



Mapping European lobster (*Homarus gammarus*) movement and habitat-use via acoustic telemetry – Implications for management

Final Progress Report

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INTRODUCTION AND RATIONALE

1.1 Introduction

The reported collapse of many major finfish stocks underscores the immediate importance of managing remaining shellfish stocks that could experience increased fishing pressure as fishing efforts are diverted from fin-fisheries to shellfisheries [1, 2]. The European lobster, *Homarus gammarus*, supports one of the most valuable fishery in the UK, yet stocks of several shellfish species, including European lobster are considered to be fully exploited, and the UK government is seeking improved management of key shellfish resources [3, 4]. It is recognised that there are significant gaps in knowledge regarding habitat-use and movements of *H. gammarus* [5], which directly influences our ability to determine distribution, an important determinant of stock structure [6]. Published material on demographic, temporal and spatial patterns of distribution and movement are insignificant compared to that of fin-fish or *H. americanus* [7] (Fig.1). Despite shellfisheries accounting for 35% of total UK landings by weight, studies that do exist are either limited spatially [8] or methodologically [7, 9], conducted on hatchery reared lobster [10], *ex situ* [11], or more often inferred from the American species. There is a danger in freely interpreting results from one species to another [12], and accurate information on *Homarus gammarus* is urgently required.

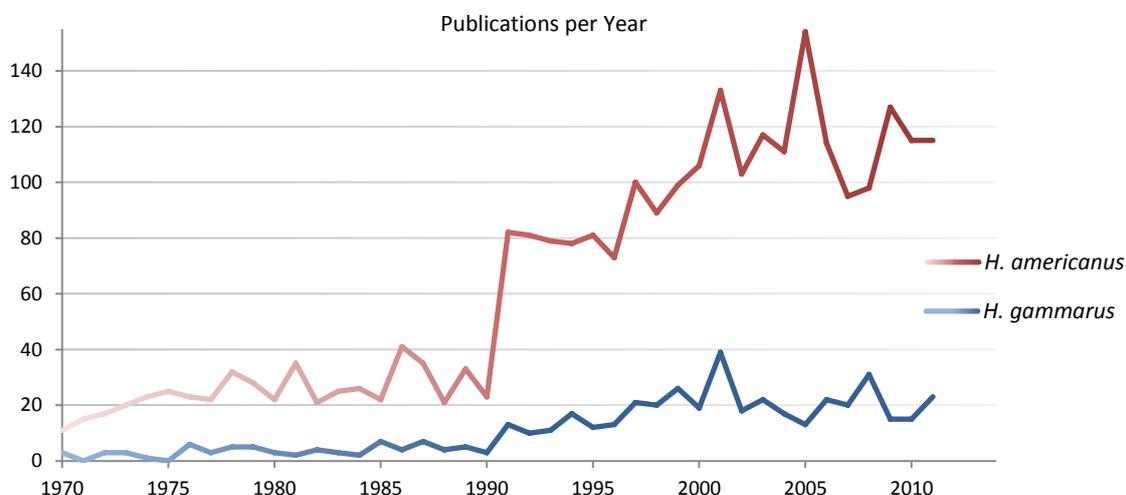


Figure 1. Search results from Web of Knowledge for "*Homarus gammarus*" and "*Homarus americanus*" showing number of published papers by year.

One of the largest foreseeable changes to future marine management and enforcement will undoubtedly be the introduction of a network of MPAs throughout UK waters; however, we still know relatively little about the potential ecological, environmental, and social affects, in comparison to the wealth of knowledge accrued in tropical or coral reef environments [13]. To understand how MPAs impact shellfish stocks, it is vital that data on movements and distributions is made available. Traditionally shellfish studies are conducted using baited traps, which restrict the user to discrete point data at the risk of misinterpreting

seasonal change and small scale behaviours, connectivity between stocks, and an insight on how shellfish will interact with MPA edges.

This research, however, aims to identify patterns of lobster movements through the use of a sophisticated acoustic telemetry (AT) array which will continuously map the movement of tagged individuals, to within metres, within a large area over several months. Improvements in AT now allow us to tag and track large numbers of wild lobster *in situ* with minimal amount of disturbance, permitting studies which were previously impossible using traditional techniques such as catch data, thus improving quantification of movements, habitat utilisation and zonation in a way that was previously impossible.

An acoustic array consists of multiple receivers arranged in a grid-like formation; the individual animals are tagged with transmitters that emit a unique acoustic signature every 1-5 minutes. As they move around their habitat, and between the acoustic array, each time at least three receivers pick up the acoustic signal a detection is made and the location determined by triangulating time difference between the three or more detections, to give a GPS position. Thus eliminating issues of fishing effort; catchability; species interaction and pot saturation, that otherwise hinder the robustness of conclusions drawn from trapping surveys. Despite obvious advantages, AT has been scarcely applied in crustacean studies [14]. The resulting movement vectors will help in management of this valuable and vulnerable food-source, by adding to our knowledge and understanding habitat importance, monitoring local stocks, inferring movement patterns and home-range size, and aiding the design and assessment of MPA effect.

This report outlines work completed for the Marine Management Organisation, Fisheries Challenge Fund: FES 289 – ‘Mapping European lobster (*Homarus gammarus*) movement and habitat-use via acoustic telemetry – Implications for management’; progress to date and preliminary data gathered from the first study conducted 23rd April to 03rd June 2013, along with the future work for 2013 are presented. The first study was intended to run continuously until November 2013, however interactions with other sea users, meant the study was truncated over the summer. The equipment is now back in the water, and work beyond that funded directly by this grant continues with NIFCA.

1.2 Rationale

This study aims to build upon Newcastle University (NU) and Northumberland Inshore Fisheries & Conservation Authorities (NIFCA) knowledge of local lobster stocks and several recent studies, by tracking fine-scale movements of *H. gammarus*, in their natural habitat to determine accurate estimations of *H. gammarus* activity patterns and home-range size to elucidate if there are any predictable movement behaviours and connections between size/sex and distribution or movement; as well as coupling the tracking data with habitat mapping of the area, to determine habitat utilisation.

Results will help in management of this valuable and vulnerable food-source, by adding to our knowledge and understanding by locating habitats of importance, monitoring local stocks, inferring movement patterns and home-range size, and aiding the design and assessment of MPA effect.

Objectives are to:

- use an AT array to track small scale movements of *H. gammarus*
- determine relationships between habitat and movement
- establish connections between size/sex and movements
- determine size of home range

METHODOLOGY

2.1 Study Area

The study is being conducted within the NIFCA district, specifically the south of the district, focused around the port of Blyth (Fig. 2). Potting within the region is restricted by the available habitat for target species and potential conflict with other gear types, particularly trawlers. The trap fishery targets four main species: European lobster (*H. gammarus*), brown crab (*Cancer pagurus*), velvet swimming crab (*Necora puber*) and prawns (*Nephrops norvegicus*). Many fishers use an assortment of trap type; the majority being multi-purpose, and deployed on various ground types at different times of year to target particular species. There are ~132 shellfish permit holders operating within the district with ~31 vessels <10m in length registered at the Port of Blyth, of which 12 are potting vessels. Each has the ability to fish up to 800 traps within 6 nm of shore, and 95% of all Blyth potting activity occurs within the surrounding 190km² [15].

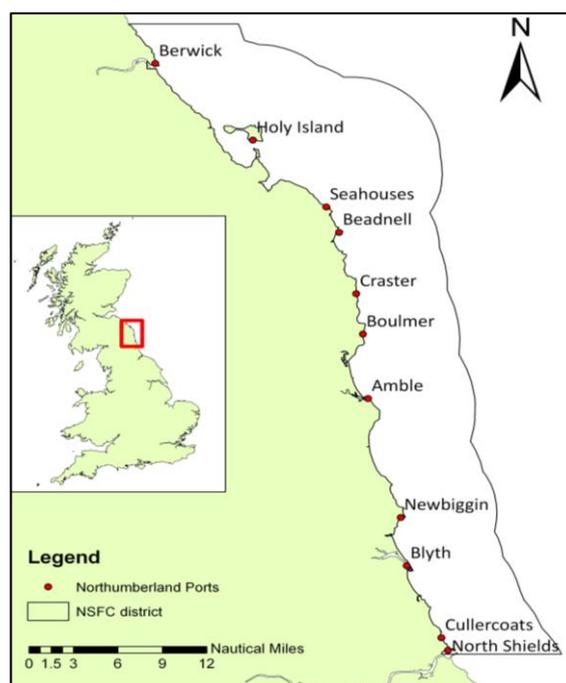


Figure 2. Northumberland coastline, the NIFCA district boundaries and major fishing ports

The study site was identified based on previous survey sites and NIFCA and NU knowledge; the location has been well studied and is positioned 2 km due East of the Port of Blyth, allowing for easy access (approx. $55^{\circ}07'46\text{N}$, $-01^{\circ}26'89\text{W}$) (Fig. 3). The site ranges in depth from ~ 20 m at the south eastern end to maximum depths of no greater than 31 m, habitat also with the site composed of a mixture of hard and soft substrate, but predominated by rock and cobble forming distinct areas of complex habitat; one large rocky-reef runs from the north-west to southern centre of the site, with coarse sand and mud throughout (Fig. 3). Remote from any significant features this site is regarded as a “typical” inshore habitat. In previous fishing studies within the area, the catch of crab and lobster has been predictable by the underlying habitat, with the largest lobster catches coming from within the rocky habitat, and much lower lobster catch and subsequently larger crab catches coming from within the softer sediment areas.

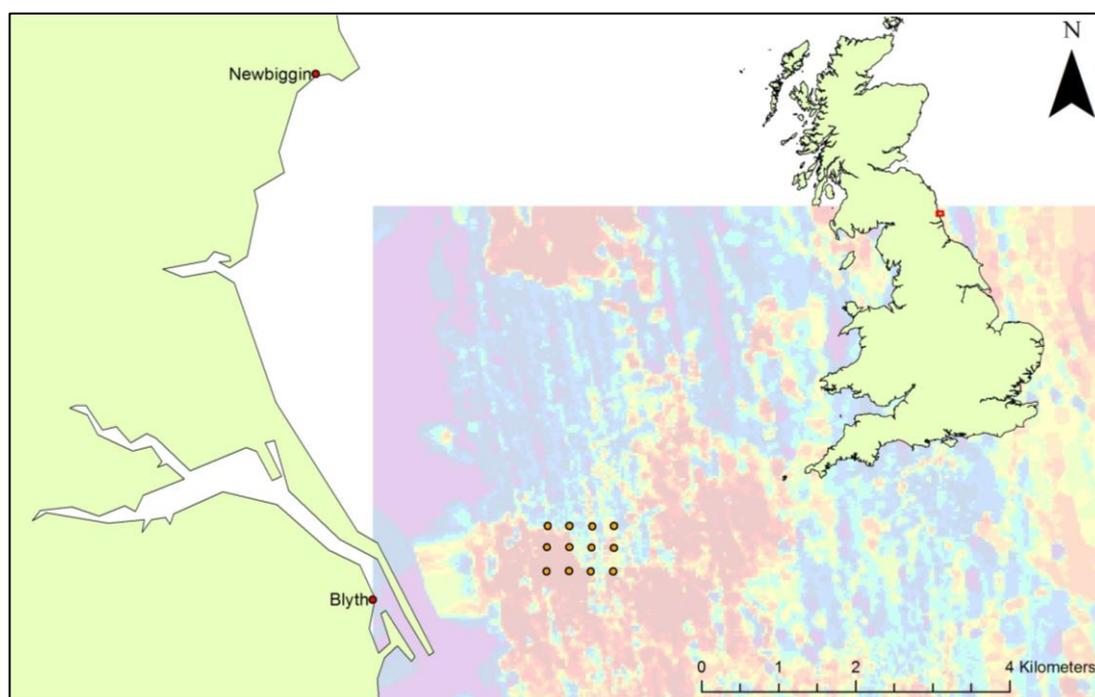


Figure 3. Study site showing the locations of the hydrophones (●), overlaid on top of a habitat map of hardness for the area, showing rock in red, sand in yellow and green and silt in blue and purple.

2.2 Range Test

The concept of the range-test is to determine the range that the VR2W's (Fig. 4a) can accurately detect the acoustic signal from the V13 tags (Fig. 4c), as benthic complexity and the presence of hard objects can interfere with an acoustic signal the range test was split firstly, over softer more homogenous habitat and secondly over hard more complex habitat. The array consisted of using nine receivers arranged in an 'L' shape, with receivers approximately 100 m apart and the V13 tags at either end of the line of six receivers

Range test fieldwork commenced on the 21st November 2012, and involved three days at sea; to set the first test situated over soft sediment (21/11/2012); to download data from the first range-test and to relocate the receivers for the second range-test over harder sediment (30/11/2012); and to download data from the second range-test (12/12/2012).

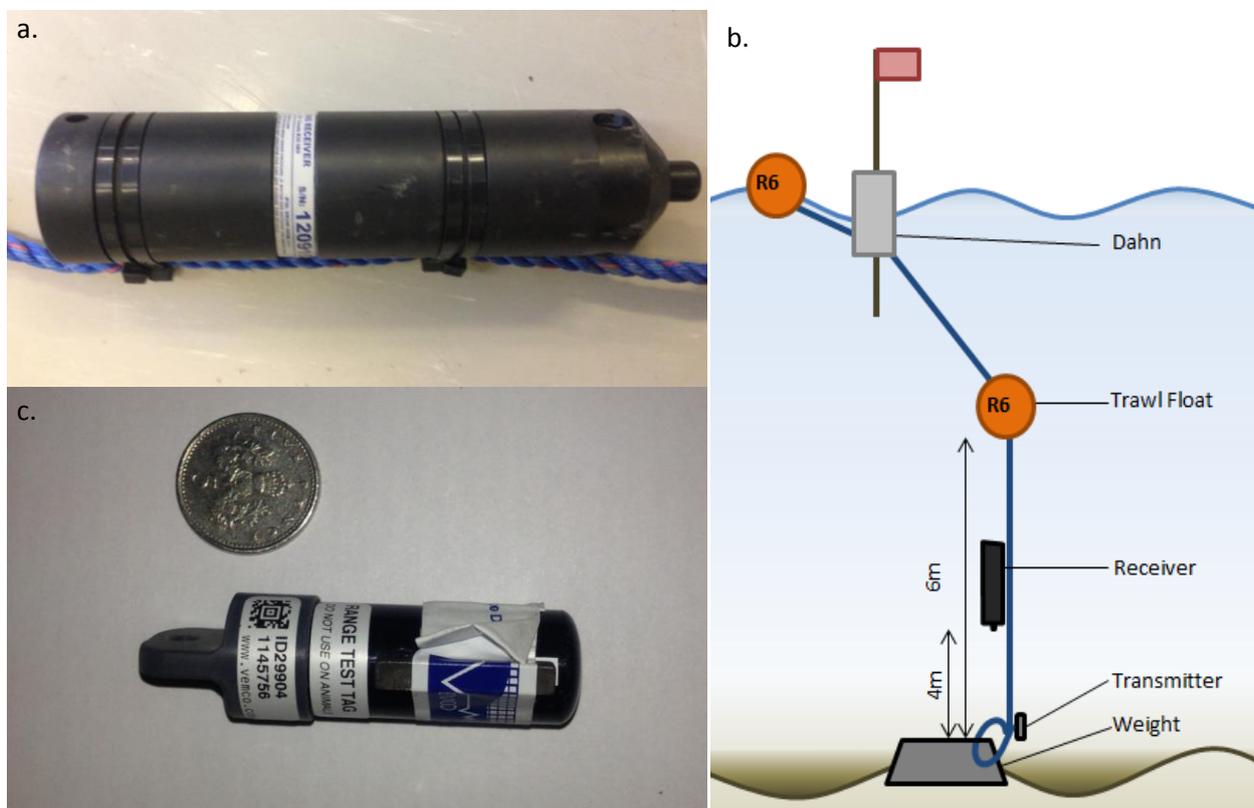


Figure 4. Images of a. VR2W acoustic receiver; b. Receiver and transmitter rigged to a hard trawl float and surface dahn and buoy; c. V13 range test tag (transmitter)

At both sites higher tides produced a decrease in detection %, with a variation between 50-80 % detection for Test 1 (hard substrate), and from 60-100 % detection for Test 2 (soft substrate), during rising or falling tides. During Test 2 high tides also showed a calming effect to hourly variations in detection %. Tidal and wave noise were found not to have an effect, especially as distance from transmitter increases, but this is unavoidable. Wind and poor weather, however, had no discernible effect during both tests, despite very strong winds being present.

The range tests showed the tags to be well suited to the location, with the softer sediment test having good (~50 % detection) range up to 600 m and very good range (~80 % detection) at 300 m. Test 2 on the harder substrate, had good range (~85 % detection) up to 400 m and poor range (~20 % detection) up to 580 m. Therefore receivers were spaced approximately 300-400 m apart during the full study.

2.3 Data Collection

Several days prior to the setting of the array of 12 VR2W receivers, two strings of eight baited parlour traps were set in the middle of the site, to catch a range of lobsters for tagging. Lobster from the subsequent catch were selected, tagged with Hallprint, T-bar ID tags and also fitted with a Vemco, V13 Coded Transmitters (6g in water, ~10% body weight), and released in their capture location with as little disturbance and time out of water as possible. Catching, tagging and releasing the lobster at least one day prior to the start of the study meant they would be accustomed to the tag, and would have fallen back into natural behavioural routine. The lobsters were selected to get an equal ratio of male and females, and to get a size distribution similar to that of the natural population. The morphometric data of the tagged lobsters is shown in Table 1, it shows that the male lobsters tagged were slightly smaller on average than the females.

Table 1. Showing Tag ID's, sex, size and release date and location for all tagged lobster

Serial No.	ID	T-Bar No.	Sex	CL (mm)	Release Date	Release Location	Serial No.	ID	T-Bar No.	Sex	CL (mm)	Release Date	Release Location
1158876	28174	1564	F	65	22/04/2013	55 07.643' -00127.122'	1158911	28168	1559	M	69	19/04/2013	55 07.786' -00127.328'
1158877	28175	1566	F	65	22/04/2013	55 07.643' -00127.122'	1158909	28166	1568	M	71	22/04/2013	55 07.643' -00127.122'
1158881	28199	1532	F	71	18/04/2013	55 07.750' -00127.160'	1158914	28177	1561	M	71	22/04/2013	55 07.643' -00127.122'
1158873	28169	1560	F	73	19/04/2013	55 07.786' -00127.328'	1158908	28162	1551	M	71	19/04/2013	55 07.786' -00127.328'
1158871	28164	1556	F	74	19/04/2013	55 07.786' -00127.328'	1158910	28167	1558	M	72	19/04/2013	55 07.786' -00127.328'
1158878	28176	1567	F	74	22/04/2013	55 07.643' -00127.122'	1158922	28210	1542	M	72	18/04/2013	55 07.750' -00127.160'
1158869	28161	1552	F	75	19/04/2013	55 07.786' -00127.328'	1158918	28197	1548	M	72	18/04/2013	55 07.750' -00127.160'
1158874	28171	1563	F	76	22/04/2013	55 07.643' -00127.122'	1158920	28206	1530	M	73	18/04/2013	55 07.750' -00127.160'
1158875	28172	1562	F	76	22/04/2013	55 07.643' -00127.122'	1158925	28213	1545	M	74	18/04/2013	55 07.750' -00127.160'
1158880	28198	1536	F	79	18/04/2013	55 07.750' -00127.160'	1158912	28170	1569	M	75	22/04/2013	55 07.643' -00127.122'
1158885	28203	1546	F	80	18/04/2013	55 07.750' -00127.160'	1158913	28173	1565	M	75	22/04/2013	55 07.643' -00127.122'
1158904	28215	1357	F	82	18/04/2013	55 07.750' -00127.160'	1158917	28196	1547	M	76	18/04/2013	55 07.750' -00127.160'
1158870	28163	1553	F	83	19/04/2013	55 07.786' -00127.328'	1158907	28160	1555	M	76	19/04/2013	55 07.786' -00127.328'
1158872	28165	1557	F	85	19/04/2013	55 07.786' -00127.328'	1158927	28216	1539	M	76	18/04/2013	55 07.750' -00127.160'
1158879	28195	1527	F	85	18/04/2013	55 07.750' -00127.160'	1158921	28208	1541	M	77	18/04/2013	55 07.750' -00127.160'
1158886	28204	1549	F	86	18/04/2013	55 07.750' -00127.160'	1158926	28214	1544	M	77	18/04/2013	55 07.750' -00127.160'
1158887	28207	1538	F	86	18/04/2013	55 07.750' -00127.160'	1158906	28159	1554	M	78	19/04/2013	55 07.786' -00127.328'
1158882	28200	1540	F	87	18/04/2013	55 07.750' -00127.160'	1158924	28212	1531	M	81	18/04/2013	55 07.750' -00127.160'
1158883	28201	1533	F	88	18/04/2013	55 07.750' -00127.160'	1158919	28205	1535	M	83	18/04/2013	55 07.750' -00127.160'
1158888	28209	1543	F	91	18/04/2013	55 07.750' -00127.160'	1158916	28194	1529	M	84	18/04/2013	55 07.750' -00127.160'
1158884	28202	1534	F	92	18/04/2013	55 07.750' -00127.160'	1158923	28211	1537	M	84	18/04/2013	55 07.750' -00127.160'
							1158915	28193	1528	M	85	18/04/2013	55 07.750' -00127.160'
							1158905	28158	1550	M	98	19/04/2013	55 07.786' -00127.328'

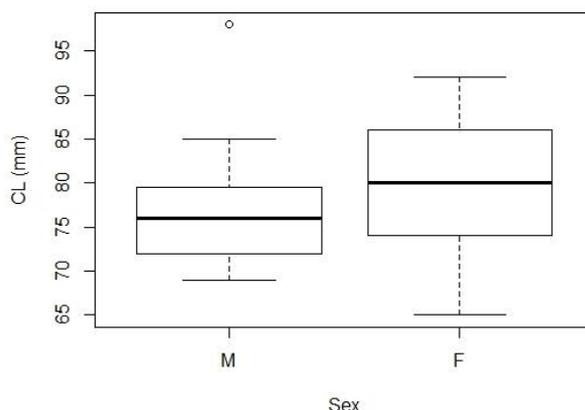


Figure 5. Boxplots showing the size distribution of the two sexes tagged.

Once tagged and released the V13 tags will emit an acoustic 'ping' at 69 kHz and delay of 200-400 seconds, to give high resolution data, considering their walking speeds ($2.5\text{m}^{\text{-min}}$ max [16]). This ping includes an ID number which allows identification of the specific tag, which will stop pinging after 12 months, to avoid lost tags, through ecdysis or other, impeding future data.

The approach to continuously and accurately monitor the movements of lobsters over a large area, used an array of 12 Vemco, VR2W Single Channel Receivers (consisting a hydrophone, receiver, ID detector, data logging memory, and battery in submersible case), arranged in a grid-like formation, approximately 350 m apart, covering an area upwards of 1km^2 (Fig. 3) [17]. Each hydrophone was also set with a unique synctag co located, and receiver R6 also had a second synctag that monitored, salinity, depth and temperature. However, due to interactions with local commercial drift net fishermen, this was not achievable, and to avoid equipment loss for both parties it was decided to withdraw the array for the months of June, July and August. The equipment was replaced on 17/10/2013; giving us one month of data at the beginning of the season, and over one month of data at the end of the season. For this reason we have only received data from the first period of data gathering (23/04/2013 – 03/06/2013).

2.4 Analysis

Full analysis of the data will not be conducted until after all data from the study has been collected in early 2014. Analysis of the preliminary set of data from the first study period will be kept to a minimum, but will include; elucidating the movements of each individual from the raw data, mapping of 50 % and 95 % home range of each individual. Once all data is collected the full analysis will be much more sufficient, and will include looking at the habitat hardness in relation to movements and distributions, looking at size and sex related differences between movement and home range.

PRELIMINARY RESULTS

In the VEMCO Positioning System the nature of error is very complex, and understanding error in VPS results has been a challenge. VPS does not provide calibrated accuracy estimates for calculated positions measured in terms of distance. Instead, it provides a relative, unitless estimate of how sensitive a calculated position is to errors in its inputs; this is referred to as horizontal position error (HPE).

Therefore, the first process once we received the raw data, which comprised of 112,623 individual positions for both the 42 tagged animals and the 13 synctags, was to eliminate positions with large HPE values, which are the positions with the most error. These positions tend to be those from outside the immediate study area, as animals are moving from the area, therefore removing these data points, is not believed to impact the results at all, we removed 1,1882, (~1.7%) of the positions.

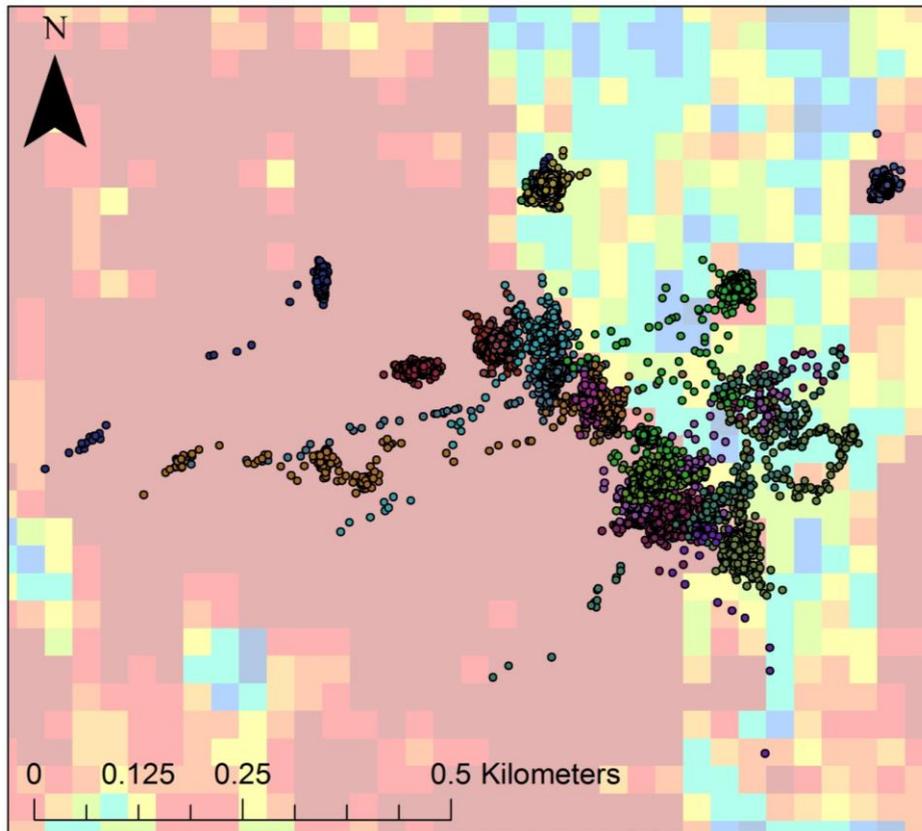


Figure 6. All female positions, individuals are distinguished by the colour of the marks. The underlying habitat layer shows hardness, from rock (red) to mud (purple)

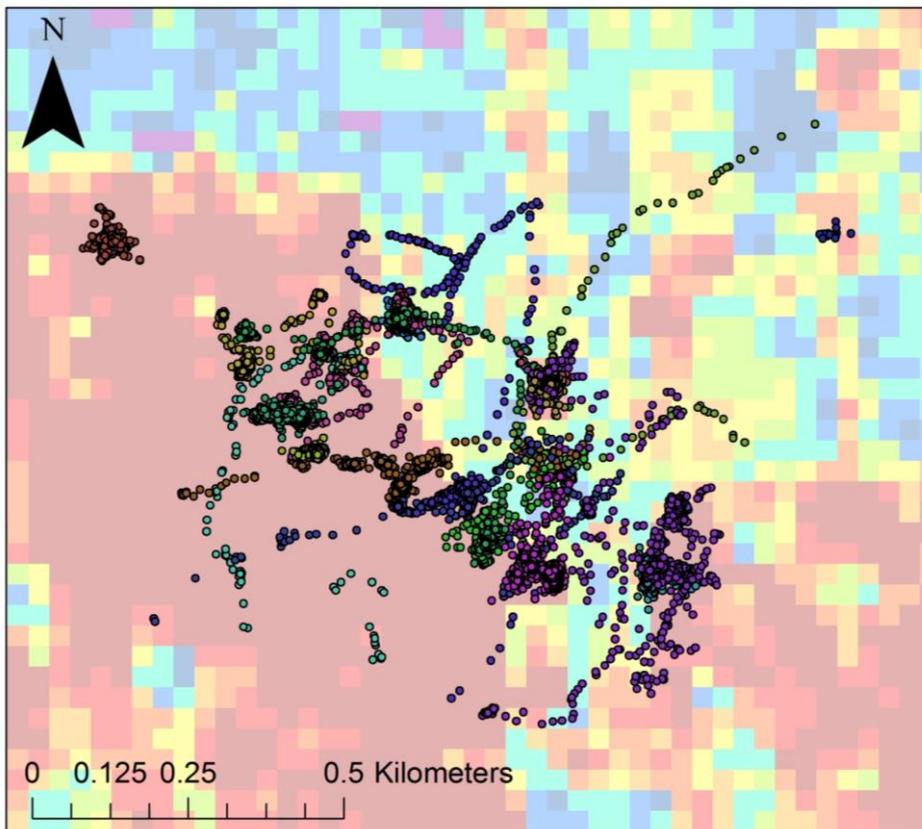


Figure 7. All male positions, individuals are distinguished by the colour of the marks. The underlying habitat layer shows hardness, from rock (red) to mud (purple)

Of the 42 animals tagged, data was collected for 41 of them; one male was not observed in the study, they may have migrated from the study area prior to the setting of the hydrophones, their tags may have stopped working, or they could have been removed in another manner.

In total there were 23,504 verified and accurate positions for the 20 female tagged lobsters (min; 45, max; 3,970), and 22,006 for the 21 male tagged lobsters (min; 12, max; 2,506), these can be seen in figures 6 and 7 respectively.

From the remaining positions we estimated both the 95 % and 50 % utilisation distribution, using kernel density estimator, for males and females (Worton 1989). 95 % and 50 % utilisation distribution can be seen for males only in figure 8 and 9 respectively.

Further analysis will be conducted once all the data has been gathered; this will include the estimation of a minimum convex polygon of average daily home ranges for both males and females for both time periods (beginning of summer and end of summer). It will also include much more in depth analysis of the relationships between home range, and utilisation distribution and size and sex, as well as looking at the time spent on each of the various habitat hardness' within the array.

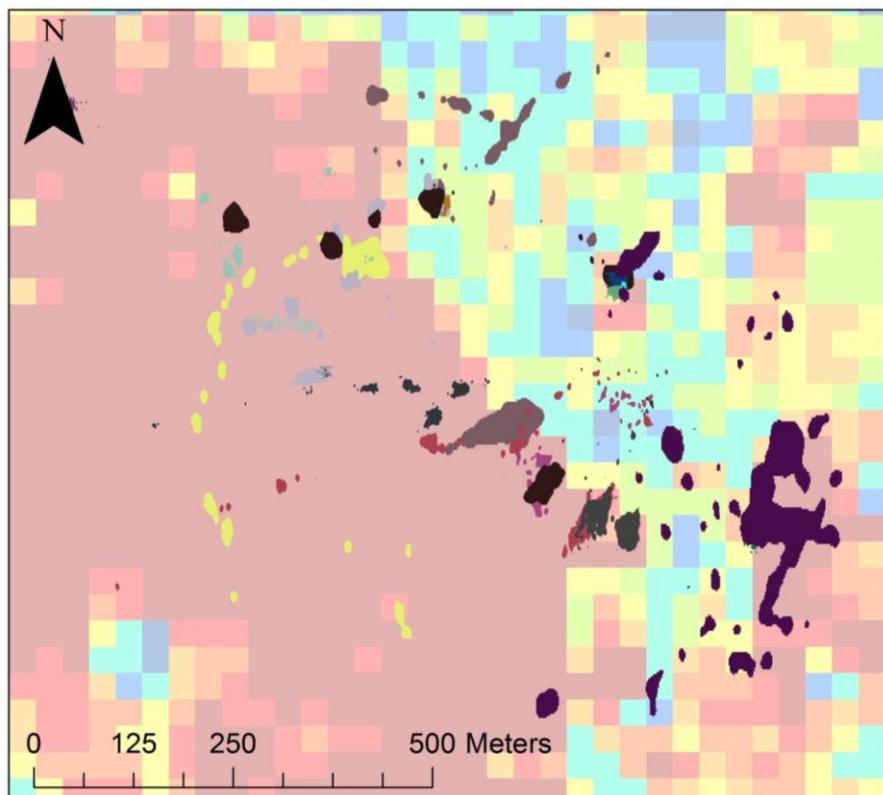


Figure 8. Map showing individual male lobster 95% UD, overlaid on a map of hardness

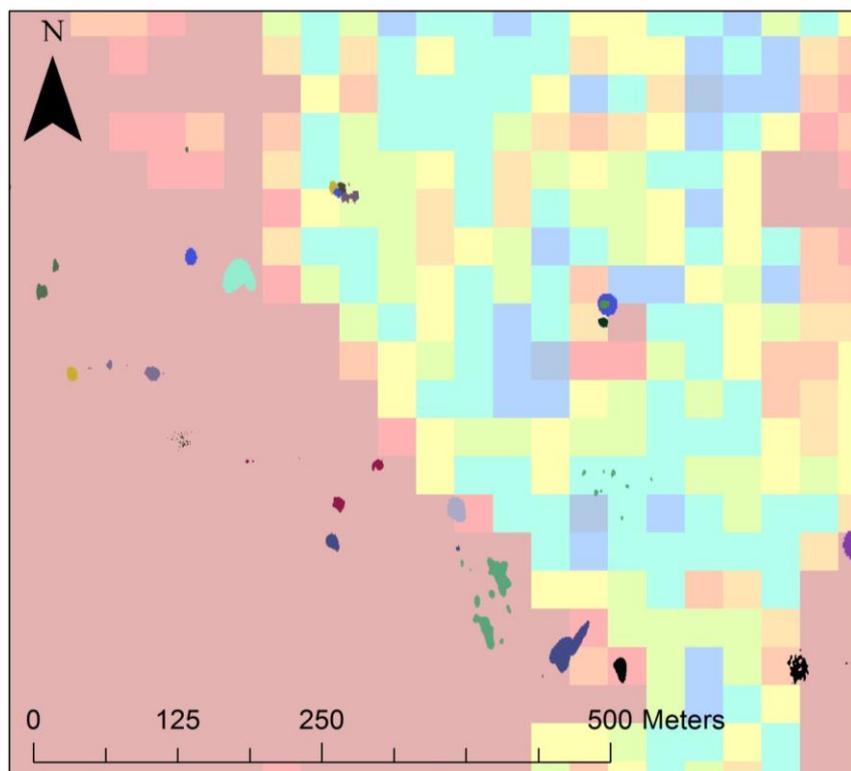


Figure 9. Map showing individual male lobster 50% UD, overlaid on a map of hardness

PROBLEMS AND ASSUMPTIONS

Several problems arose during the study, many of which restricted the scope of achievement in the short term. However, initial results are positive and the MMO will be provided with copies of all resultant publications on the basis of the full data set in the coming year.

Delays in funding and the subsequent ordering of the equipment meant the range test could not be completed on schedule and was delayed until the winter of 2012. Further restrictions meant the full array was not implemented until the end of April 2013. Only six weeks into the full array deployment, interactions with other sea users forced the project to be suspended temporarily until September 2013. It is thought that with no further delays or interruptions the study will be complete by early 2014.

Further interactions with other sea users, has also added some degree of error to the position data, as the hydrophone receivers were dragged and moved about by other vessels (figure 10.), however, much of this error is able to be removed, by the complex processing carried out by VEMCO. The placement of the syntags on the receivers themselves means that the movement can be accounted for in the subsequently recorded positions of each animal tag.



Figure 10. Map showing the positions of the syntags on each receiver, these are subsequently used to work out the positioning error of each recorded position for the animals. Note the movement of the receivers in the South east corner of the study site.

THE NEXT STEPS

Once all the data has been gathered, processed and erroneous positions removed, full and in depth analysis will be able to commence. The results from which will be the first of their kind in England, and will help to inform fisheries managers, and spatial planners on the distribution and small scale movements of lobster within the North Sea, which is paramount when attempting to manage shellfish stocks or implement marine protected areas.

The project so far has successfully completed the two planned range tests for the primary site, and the full study using 42 tagged animals in April-June 2013. As previously mentioned, interactions with other sea users put a risk to leaving the equipment in the water for the entire duration planned. So two short study periods will be analysed instead, due to this interruption for more than three months, the project is now planned for completion by early 2014.

This document forms the final report to the Marine Management Organisation, for the project; BH120694– ‘Mapping European lobster (*Homarus gammarus*) movement and habitat-use via acoustic telemetry – Implications for management’.

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