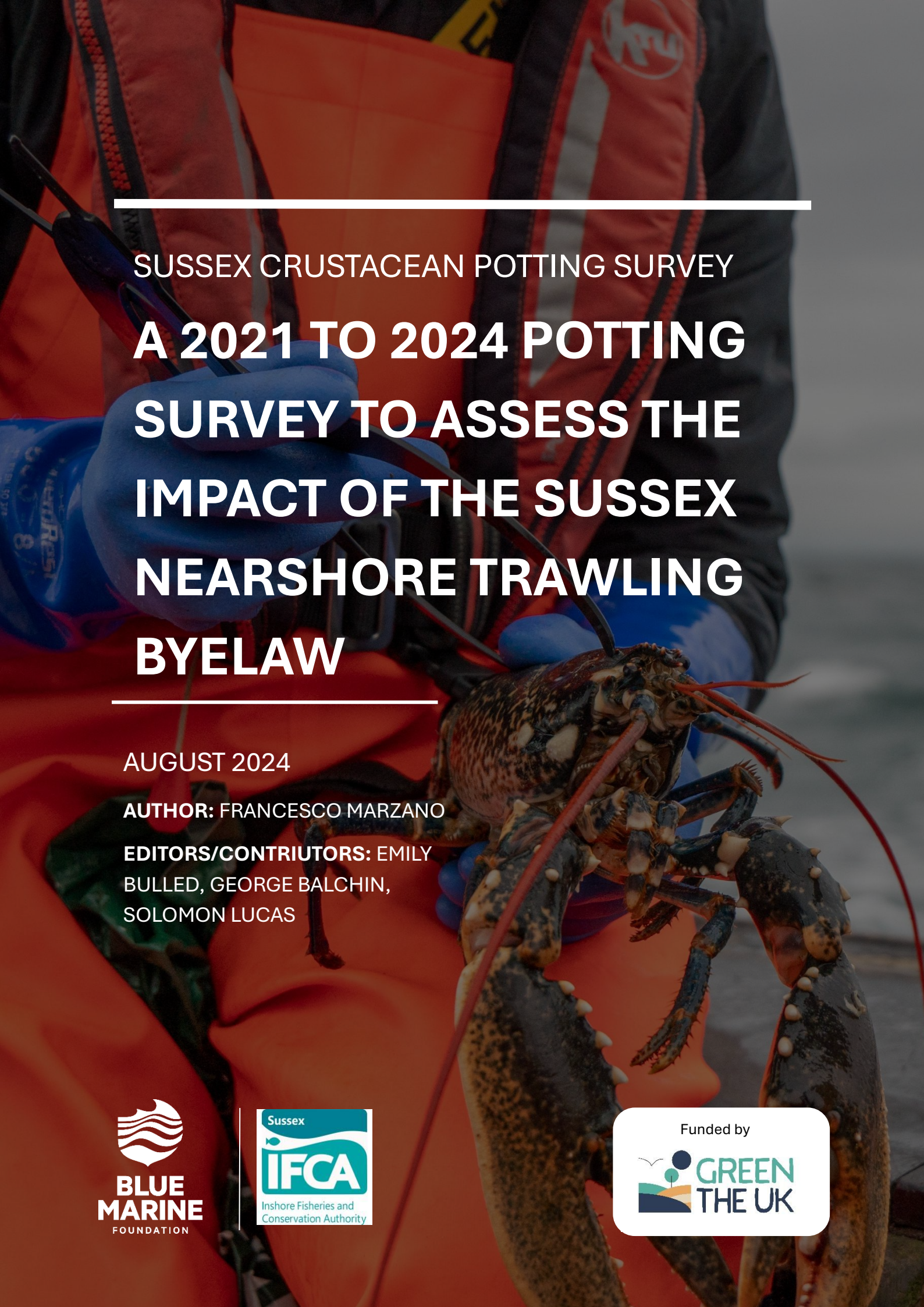


SUSSEX CRUSTACEAN POTTING SURVEY

A 2021 TO 2024 POTTING SURVEY TO ASSESS THE IMPACT OF THE SUSSEX NEARSHORE TRAWLING BYELAW

AUGUST 2024

AUTHOR: FRANCESCO MARZANO

EDITORS/CONTRIUTORS: EMILY BULLED, GEORGE BALCHIN, SOLOMON LUCAS

BLUE MARINE FOUNDATION

Sussex IFCA Inshore Fisheries and Conservation Authority

Funded by GREEN THE UK

Executive summary

In the late 1970s, abundant kelp beds between Selsey and Shoreham-by-Sea teemed with life. This biodiverse environment played a key ecological role in providing shelter, feeding and nursery grounds for marine life, including commercially important crustaceans. However, by the end of the 1990s, 96 per cent of the kelp had disappeared. Among the factors that caused the kelp to disappear were the great storm of 1987 and intensive fishing activity in the area using heavy trawl nets (trawling), which, when dragged along the seafloor, can destroy seabed habitats.

In 2015, an inshore habitat map commissioned by Sussex Inshore Fisheries and Conservation Authority (IFCA) showed how habitats in the area had changed and initiated discussions about kelp's role in the ecosystem. Over subsequent years, Sussex IFCA, who manage the area from the shoreline out to 6 nautical miles, created a compelling case for a new piece of legislation which aimed to protect essential fish and marine habitats and support sustainable inshore fisheries: the Sussex Nearshore Trawling Byelaw.

The Nearshore Trawling Byelaw came into effect in March 2021, prohibiting trawling over 304 square kilometres of seabed. To understand the ecological, social and economic value of kelp and the benefits of the Byelaw on kelp recovery, local inshore fisheries and the wider ecosystem, Blue Marine and partners of the Sussex Kelp Recovery Project have established an extensive monitoring and research programme.

Part of this research includes a long-term programme of potting surveys to understand the impact of the Byelaw on commercial crustacean fisheries, specifically European lobster (*Homarus gammarus*) and brown crab (*Cancer pagurus*) (also known as edible crab). The first surveys were carried out in 2021, within six months of the introduction of the Byelaw, establishing a baseline against which future changes can be measured.

In 2021, data was collected on crab and lobster abundance, carapace size, weight, sex ratio and condition at 12 sites around Selsey, both within and outside the trawling exclusion zone, with the help of local fishermen. In 2022, surveys were conducted at a total of 24 sites, extending the range of the project to include sites off Brighton and Eastbourne as well as Selsey, again surveying on board local fishing boats. In 2023, the same 12 sites at Selsey were surveyed, but the location of the Brighton sites was adjusted to reflect fishermen’s local knowledge of the extent of rocky reef habitat. In 2023 and 2024, it was not feasible to repeat the six sites at Eastbourne due to lack of funding and fishermen availability. In 2024, all the 21 sites surveyed in 2023 were repeated, with 12 sites in Selsey and nine in Brighton and sea temperature was added to the metrics measured at each site to test the potential impact of this variable. From these surveys, a four-year dataset has been collated from Selsey in the western part of the trawling exclusion zone, and a two-year dataset from Brighton in the eastern part of the trawling exclusion zone. Analysis of these datasets indicates where changes

in crab and lobster populations have occurred inside and outside the trawling exclusion zone over time. To see if there were any differences in crab and lobster population metrics inside and outside the trawling exclusion zone in 2024 across a wider area, the 2023-2024 data from Selsey and Brighton was combined and a second test for significant differences was completed.

Overall, the results from the four-year dataset at Selsey showed no significant differences in crab or lobster abundance between sites inside and outside the trawling exclusion zone or between the years 2021, 2022, 2023 and 2024. This was expected, given that the final year's survey was undertaken only three years and five months from when the Nearshore Trawling Byelaw was introduced, and ecological recovery of rocky reef habitats has been shown to take five to ten years after bottom towed gear has been prohibited. Areas inside and outside can, therefore, be considered similar in terms of their state over the time period of the study to date.

However, other metrics had a few significant correlations. The number of brown crabs recorded at the survey sites in Selsey decreased as depth increased. This was true for individuals both above and below the Minimum Conservation Reference Size. Brown crab carapace size also recorded a significant decrease from 2021 to 2022 inside the trawling exclusion zone and a significant increase from 2022 to 2024 outside the trawling exclusion zone. No metrics had a significant correlation for European lobsters.

It is expected, as evidenced in other areas where trawling is removed, that as the kelp beds and other habitats recover, crab and lobster populations will increase in number, there will be a greater number of larger mature individuals and smaller juvenile individuals, and individuals caught would be in better condition.

During the surveys in 2022 and 2023, but less so in 2024, observations of sedimentation in crab and lobster potting areas were reported by all fishermen, especially out of Brighton Marina. Such reports are important to note due to the potential influence of sediment on kelp settlement and growth and crustaceans, which could alter their response to spatial management measures.

In 2025, with continued engagement with Sussex's fishing fleet, Blue Marine Foundation aims to repeat the survey at the same sites surveyed in previous years. It will be important to incorporate local fishermen's knowledge of the trends observed throughout the year, including abundance and condition of the species caught, or environmental variables, such as the level of sedimentation. These observed trends will build our understanding of any additional factors which could prevent the recovery of these species. Additional research into the impact of sediment on the recovery of kelp and crustaceans would also complement the study.

Contents

Introduction

In the late 1970s, abundant kelp beds between Selsey and Shoreham-by-Sea teemed with life. This biodiverse environment played a key ecological role by providing shelter, feeding and nursery grounds for many important marine species including European sea bass, black seabream, European lobster and common cuttlefish[1]. These fish populations have supported commercial fisheries and local communities across Sussex for many years. Kelp also has the ability to improve water quality through nutrient filtration and can prevent coastal erosion by acting as a buffer from the impacts of waves and storms[2].

However, by the end of the 1990s, 96 per cent of the kelp beds had disappeared, along with the high biodiversity and abundance of species they supported and the ecosystem services they provided[3]. The great storm of 1987 and intensive fishing activity in the area were among some of the factors that caused the kelp to disappear. Heavy trawl nets (trawling), dragged along the seafloor, had contributed to destroying the seabed habitats.

In 2010, an inshore habitat map commissioned by Sussex Inshore Fisheries and Conservation Authority (IFCA), who manage the area from the shoreline out to 6 nautical miles, showed how habitats in the area had changed and ignited discussions about kelp's role in the ecosystem. Over subsequent years, Sussex IFCA created a compelling case for a new piece of legislation which aimed to protect essential fish and marine habitats and support sustainable inshore fisheries: the Sussex Nearshore Trawling Byelaw (2019).

Blue Marine Foundation worked with Sussex Wildlife Trust, Marine Conservation Society, University of Portsmouth and Big Wave Media as part of the Help our Kelp campaign to mobilise public support for the Nearshore Trawling Byelaw.

The Sussex Nearshore Trawling Byelaw (2019) finally came into effect on 18 March 2021, prohibiting trawling over 304 square kilometres of seabed, creating one of the largest inshore areas closed to trawling in England and the UK's first kelp recovery project (Figure 1).

Following the introduction of the Byelaw, Blue Marine and Help our Kelp partners created a new partnership encompassing Sussex IFCA, Universities and local authorities to deliver the Sussex Kelp Recovery Project, which aims to 'champion, study and facilitate the restoration of Sussex kelp to support a thriving and sustainable marine ecosystem'[4].

---

[1] Norderhaug, K.M., Christie, H., Fosså, J.H. and Fredriksen, S., 2005. Fish-macrofauna interactions in a kelp (Laminaria hyperborea) forest. *Marine Biological Association of the United Kingdom. Journal of the Marine Biological Association of the United Kingdom*, *85*(5), p.1279.

[2] Duarte, C.M., 2017. Reviews and syntheses: Hidden forests, the role of vegetated coastal habitats in the ocean carbon budget. *Biogeosciences*, *14*(2), pp.301-310.

[3] Williams, C. and Davies, W., 2019. Valuing the ecosystem service benefits of kelp bed recovery off West Sussex. *Report for Sussex IFCA. London: New Economics Foundation*.

[4] Sussex Wildlife Trust. 2022. *Sussex Kelp Restoration Project*. Available at: https://sussexwildlifetrust.org.uk/helpourkelp

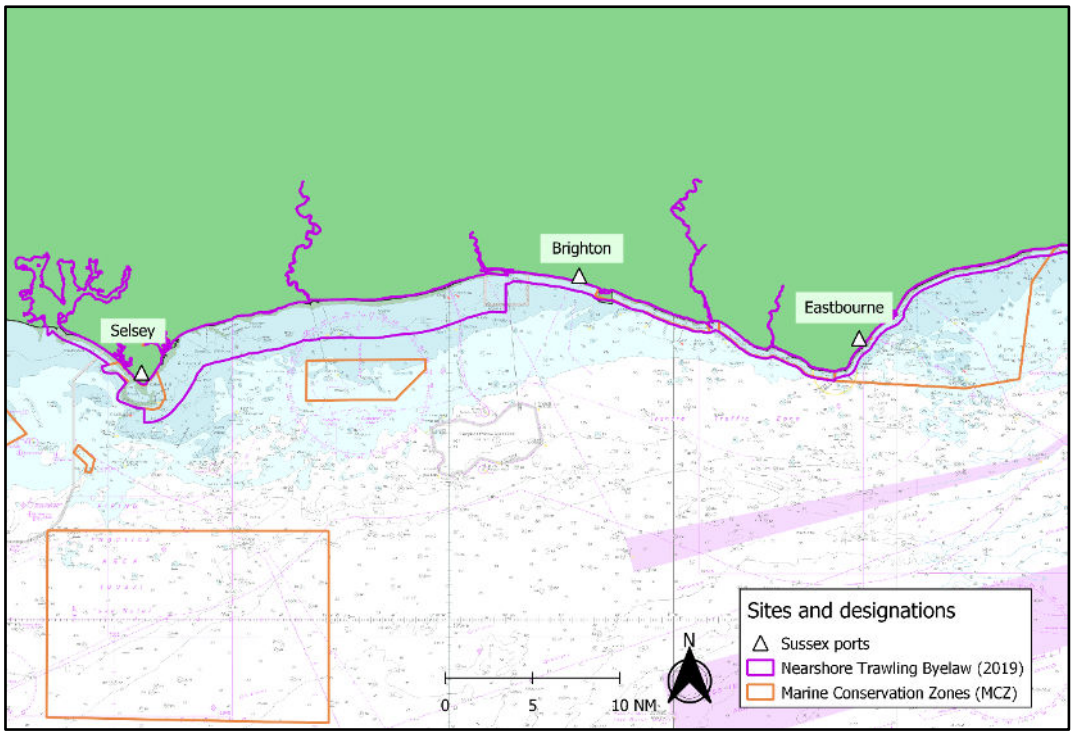


Figure 1: Sussex's ports, MCZs and the Nearshore Trawling Byelaw

Part of the project is to support an extensive research programme to 'understand the ecological, social and economic value of kelp and the Sussex IFCA Nearshore Trawling Byelaw', using a range of methods including:

- Annual Baited Remote Underwater Video (BRUV) to assess recovery of mobile fauna.
- Annual towed video assessments of benthic recovery.
- Environmental eDNA surveys.
- Commercial fish surveys.
- Socio-economic benchmarking to assess the impacts of kelp recovery on the local socioeconomics of relevant stakeholders.
- Carbon sequestration potential of recovered kelp habitats.

The results from regular annual species and habitat monitoring will contribute to a comprehensive assessment of the ecological, social and economic changes resulting from the recovery of the kelp beds.

The ecological effects of spatial protection measures and kelp recovery on commercial fisheries of interest within the trawling exclusion zone are important to capture, to help understand the interlinked ecological service provision of kelp forest and commercial fisheries.

Recent literature has highlighted the importance of kelp for crustacean fisheries. Smale *et al.* (2022)[5] has quantified the use of kelp forest habitat by commercially important crustacean species in the UK. Crustacean species were observed in all kelp habitats in this study. Brown crab (*Cancer pagurus*) and velvet swimming crab (*Necora puber*) were the most abundant, although spider crab (*Maja brachydactyla*), European lobster (*Homarus gammarus*) and common prawn (*Palaemon serratus*) were also recorded. This paper found:

- An association between commercially valuable crustaceans and kelp habitats, which is of particular importance due to the large market value and existing local fisheries of these animals.
- Positive relationship between the amount and structural complexity of kelp species and the amount of their associated commercially valuable species – due to the role of kelp as a foundation species that is able to provide space, food and protection to a number of organisms.
- Most individuals found in kelp habitats were juveniles or sub-adults. This has been associated with kelp's relatively high structural complexity – making kelp a good nursery ground.

To understand the impact of the Byelaw on commercial crustacean fisheries, a long-term programme of potting surveys is being supported by Blue Marine, Sussex IFCA and local fishermen. The study aims to understand the long-term effect of the Byelaw on brown crab (*Cancer pagurus*) and European lobster (*Homarus gammarus*) populations (Figure 2) to monitor changes in the fishery over time as the historic kelp beds recover. Crab and lobster potting has had a long history in West and East Sussex. Due to the known association of crab and lobster with kelp habitat, it is hoped that the recovery of kelp can help to support and sustain the crab and lobster fisheries in this area.

Working with fishermen out of Selsey and Brighton, we can actively engage the fishing community in the research, incorporate their local knowledge into survey planning and design, and gain an insightful understanding of the causes of any patterns or trends observed. Year One of the programme began in 2021, where data was collected to establish a baseline that can be compared against in future years. Year Two of this survey was conducted in 2022, and Year Three in 2023. This report outlines the potting survey undertaken in Year Four (2024) and compares the data collected on crab and lobster to the findings of previous years to assess

[5] Smale, D.A., King, N.G., Jackson-Bué, M. and Moore, P.J., 2022. Quantifying use of kelp forest habitat by commercially important crustaceans in the United Kingdom. *Journal of the Marine Biological Association of the United Kingdom*, *102*(8), pp.627-634.

general trends and whether there has been any recovery inside the trawling exclusion zone since its designation in March 2021.

Figure 2: Brown crab (Cancer pagurus, left) and European lobster (Homarus gammarus, right)

Commercial Fisheries in Sussex

The Sussex inshore marine environment has a wide diversity of habitats and species that support rich inshore fishing grounds. Whelk, lobster, crab and cuttlefish are all extremely important commercial fishing species in Sussex inshore waters. In 2023, there were 75 active commercial permits registered within the Sussex IFCA district, dominated by smaller vessels under 10 metres (91% of the fleet), with vessels largely using static gear (69% of the fleet). These boats usually fish within six nautical miles (nm) of the coast and land their catch daily. Most of the fleet is multi-purpose, operating throughout the year in pursuit of whichever stock (and or quota) is available during the relevant season.

There are six key fishing communities along West Sussex: Emsworth (Chichester Harbour), Selsey, Bognor Regis, Littlehampton, Worthing and Shoreham-by-sea. Emsworth has a mixed fishery for finfish and shellfish. Selsey landings are mainly focused on shellfish, with lobster, crab and whelk being the main species landed in terms of value[3]. Landings in Bognor Regis are dominated by lobsters, with low landings of some other demersal species such as cod and shellfish (mainly crabs). Littlehampton is also a mixed fishery, where whelk have been the main species landed, followed by cuttlefish, bass and plaice, as well as crabs and lobsters. Shoreham-by-sea landings are mainly scallops, caught by visiting and local vessels who dredge in scallop grounds along the south coast.

Mixed inshore fisheries also operate in Eastern Sussex. Brighton has a mixed fishery with species including sole, plaice, turbot and cuttlefish landed regularly, along with whelks and scallops. Crab and lobster potting effort is higher out of Eastbourne, but a range of species are also landed, such as whelks, cuttlefish, bass, cod and bream.

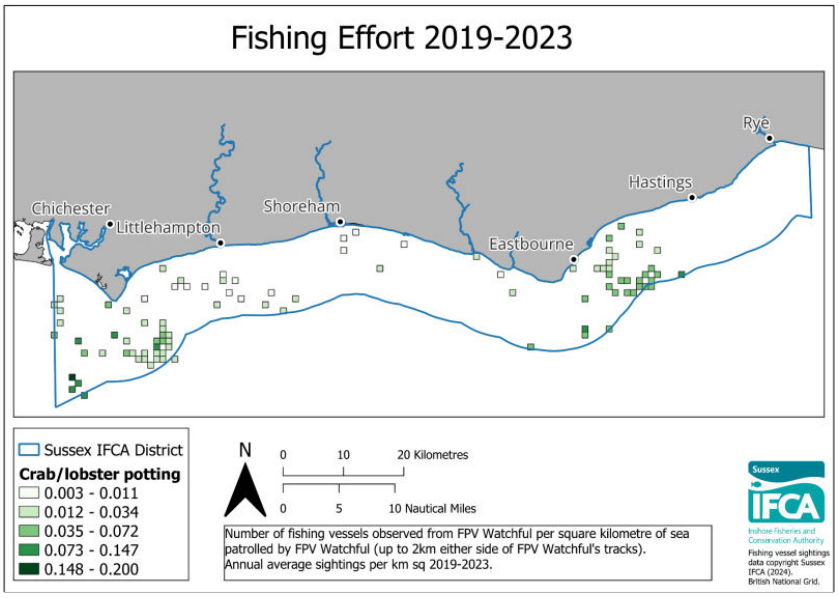


Figure 3: Fishing effort for crab and lobster potting across West and East Sussex from 2019-2023[6]

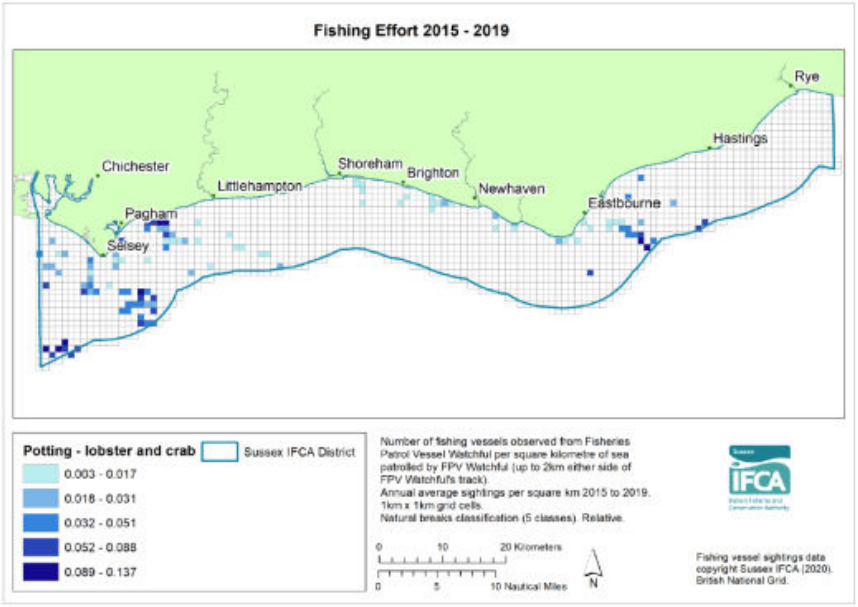


Figure 4: Fishing effort for crab and lobster potting across West and East Sussex between 2015-2019[7]

[6] Sussex IFCA. 2024. *Sussex Inshore Fishing Effort 2019-2023*. Available at: https://www.sussex-ifca.gov.uk/conservation-research

[7] Sussex IFCA (2020). *Fishing vessel sightings data*. British National Grid.

Crab and lobster potting fishing effort mostly occurs between Chichester Harbour and Littlehampton, and between Shoreham and Hastings (Figure 3), as these areas are associated with preferential crustacean rocky reef ground. Anecdotal evidence from Sussex fishermen suggests that the crab and lobster fishery off Brighton is smaller than other areas along the Sussex coast, due to smaller areas of rocky reef lobster habitat, mainly occurring inshore. Between 2019 and 2023, crabs were the 4th highest-value species landed in Sussex ports and lobsters were the 11th highest[6]. Figure 4 shows an earlier map presenting the pot fishing effort from 2015-2019 and shows that potting effort across Sussex has slightly reduced between the years[7].

The crab and lobster fishery in West and East Sussex is a small-scale inshore fishery that mostly uses boats of 10 m or under with inkwell or parlour pots. Commercial and recreational potting in Sussex is currently managed through the Sussex IFCA Shellfish Permit Byelaw 2015[8]. This Byelaw contains a range of measures to manage crustacean, gastropod and cephalopod fisheries within the Sussex IFCA District. Measures include mandatory escape hatches (80x45 mm) fitted to parlour pots, limits on pot numbers, no v-notched or ovigerous (berried) lobsters to be landed and a requirement for catch returns to be submitted to Sussex IFCA.

In 2023, there were 51 active shellfish recreational permits and 75 active commercial permits, with a decrease in recreational permits (from 65) and commercial permits (from 93) compared to 2022[9] The catch returns data from Sussex IFCA showed that the four main shellfish species landed across Sussex in 2023 were whelks (78 per cent), cuttlefish (17 per cent), brown crab (4 per cent) and lobster (2 per cent)[9]. As shown in Figure 5, lobster and brown crab landings were greatest in 30E9West, whelk landings were greatest in 30F0West, and cuttlefish landings were greatest in 30F0East. Landings were lowest for lobster, brown crab and cuttlefish in 30E9East, less than 1 tonne of lobster or brown crab were landed in 30E9East. The highest Landing Per Unit Effort (LPUE) measured as kg per pot was 30E9West for brown crab and cuttlefish, and 30F0West for lobsters and whelk. The lowest LPUE for lobsters and whelk was in 30E9West, for cuttlefish was 30E9East, for brown crab was 30F0East[9].

Landing Per Unit Effort (LPUE) for lobster declined from 2017 (0.09kg/pot) to 2021 (0.05kg/pot), followed by a slight increase in 2022(0.07 kg/pot) and 2023 (0.08 kg/pot)[9]. Brown crab LPUE steadily declined from 2018 (0.48 kg/pot) to 2023 (0.20 kg/pots)[9]. In 2023, crab landings were highest in June than any other month, with landings remaining relative constant throughout the rest of the year (Figure 6). For lobsters, landings were highest in May and September, and lowest in November (Figure 6). This is important when designing the study to ensure that the survey is completed in the summer period when potting activity is at its peak and at the same time each year to remove any seasonal variations.

[8] Sussex IFCA. 2015. *Shellfish Permit Byelaw*. Available at: https://www.sussex-ifca.gov.uk/regulations

[9] Sussex IFCA. 2023. *Sussex IFCA Shellfish Permit Catch Returns Data Summary 2023.* (Note: 2024 Catch Return Data Summary to be published by mid-year 2025, this report will be updated once the catch return data summary for 2024 is published)

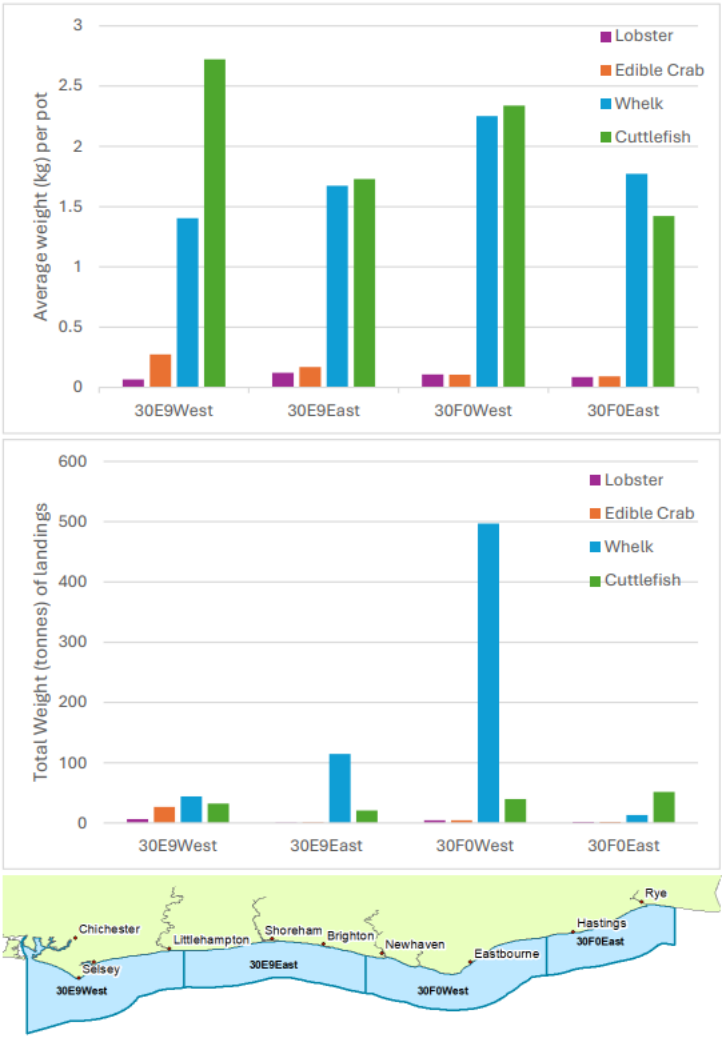


Figure 5: Landings of the four key shellfish species across Sussex in 2023[9]

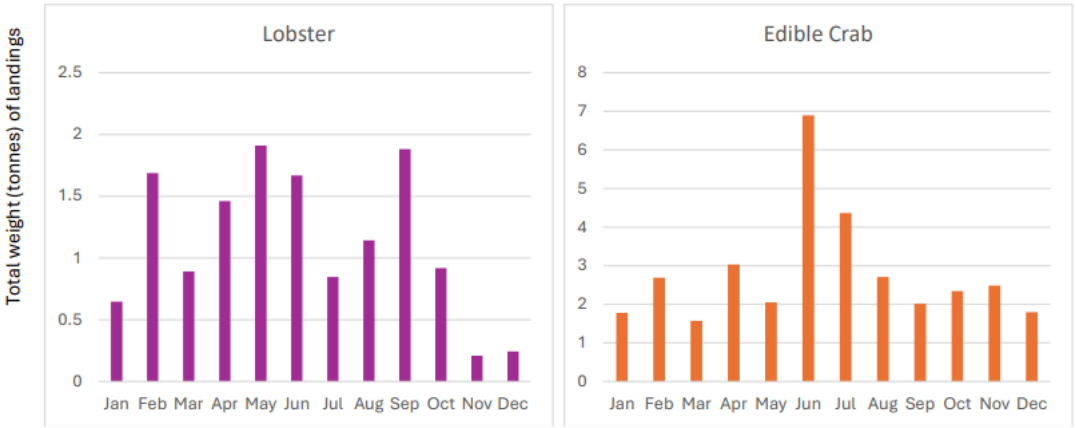


Figure 6: Total weight of landings across the months of the year for European lobster (left) and brown crab (right) in 2023[9].

Environmental Pressures in Sussex

Concerns have been raised by local fishermen and other marine users around human activities other than trawling that could have impacts on the quality of the marine environment in Sussex, and therefore, the crab and lobster populations (Appendix E). Sedimentation is one considerable concern[10]. Blue Marine is leading an investigation in collaboration with Sussex Kelp Recovery Project partners into the sources and impacts of sediment to inform future action. High levels of sedimentation from a range of sources, such as aggregate dredging and disposal[11], coastal erosion, land run-off, sewage pipes and industrial development, can have impacts on crab and lobster migration, health and reproduction. Therefore, these environmental pressures could have an impact on the effectiveness of the Nearshore Trawling Byelaw for these key fisheries, so it is important that this is considered as this study progresses.

Crustaceans are considered resilient to gradual climate changes, but they are highly susceptible to sudden extreme events, such as marine heatwaves[12]. In addition to marine heatwaves, the topographic nature of Sussex Bay makes it sensitive to atmospheric heatwaves[13]. Therefore, the impact of temperature is important to note for this potting survey.

Research Aims and Hypotheses

Research shows that there is a positive association between the abundance of lobster and crab and kelp beds[14]. There is also a positive relationship between the amount and structural complexity of kelp species and the abundance of associated commercially valuable species. This is due to the role that kelp plays in providing space, food and refuge from predators[14]. Therefore, it would be expected that throughout the study, as kelp recovers following the removal of trawling, the abundance of both crab and lobster would increase. It would also be expected for there to be a greater range of crab and lobster sizes (more mature and juvenile individuals) and that individuals caught would be in better condition. As this study is only the fourth year of a longer-term monitoring programme, we would not yet expect to see

[10] Sussex Kelp Restoration Project. 2022. *Sediment in Sussex coastal waters – Sea user survey results. A report prepared for the SKRP by Blue Marine Foundation and Wayforward Brighton*. Available at: https://sussexkelp.org.uk/news/reportsandpublications

[11] Cooper, K.M., 2005. Cumulative effects of marine aggregate extraction in an area east of the Isle of Wight- a fishing industry perspective. *Science series technical report. Centre for Environment, Fisheries and Aquaculture Science*, *126*, p.28.

[12] Monteiro, M., de Castro, S.L., Marques, S.C., Freitas, R. and Azeiteiro, U.M., 2023. An emergent treat: Marine heatwaves-Implications for marine decapod crustacean species-An overview. *Environmental Research*, *229*, p.116004.

[13] Cook, F., Smith, R.O., Roughan, M., Cullen, N.J., Shears, N. and Bowen, M., 2022. Marine heatwaves in shallow coastal ecosystems are coupled with the atmosphere: Insights from half a century of daily in situ temperature records. *Frontiers in Climate*, *4*, p.1012022.

[14] Bertocci, I., Araújo, R., Oliveira, P. and Sousa-Pinto, I., 2015. Potential effects of kelp species on local fisheries. *Journal of Applied Ecology*, *52*(5), pp.1216-1226.

significant differences between years and treatments, due to the time it takes for kelp and associated species to recover.

This study aims to:

- Investigate the effect of the trawling exclusion zone, implemented under the Nearshore Trawling Byelaw, on commercial crustacean fisheries by collecting and comparing data on European lobster and brown crab inside and outside the designated area.

Objectives:

- Compare the trait and abundance data collected from consecutive annual surveys since the introduction of the Nearshore Trawling Byelaw, to monitor crustacean population changes over time across the survey area.
- Investigate how temperature and depth may affect crab and lobster abundance obtained across the survey area.

Methodology

Site Selection

Sites were chosen inside and outside the Nearshore Trawling Byelaw (NTB) area (stated as 'trawling exclusion zone' throughout the report) using bathymetry maps to select suitable rocky reef areas. However, after the pilot study proved unsuitable, local fishermen's knowledge to find areas of 'known' ground that supports the local crab and lobster fishery (Figure 7). 12 sites were selected around Selsey Bill inside and outside the trawling exclusion zone. These sites were surveyed annually from 2021 to 2024 (Figure 7, red sites; Table 1). Six sites were selected in Brighton in 2022, the sites were revised in 2023 with the help of local fishermen, and the revised sites were surveyed in 2023 and 2024 (Figure 7, yellow sites; Table 1). The six sites surveyed in Eastbourne in 2022 (Table 1), were not repeated in 2023 and 2024 due to lack of funding and fishermen availability. All sites selected were between 2-17 m depth. A closer map to site location, and a full list of coordinates and depths for the sites surveyed is included in Appendix B.

Table 1: Summary table of the number and location of sites surveyed each year

Year	Locations	Number of Sites Surveyed
2021	Selsey	12 (5 Inside and 7 Outside)
2022	Selsey	12 (5 Inside and 7 Outside)
	Brighton	6 (2 Inside and 4 Outside)
	Eastbourne	6 (2 Inside and 4 Outside)
2023	Selsey	12 (5 Inside and 7 Outside)
	Brighton	9 (5 Inside and 4 Outside)
2024	Selsey	12 (5 Inside and 7 Outside)
	Brighton	9 (5 Inside and 4 Outside)

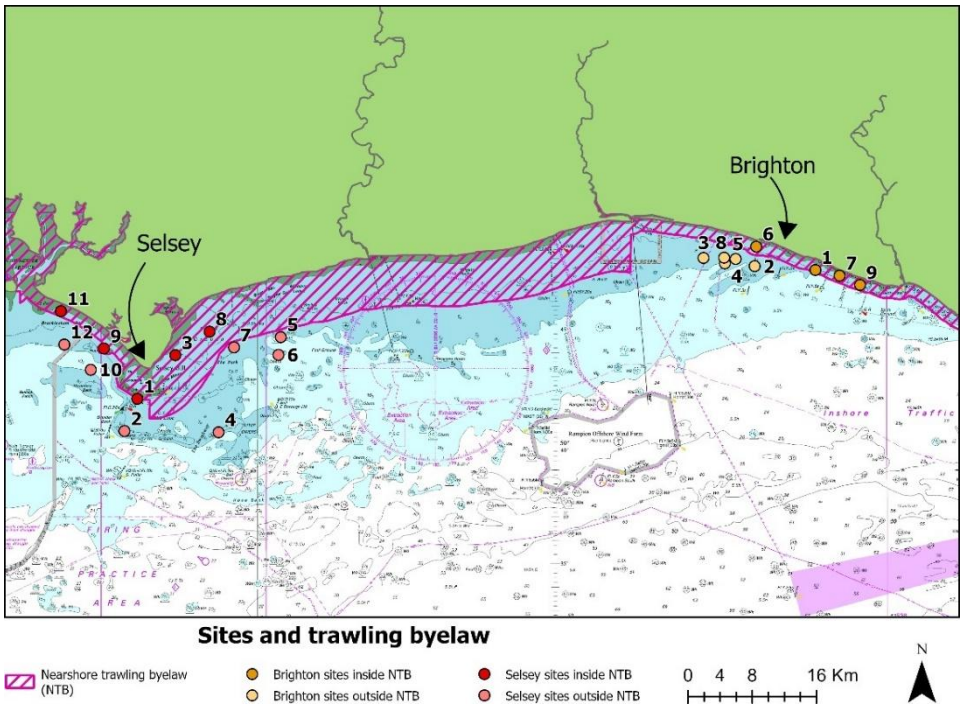


Figure 7: Survey sites used in data analysis across Selsey (2021-2024) and Brighton (2023-2024)

Some sites inside the trawling exclusion zone were also within Marine Conservation Zones (MCZs), with some sites around Selsey overlapping with Selsey Bill and the Hounds MCZ (UKMCZ0068) and some sites near Brighton overlapping with Beachy Head West (UKMCZ0002). This does not affect the dataset as the management does not differ in these MCZs to the trawling exclusion zone.

Data Collection

Potting surveys were used to collect data on the key commercial species of European lobster and brown crab, and associated bycatch. The number of individual spider crab caught in the pots were also reported, as although not a commercially important species in Sussex, increased numbers have been observed in recent years and may have an impact on other crustacean species. Other metrics for spider crab were not recorded. This is because, as shown in other case studies such as Lyme Bay[15], this species has not been shown to respond to spatial protection measures due to its ability to live in a variety of habitats, including degraded habitats.

Local fishermen and their vessels were hired to support the survey, taking Blue Marine researchers on board to set and retrieve the pots. Pots were divided into strings of 20 and one string was left at each site to soak for 24 hours depending on weather and practicalities. While

[15] Rees, A. 2019. *The Lyme Bay experimental potting study*. Available at: https://pearl.plymouth.ac.uk/handle/10026.1/16833

fishermen often deploy their pots for longer than 24 hours when fishing, this length of time provides a practical and consistent sample. In 2024, all sites were sampled within the same period between 12 August to 23 August. In 2023, sites were sampled between 16 to 23 August. In 2022, sites were sampled between 23 to 25 August. In 2021, sites were sampled between 9 to 12 September.

All pots were 'parlour' pots and were baited with 'gurnard' (*Chelidonichthys cuculus*), except in Brighton 2024, where scad (*Trachurus trachurus*) was used as bait due to gurnard being unavailable. Escape gaps were closed following dispensation provided by Sussex IFCA for the specified period of the survey (Appendix D). This allowed a greater range of crustacean sizes to be caught to provide a representative sample of the whole population, including juveniles. In 2024, a total of ten strings (200 pots) were set within the trawling exclusion zone and a total of 11 strings (220 pots) were set outside the exclusion zone. There were no more than 60 pots deployed within 24 hours. This was a consistent method used in all years of the survey.

Gear was hauled and all individuals were identified. For crab and lobster, abundances were recorded and measurements including carapace length and width, weight, sex, condition and berried status were taken. Condition score was assessed based on physical health (Table 2) using a method outlined by Haig *et al.* (2016)[16]. Haig *et al.* index only mentions the presence or absence of black spots in index 1 of crustacean condition, however, in this study, the quantity of black spots present on a crab was also taken into consideration. When deciding on an index, "limited black spot lesions" would be used in indexes 2 and 3, "black spots covering around 50% of the carapace" used in Index 4, and "large surface area of black spot lesions on the body" used in Index 5. All catch was returned alive to the location where it was caught. Other species caught as bycatch were identified, noted and returned immediately to sea after identification (Appendix G).

Table 2: Crustacean conditions and description

Index	Description
1	All legs present. No black spot. No damage.
2	One or two legs missing
3	More than two legs missing (number of missing limbs noted)
4	One or both claws missing
5	One or both claws missing and some legs missing

Data Analysis

To understand the effect of the Nearshore Trawling Byelaw on commercial crustacean species over time, the independent variables in this analysis were 'Treatment', split into two

[16] Haig, J.A., Bakke, S., Bell, M.C., Bloor, I.S., Cohen, M., Coleman, M., Dignan, S., Kaiser, M.J., Pantin, J.R., Roach, M. and Salomonsen, H., 2016. Reproductive traits and factors affecting the size at maturity of Cancer pagurus across Northern Europe. *ICES Journal of Marine Science*, *73*(10), pp.2572-2585.

categories, inside the trawling exclusion zone (NTB) and outside the trawling exclusion zone (Outside), and 'Year' (2021 to 2024) to analyse differences between years.

To achieve the aims of the study and understand the effect of the Byelaw on crab and lobster over time, the analysis undertaken in 2024 shown in the main report included Selsey data only, unless specified when Brighton data is included. This is because the data collected at Selsey is the only longer-term 4-year dataset; the location of the Brighton sites changed between 2022 and 2023, so there is only comparable data for 2023 and 2024. The analysis comparing Brighton and Selsey data is included in Appendix A.

The metrics recorded for brown crab and European lobster were:

- Abundance
- Carapace size (and abundances < Minimum Conservation Reference Size (MCRS))
- Weight
- Condition score
- Sex ratio

Abundances are calculated as the number of individuals per pot for each site and then averaged per treatment for the graphs presented in the results. Results are expressed as Catch Per Unit Effort (CPUE), calculated by dividing the sum value of individuals caught per species divided by the number of pots on the string. All weights recorded as < 100 g were replaced with 99g. Univariate testing was performed using Generalised Linear Models (GLMs). A log transformation was applied to the data to meet model assumptions. All results are expressed to 2 decimal places.

The explanatory factors to assess the differences in abundance at Selsey were Year (2021-2024), Treatment, and Depth. Then a secondary GLM was run including only Year 2023 and 2024 data so Location (Brighton (n=9) vs Selsey (n=12)) could be used as an additional explanatory factor. The average sea surface temperature for August was taken from SeaTemperatures.net, this website uses raw data from the National Oceanic and Atmospheric Administration (NOAA) to obtain temperatures for Selsey and Brighton. Sea surface temperature was used to describe temperature trends in Sussex, but was not included in the GLM models due to sea surface temperature varying within the water column and so is not representative of benthic temperature. There was a total of four GLMs to analyse catch per unit effort, two only including Selsey data (Appendix C), and two including Selsey and Brighton (Appendix A), each GLM focused on either brown crabs or European lobsters. Treatment, Year, or Depth were the explanatory variables used to investigate the variation in the dataset and therefore contribute to variations in abundance. As scad was used instead of gurnard in Brighton 2024 due to the availability of bait, the bait type was tested to understand whether it had a significant effect on crab and lobster catch. However, due to the little effect on the dataset, bait was removed as an explanatory variable from the model. The statistical models have undergone a stepwise selection to investigate which variables best fit the model

(Appendix C). Interactions and variables that were not significant were removed. However, treatment and year were retained in all models regardless of significance, as they were central to the hypotheses being tested. Therefore, the final models reported were not necessarily those that explained the most variance in the dataset, but those that best aligned with the experimental hypotheses and allowed for comparisons across treatments and years (Appendix C for Selsey models, Appendix A for Selsey and Brighton models).

An additional dataset was created using only individuals below the MCRS, for which a GLM was used to understand the trends. Data were cleaned and error-checked before processing. Using the same explanatory variables as above (Year, Treatment, Location, Depth, Temperature), a GLM with a binomial distribution was used to test the sex ratio, with females labelled as "1" and males as "0". Carapace size and weight were both normally distributed, but a GLM was run to explain the variation in the datasets. To test the condition score, an ordinal logistic regression model was used because the variable contains ordered categories (1-5).

Results

Abundance

The abundance of individuals caught before the transformation to catch per unit effort is shown in Table 3 for both Brighton and Selsey.

Table 3: Raw abundance of individuals caught in the surveys

Species	Year	Selsey	Brighton
European lobsters	2021	23	-
	2022	66	-
	2023	63	26
	2024	47	36
Brown crabs	2021	66	-
	2022	45	-
	2023	26	21
	2024	47	54
Spider crabs	2021	51	-
	2022	44	-
	2023	75	62
	2024	87	121

For Selsey, the abundance of brown crabs in 2024 on average was higher outside the trawling exclusion zone (0.28 ± 0.21) than inside the designation area (0.08 ± 0.05). The survey showed that the abundance of brown crabs caught has declined from 2021 to 2023, with a slight increase in 2024 (Figure 8). Although trends are described, these were not statistically significant (Appendix C).

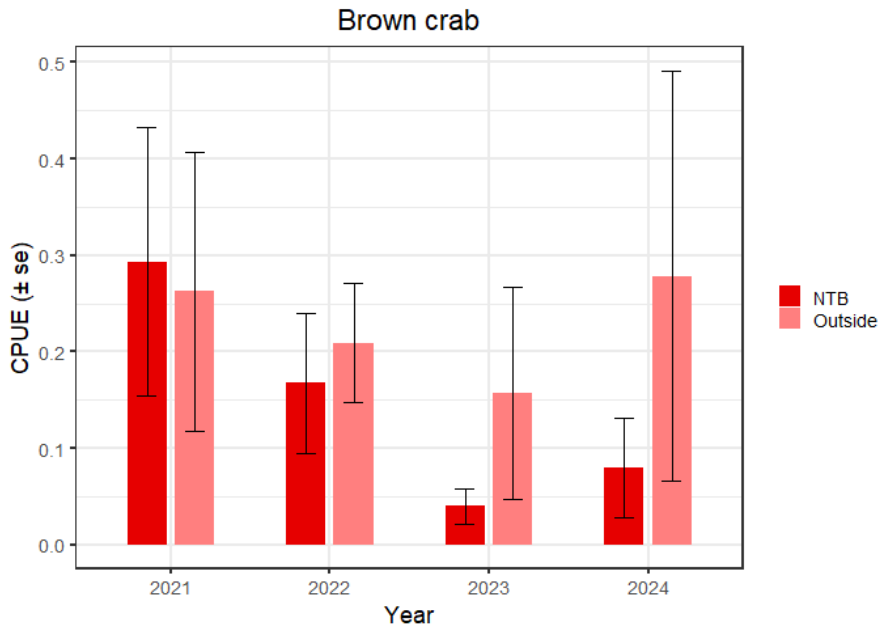


Figure 8: Mean abundance of brown crab caught inside and outside the trawling exclusion zone, from 2021 to 2024

Lobsters' abundance in 2024 on average was higher outside the trawling exclusion zone (0.22 ± 0.04) than inside the designated area (0.16 ± 0.05). The survey showed that the abundance of lobsters increased from 2021 to 2022 and has been decreasing since in the trawling exclusion zone, whereas the abundance outside the trawling exclusion zone increased from 2021 to 2023, with a slight decrease in 2024 (Figure 9). Although trends are described, these were not statistically significant (Appendix C).

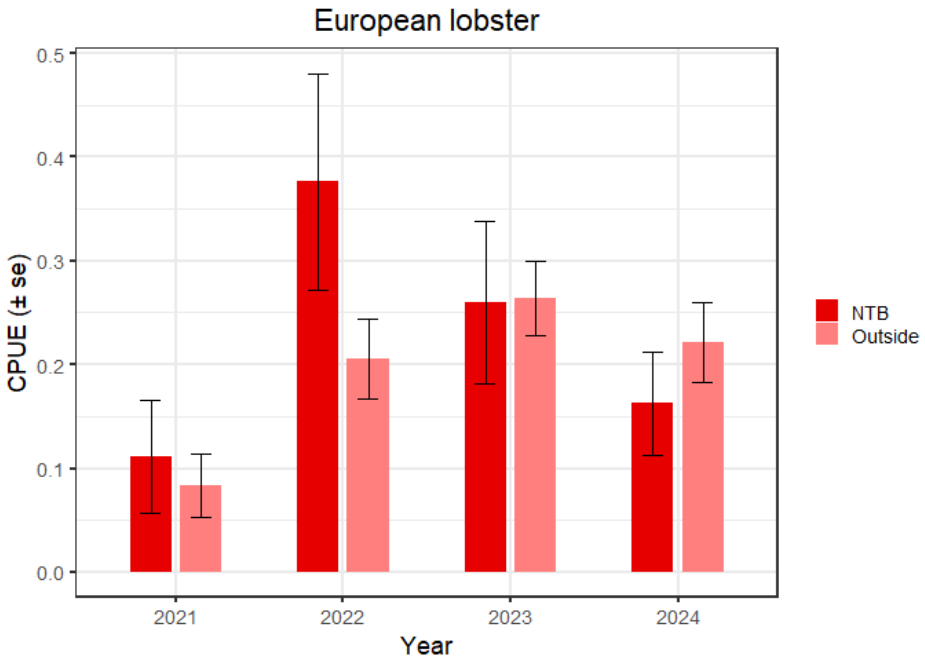


Figure 9: Mean abundance of European lobster caught inside and outside the trawling exclusion zone, from 2021 to 2024

Carapace size

In 2024, brown crabs had a shorter average carapace size inside the trawling exclusion zone (135.13 ± 2.57 mm) compared to those caught outside the zone (137.49 ± 2.52 mm; Figure 10), although these sizes are both higher than recorded in 2023 (inside: 117.00 ± 6.59, outside: 132.17 ± 3.46 mm). The results show a slight reduction in average carapace size inside the trawling exclusion zone between 2021 and 2023, then an increase in 2024. A slight increase was recorded outside the trawling exclusion zone between 2021 and 2024 (Figure 10). The significant trends obtained from the analysis showed a decrease in carapace size from 2021 to 2022 inside the trawling exclusion zone, and a significant increase from 2022 to 2024 inside the trawling exclusion zone. From 2021 and 2022 to 2024 carapace size has increased outside the trawling exclusion zone (Appendix C).

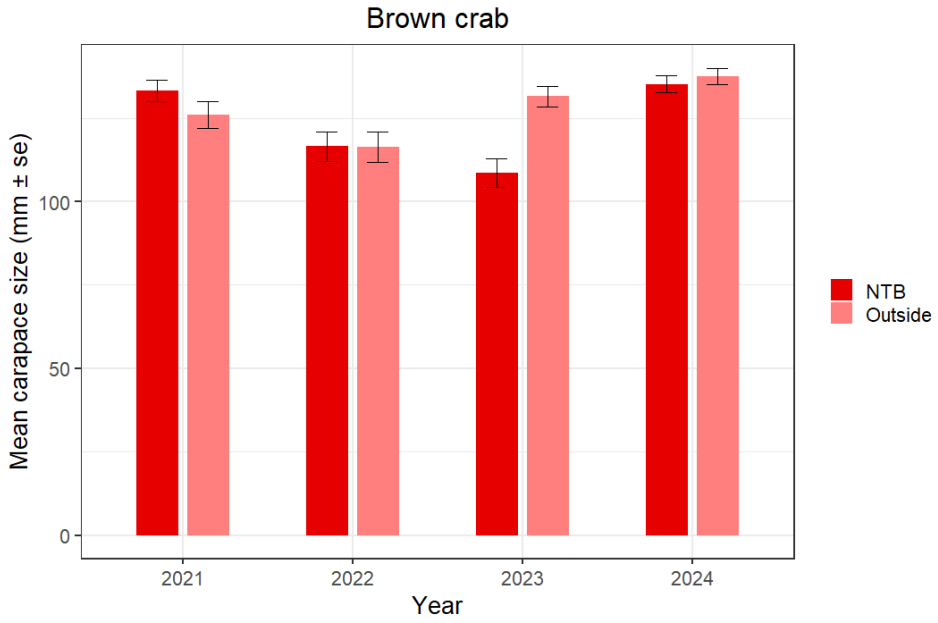


Figure 10: Mean carapace size of brown crabs caught inside and outside the trawling exclusion zone from 2021 to 2024 at Selsey

On average, in 2024 the carapace length of lobster was smaller inside the trawling exclusion zone (87.25 ± 2.99) compared to outside (89.77 ± 2.74), although the carapace sizes in 2024 were higher than their respective sizes in 2023 (inside: 84.09 ± 1.91 mm, outside: 88.29 ± 2.10 mm; Figure 11). The results show a slight reduction in average carapace size inside the trawling exclusion zone between 2021 and 2023, then an increase in 2024. There was a slight increase outside the exclusion zone between 2021 and 2024. There was a decrease inside the exclusion zone from 2021 to 2023 then an increase from 2023 to 2024 (Figure 11), but none of the differences were significant (Appendix C).

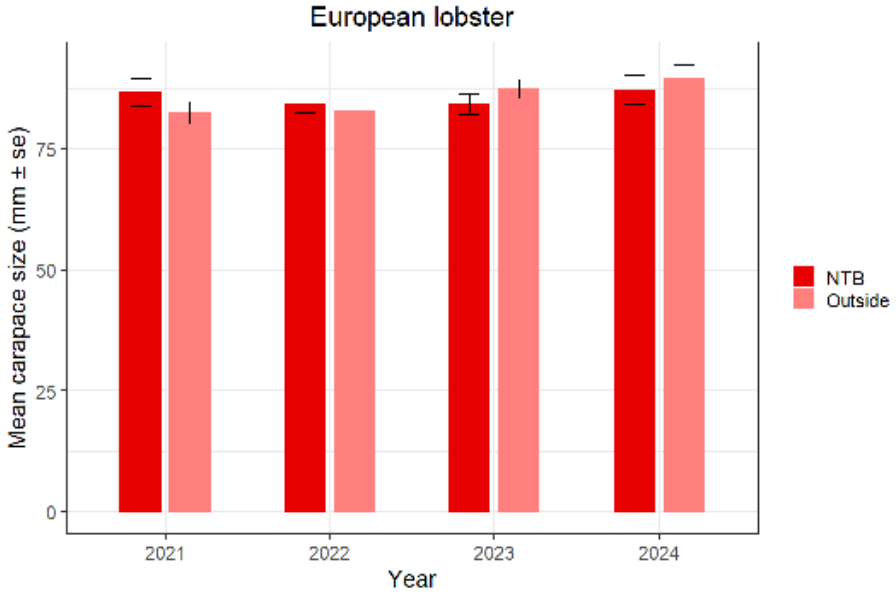


Figure 11: Mean carapace size of European lobsters caught inside and outside the trawling exclusion zone from 2021 to 2024 at Selsey

MCRS

The abundance of brown crab below MCRS (140 mm) was higher outside the exclusion zone (0.2 ± 0.15) compared to inside in 2024 (0.18 ± 0.03). Brown crabs Catch Per Unit Effort was higher inside the trawling exclusion zone in 2021 and 2022. This reversed in 2023 and 2024 when the Catch Per Unit Effort was higher outside the exclusion zone. (Figure 12). The trends for both treatments have seen a decrease in abundance from 2021 to 2023 and an increase from 2023 to 2024 inside the trawling exclusion zone and remained the same between 2023 and 2024 outside the trawling exclusion zone (Figure 12). No significant differences between treatments and years were identified (Appendix C).

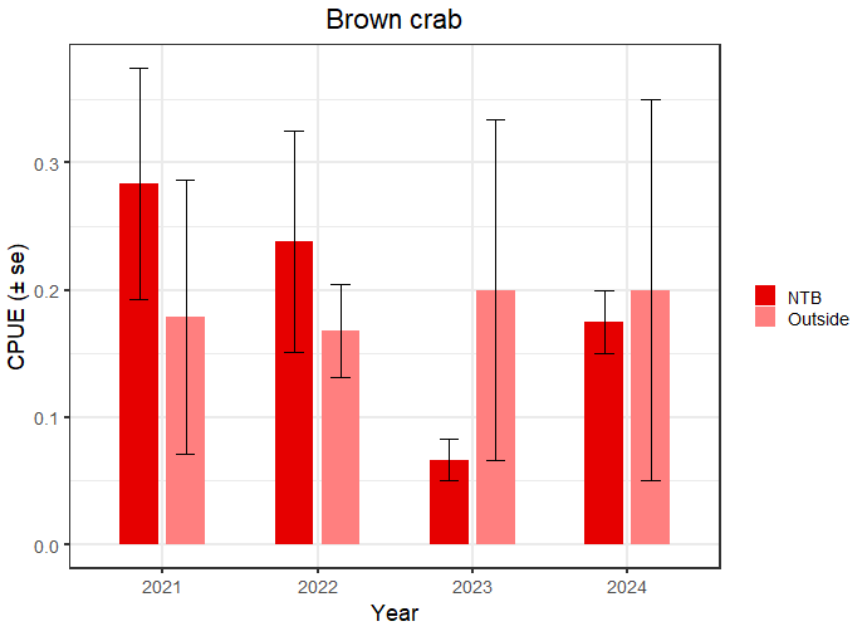


Figure 12: Mean abundance of brown crabs caught below MCRS inside and outside the trawling exclusion zone from 2021 to 2024 at Selsey

The abundance of lobster caught below the Minimum Conservation Reference Size (87 mm) was higher outside the exclusion zone (0.14 ± 0.06) compared to inside in 2024 (0.13 ± 0.01; Figure 13). The abundance of small lobsters has been higher inside the trawling exclusion zone compared to outside from 2021 to 2024 (Figure 13). Overall, the abundance of small lobsters both inside and outside the trawling exclusion zone has shown an increase from 2021 to 2022 and a decrease from 2022 onwards (Figure 13). No significant differences between treatments and years were identified (Appendix C).

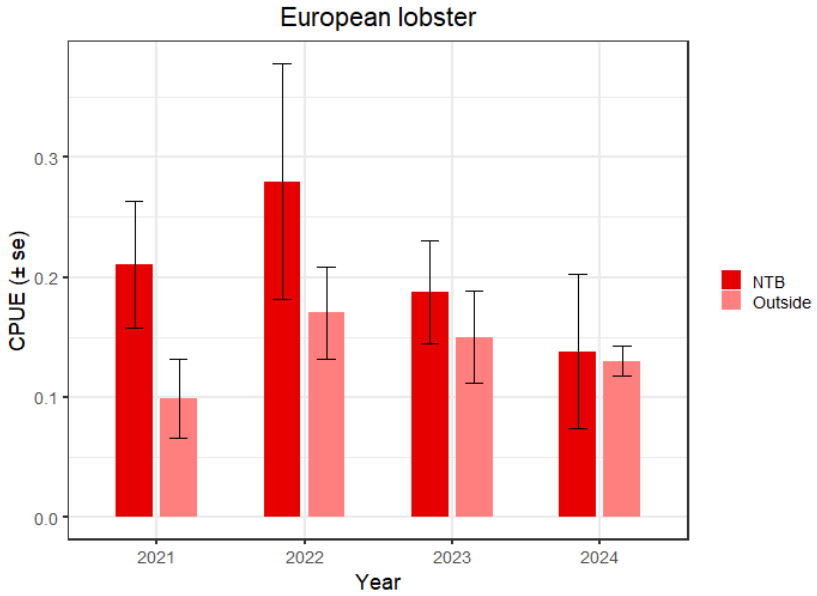


Figure 13: Mean abundance of European lobsters below MCRS inside and outside the trawling exclusion zone between from 2021 to 2024 at Selsey

Weight

In 2024, brown crabs were on average heavier outside the trawling exclusion zone (411.46 ± 24.40 g) compared to inside (370.50 ± 32.82 g). Brown crab average weight has decreased from 2021 to 2022 and has seen an increase from 2022 to 2024 (Figure 14). The significant results from the analysis showed a decrease in weight from 2021 to 2022 inside the trawling exclusion zone, and a significant increase from 2022 to 2024 inside the trawling exclusion zone. Brown crab weight outside the trawling exclusion zone has significantly increased from 2022 to 2023, and from 2023 to 2024. (Appendix C).

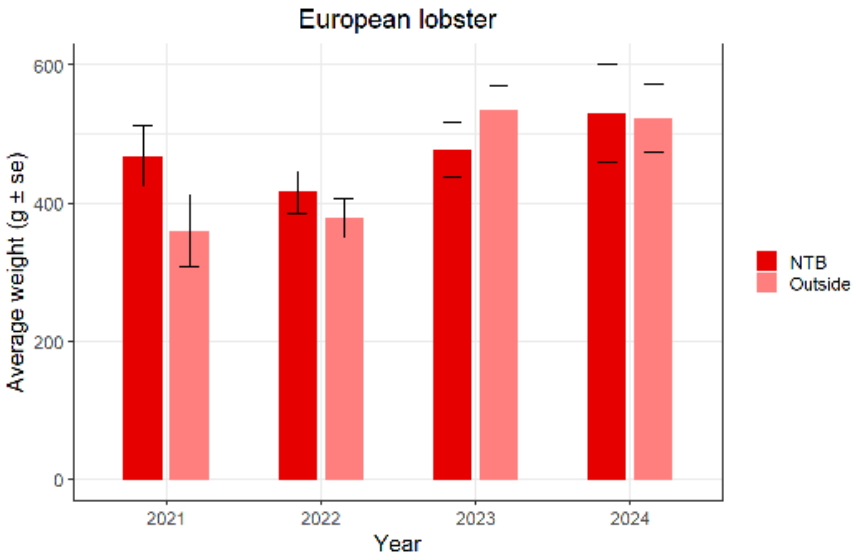


Figure 14: Mean weight of brown crab inside and outside the trawling exclusion zone from 2021 to 2024 at Selsey

In 2024, lobsters were on average heavier inside the trawling exclusion zone (530.50 ± 70.41 g) compared to outside (523.32 ± 49.02 g), this has reversed from the previous year, as in 2023 lobsters were heavier outside compared to inside. Overall, there has been a dip in weight from 2021 to 2022 and then an increase since (Figure 15). Lobster weight has varied between treatment and year (Figure 15), but no differences were statistically significant (Appendix C).

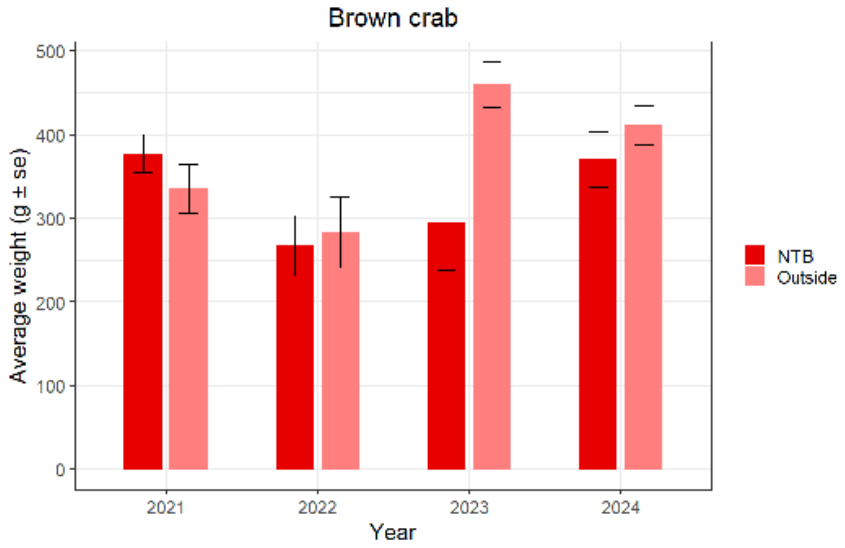


Figure 15: Mean weight of lobsters caught inside and outside the trawling exclusion zone from 2021 to 2024 at Selsey

Sex ratio

Male brown crabs inside the trawling exclusion zone from 2021 to 2023 had been caught in higher numbers compared to females, although this reversed in 2024. Female brown crabs outside the trawling exclusion zone have been caught in higher numbers than males in all four years (Figure 16). In 2024, the sex ratio was 62.5% females to 37.5% males inside the trawling exclusion zone (Figure 16A), and 30.8% females to 69.2% males outside the trawling exclusion zone (Figure 16B).

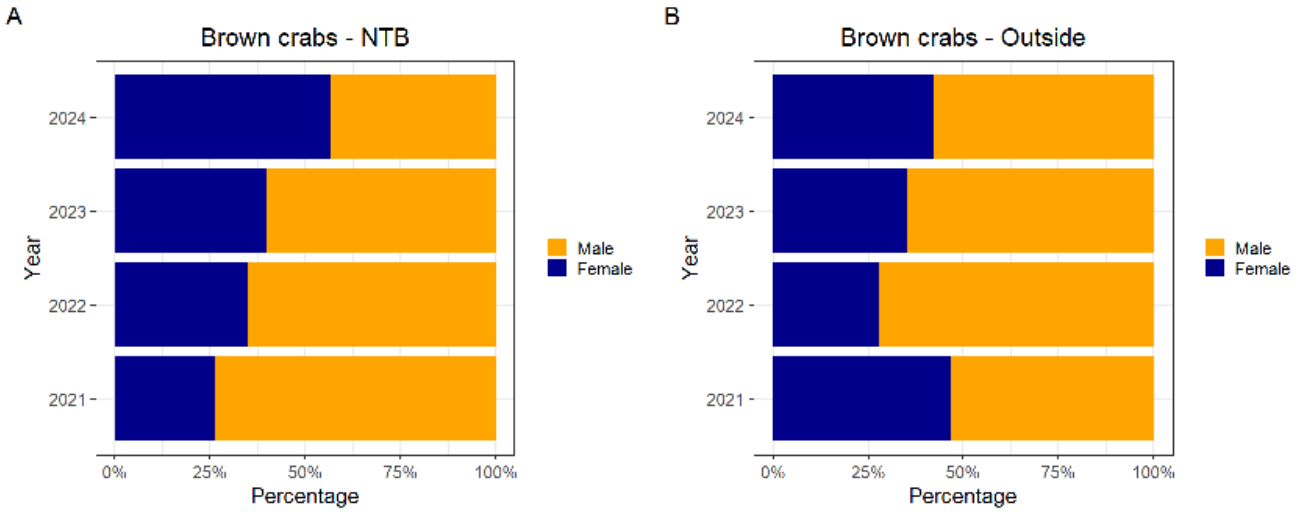


Figure 16: Sex ratio of brown crabs from 2021 to 2024 at Selsey A) inside (NTB) and B) outside the trawling exclusion zone

In 2024, a higher proportion of female lobsters were caught inside the trawling exclusion zone, and a similar proportion of male and female lobsters were caught outside the trawling exclusion zone (Figure 17). The sex ratio has stayed relatively similar for lobsters in both treatments between 2021 and 2024, although in 2022, the data showed a higher proportion of males across both treatments and in 2024, there was an increase in the number of females (Figure 17). In 2024, the sex ratio was 68.8% females to 31.2% males inside the trawling exclusion zone (Figure 17A), and 54.8% females to 45.2% males outside the trawling exclusion zone (Figure 17B).

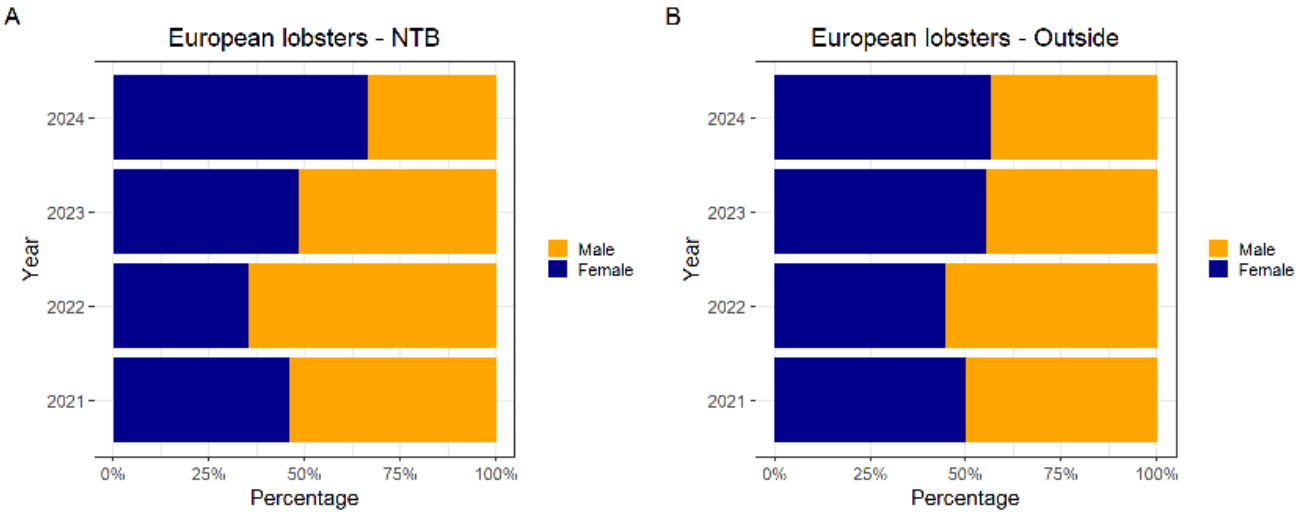


Figure 17: Sex ratio of European lobsters from 2021 to 2024 at Selsey A) Inside (NTB) and B) outside the trawling exclusion zone

Condition

Brown crab condition decreased from 2021 to 2022 across both treatments. Scoring a higher number of condition 2 and 3, and fewer condition 1 (Figure 18). Brown crab condition showed improvements from 2022 to 2024 with higher individuals caught noted as condition 1. The frequency of individuals with one claw missing was relatively similar between 2023 and 2024 for crabs caught outside the trawling exclusion zone (Figure 18). However, there was a decrease in the frequency of individuals caught with one claw (condition 4) inside the trawling exclusion zone (Figure 18). There has been an increase in the number of individuals caught with both claws missing (condition 5) from 2023 to 2024 across treatments (Figure 18). Results included in Appendix F.

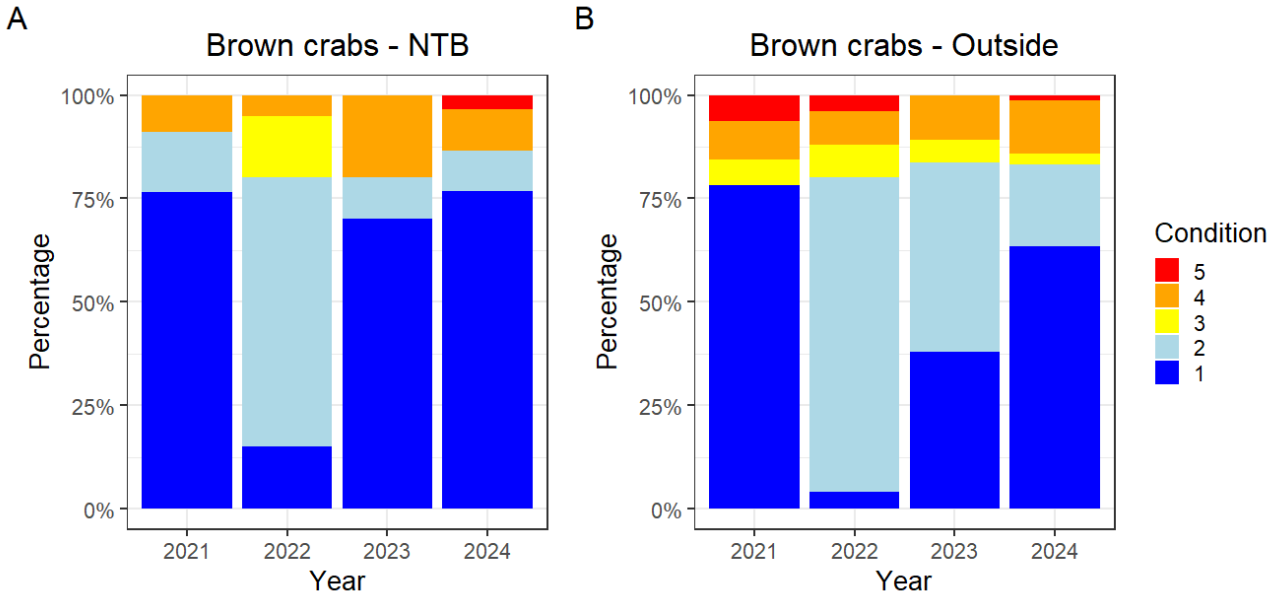


Figure 18: Percentage frequency of brown crab caught in each condition category from 2021 to 2024 at Selsey and between A) inside (NTB) and B) Outside the trawling exclusion zone

The condition of lobsters has remained relatively constant from 2021 to 2024 (Figure 19). Individuals most frequently scored condition 1, showing lobsters of good condition. In 2023 and 2024 outside the trawling exclusion zone, some lobsters scored condition 5 (Figure 19B), meaning the lobster's condition was low, and the individuals had both claws missing. Results included in Appendix F.

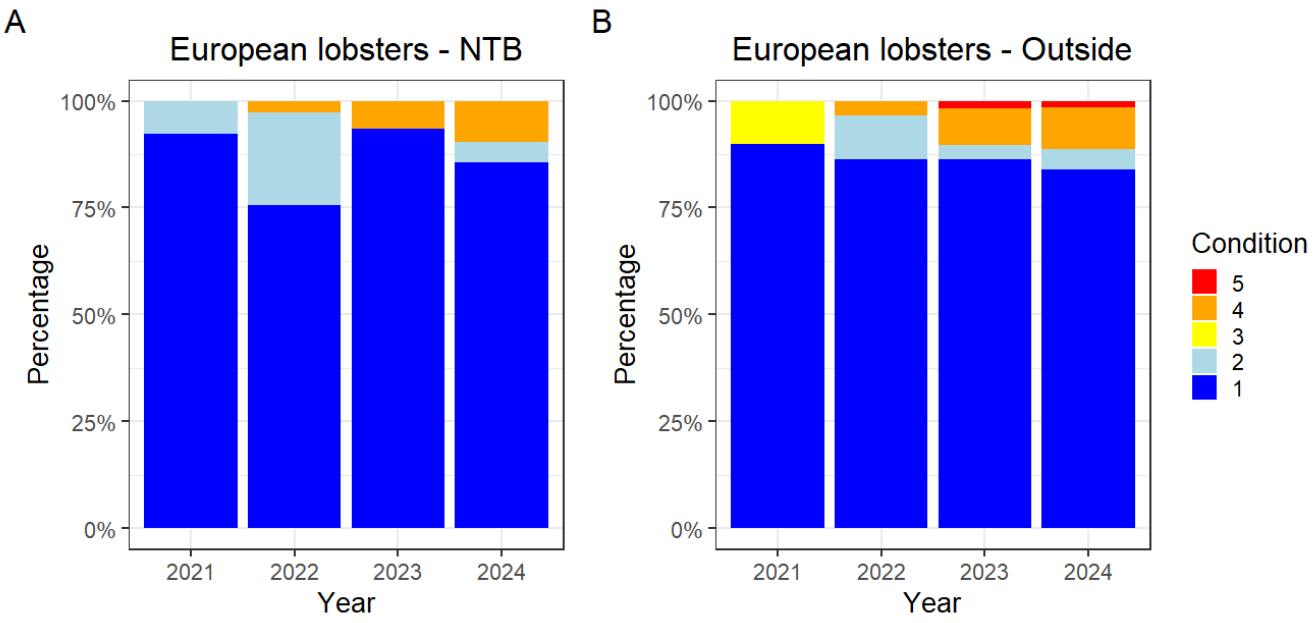


Figure 19: Percentage frequency of European lobsters caught in each condition category from 2021 to 2024 at Selsey and between A) inside (NTB) and B) outside the trawling exclusion zone

Since 2021, the average condition index of brown crabs has been higher outside the trawling exclusion zone, compared to inside (Table 4). European lobsters also had a higher average condition index outside the trawling exclusion zone, compared to inside, except for 2022, where inside individuals had a higher condition index than outside (Table 4).

Year	Brown crabs		European lobsters	
	NTB	Outside	NTB	Outside
2021	1.41	1.66	1.08	1.2
2022	2.1	2.32	1.3	1.21
2023	1.7	1.89	1.19	1.36
2024	1.53	1.69	1.33	1.4

Table 4: Average condition index of brown crabs and European lobsters in Selsey

Bycatch

In 2024, bycatch was dominated by velvet swimming crabs both inside the trawling exclusion zone (57.9%; Figure 20A) and outside (47.5%; Figure 20B). More velvet crabs were caught inside the trawling exclusion zone (33 individuals) than outside (19 individuals). The second most frequently caught bycatch species outside was ballan wrasse (42.5%, 17 individuals), whereas, inside the trawling exclusion zone, hermit crabs were the second most frequently caught bycatch species (28.1%, 16 individuals, Figure 20A). Ballan wrasse was the third most frequently caught species (14%, 8 individuals; Figure 20A).

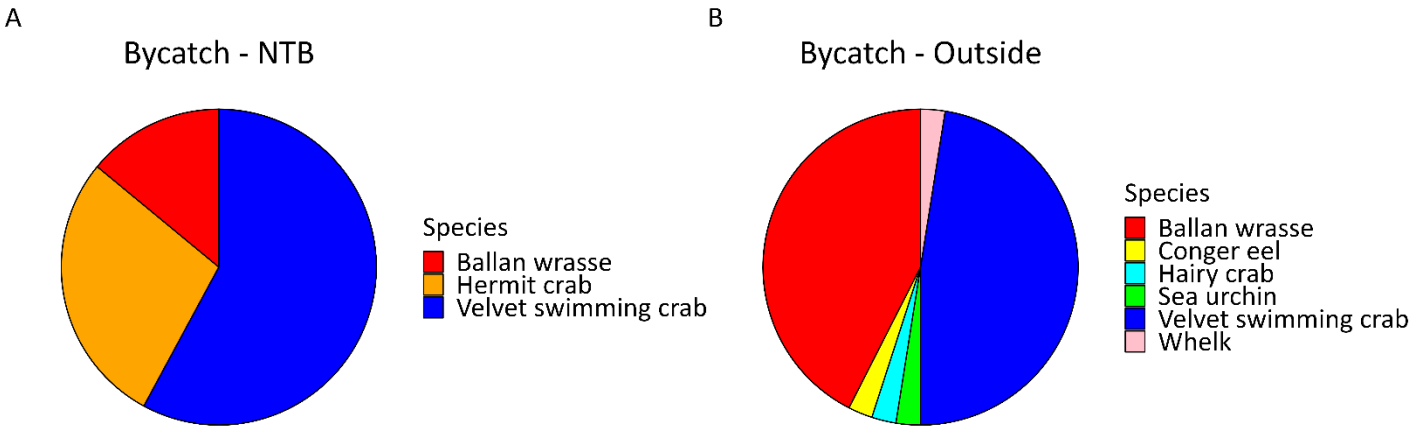


Figure 20: Bycatch caught in 2024 at Selsey A) inside (NTB) and B) outside the trawling exclusion zone

Depth

Analysis indicates that depth had a significant negative effect on brown crab abundance. As depth increased, the number of brown crabs decreased (Appendix C, Figure 21). Depth did not influence European lobster abundance (Appendix C).

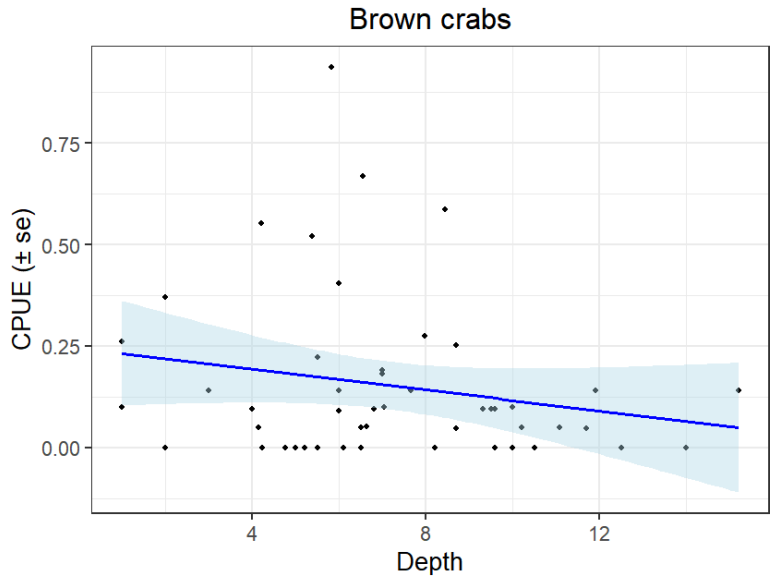


Figure 21: Brown crab abundance plotted against site depth in Selsey

Temperature

August sea temperature in Sussex significantly fluctuated every year between 2021 and 2024 (Appendix H, Figure 22).

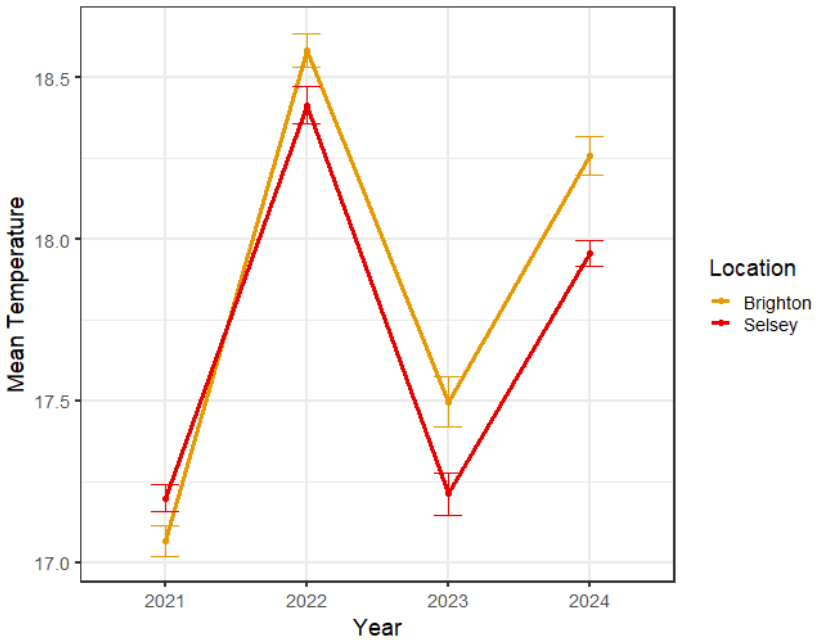


Figure 22: Average August temperature in Brighton and Selsey from 2021 to 2024

Location

The combination of variables "Location" and "Treatment" indicated no significant difference between Brighton and Selsey brown crab abundance both inside and outside the trawling exclusion zone. The same result was found for European lobster abundance and did not differ between Brighton and Selsey, whether inside or outside the trawling exclusion zone (Appendix A).

Discussion

The potting survey conducted from 2021 to 2024 across Sussex is part of a wider assessment to look at the ecological, social and economic changes resulting from the recovery of habitat and kelp beds following the introduction of the Nearshore Trawling Byelaw (2019) in March 2021. The study aims to monitor the recovery of the commercially important brown crab (*Cancer pagurus*) and European lobster (*Homarus gammarus*) by collecting data from inside and outside the trawling exclusion zone on abundance, sex ratio, size, weight and condition. The results will be compared year on year to record trends that may be associated with wider ecosystem changes, such as signs of the recovery of the historically dense kelp beds that once occurred within the region.

In summary, all features for European lobsters' abundance, size and weight showed no significant differences between treatments (inside and outside the trawling exclusion zone), or with depth. Brown crab abundance has not changed significantly between years, but depth

has been shown to be negatively correlated with crab abundance. Brown crab average weight showed a significant increase from 2022 to 2024 outside the trawling exclusion zone (although years 2022 to 2023, and 2023 to 2024 were statistically similar). Brown crab size showed a significant decrease inside the trawling exclusion zone from 2021 to 2022, and although not statistically significant, there has been an increase in average carapace size inside the trawling exclusion zone since 2022. Carapace size for brown crabs has also shown a significant increase outside the trawling exclusion zone from 2022 to 2024 (although years 2022 to 2023, and 2023 to 2024 were statistically similar). These show that although brown crab abundance has not changed, the increase in average size could be an indication that this species is surviving for longer, showing a potential sign of recovery.

In 2024, there have not been many significant results, but this was not surprising. This survey was the fourth year of monitoring since the Byelaw was introduced in March 2021. Similar studies monitoring the recovery of MPAs in which trawling is prohibited have reported over three years for any changes to be detected in the habitat and five to ten years to show noticeable ecological recovery[17]. The recovery of crab and lobster will depend on the recovery of areas of crustacean habitat, including kelp beds, as well as the limitation and removal of other external pressures on these habitats and populations. Sedimentation, water quality and shifting ecosystem baselines due to climate change or changes in food web dynamics are all variables that could have an impact[18,19,20]. Recovery of commercial crustaceans can also often be hindered by continued high levels of potting inside MPAs[21,22].

Despite not being statistically significant, some trends were of note which should be looked at in future years of the survey. The abundance of brown crab has seen a decrease in Selsey from 2021 to 2023, but in 2024 there was an increase from previous years. The abundance of lobsters has seen an increase from 2021 to 2022 and then a slight decrease from 2022 to 2024. Another trend to consider is the condition of individuals caught. On average every year, brown crab condition has been higher inside the trawling exclusion zone than outside the area. On average every year, brown crab condition has been higher outside the trawling exclusion zone than inside the area, indicating that brown crabs caught inside the trawling exclusion zone

[17] Renn, C., Rees, S., Rees, A., Davies, B.F., Cartwright, A.Y., Fanshawe, S., Attrill, M.J., Holmes, L.A. and Sheehan, E.V., 2024. Lessons from Lyme Bay (UK) to inform policy, management, and monitoring of Marine Protected Areas. *ICES Journal of Marine Science*, *81*(2), pp.276-292.

[18] Smale, D.A., 2020. Impacts of ocean warming on kelp forest ecosystems. *New Phytologist*, *225*(4), pp.1447-1454.

[19] Picard, M.M., Johnson, L.E. and Côté, I.M., 2022. Effects of sediment on spore performance as a potential constraint on kelp distribution. *Marine Pollution Bulletin*, *185*, p.114336.

[20] 22 Connell, S.D., 2007. Water quality and the loss of coral reefs and kelp forests: alternative states and the influence of fishing. Marine ecology. Oxford University Press, Melbourne, pp.556-568.

[21] Davies, B.F., Holmes, L., Rees, A., Attrill, M.J., Cartwright, A.Y. and Sheehan, E.V., 2021. Ecosystem Approach to Fisheries Management works—How switching from mobile to static fishing gear improves populations of fished and non-fished species inside a marine-protected area. *Journal of Applied Ecology*, *58*(11), pp.2463-2478.

[22] Rees, S.E., Ashley, M., Evans, L., Mangi, S., Sheehan, E.V., Mullier, T., Rees, A. and Attrill, M.J., 2021. An evaluation of the social and economic impact of a Marine Protected Area on commercial fisheries. *Fisheries Research*, *235*, p.105819.

were found in healthier conditions compared to those caught outside. This was also seen in the condition of European lobsters, apart from 2022 where the average condition was slightly higher inside than outside. Although a table with a clear condition index description was used to minimise research bias, the differences in its interpretation among different researchers conducting the survey could be a factor when describing the variation of conditions recorded between different years. This is a limitation to the method, as levels of black spot, could be interpreted differently depending on the person undertaking the survey.

Although sea temperature increased significantly from 2021 to 2022, decreased in 2023, and increased again in 2024, we cannot make solid conclusions on whether these changes impacted CPUE or other traits of crab and lobster, as benthic sea temperature at each site was not included in the model. The temperatures found in Sussex are within the natural range of both European lobsters and Brown crab[23,24]. Both species can be found from Norway down to Morocco and the Mediterranean, so their temperature range is wide. European lobsters have shown optimal survival from 15°C and above, with larval survival being higher when exposed to waters of 23°C and 24°C, regardless of low or high partial pressure of carbon dioxide in water[25]. Brown crabs will not feed between 0-5°C[26] and embryos do not develop below 8°C[27]. The upper critical temperature of brown crabs is 22°C[28]. In future studies, benthic temperature at each site should be monitored instead of sea surface temperature, as local temperature changes could impact both species[23,24].

Anecdotal accounts of sediment deposits have been noted by fishermen along the Sussex coastline, especially in Brighton (Appendix E). Sedimentation is known to have impacts on kelp systems by smothering and modifying light and nutrient availability[29]. Reduced light caused by increased sediment levels can severely hinder the growth of kelp, reducing its productivity by up to 95 per cent[30]. Sedimentation also has a direct impact on crustacean species by smothering nursery and refuge areas, increasing competition for habitats, and clogging crustacean gills, increasing the risk of suffocation[31]. Published studies reference the impact of aggregate dredging specifically on crustaceans in Selsey[11]. Blue Marine and project partners

[23] Wilson, E. 2008. *Homarus gammarus* Common lobster.
[24] Neal, K.J. and Wilson, E., 2008. Cancer pagurus. Edible crab.
[25] Leiva, L., Tremblay, N., Torres, G., Boersma, M., Krone, R. and Giménez, L., 2022. European lobster larval development and fitness under a temperature gradient and ocean acidification. *Frontiers in Physiology*, *13*, p.809929.
[26] Karlsson, K. and Christiansen, M.F., 1996. Occurrence and population composition of the edible crab (Cancer pagurus) on rocky shores of an islet on the south coast of Norway. *Sarsia*, *81*(4), pp.307-314.
[27]Thompson, B.M., Lawler, A.R. and Bennett, D.B., 1995. Estimation of the spatial distribution of spawning crabs (Cancer pagurus L.) using larval surveys in the English Channel.
[28] Bakke, S., Siikavuopio, S.I. and Christiansen, J.S., 2019. Thermal behaviour of edible crab Cancer pagurus Linnaeus, 1758 in coastal Norway.
[29] Dayton, P.K. 1985. Ecology of kelp communities. Annu. Rev. Ecol. Syst. 16: 215-245.
[30] Blain, C.O., Hansen, S.C. and Shears, N.T., 2021. Coastal darkening substantially limits the contribution of kelp to coastal carbon cycles. *Global Change Biology*, *27*(21), pp.5547-5563.
[31] Carvalho, P.S.M. and Phan, V.N., 1998. Oxygen consumption and ammonia excretion during the moulting cycle in the shrimp Xiphopenaeus kroyeri. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, *119*(3), pp.839-844.

in the Sussex Kelp Recovery Project, such as Sussex Wildlife Trust[32], are working to gather evidence on sedimentation in Sussex to inform further research and action.

Conclusion and Recommendations

The pot fishery survey completed in August 2024 was conducted three years and five months after the designation of the Byelaw. As this data is part of a long-term study, it is still too early to make solid conclusions on the impact of the Nearshore Trawling Byelaw on brown crab and European lobster fisheries.

Although the survey has four full years of data at Selsey, which has been used in the analysis for this report, only two years of data have been collected from around Brighton. Therefore, it will be important in future years to repeat monitoring at these sites in both areas, so a long-term dataset can be produced across a wider extent of the Sussex inshore waters.

The crustacean survey could be enhanced by undertaking multivariate analysis and including a greater range of environmental variables in the study. With further funding, temperature loggers could be placed on strings of pots to understand the impact of water temperature changes on crab and lobster population trends at each site. Additional temperature readings could be exported from the databases, analysing survey day temperatures and seasonal temperatures. Daily average temperature readings for each survey day would increase the accuracy of the relationship between crustacean abundance and temperature. Seasonal temperatures from the first survey year up to the most recent survey could highlight the effect of cold winters and heatwaves on crustacean abundance, which can be missed when only temperatures are observed during the survey period. Taking note of tide and wave exposure during surveys would also be useful. If time and resources allowed, undertaking surveys at the selected sites at different times of the year could provide robust baselines against which to detect future changes. Additional research into the impact of sediment on the recovery of kelp, other important habitats, and crustaceans would also complement the study.

[32] Sussex Wildlife Trust. 2024. *Sedimentation.* Available at: https://sussexwildlifetrust.org.uk/what-we-do/living-seas/kelp/sedimentation

Appendix A – Supplementary Results

Abundance

Table 5: Model selection using AICc for brown crab abundance in Brighton and Selsey

Log CPUE~	*logLik*	*AICc*	*delta*	*we*
Year * Location * Treatment * Depth	23.9486	11.6027	32.6251	0.0
Treatment + Location + Year + Depth + Treatment:Location + Treatment:Year + Location:Year + Treatment:Depth + Location:Depth +Year:Depth + Treatment:Location:Year + Treatment:Location:Depth + Treatment:Year:Depth + Location:Year:Depth	23.3149	7.1301	28.1525	0.0
Treatment + Location + Year + Depth + Treatment:Location + Treatment:Year + Location:Year + Treatment:Depth + Location:Depth + Year:Depth + Treatment:Location:Depth + Treatment:Year:Depth + Location:Year:Depth	23.3140	1.8335	22.8559	0.0
Treatment + Location + Year + Depth + Treatment:Location + Treatment:Year + Location:Year + Treatment:Depth + Location:Depth + Year:Depth + Treatment:Year:Depth + Location:Year:Depth	23.2192	-2.8829	18.1395	0.0
Treatment + Location + Year + Depth + Treatment:Year + Location:Year + Treatment:Depth + Location:Depth + Year:Depth + Treatment:Year:Depth + Location:Year:Depth	23.1501	-7.3002	13.7222	0.0
Treatment + Location + Year + Depth + Treatment:Year + Location:Year + Treatment:Depth + Location:Depth + Year:Depth + Treatment:Year:Depth	23.0673	-11.3760	9.6464	0.0
Treatment + Location + Year + Depth + Treatment:Year + Location:Year + Treatment:Depth + Year:Depth + Treatment:Year:Depth	22.6614	-14.5228	6.4996	0.0
Treatment + Location + Year + Depth + Treatment:Year + Treatment:Depth + Year:Depth + Treatment:Year:Depth	21.9279	-16.7591	4.2633	0.0
Treatment + Location + Year + Depth + Treatment:Year + Treatment:Depth + Year:Depth	21.0072	-18.3895	2.6329	0.1
Treatment + Location + Year + Depth + Treatment:Depth + Year:Depth	20.6930	-21.0224	0.0000	0.6

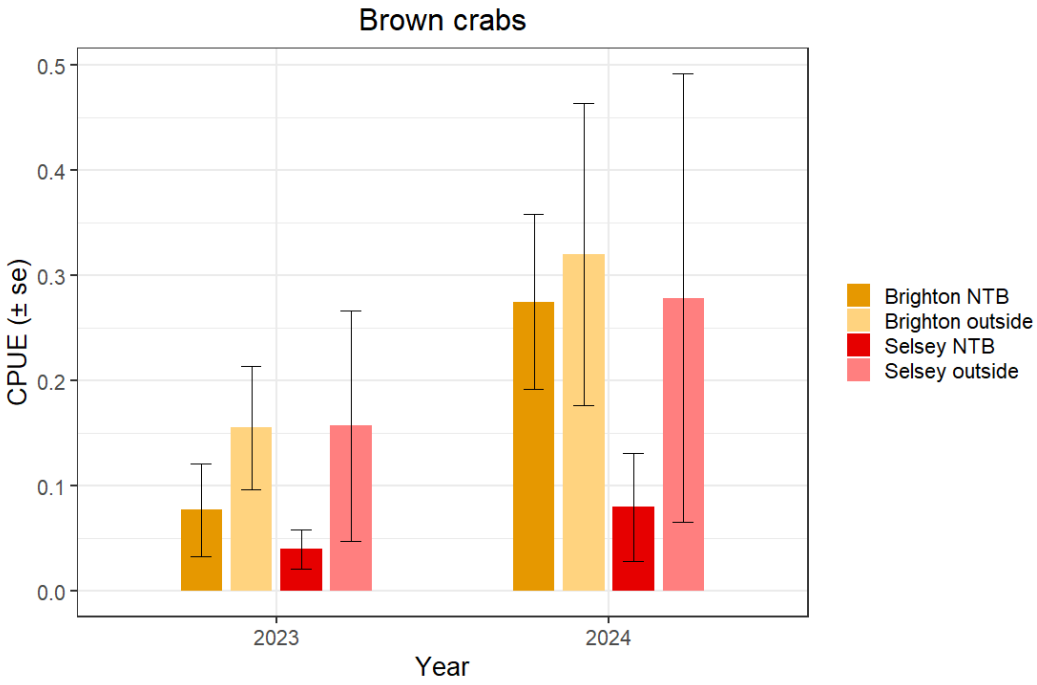


Figure 23: Catch per unit effort of brown crabs in 2023 and 2024, at Selsey and Brighton, both inside and outside trawling exclusion zone

Table 6: GLM Analysis for brown crabs' abundance in Brighton and Selsey combined

	Brown Crab Logged Catch Per Unit Effort		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.19	-0.22 – 0.59	0.365
Treatment [Outside]	0.54	0.13 – 0.94	**0.009**
Location [Selsey]	-0.17	-0.30 – -0.05	**0.007**
Year [2024]	0.29	-0.03 – 0.61	0.080
Depth	-0.01	-0.05 – 0.04	0.767
Treatment [Outside] :Depth	-0.03	-0.08 – 0.01	0.148
Year [2024]: Depth	-0.02	-0.05 – 0.01	0.146
Observations	42		
R^2	0.398		

Table 7: Model selection using AICc for brown crab abundance in Brighton and Selsey

Log CPUE ~	*logLik*	*AICc*	*delta*	*weight*
Year * Location*Treatment * Depth	46.2870	-33.0740	36.4715	0.0000
Treatment + Location + Year + Depth + Treatment:Location + Treatment:Year + Location:Year + Treatment:Depth + Location:Depth + Year:Depth + Treatment:Location:Year + Treatment:Location:Depth + Treatment:Year:Depth + Location:Year:Depth	46.1966	-38.6333	30.9122	0.0000
Treatment + Location + Year + Depth + Treatment:Location + Treatment:Year + Location:Year + Treatment:Depth + Location:Depth + Year:Depth + Treatment:Location:Depth + Treatment:Year:Depth + Location:Year:Depth	46.1409	-43.8203	25.7252	0.0000
Treatment + Location + Year + Depth + Treatment:Location + Treatment:Year + Location:Year + Treatment:Depth + Location:Depth + Year:Depth + Treatment:Year:Depth + Location:Year:Depth	46.1021	-48.6487	20.8967	0.0000
Treatment + Location + Year + Depth + Treatment:Year + Location:Year + Treatment:Depth + Location:Depth + Year:Depth + Treatment:Year:Depth + Location:Year:Depth	46.0801	-53.1602	16.3853	0.0002
Treatment + Location + Year + Depth + Treatment:Year + Location:Year + Treatment:Depth + Location:Depth + Year:Depth + Treatment:Year:Depth	45.8178	-56.8769	12.6686	0.0013
Treatment + Location + Year + Depth + Treatment:Year + Location:Year + Treatment:Depth + Year:Depth + Treatment:Year:Depth	45.5810	-60.3619	9.1836	0.0072
Treatment + Location + Year + Depth + Treatment:Year + Treatment:Depth + Year:Depth + Treatment:Year:Depth	45.5766	-64.0565	5.4889	0.0458
Treatment + Location + Year + Depth + Treatment:Year + Treatment:Depth + Year:Depth	45.4710	-67.3170	2.2285	0.2336
Treatment + Location + Year + Depth + Treatment:Depth + Year:Depth	44.9545	-69.5455	0.0000	0.7119

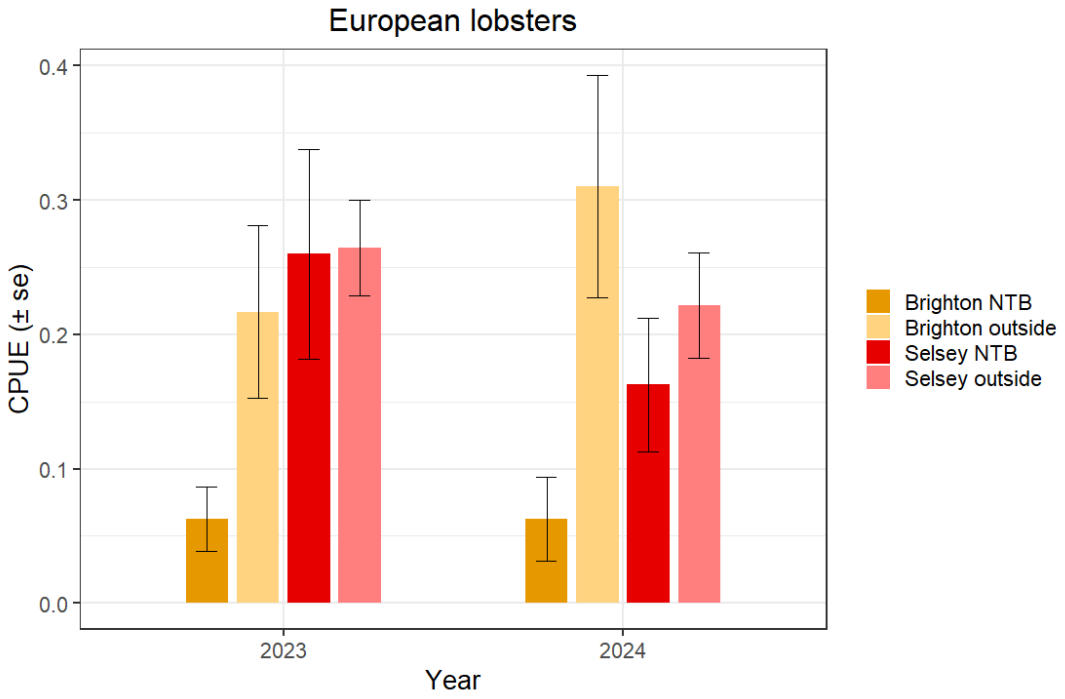


Figure 24: Catch per unit effort of European lobsters in 2023 and 2024, at Selsey and Brighton, both inside and outside trawling exclusion zone

Table 8: GLM analysis of European lobsters' abundance for Brighton and Selsey combined

	European LobsterLogged Catch Per Unit Effort		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.43	0.18 – 0.69	0.001
Year [2024]	-0.05	-0.11 – 0.01	0.082
Location [Selsey]	-0.29	-0.56 – -0.02	0.036
Treatment [Outside]	0.36	0.21 – 0.51	<0.001
Depth	-0.04	-0.06 – -0.01	0.003
Location [Selsey]:Treatment [Outside]	-0.37	-0.55 – -0.19	<0.001
Location [Selsey]:Depth	0.05	0.02 – 0.08	0.002
Observations	42		
R^2	0.453		

Table 9: Model selection using AICc for brown crab carapace size in Brighton and Selsey

contrast	*estimate*	*SE*	*df*	*t.ratio*	*p.value*
Brighton Inside Year2023 - Selsey Inside Year2023	-0.2008	0.0540	35	-3.7202	**0.0143**
Brighton Inside Year2023 - Brighton Outside Year2023	-0.3586	0.0776	35	-4.6229	**0.0012**
Brighton Inside Year2023 - Brighton Inside Year2024	0.0539	0.0310	35	1.7399	0.6623
Selsey Inside Year2023 - Selsey Outside Year2023	0.0080	0.0488	35	0.1629	1.0000
Selsey Inside Year2023 - Selsey Inside Year2024	0.0539	0.0310	35	1.7399	0.6623
Brighton Outside Year2023 - Selsey Outside Year2023	0.1657	0.0634	35	2.6146	0.1848
Brighton Outside Year2023 - Brighton Outside Year2024	0.0539	0.0310	35	1.7399	0.6623
Selsey Outside Year2023 - Selsey Outside Year2024	0.0539	0.0310	35	1.7399	0.6623
Brighton Inside Year2024 - Selsey Inside Year2024	-0.2008	0.0540	35	-3.7202	**0.0143**
Brighton Inside Year2024 - Brighton Outside Year2024	-0.3586	0.0776	35	-4.6229	**0.0012**
Brighton Inside Year2024 - Selsey Outside Year2024	-0.1929	0.0425	35	-4.5330	**0.0015**
Selsey Inside Year2024 - Selsey Outside Year2024	0.0080	0.0488	35	0.1629	1.0000
Brighton Outside Year2024 - Selsey Outside Year2024	0.1657	0.0634	35	2.6146	0.1848

Carapace size

Table 10: Model selection using AICc for brown crab carapace size in Brighton and Selsey

Carapace size ~	*logLik*	*AICc*	*delta*	*weight*
Year * Location * Treatment * Depth	-640.9369	1320.5815	14.9183	0.0002
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Location:Treatment + Year:Location:Depth + Year:Treatment:Depth + Location:Treatment:Depth	-641.4598	1319.0722	13.4090	0.0004
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth +Treatment:Depth + Year:Location:Treatment + Year:Location:Depth + Year:Treatment:Depth	-641.4635	1316.5633	10.9001	0.0015
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Location:Treatment + Year:Location:Depth	-641.6347	1314.4272	8.7640	0.0044
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Year:Location:Treatment + Year:Location:Depth	-641.6900	1312.0964	6.4332	0.0141
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Year:Location:Depth	-641.7878	1309.8868	4.2236	0.0424
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth	-642.6729	1309.2871	3.6239	0.0573
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Location:Depth	-643.2121	1308.0301	2.3670	0.1074
Year + Location + Treatment + Depth + Year:Location + Location:Treatment + Location:Depth	-643.9860	1307.2764	1.6132	0.1565
Year + Location + Treatment + Depth + Location:Treatment + Location:Depth	-644.5934	1306.2228	0.5597	0.2651
Location + Treatment + Depth + Location:Treatment + Location:Depth	-645.4316	1305.6632	0.0000	0.3507

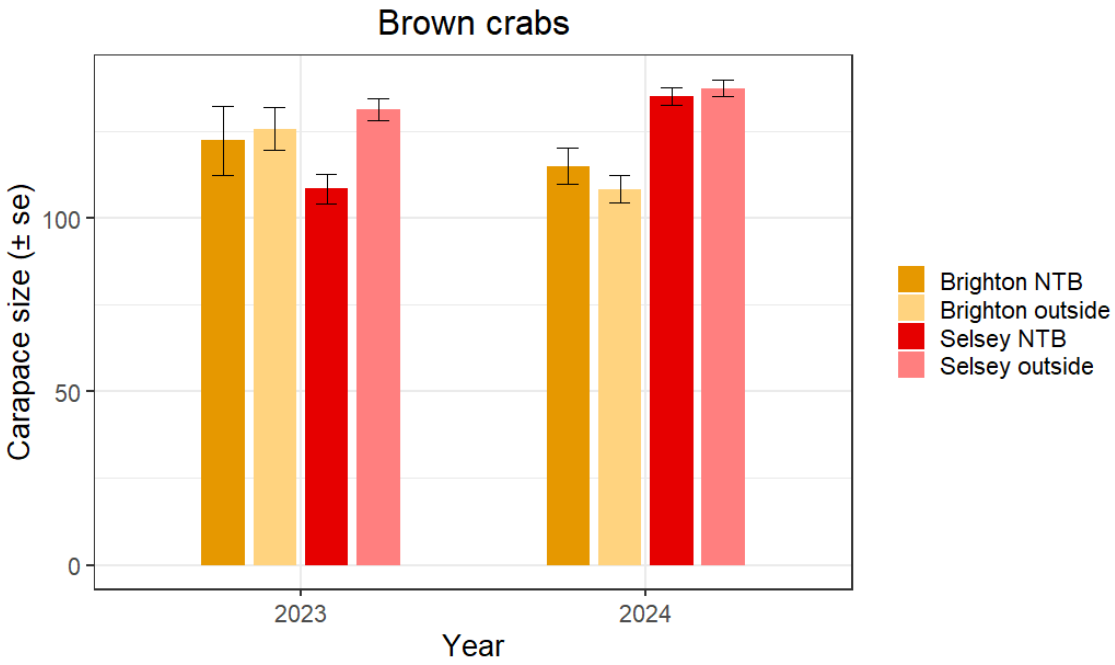


Figure 25: Carapace size of brown crabs in 2023 and 2024, at Selsey and Brighton, both inside and outside trawling exclusion zone

Table 11: GLM analysis of European lobsters' carapace size for both Brighton and Selsey

	Carapace size for brown crabs		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	74.54	50.61 – 98.46	**<0.001**
Year [2024]	5.22	-2.86 – 13.31	0.205
Location [Selsey]	53.50	28.22 – 78.78	**<0.001**
Treatment [Outside]	-18.33	-30.20 – -6.46	**0.002**
Depth	4.41	2.21 – 6.61	**<0.001**
Location [Selsey]: Treatment [Outside]	28.37	11.48 – 45.26	**0.001**
Location [Selsey]:Depth	-5.21	-7.93 – -2.48	**<0.001**
Observations	148		
R^2	0.283		

Table 12: Model selection using AICc for European lobster carapace size in Brighton and Selsey

Carapace size ~	*logLik*	*AICc*	*delta*	*weight*
Year * Location * Treatment * Depth	-660.5696	1359.1132	9.8744	0.0044
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Location:Treatment + Year:Location:Depth + Year:Treatment:Depth + Location:Treatment:Depth	-660.9154	1357.3405	8.1018	0.011
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Location:Treatment + Year:Treatment:Depth + Location:Treatment:Depth	-661.0597	1355.1963	5.9575	0.0314
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Treatment:Depth + Location:Treatment:Depth	-661.1829	1353.0410	3.8022	0.0922
Year + Location + Treatment + Depth + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Treatment:Depth + Location:Treatment:Depth	-661.3945	1351.0928	1.8541	0.2442
Year + Location + Treatment + Depth + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Treatment:Depth	-661.6382	1349.2388	0.0000	0.6171

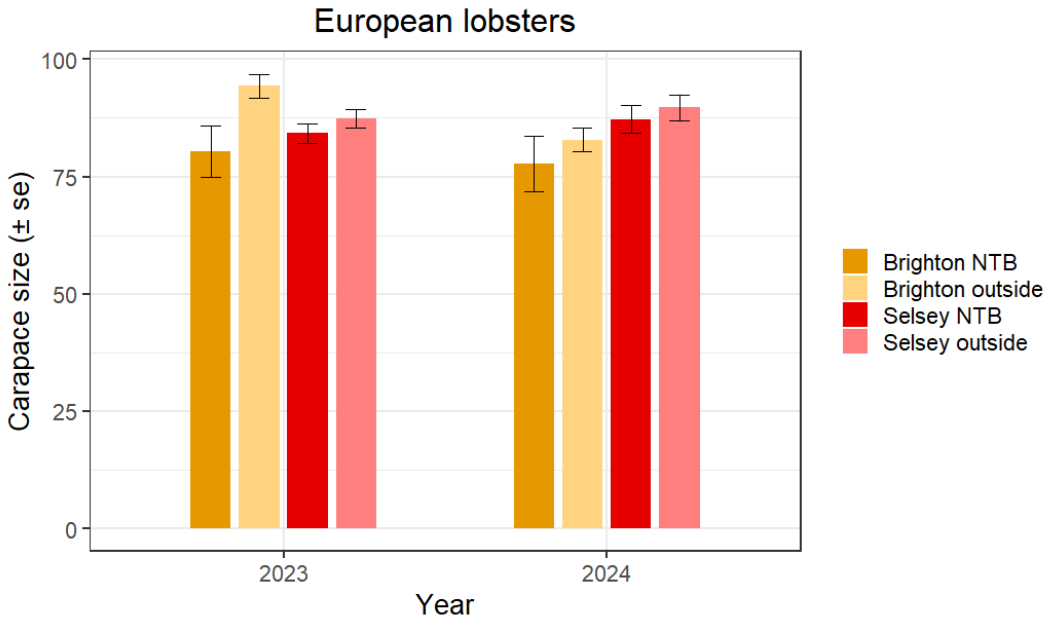


Figure 26: Carapace size of European lobsters in 2023 and 2024, at Selsey and Brighton, both inside and outside trawling exclusion zone

Table 13: GLM analysis of Carapace size for European lobsters in Brighton and Selsey

	Carapace size for European lobster		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	52.34	26.62 – 78.06	**<0.001**
Year [2024]	-29.23	-57.45 – -1.02	**0.042**
Location [Selsey]	46.07	29.30 – 62.84	**<0.001**
Treatment [Outside]	-27.76	-56.57 – 1.05	0.059
Depth	2.91	0.03 – 5.80	**0.048**
Year [2024]:Treatment [Outside]	39.42	4.74 – 74.11	**0.026**
Location [Selsey]: Treatment [Outside]	20.53	7.74 – 33.32	**0.002**
Year [2024]:Depth	4.77	0.87 – 8.68	**0.016**
Location [Selsey]:Depth	-5.07	-6.82 – -3.32	**<0.001**
Treatment [Outside]: Depth	1.78	-1.06 – 4.62	0.221
Year [2024]:Treatment [Outside]:Depth	-5.46	-9.70 – -1.21	**0.012**
Observations	172		
R^2	0.260		

MCRS

Table 14: Model selection using AICc for brown crabs abundance below MCRS in Brighton and Selsey

Abundance Below MCRS~	*logLik*	*AICc*	*delta*	*weight*
Year * Location * Treatment * Depth	15.9139	63.3721	63.1480	0.0000
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Location:Treatment + Year:Location:Depth + Year:Treatment:Depth + Location:Treatment:Depth	15.7927	49.8691	49.6450	0.0000
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Location:Treatment + Year:Location:Depth + Location:Treatment:Depth	15.7676	38.4648	38.2407	0.0000
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Location:Treatment +Location:Treatment:Depth	15.5753	29.1572	28.9330	0.0000
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Location:Treatment:Depth,	15.2320	21.5360	21.3119	0.0000
Year + Location + Treatment + Depth + Year:Location + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Location:Treatment:Depth	15.2277	14.3445	14.1204	0.0006
Year + Location + Treatment + Depth + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Location:Treatment:Depth	15.1724	8.1552	7.9311	0.0134
Year + Location + Treatment + Depth + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth	14.7479	3.4454	3.2213	0.1407
Year + Location + Treatment + Depth + Location:Treatment + Year:Depth + Treatment:Depth	13.8879	0.2241	0.0000	0.7045

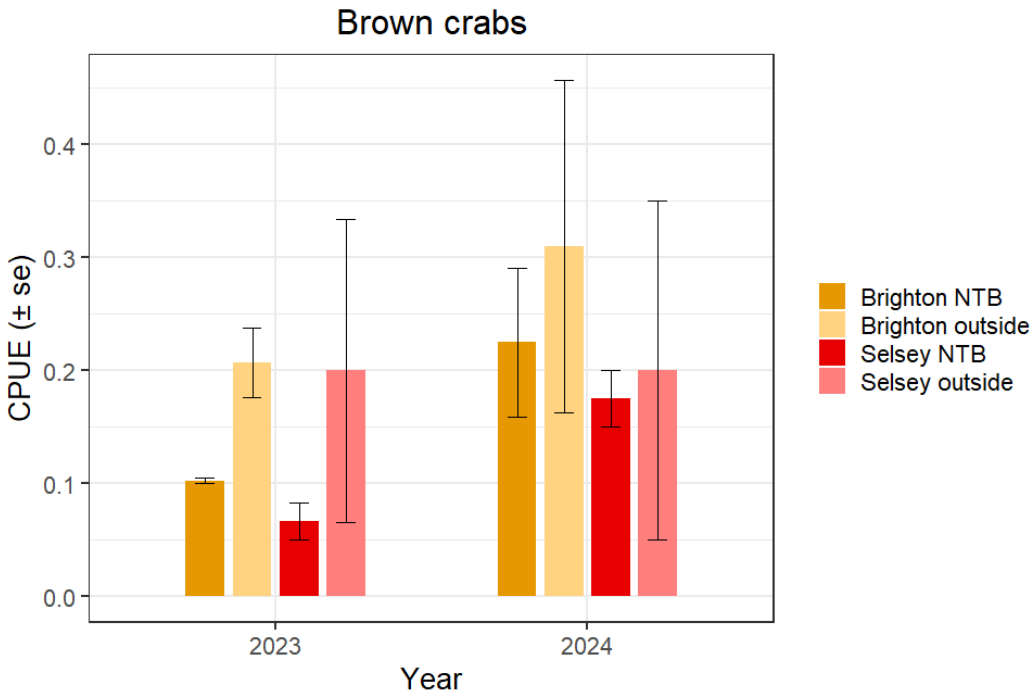


Figure 27: Catch per unit effort of brown crabs below minimum conservation reference size in 2023 and 2024, at Selsey and Brighton, both inside and outside trawling exclusion zone

Table 15: GLM analysis of brown crab abundance below MCRS in Brighton and Selsey

	Abundance below MCRS for brown crabs		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	-0.01	-0.64 – 0.63	0.984
Year [2024]	0.37	-0.07 – 0.81	0.096
Location [Selsey]	-0.03	-0.29 – 0.22	0.790
Treatment [Outside]	1.03	0.29 – 1.77	**0.006**
Depth	0.01	-0.05 – 0.08	0.688
Location [Selsey]: Treatment [Outside]	-0.29	-0.62 – 0.03	0.078
Year [2024]:Depth	-0.03	-0.07 – 0.01	0.106
Treatment [Outside]: Depth	-0.07	-0.14 – 0.01	0.070
Observations	28		
R^2	0.530		

Table 16 Model selection using AICc for European lobster abundance below MCRS in Brighton and Selsey

Abundance Below MCRS~	*logLik*	*AICc*	*delta*	*weight*
Year * Location * Treatment * Depth	44.5112	-4.0224	40.4245	0.0000
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Location:Treatment + Year:Location:Depth + Year:Treatment:Depth + Location:Treatment:Depth	44.3130	-14.7799	29.6670	0.0000
ear + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Location:Depth + Year:Treatment:Depth + Location:Treatment:Depth	44.1188	-23.9520	20.4949	0.0000
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Year:Location:Depth + Location:Treatment:Depth	43.8222	-31.6445	12.8024	0.0016
Year + Location + Treatment + Depth + Year:Location + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Location:Treatment:Depth	43.4118	-38.0735	6.3733	0.0396
Year + Location + Treatment + Depth + Year:Treatment + Location:Treatment + Year:Depth + Location:Depth + Treatment:Depth + Location:Treatment:Depth	43.3999	-44.4469	0.0000	0.9588

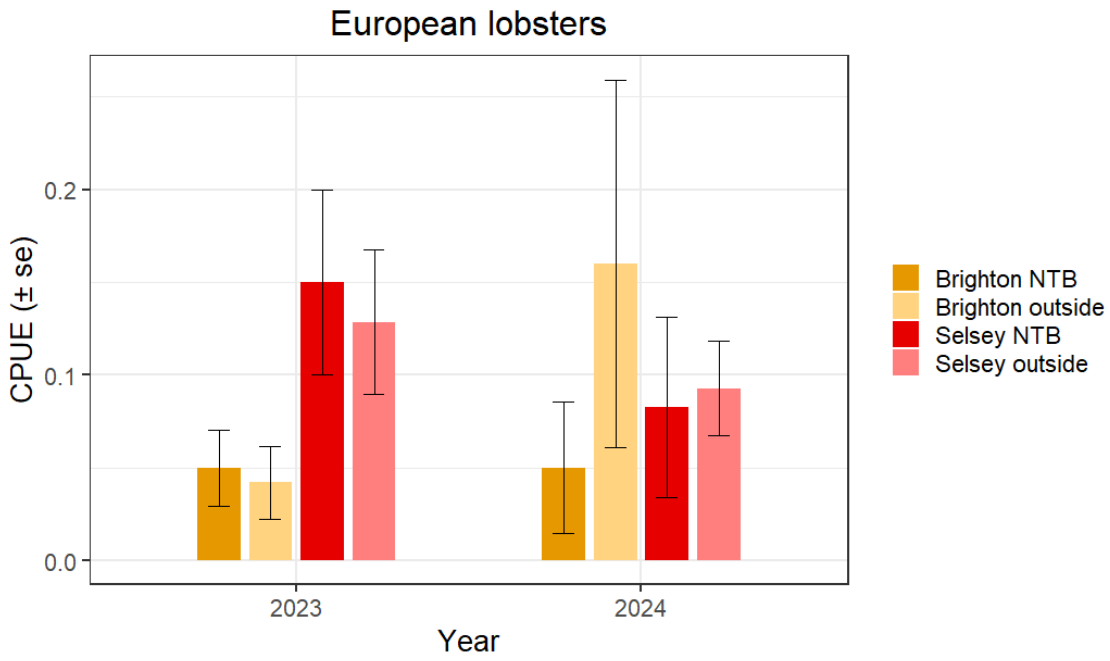


Figure 28: Catch per unit effort of European lobsters below minimum conservation reference size in 2023 and 2024, at Selsey and Brighton, both inside and outside trawling exclusion zone

Table 17: GLM analysis of European lobsters below MCRS in Brighton and Selsey

	European lobster below MCRS		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.35	-0.11 – 0.82	0.137
Year [2024]	0.18	-0.02 – 0.38	0.074
Location [Selsey]	-0.21	-0.71 – 0.29	0.410
Treatment [Outside]	0.70	0.08 – 1.32	**0.028**
Depth	-0.03	-0.08 – 0.02	0.259
Year [2024]:Treatment [Outside]	0.15	-0.02 – 0.32	0.092
Location [Selsey]: Treatment [Outside]	-0.85	-1.53 – -0.18	**0.013**
Year [2024]:Depth	-0.03	-0.06 – -0.01	**0.010**
Location [Selsey]:Depth	0.04	-0.03 – 0.10	0.253
Treatment [Outside]:Depth	-0.04	-0.09 – 0.02	0.230
Location [Selsey]:Treatment [Outside]:Depth	0.05	-0.02 – 0.12	0.202
Observations	30		
R^2	0.702		

Weight

Table 18: Model selection using AICc for brown crab weight in Brighton and Selsey

Weight ~	*logLik*	*AICc*	*delta*	*weight*
Year*Location*Treatment*Depth	66.4655	-94.2233	0	1

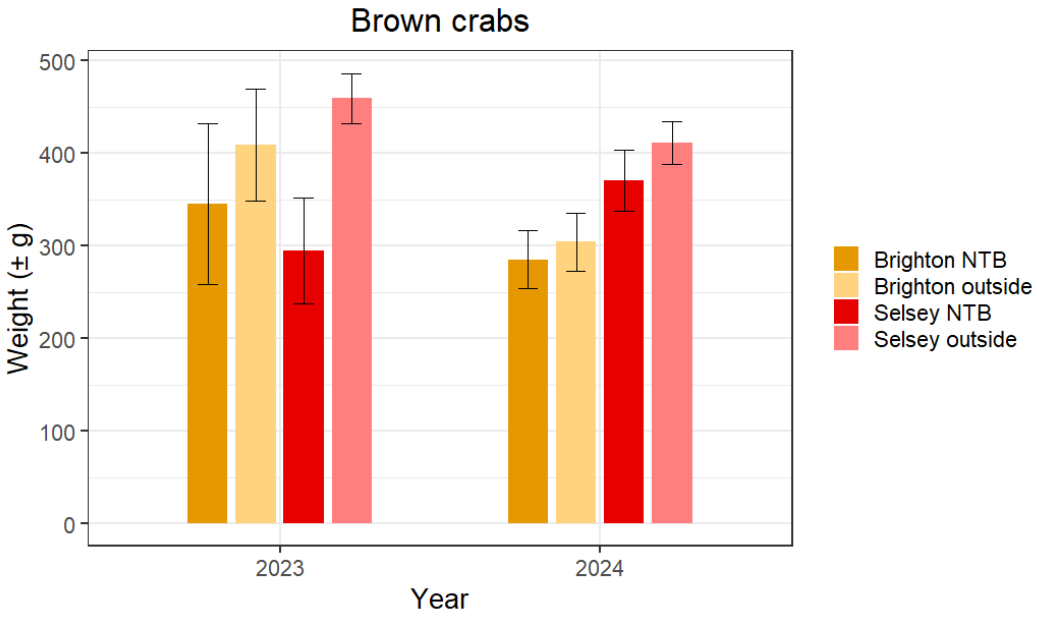


Figure 29: Weight of brown crabs in 2023 and 2024, at Selsey and Brighton, both inside and outside trawling exclusion zone

Table 19: GLM analysis for brown crab weight in Brighton and Selsey

		Brown crab weight	
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.10	-0.90 – 1.11	0.838
Year [2024]	0.42	-0.80 – 1.63	0.502
Location [Selsey]	0.25	-0.90 – 1.40	0.668
Treatment [Outside]	2.11	-0.79 – 5.01	0.153
Depth	0.02	-0.07 – 0.12	0.635
Year [2024]:Location[Selsey]	-0.49	-2.00 – 1.02	0.523
Year [2024]:Treatment[Outside]	-2.55	-5.55 – 0.44	0.095
Location [Selsey]:Treatment [Outside]	-1.94	-4.93 – 1.04	0.202
Year [2024]:Depth	-0.05	-0.18 – 0.08	0.424
Location [Selsey]:Depth	-0.03	-0.15 – 0.09	0.609
Treatment [Outside]:Depth	-0.14	-0.34 – 0.06	0.170
Year [2024]:Location[Selsey]:Treatment[Outside]	2.55	-0.61 – 5.71	0.114
Year [2024]:Location[Selsey]: Depth	0.07	-0.11 – 0.26	0.424
Year [2024]:Treatment[Outside]:Depth	0.19	-0.03 – 0.41	0.090
Location [Selsey]:Treatment [Outside]:Depth	0.14	-0.08 – 0.36	0.206
Year [2024]:Location[Selsey]:Treatment[Outside]:Depth	-0.21	-0.47 – 0.05	0.115
Observations	148		
R^2	0.171		

Table 20: Model selection using AICc for brown crab weight in Brighton and Selsey

Weight ~	*logLik*	*AICc*	*delta*	*weight*
Year*Location* Treatment*Depth	7.9418	22.0903	0	1

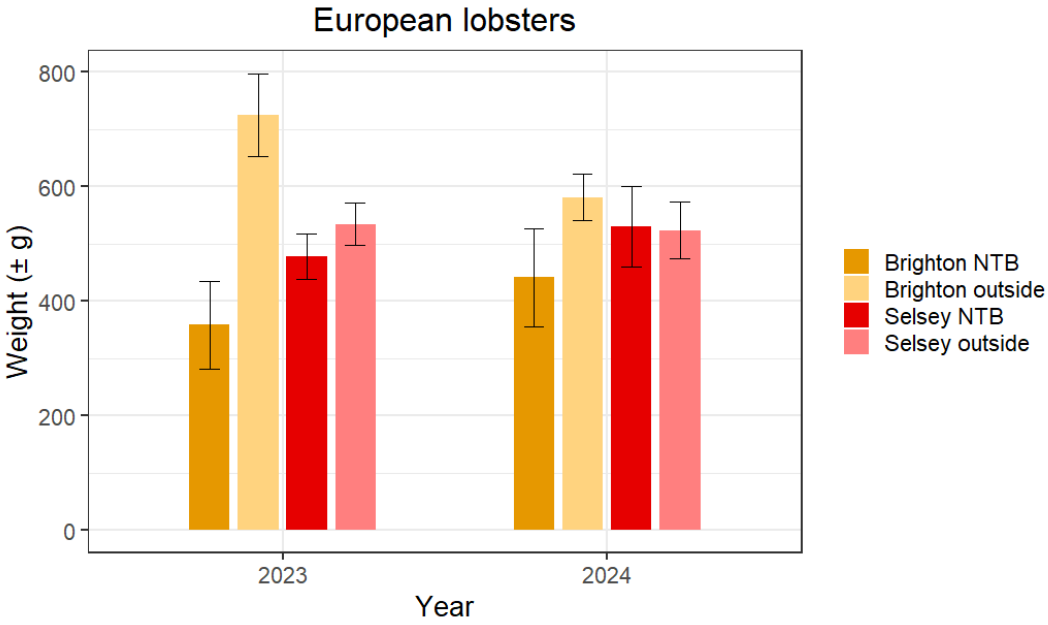


Figure 30: Weight of European lobsters in 2023 and 2024, at Selsey and Brighton, both inside and outside trawling exclusion zone

Table 21: GLM analysis for European lobsters' weight in Brighton and Selsey

	European lobsters weight		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	52.34	26.62 – 78.06	**<0.001**
Year [2024]	-29.23	-57.45 – -1.02	**0.042**
Location [Selsey]	46.07	29.30 – 62.84	**<0.001**
Treatment [Outside]	-27.76	-56.57 – 1.05	0.059
Depth	2.91	0.03 – 5.80	**0.048**
Year [2024]:Treatment[Outside]	39.42	4.74 – 74.11	**0.026**
Location [Selsey]:Treatment [Outside]	20.53	7.74 – 33.32	**0.002**
Year [2024]:Depth	4.77	0.87 – 8.68	**0.016**
Location [Selsey]:Depth	-5.07	-6.82 – -3.32	**<0.001**
Treatment [Outside]:Depth	1.78	-1.06 – 4.62	0.221
Year [2024]:Treatment[Outside]:Depth	-5.46	-9.70 – -1.21	**0.012**
Observations	172		
R^2	0.260		

Appendix B – Sites, Co-Ordinates and Depths

Table 22: Selsey sites coordinates and respective depth

Site	Latitude (DM.m)	Longitude (DM.m)	Depth (m)
Site 1	50’42.13	00’48.19	2
Site 2	50’40.71	00’48.97	7
Site 3	50’43.80	00’45.67	2
Site 4	50’40.58	00’42.89	6
Site 5	50'44.84	00'37.61	4
Site 6	50'42.54	00'36.21	7
Site 7	50’44.18	00’41.39	6
Site 8	50’44.88	00’43.28	3
Site 9	50’44.18	00’50.30	1
Site 10	50’42.86	00’50.83	6
Site 11	50’45.81	00’53.35	1
Site 12	50’44.76	0’53.07	5

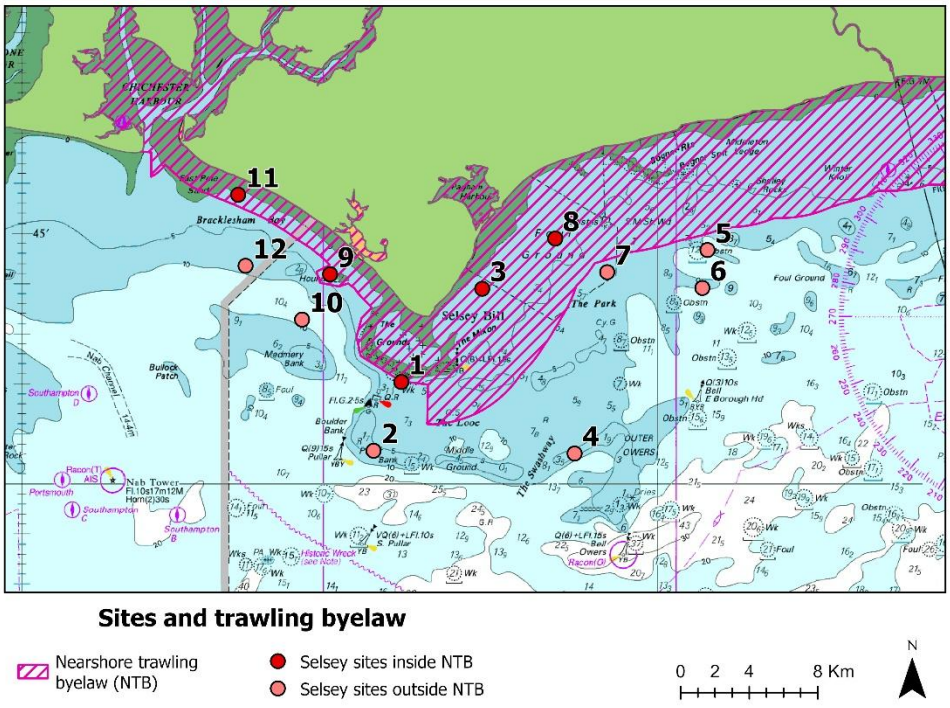


Figure 31: Survey sites used in data analysis across Selsey (2021 – 2024)

Table 23: Brighton sites coordinates and respective depths

Site	Latitude (DM.m)	Longitude (DM.m)	Depth (m)
Site 1	50’47.619	00’02.673	11
Site 2	50’47.712	00’02.568	9
Site 3	50’48.069	00’09.698	14
Site 4	50’47.768	00’08.371	15
Site 5	50'48.007	00'07.958	16
Site 6	50'48.514	00'06.529	9
Site 7	50’44.18	00’41.39	6
Site 8	50’48.076	00’08.459	16
Site 9	50’46.823	00’00.63	12

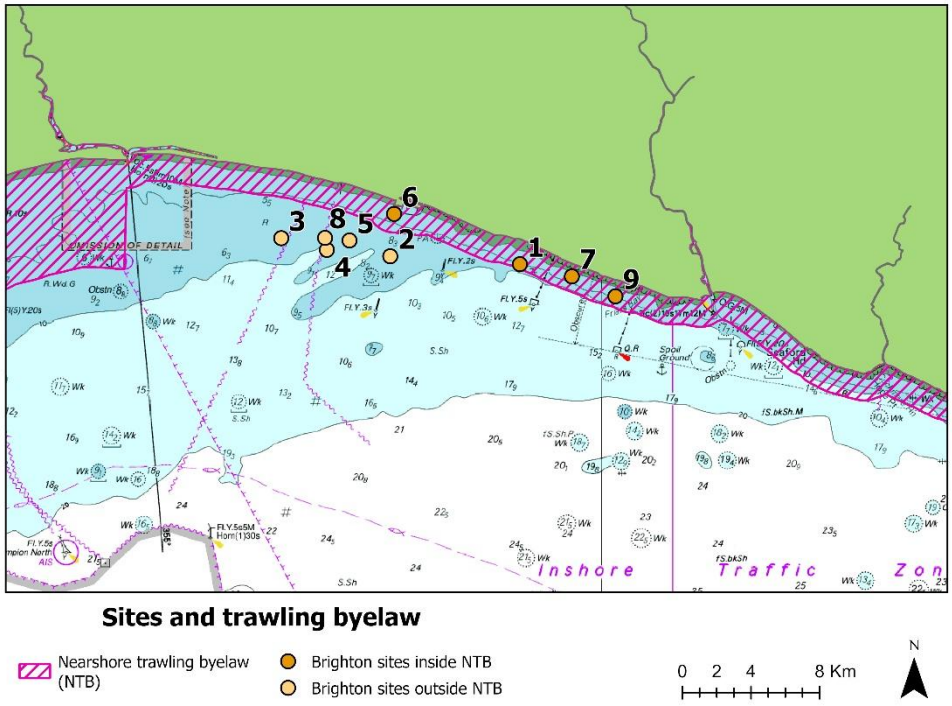


Figure 32: Brighton sites surveyed (2023-2024)

Appendix C – GLM analysis tables and post-hoc

Abundance

Table 24: Model selection using AICc for brown crab abundance in Selsey

Logged CPUE ~	*logLik*	*AICc*	*delta*	*weight*
Year * Treatment * Depth	18.2923	17.8155	32.7720	0.0000
Year + Treatment + Depth + Year:Treatment + Year:Depth + Treatment:Depth	17.1542	6.4190	21.3755	0.0000
Year + Treatment + Depth + Treatment:Depth	14.5413	-9.3903	5.5662	0.0402
Treatment + Depth + Treatment:Depth	12.4536	-13.4786	1.4779	0.3102
Treatment + Depth	11.9434	-14.9565	0.0000	0.6496

Table 25: GLM analysis of brown crab abundance in Selsey

	Brown crab abundance		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.35	0.09 – 0.61	**0.008**
Year2022	-0.16	-0.34 – 0.02	0.078
Year2023	-0.09	-0.25 – 0.07	0.272
Year2024	-0.02	-0.18 – 0.14	0.791
TreatmentOutside	0.29	-0.03 – 0.61	0.080
Depth	-0.03	-0.07 – 0.01	0.160
TreatmentOutside:Depth	-0.01	-0.06 – 0.03	0.512
Observations	48		
R^2	0.215		

Table 26: Model selection using AICc for European lobster abundance in Selsey

Logged CPUE ~	*logLik*	*AICc*	*delta*	*weight*
Year * Treatment * Depth	48.6742	-42.9485	24.4928	0.0000
Year + Treatment + Depth + Year:Treatment + Year:Depth + Treatment:Depth	45.7936	-50.8598	16.5814	0.0002
Year + Treatment + Depth + Year:Depth + Treatment:Depth	45.3101	-61.2869	6.1544	0.0440
Year + Treatment + Depth + Treatment:Depth	43.5668	-67.4413	0.0000	0.9557

Table 27: GLM analysis of European lobster abundance in Selsey

	European lobster abundance		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.17	0.03 – 0.31	**0.017**
Year2022	0.14	0.04 – 0.24	**0.006**
Year2023	0.14	0.05 – 0.22	**0.002**
Year2024	0.09	-0.00 – 0.17	0.057
TreatmentOutside	-0.17	-0.35 – -0.00	**0.046**
Depth	-0.01	-0.04 – 0.01	0.258
TreatmentOutside:Depth	0.02	-0.00 – 0.05	0.058
Observations	48		
R^2	0.315		

Carapace size

Table 28: Model selection using AICc for brown crab carapace size in Selsey

Carapace size~	*logLik*	*AICc*	*delta*	*weight*
Year*Treatment*Depth	-788.6494	1614.9856	4.0587	0.1162
Year + Treatment + Depth + Year:Treatment + Year:Depth + Treatment:Depth	-790.2208	1610.9269	0.0000	0.8838

Table 29: GLM analysis of brown crab carapace size in Selsey

	Brown crabs carapace size		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	133.51	113.08 – 153.95	**<0.001**
Year [2022]	9.85	-14.05 – 33.75	0.419
Year [2023]	-0.35	-44.80 – 44.11	0.988
Year [2024]	29.10	-3.06 – 61.27	0.076
Treatment [Outside]	-34.83	-67.59 – -2.07	**0.037**
Depth	-0.04	-3.57 – 3.49	0.980
Year [2022]:Treatment[Outside]	78.74	40.62 – 116.87	**<0.001**
Year [2023]:Treatment[Outside]	29.34	5.41 – 53.26	**0.016**
Year [2024]:Treatment[Outside]	13.68	-3.90 – 31.25	0.127
Year [2022]:Depth	-15.27	-23.19 – -7.36	**<0.001**
Year [2023]:Depth	-3.32	-9.04 – 2.39	0.254
Year [2024]:Depth	-4.31	-9.00 – 0.37	0.071
Treatment [Outside]:Depth	3.79	-0.89 – 8.48	0.112
Observations	184		
R^2	0.241		

Table 30: Post-hoc analysis of brown crab carapace size with Year and Treatment in Selsey

contrast	*estimate*	*SE*	*df*	*t.ratio*	*p.value*
Year2021 Inside - Year2022 Inside	86.3886	18.5244	171	4.6635	**0.0002**
Year2021 Inside - Year2023 Inside	21.2876	10.3692	171	2.0530	0.4497
Year2021 Inside - Year2024 Inside	-1.9199	7.3682	171	-0.2606	1.0000
Year2021 Inside - Year2021 Outside	10.9232	5.3769	171	2.0315	0.4639
Year2022 Inside - Year2023 Inside	-65.1010	21.3621	171	-3.0475	0.0531
Year2022 Inside - Year2024 Inside	-88.3086	19.5666	171	-4.5132	**0.0003**
Year2022 Inside - Year2022 Outside	-67.8186	18.4028	171	-3.6852	**0.0073**
Year2023 Inside - Year2024 Inside	-23.2076	11.6401	171	-1.9938	0.4891
Year2023 Inside - Year2023 Outside	-18.4123	11.2166	171	-1.6415	0.7244
Year2024 Inside - Year2024 Outside	-2.7532	7.1855	171	-0.3832	0.9999
Year2021 Outside - Year2022 Outside	7.6468	5.4228	171	1.4101	0.8516
Year2021 Outside - Year2023 Outside	-8.0479	8.0313	171	-1.0021	0.9736
Year2021 Outside - Year2024 Outside	-15.5963	4.9348	171	-3.1605	**0.0385**
Year2022 Outside - Year2023 Outside	-15.6946	8.3123	171	-1.8881	0.5610
Year2022 Outside - Year2024 Outside	-23.2431	4.8122	171	-4.8300	**0.0001**
Year2023 Outside - Year2024 Outside	-7.5485	7.9944	171	-0.9442	0.9812

Table 31: Model selection using AICc for European lobster carapace size in Selsey

Carapace size~	*logLik*	*AICc*	*delta*	*weight*
Year*Treatment*Depth	-756.4595	1550.3002	0	1

Table 32: GLM analysis of European lobster carapace size in Selsey

	European lobsters carapace size		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	71.39	51.02 – 91.75	**<0.001**
Year [2022]	4.18	-17.87 – 26.24	0.710
Year [2023]	29.35	1.07 – 57.63	**0.042**
Year [2024]	-0.93	-30.51 – 28.65	0.951
Treatment [Outside]	6.39	-51.67 – 64.44	0.829
Depth	2.75	-0.72 – 6.21	0.121
Year [2022]:Treatment[Outside]	3.47	-59.89 – 66.83	0.915
Year [2023]:Treatment[Outside]	-19.13	-82.59 – 44.33	0.555
Year [2024]:Treatment[Outside]	26.61	-38.09 – 91.31	0.420
Year [2022]:Depth	3.09	-3.03 – 9.21	0.323
Year [2023]:Depth	-5.25	-9.78 – -0.72	**0.023**
Year [2024]:Depth	-0.31	-4.90 – 4.27	0.893
Treatment [Outside]:Depth	-2.16	-9.71 – 5.39	0.575
Year [2022]:Treatment[Outside]:Depth	-4.12	-14.04 – 5.80	0.416
Year [2023]:Treatment[Outside]:Depth	4.61	-3.62 – 12.85	0.272
Year [2024]:Treatment[Outside]:Depth	-1.56	-9.86 – 6.75	0.713
Observations	199		
R^2	0.116		

Weight

Table 33: Model selection using AICc for brown crab carapace size in Selsey

Weight ~	*logLik*	*AICc*	*delta*	*weight*
Year*Treatment*Depth	92.1620	-146.6373	6.8230	0.0202
Year + Treatment + Depth + Year:Treatment + Year:Depth + Treatment:Depth	91.4524	-152.4196	1.0407	0.3652
Year + Treatment + Depth + Year:Treatment + Year:Depth	90.8007	-153.4603	0.0000	0.6145

Table 34: GLM analysis of brown crab weight in Selsey

	Brown crab weight		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.34	0.19 – 0.49	**<0.001**
Year [2022]	0.10	-0.10 – 0.29	0.338
Year [2023]	0.01	-0.34 – 0.36	0.954
Year [2024]	0.06	-0.16 – 0.27	0.611
Treatment [Outside]	-0.05	-0.14 – 0.03	0.227
Depth	0.01	-0.02 – 0.03	0.620
Year [2022]:Treatment[Outside]	0.50	0.21 – 0.79	**0.001**
Year [2023]:Treatment[Outside]	0.23	0.04 – 0.42	**0.020**
Year [2024]:Treatment[Outside]	0.10	-0.05 – 0.24	0.189
Year [2022]:Depth	-0.10	-0.17 – -0.04	**0.002**
Year [2023]:Depth	-0.01	-0.06 – 0.03	0.540
Year [2024] :Depth	-0.01	-0.04 – 0.02	0.496
Observations	184		
R^2	0.189		

Table 35: Post-hoc analysis for Year and treatment of brown crab weight in Selsey

contrast	*estimate*	*SE*	*df*	*t.ratio*	*p.value*
Year2021 Inside - Year2022 Inside	0.5565	0.1456	172	3.8211	**0.0045**
Year2021 Inside - Year2023 Inside	0.0797	0.0838	172	0.9512	0.9803
Year2021 Inside - Year2024 Inside	0.0121	0.0609	172	0.1992	1.0000
Year2022 Inside - Year2023 Inside	-0.4768	0.1632	172	-2.9212	0.0746
Year2022 Inside - Year2024 Inside	-0.5444	0.1528	172	-3.5634	**0.0109**
Year2022 Inside - Year2022 Outside	-0.4434	0.1421	172	-3.1212	**0.0431**
Year2023 Inside - Year2024 Inside	-0.0675	0.0956	172	-0.7064	0.9967
Year2023 Inside - Year2023 Outside	-0.1767	0.0883	172	-2.0007	0.4845
Year2024 Inside - Year2024 Outside	-0.0441	0.0597	172	-0.7393	0.9956
Year2021 Outside - Year2022 Outside	0.0597	0.0430	172	1.3903	0.8607
Year2021 Outside - Year2023 Outside	-0.1504	0.0666	172	-2.2576	0.3233
Year2021 Outside - Year2024 Outside	-0.0853	0.0392	172	-2.1762	0.3714
Year2022 Outside - Year2023 Outside	-0.2102	0.0671	172	-3.1343	**0.0415**
Year2022 Outside - Year2024 Outside	-0.1451	0.0399	172	-3.6331	**0.0087**
Year2023 Outside - Year2024 Outside	0.0651	0.0647	172	1.0061	0.9730

Table 36: Model selection using AICc for brown crab carapace size in Selsey

Weight~	*logLik*	*AICc*	*delta*	*weight*
Year*Treatment*Depth	-756.4595	1550.3002	0	1

Table 37: GLM analysis of European lobster weight in Selsey

	European lobsters weight		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	71.39	51.02 – 91.75	**<0.001**
Year [2022]	4.18	-17.87 – 26.24	0.710
Year [2023]	29.35	1.07 – 57.63	**0.042**
Year [2024]	-0.93	-30.51 – 28.65	0.951
Treatment [Outside]	6.39	-51.67 – 64.44	0.829
Depth	2.75	-0.72 – 6.21	0.121
Year [2022]:Treatment[Outside]	3.47	-59.89 – 66.83	0.915
Year [2023]:Treatment[Outside]	-19.13	-82.59 – 44.33	0.555
Year [2024]:Treatment[Outside]	26.61	-38.09 – 91.31	0.420
Year [2022]:Depth	3.09	-3.03 – 9.21	0.323
Year [2023]:Depth	-5.25	-9.78 – -0.72	**0.023**
Year [2024]:Depth	-0.31	-4.90 – 4.27	0.893
Treatment [Outside]:Depth	-2.16	-9.71 – 5.39	0.575
Year [2022]:Treatment[Outside]:Depth	-4.12	-14.04 – 5.80	0.416
Year [2023]:Treatment[Outside]:Depth	4.61	-3.62 – 12.85	0.272
Year [2024]:Treatment[Outside]:Depth	-1.56	-9.86 – 6.75	0.713
Observations	199		
R^2	0.116		

MCRS

Table 38: Model selection using AICc for brown crab abundance below MCRS in Selsey

Abundance below MCRS~	*logLik*	*AICc*	*delta*	*weight*
Year * Treatment * Depth	14.6431	42.9638	52.9096	0.0000
Year + Treatment + Depth + Year:Treatment + Year:Depth + Treatment:Depth	14.5115	21.0822	31.0279	0.0000
Year + Treatment + Depth + Year:Depth + Treatment:Depth	12.8591	8.2818	18.2275	0.0001
Year + Treatment + Depth + Year:Depth	12.8516	3.8620	13.8078	0.0001
Year + Treatment + Depth	10.6662	-3.0246	6.9212	0.0219
Treatment + Depth	8.7448	-8.1104	1.8354	0.2789
Depth	8.3729	-9.9458	0.0000	0.6983

Table 39: GLM analysis of brown crab abundance below MCRS in Selsey

	Brown crab bundance of individuals below MCRS		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.49	0.25 – 0.74	**<0.001**
Year [2022]	-0.18	-0.39 – 0.03	0.092
Year [2023]	-0.05	-0.24 – 0.14	0.639
Year [2024]	0.02	-0.17 – 0.21	0.836
Treatment [Outside]	0.13	-0.05 – 0.31	0.152
Depth	-0.05	-0.08 – -0.01	**0.011**
Observations	34		
R^2	0.207		

Table 40: Model selection using AICc for European lobster abundance below MCRS in Selsey

Abundance below MCRS~	*logLik*	*AICc*	*delta*	*weight*
Year*Treatment*Depth	45.5708	-21.1416	0	1

Table 41: GLM analysis of European lobster abundance below MCRS in Selsey

	Abundance of European lobsters below MCRS		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.64	-0.37 – 1.65	0.217
Year [2022]	-0.02	-1.05 – 1.02	0.977
Year [2023]	-0.54	-1.62 – 0.55	0.334
Year [2024]	-0.28	-1.36 – 0.80	0.611
Treatment [Outside]	-0.90	-2.19 – 0.39	0.171
Depth	-0.09	-0.30 – 0.12	0.405
Year [2022]:Treatment[Outside]	0.37	-0.99 – 1.74	0.592
Year [2023]:Treatment[Outside]	0.83	-0.55 – 2.21	0.236
Year [2024]:Treatment[Outside]	0.79	-0.61 – 2.19	0.270
Year [2022]:Depth	-0.11	-0.34 – 0.13	0.373
Year [2023]:Depth	0.10	-0.12 – 0.32	0.359
Year [2024]:Depth	0.06	-0.16 – 0.27	0.605
Treatment [Outside]:Depth	0.14	-0.10 – 0.37	0.252
Year [2022]:Treatment[Outside]:Depth	0.07	-0.19 – 0.34	0.597
Year [2023]:Treatment[Outside]:Depth	-0.14	-0.38 – 0.10	0.265
Year [2024]:Treatment[Outside]:Depth	-0.12	-0.36 – 0.13	0.353
Observations	35		
R^2	0.597		

Appendix D – Byelaw Dispensations

SUSSEX
Inshore Fisheries and Conservation Authority

Chairman: Professor Peter Jones
Chief Fisheries & Conservation Officer: R.J. Pearson M.Sc. MIFM

Your Ref:
Our Ref: Blue Marine Eastbourne Crustacean Pot Fish Survey 2024

e-mail: admin@sussex-ifca.gov.uk

Byelaw dispensation- Shellfish Permit Byelaw 2015
Sussex Inshore Fisheries and Conservation District

AUTHORISATION TO FISH FOR SCIENTIFIC OR BREEDING PURPOSES

Sussex Inshore Fisheries and Conservation Authority Byelaws shall, unless otherwise specified, apply to the whole of the District, provided that nothing in these Byelaws shall apply to any person fishing for sea fish for scientific purposes, or breeding purposes, under written authority signed by the Clerk and in accordance with any conditions contained in such Authority.

The Authority hereby authorise:

Section 1: Details of applicant

Name of Applicant(s)

Title: MR

Forename: FRANCESCO

Surname: MARZANO

Email: francesco@bluemarinefoundation.com

Phone: +447482008484

Business Name:

Blue Marine Foundation

Correspondence Address:

South Building
Somerset House
London
WC2R 1LA
United Kingdom

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

SUSSEX
Inshore Fisheries and Conservation Authority

Section 2: Request for derogation
From which bye-law(s) are you seeking derogation?
Shellfish Permit Byelaw 2015 - Wishing to remove escape gaps for scientific data collection of brown crab and European lobster

Location

Where will this activity take place? Please provide GIS Shape files (.tab or .shp) wherever possible and attach them to the application or, if sending co-ordinates please give them in Latitude/Longitude Decimal Degrees.

Site	Latitude (DM.m)	Longitude (DM.m)	Depth (m)
Site 1	50'47.619	00'02.673	11
Site 2	50'47.712	00'02.568	9
Site 3	50'48.069	00'09.698	14
Site 4	50'47.768	00'08.371	15
Site 5	50'48.007	00'07.958	16
Site 6	50'48.514	00'06.529	9
Site 7	50'44.18	00'41.39	6
Site 8	50'48.076	00'08.459	16
Site 9	50'46.823	00'00.63	12

Time
Please provide details of the timetable for this project. Continue on a separate sheet if necessary and attach it to the application.

Derogation period – 19th-25th of August 2024. This is longer than the proposed survey period but will allow contingency for bad weather days. Pots will be deployed, hauled and data collection carried out on board the named vessel during this period.

Vessel details

Vessel name: Peter Paul II
Registry of Shipping Number: A19837
Port letters and numbers: SM694
Owner of vessel: Neil Messenger
Skipper of vessel: Neil Messenger

Gear description (including mesh size, tow speed and duration)
Parlour pots. A total of 60 pots in 2-3 strings. Deployed at proposed survey locations for no longer than 48 hrs unless weather restricts hauling. Pots will be baited and escape gaps will be closed.

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

SUSSEX
Inshore Fisheries and Conservation Authority

Details of activity
Please give a description of the proposed activity including its purpose. Continue on a separate sheet if necessary.

A derogation is sought to allow the removal of/closing of mandatory escape gaps fitted within parlour pots used by the applicant in line with the Shellfish Permit Byelaw 2015. The purpose for this derogation is to aid the capture of brown crab and European lobster individuals across a wide size and age range for scientific sampling. A project led by Blue Marine Foundation aims to assess changes in key crustacean fisheries following the introduction of the IFCA Nearshore Trawling Byelaw in Sussex. Surveys will be carried out at multiple locations inside and outside the Nearshore Trawling Byelaw and data (abundance, condition, carapace size, wet weight, sex) will be extracted from caught brown crab and European lobster individuals. Conversations during the planning of this research project between Blue Marine Foundation and Sussex IFCA have ensured that the data being collected will compliment ongoing Sussex IFCA crustacean data collection and methods will be comparable where possible.

Presence/absence of parasitic lice on European lobsters will also be noted to contribute to the data collection being led by North Eastern IFCA.

To aid accurate data collection it is important to collect data from a range of individuals within each population and understanding the current status of smaller individuals allows a more robust assessment of the wider populations of crab and lobster, hence the derogation application. The species abundance of bycaught species will also be recorded. This is the second year of an annual monitoring program to assess changes in the populations of these key commercially targeted crustaceans over time. Results will be published through interim reports by the funder/partners and distributed to a wide range of stakeholders. The project will complement the ongoing towed and baited underwater videos survey of the same area carried out in Summer 2021, 2022 and 2023. This research is part of the Sussex Kelp Restoration Project's overall research plan which aims to measure the impact of the Nearshore Trawling Byelaw on ecosystems, fisheries and local communities. This will allow benefits from the byelaw and associated impacts to be evaluated and quantified. The programme will be undertaken in collaboration with research organisations, regulators, fishermen, conservation groups, marine user groups and local communities.
In addition, swabs will be taken from each lobster caught to identify any ectoparasites or infections. This involves a non-invasive technique, in which the carapace is lifted on the side and the gills are gently brushed with a special sterile DNA swab (CITOSWAB UK) for 5-10 seconds. Swabs will be kept in test tubes and labelled to be sent away for analysis.

Mitigation

Please give details of any mitigation taken to minimise the impact of the proposed activity. Continue on a separate sheet if necessary.

All animals will be returned where they were caught shortly after capture. Animals will be kept safely out of water to allow data to be collected, handled with care and then returned with appropriate SOPs in place. Incidental by caught species will be returned immediately. Pots will be left to soak for short periods of time (24hrs-48hrs) to minimise time individuals spend inside pots.

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

SUSSEX
Inshore Fisheries and Conservation Authority

Section 3: Applicant declaration
Please enter the number of continuation sheets used. None

Please enter the number of supporting documents. None

I/we declare that:

I/we have read and understand the IFCA bye-laws and have complied with them, except as otherwise approved by the relevant IFCA; and

The information given in this form is to the best of my/our knowledge correct and I/we accept full responsibility for it.

I/we agree to share any findings and data with the relevant IFCA.

This declaration must be signed by all signatories to the agreement.

Signature(s)	Name(s) in BLOCK capitals	Title	Date
	FRANCESCO MARZANO	MR	22/7/2024

Warning
If you knowingly or recklessly make a false or misleading statement for yourself or anyone else, you risk prosecution.

Warning

If you knowingly or recklessly make a false or misleading statement for yourself or anyone else, you risk prosecution.

Conditions of Authorisation

1. At all times during the sampling the individual named on this authorisation must be present on the vessel (The Authority should be notified in advance if there is any change in responsibility).

2. Prior to commencing any fishing activity (to which this dispensation applies) verbal notification to the offices of the Sussex IFCA is required (contact number 01273

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

SUSSEX
Inshore Fisheries and Conservation Authority

454407), if no officer is available a message should be left on the available answer system.

3. This permission is granted in respect to sampling for scientific purposes only; whereby surveys will be undertaken in accordance with a cruise program described above.

4. If the vessel is fitted with an Automatic Identification System (AIS), this equipment is to be turned on and functioning at all times during the Survey within the Sussex IFCA District.

5. This original authorisation should be available to Fishery Officers during any inspection and kept on the vessel during the sampling period.

6. This authorisation applies only in relation to Sussex Inshore Fisheries and Conservation Authority Byelaws; it does not apply to British Statutory & EU Regulations regarding the control of fisheries. Dispensation for regulations other than Authority Byelaws is required from Marine Management Organisation.

7. The Authority has the right to rescind this authorisation without notice if the above conditions are not met as specified.

8. **The Authority wishes to highlight the likely presence of significant volumes of set static gear (pots and nets) within its District. Survey managers should be aware of these inshore fishing operations when navigating within the Sussex IFCA District and duly mitigate against any interactions with survey vessel and any sampling gears.**

On behalf of the Authority
Granted and signed by:

Tim Dapling
Acting Clerk for purposes of the Authority

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

SUSSEX
Inshore Fisheries and Conservation Authority

Chair: Professor Peter Jones
Chief Fisheries & Conservation Officer: R.J. Pearson MSc MIFM

Your Ref:
Our Ref: Blue Marine Survey Selsey 2024

e-mail: admin@sussex-ifca.gov.uk

Byelaw dispensation- Shellfish Permit Byelaw 2015
Sussex Inshore Fisheries and Conservation District

AUTHORISATION TO FISH FOR SCIENTIFIC OR BREEDING PURPOSES

Sussex Inshore Fisheries and Conservation Authority Byelaws shall, unless otherwise specified, apply to the whole of the District, provided that nothing in these Byelaws shall apply to any person fishing for sea fish for scientific purposes, or breeding purposes, under written authority signed by the Clerk and in accordance with any conditions contained in such Authority.

The Authority hereby authorise:

Section 1: Details of applicant

Name of Applicant(s)

Title: Mr
Forename: Francesco
Surname: Marzano
Email: Francesco@bluemarinefoundation.com
Phone: +447482008484
Business Name:

Blue Marine Foundation

Correspondence Address:

South Building
Somerset House
London
WC2R 1LA
United Kingdom

info@bluemarinefoundation.com

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

SUSSEX
Inshore Fisheries and Conservation Authority

Section 2: Request for derogation

From which bye-law(s) are you seeking derogation?

Shellfish Permit Byelaw 2015 - Wishing to remove escape gaps for scientific data collection of brown crab and European lobster

Location

Where will this activity take place? Please provide GIS Shape files (.tab or .shp) wherever possible and attach them to the application or, if sending co-ordinates please give them in Latitude/Longitude Decimal Degrees.

Inside and outside the Nearshore Trawling Byelaw. Proposed locations for deployment of pots are provided in the map below (red dots) along with a list of coordinates. These locations may move slightly depending on current fishing already deployed in these areas or other unforeseen circumstances. Exact locations of deployed gear will be supplied to Sussex IFCA during the survey period.

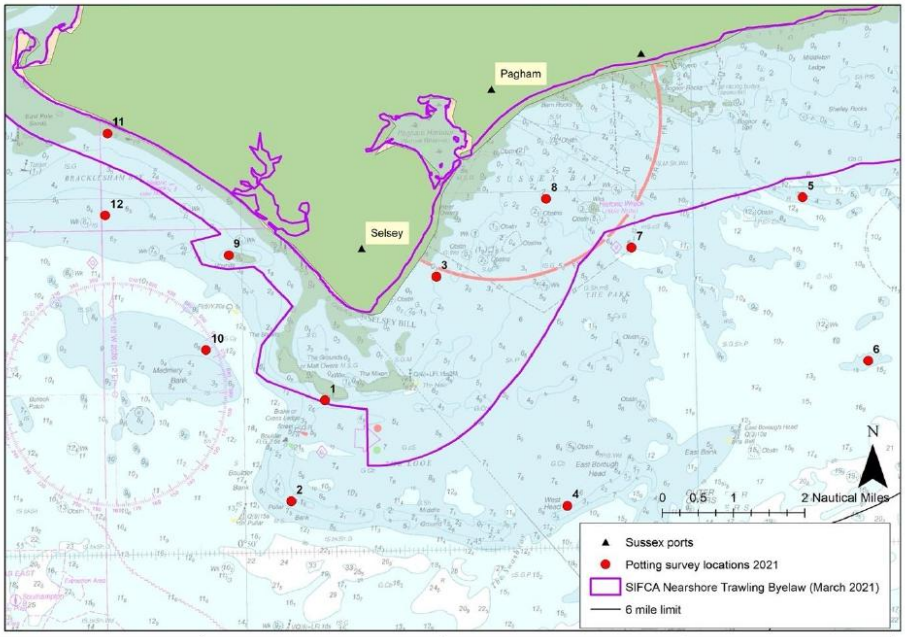


Figure 1. Draft map of survey locations (red dots). Produced by the Blue Marine Foundation

Table 1. Draft target sites

Site	Latitude	Longitude	Depth (m)
1	50 42. 134N	0 48.193W	2
2	50 40. 714N	0 48.976 W	7
3	50 43.780 N	0 45.749W	2
4	50 40.586N	0 42.895W	6

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

SUSSEX
Inshore Fisheries and Conservation Authority

5	50 44.792N	0 37.609W	4
6	50 42.562N	0 36.155W	7
7	50 44.187N	0 41.396W	6
8	50 44.887N	0 43.280W	3
9	50 44.182N	0 50. 301W	1
10	50 42. 860N	0 50.835W	6
11	50 45. 772 N	0 53. 122W	1
12	50 44. 756N	0 53. 067W	5

Time

Please provide details of the timetable for this project. Continue on a separate sheet if necessary and attach it to the application.

Derogation period 12th-18th of august 2024. This is longer than the proposed survey period but will to allow contingency for bad weather days. Pots will be deployed, hauled and data collection carried out on board the named vessel during this period.

Vessel details

Vessel name: Rapid return

Registry of Shipping Number: B10050

Port letters and numbers: LI77

Owner of vessel: Daniel Langford

Skipper of vessel: Daniel Langford

Gear description (including mesh size, tow speed and duration)
Parlour pots. A total of 40 pots in 2-3 strings. Deployed at proposed survey locations for no longer than 48 hrs unless weather restricts hauling. Pots will be baited and escape gaps will be closed.

Details of activity

Please give a description of the proposed activity including its purpose. Continue on a separate sheet if necessary.

A derogation is sought to allow the removal of/closing of mandatory escape gaps fitted within parlour pots used by the applicant in line with the Shellfish Permit Byelaw 2015. The derogation is sought from the 12th – 18th August 2024. The purpose for this derogation is to aid the capture of brown crab and European lobster individuals across a

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

SUSSEX
Inshore Fisheries and Conservation Authority

wide size and age range for scientific sampling. A project led by Blue Marine Foundation aims to assess changes in key crustacean fisheries following the introduction of the IFCA Nearshore Trawling Byelaw in

Sussex. Surveys will be carried out at multiple locations inside and outside the Nearshore Trawling Byelaw and data (abundance, condition, carapace size, wet weight, sex) will be extracted from caught brown crab and European lobster individuals. Conversations during the planning of this research project between Blue Marine Foundation and Sussex IFCA have ensured that the data being collected will compliment ongoing Sussex IFCA crustacean data collection and methods will be comparable where possible. Presence/absence of parasitic lice on European lobsters will also be noted to contribute to the data collection being led by North Eastern IFCA.

To aid accurate data collection it is important to collect data from a range of individuals within each population and understanding the current status of smaller individuals allows a more robust assessment of the wider populations of crab and lobster, hence the derogation application. The species abundance of bycaught species will also be recorded. This is the fourth year of an annual monitoring program to assess changes in the populations of these key commercially targeted crustaceans over time. Results will be published through interim reports by the funder/partners and distributed to a wide range of stakeholders. The project will complement the ongoing towed and baited underwater videos survey of the same area carried out in Summer 2021, 2022 and 2023. This research is part of the Sussex Kelp Restoration Project's overall research plan which aims to measure the impact of the Nearshore Trawling Byelaw on ecosystems, fisheries and local communities. This will allow benefits from the byelaw and associated impacts to be evaluated and quantified. The programme will be undertaken in collaboration with research organisations, regulators, fishermen, conservation groups, marine user groups and local communities.

Mitigation

Please give details of any mitigation taken to minimise the impact of the proposed activity. Continue on a separate sheet if necessary.

All animals will be returned where they were caught shortly after capture. Animals will be kept safely out of water to allow data to be collected, handled with care and then returned with appropriate SOPs in place. Incidental by caught species will be returned immediately. Pots will be left to soak for short periods of time (24hrs-48hrs) to minimise time individuals spend inside pots.

Section 3: Applicant declaration
Please enter the number of continuation sheets used.

Please enter the number of supporting documents.

I/we declare that:

I/we have read and understand the IFCA bye-laws and have complied with them, except as otherwise approved by the relevant IFCA; and

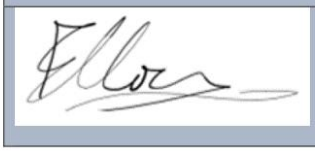
The information given in this form is to the best of my/our knowledge correct and I/we accept full responsibility for it.

I/we agree to share any findings and data with the relevant IFCA.

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

SUSSEX
Inshore Fisheries and Conservation Authority

This declaration must be signed by all signatories to the agreement.

Signature(s)	Name(s) in BLOCK capitals	Title	Date
	FRANCESCO MARZANO	Mr	6/8/2024

Warning

If you knowingly or recklessly make a false or misleading statement for yourself or anyone else, you risk prosecution.

Warning

If you knowingly or recklessly make a false or misleading statement for yourself or anyone else, you risk prosecution.

Conditions of Authorisation

1. At all times during the sampling the individual named on this authorisation must be present on the vessel (The Authority should be notified in advance if there is any change in responsibility).

2. Prior to commencing any fishing activity (to which this dispensation applies) verbal notification to the offices of the Sussex IFCA is required (contact number 01273 454407), if no officer is available a message should be left on the available answer system.

3. This permission is granted in respect to sampling for scientific purposes only; whereby surveys will be undertaken in accordance with a cruise program described above.

4. If the vessel is fitted with an Automatic Identification System (AIS), this equipment is to be turned on and functioning at all times during the Survey within the Sussex IFCA District.

5. This original authorisation should be available to Fishery Officers during any inspection and kept on the vessel during the sampling period.

6. This authorisation applies only in relation to Sussex Inshore Fisheries and Conservation Authority Byelaws; it does not apply to British Statutory & EU Regulations regarding the control of fisheries. Dispensation for regulations other than Authority Byelaws is required from Marine Management Organisation.

7. The Authority has the right to rescind this authorisation without notice if the above conditions are not met as specified.

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

SUSSEX
Inshore Fisheries and Conservation Authority

8. **The Authority wishes to highlight the likely presence of significant volumes of set static gear (pots and nets) within its District. Survey managers should be aware of these inshore fishing operations when navigating within the Sussex IFCA District and duly mitigate against any interactions with survey vessel and any sampling gears.**

On behalf of the Authority
Granted and signed by:

Tim Dapling
Sussex Inshore Fisheries and Conservation Authority Clerk

12a Riverside Business Centre, Brighton Road, Shoreham-by-Sea, West Sussex, BN43 6RE
Tel: 01273 454407 Fax: 01273 454408 Email: admin@sussex-ifca.gov.uk Website: www.sussex-ifca.gov.uk

Appendix E – Key Points Raised by Local Sussex Fishermen Between 2021-2024

- All fishermen were worried about increased sedimentation in the area. Increased sediment loads can smother rocky reef habitat and fill in holes where lobsters (especially juveniles) hide.
- The fishermen noted that local divers have seen increased sediment on the rocky reefs.
- Fishermen in Brighton explained that they noticed a sudden drop off in lobster numbers a couple of years ago (around 2017).
- Potential reasons for lobster declines were suggested as: sedimentation from the adjacent wind farm; algae or algal blooms; American lobsters released in the Channel; sewage regularly pumped into Brighton Marina that contains chemicals; waste dumping outside of Brighton Marina; dredge spoil from Brighton Marina dredging that is dumped outside the harbour; or all of the above.
- Brighton fishermen noticed their pots were coming up with 'gritty black mud and sediment'. Suggestions that chemicals in the water caused the sediment to stick together.
- In 2024, fishermen in Brighton said there was less gritty black mud and sediment coming up with the pots.
- Important that Blue Marine shares all research and results with local fishermen. In the past, the individuals in the industry that have helped researchers have not heard the results.
- The lobsters caught in 2024 looked dormant/weak at both Brighton and Selsey – fishermen have connected this behaviour to warmer waters
- Selsey fisherman informed us of 55 dead crabs coming up in his pots at the end of September

Appendix F – Conditions ordinal logistic regression

Table 42: Ordinal logistic regression for brown crab's condition in Selsey

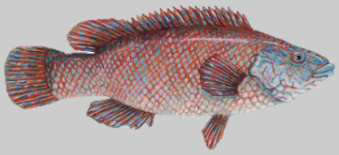
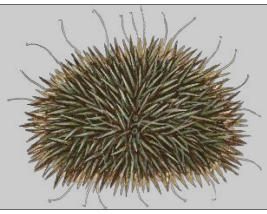
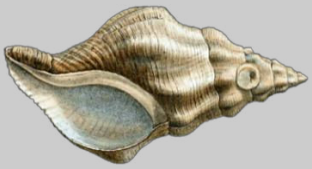
Brown crab ordinal logistic regression				
Predictor	*Value*	*Std. Error*	*t value*	*p value*
TreatmentOutside	0.0227	0.4156	0.054	0.9563
Year2022	0.977	1.049	0.9314	0.3516
Year2023	1.4519	0.5015	2.895	**0.0037**
Year2024	-0.307	0.6839	-0.4489	0.6534
Depth	0.0662	0.0883	0.7501	0.4532
Temp	0.9163	0.6952	1.3181	0.1874
1|2	17.3984	12.1471	1.4323	0.1521
2|3	19.2261	12.1515	1.5821	0.1136
3|4	19.7189	12.1519	1.6226	0.1046
4|5	21.4683	12.1605	1.7654	0.0774

Table 43: Ordinal logistic regression for brown crab's condition in Selsey

European lobster ordinal regression model				
Predictor	*Value*	*Std. Error*	*t value*	*p value*
TreatmentOutside	0.3279	0.664	0.4938	0.6214
Year2022	5.5972	3.5701	1.5678	0.1169
Year2023	1.3595	1.5458	0.8794	0.3791
Year2024	4.205	2.4612	1.7085	0.0875
Depth	-0.0508	0.1282	-0.3965	0.6916
Temp	-2.6842	1.8323	-1.4649	0.1429
1|2	-43.546	31.0684	-1.4016	0.161
2|3	-42.6681	31.0634	-1.3735	0.1695
3|4	-42.5809	31.0629	-1.3707	0.1704
4|5	-40.7176	31.0631	-1.3108	0.1899

Appendix G – Bycatch Latin Names

Table 25: Bycatch species identified during survey in 2024

Common name	Latin name	Picture of species
Ballan wrasse	*Labrus bergylta*	
Conger eel	*Conger conger*	
Green sea urchin	*Psammechinus miliaris*	
Hairy crab	*Pilumnus hirtellus*	
Hermit crab	*Pagurus bernhardus*	
Velvet swimming crab	*Necora puber*	
Whelk	*Buccinum undatum*	

Appendix H – Sea Temperature Changes Over Time

Table 26: GLM analysis for sea temperature in Brighton and Selsey between 2021 and 2024

	Temperature change		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	17.07	16.96 – 17.18	**<0.001**
as.factor(Year)2022	1.52	1.36 – 1.67	**<0.001**
as.factor(Year)2023	0.43	0.27 – 0.59	**<0.001**
as.factor(Year)2024	1.19	1.03 – 1.35	**<0.001**
LocationSelsey	0.13	-0.02 – 0.29	0.097
as.factor(Year)2022:LocationSelsey	-0.30	-0.52 – -0.08	**0.007**
as.factor(Year)2023:LocationSelsey	-0.42	-0.64 – -0.20	**<0.001**
as.factor(Year)2024:LocationSelsey	-0.43	-0.65 – -0.21	**<0.001**
Observations	248		
R^2	0.770		

Table 27: Post-hoc analysis for sea temperature in Brighton and Selsey between 2021 and 2024

contrast	*estimate*	*SE*	*df*	*t.ratio*	*p.value*
Year2021 Brighton - Year2022 Brighton	-1.5181	0.0797	240	-19.0389	**<.0001**
Year2022 Brighton - Year2023 Brighton	1.0874	0.0797	240	13.6380	**<.0001**
Year2023 Brighton - Year2024 Brighton	-0.7603	0.0797	240	-9.5356	**<.0001**
Year2021 Selsey - Year2022 Selsey	-1.2165	0.0797	240	-15.2562	**<.0001**
Year2022 Selsey - Year2023 Selsey	1.2029	0.0797	240	15.0863	**<.0001**
Year2023 Selsey - Year2024 Selsey	-0.7448	0.0797	240	-9.3415	**<.0001**
Year2021 Brighton - Year2021 Selsey	-0.1323	0.0797	240	-1.6587	0.7138
Year2022 Brighton - Year2022 Selsey	0.1694	0.0797	240	2.1240	0.4026
Year2023 Brighton - Year2023 Selsey	0.2848	0.0797	240	3.5723	**0.0100**
Year2024 Brighton - Year2024 Selsey	0.3003	0.0797	240	3.7665	**0.0051**