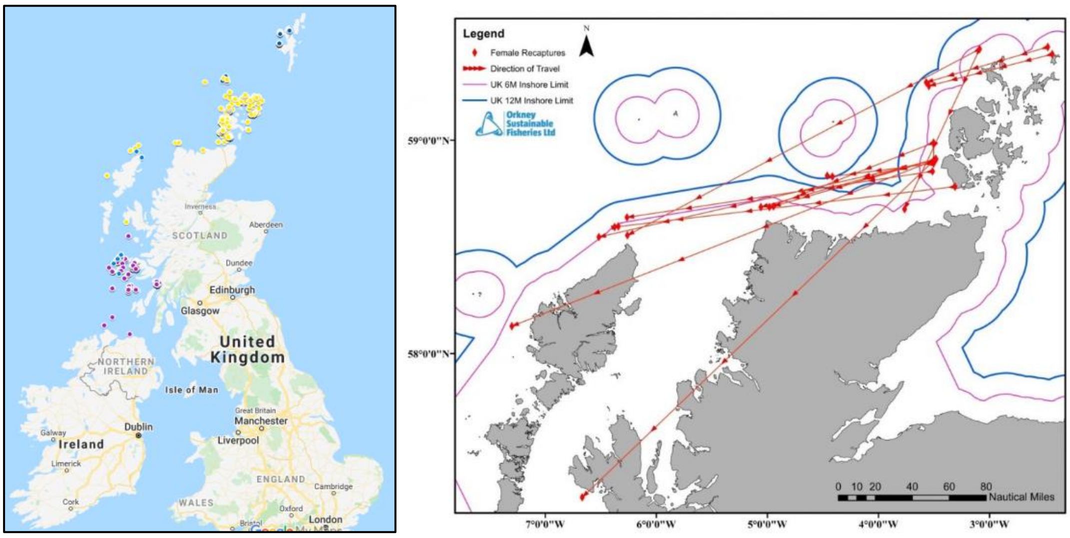

Figure 6. Known crab movements in waters adjacent to the Irish Sea. Source: Orkney Sustainable Fisheries.

6. Gear-design experiments to address 'ghost fishing' in lost or abandoned fishing pots.

Ghost fishing – or 'ghost pots' – occurs when baited pots become unreachable or lost (e.g. due to bad weather or having come into contact with mobile fishing activity). It is possible that although these pots are no longer fished by the owner (hauled, baited and re-set), they continue to capture animals on the seabed that soon perish and subsequently attract more animals into the pot/trap. The durable nature of the materials used to construct modern fishing pots means that ghost fishing may occur for long periods of time (decades) before the mortality effects are reduced.

The scale of the problem within the Isle of Man territorial sea is currently unknown, although other areas of the British Isles have documented widespread prevalence of ghost pots (Figure 7). Although DEFA does receive notification of lost pots from commercial skippers every year following storm events, this is not a legal requirement. Some of the pots are later retrieved by commercial fishers from the shoreline where they have washed up but many remain lost among the inshore reef habitats that support settlement and recruitment for crustacean fisheries. Further offshore, it is known that mobile gear fisheries (e.g. scallop dredge and queen scallop trawl fisheries) come into contact with static gear pot fisheries from time to time. Whilst this situation is usually avoided if at all possible, strings of crab and lobster traps are sometimes moved from their original position and become difficult / impossible to recover.

Firstly, the scale of the problem must be understood. We propose that when pots are lost, the quantity and location are reported to DEFA at the earliest opportunity.

Secondly, we propose to evaluate technical measures that might reduce the overall mortality effect of pots when they do go missing. Using DEFA research-pots we will evaluate the longevity of alternative materials in certain areas of the pots that eventually break down and allow escapement. Examples include cotton thread to stitch the escape panel (as newly legislated in Norway) / biodegradable twine stitching the escape panel (Canada) or biodegradable escape panels (US).

Figure 7. One of 57 'ghost-pot' being lifted from Galway Bay, Ireland (2018). Source: Marine Industry News [online]

Aim

- Understand (quantify and map) the extent of ghost fishing in the Isle of Man.
- Address the issue through technical modifications to pot design.

Specific proposal

- Create a reporting system that can be used to document area-based ghost-fishing and estimate effects on mortality.
- Design an experiment to evaluate the optimum technical modification, which will allow deterioration and thus escapement after a period of time, for the Isle of Man static-gear sector to use throughout the Isle of Man territorial sea. Must take into account cost, complexity and material durability.

Deliverables

- Annual reports on ghost fishing extent and scale.

7. Experimental Spatial Management for lobster fisheries: TURFs, restricted areas and NTZs.

Spatial management, including territorial-user-right-frameworks (TURFs), closed areas and no take zones (NTZ), has been used successfully for a number of fisheries management purposes, internationally and around the Isle of Man. There are two types of closed areas used in Manx waters for scallop fishery management, the shorter-term offshore closures and the long-term/permanent closures within 0-3 NM. The total area of inshore closed areas, where scallop dredge and trawl fishing access is now restricted, covers 430 km^2. An annual, short-duration, co-managed fishery does occur in the Fisheries Management Zone (FMZ) of Ramsey Bay Marine Nature Reserve. The Ramsey Bay MNR FMZ operates as a TURF with specific harvest rates set annually following a pre-fishery survey of abundance.

Overall, these closed areas are considered to have delivered several benefits for the Isle of Man mobile gear fisheries, including:

- boosted stock biomass (numbers and average size of individuals) in the closed areas;
- recovered the Ramsey Bay scallop fishery (via a temporary closure 2009-2013);
- provided beneficial 'spill-over' catch effects;
- provided a secure spawning stock resource that has boosted scallop recruitment over a much wider area outside (Beukers-Stewart et al., 2005);
- improved overall environmental condition for biodiversity and fishery benefits.

Lobster fisheries are typically spatially heterogeneous in terms of biology and fleet, and in these situations the placement of closed areas can significantly affect stock outcomes on a local scale. Designing spatial management systems without an understanding of spatial processes, such as source-sink dynamics, spatial-temporal dynamics of fishing activity and habitat distribution can carry the risk of limiting rather than enhancing the economic yield of commercial fisheries. Moreover, the economic outcome of spatial management will depend upon the specifications of the management structure, including the types of operational requirements demanded in terms of research, enforcement, administration and fishing operations.

Spatial management must be associated with a management plan that contains SMART (specific, measurable, achievable, relevant and time-based) objectives, a clear delegation and support of responsibility among stake-holders, and a continuing system of communication between resource users and resource managers that evaluates the evidence-base on a semi-regular basis. If properly designed, implemented, monitored and enforced, spatial management could offer significant benefits to lobster fisheries. For example, a recent study has suggested potential benefits of spatial management for lobster fisheries following an investigation into the effects of temporary exclusion of fishing activity due to wind farm construction on the Yorkshire coast (Roach, et al., 2018). The study found that temporary closure offers some respite for adult animals and leads to increases in abundance (LPUE in the windfarm was 127% greater than control sites at the end of the closure period; Figure 2a) owing to a shift in the population demographics within the area compared to control sites (Figure 3). Following the opening of the windfarm site, LPUE declined to levels not significantly different to the control sites (Figure 2b). These data suggest that a rotational system of temporary closure and re-opening of areas (to allow for population recovery and a build-up of biomass) may be beneficial and offer a management option for lobster fisheries provided they are later opened.

2a

2b

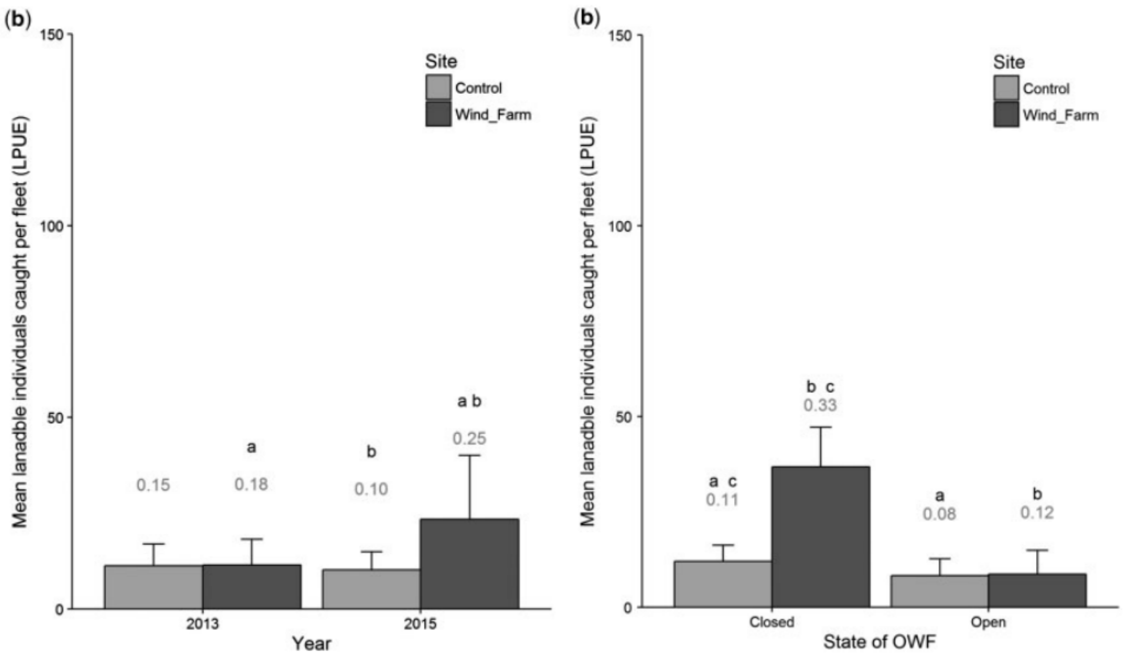

Figure 8. a) the average LPUE ± SD in the control and windfarm site at the beginning of the closure (2013) and at the end of the closure (2015). b) the average LPUE ± SD within the control and windfarm site at the end of the closure ('closed') and following a re-opening of the area ('open').

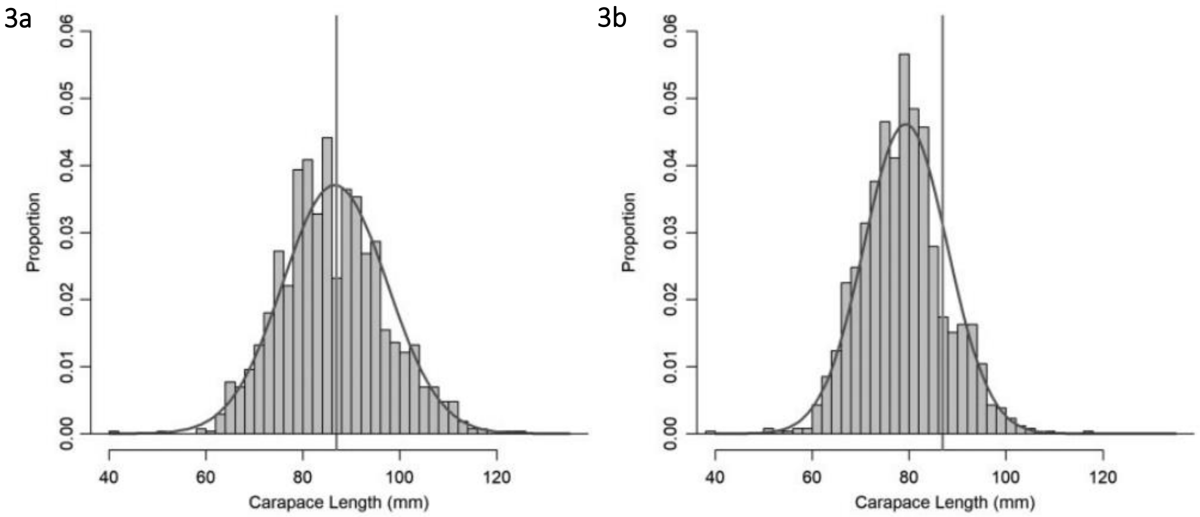

Figure 9. a) the size distribution of Lobster within the wind farm site after a 2-year closure compared to the neighbouring control sites (b).

Previous studies that have investigated European lobster home-ranges lend support to the benefits of protecting relatively small scale areas of seabed. Moland et al. (2011) found that the average home-range of European lobster ranged between 0.57% - 4.15% of a 1 km^2 marine reserve with no significant difference among males, non-ovigerous females and ovigerous females. The study also found that 95% of the extent of an average individuals home-range takes 259 days (8 months) to exhibit (Moland, et al., 2011)– meaning that lobsters show limited home-ranges that do not expand or shift over long-periods of time (years). The study suggests that small coastal reserves can be designed to afford complete or partial protection by letting boundaries engulf or intersect patches of preferred habitat for this species. These findings were supported by acoustic tagging investigations off the coast of Northumberland (Skerritt, et al., 2015).

Aim

- Investigate the application of spatial management regimes in the lobster fishery with the overall aim of improving economic yield within the fishery whilst simultaneously providing ecological benefits.

Specific proposals

- NA

Deliverables

- NA