Eastern IFCA
Inshore Fisheries and Conservation Authority

European lobster stock assessment

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2019 EUROPEAN LOBSTER STOCK ASSESSMENT

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Summary

This report utilises data collected between 2012 and 2019 through MSARs and biometric sampling to assess the current stock status of the European lobster fishery within the Eastern Inshore Fisheries and Conservation Authority (EIFCA) district. Although the volume of landings for European lobster in the district is appreciably lower than that of brown crab, the significantly higher price per kilo for the species means that the overall annual value of the lobster fishery matches the annual value of the brown crab fishery. This highlights the local economic importance of this fishery. District-wide Landings Per Unit Effort (LPUE) values for the data reporting period of 2012-2019 are stable, suggesting local European lobster stocks across the district as a whole are stable and recruitment is sufficient to replace annual depletion from fishing.

ICES statistical rectangle 34F1, in which Cromer Shoal Chalk Beds MCZ is located, is the most important fishing ground for European lobster within the district where >49% of reported landings from MSARs are fished. A similar trend to the district wide fishery is evident where LPUE has remained relatively stable suggesting that the amount of effort taking place in this ICES rectangle is seemingly not causing the density of stock to decline. Trends in LPUE for the offshore fishing grounds represented by ICES rectangles 35F0 and 35F1 differ from those seen district wide and in 34F1. Following a peak in 35F0 in 2018 after a relatively stable data series, LPUE dropped considerably from 0.14 to 0.09. Results for 35F1 indicate that LPUE has been steadily decreasing since a peak in 2015, however has shown signs of an upward trend in 2019. Results suggests the amount of effort taking place in 35F0 and 35F1 may be putting the stocks under pressure, thus reducing density on the ground. However, the 95% confidence intervals are broad for the data reporting of 35F1, reducing our confidence in the reliability of the data and suggesting differences may be attributable to variability in the data.

This report indicates that from a purely population sustainability perspective the European lobster fishery in the EIFCA district is currently not under immediate threat. Measures introduced through the Cromer Shoal Chalk Beds MCZ commercial fisheries assessment will likely satisfy management requirements to ensure the stock maintains a good population status. MSAR reporting forms are currently being replaced by an electronic reporting system which may result in a temporary absence in data available to EIFCA, impacting our ability to analyse and assess the fishery for a period of up to years. Replacement of MSARs has come at a critical point in management of the European lobster/brown crab mixed fishery with the potential to impact the assessment of the effects of any management introduced. This may also have implications when assessing progress of the Fisheries Improvement Plan (FIP), the potting assessment in Cromer Shoal Chalk Beds MCZ and any economic impacts of management.

Introduction

Eastern IFCA initiated the current Crustacean stock assessment project in 2013, focusing on brown crab *(Cancer pagurus)* and European lobster (*Homarus gammarus*) stocks with the aim of developing the techniques necessary to conduct stock assessments at a localised level, building on the current understanding of potting fisheries operating within the district. Long term monitoring, coupled with input from the fishermen, enables a better understanding of impacts on the stock through fishing and ultimately informs management decisions in the fishery.

Historically, Eastern IFCA's European lobster and brown crab stock assessments have been reported together, but this year are reported separately. As such, this report focuses exclusively on the European lobster stock assessment.

Background to the fishery

As a mixed fishery, both European lobster and brown crab are important species for the fishing industry operating within the Eastern IFCA district, from Saltfleet in Lincolnshire, through Norfolk and down to the southern limits of the District in Harwich. European lobster forms an important economic element of potted catch in the district. Landings are generally only 8 – 10% those of brown crab, however due to the value per kilo for lobster being £12.50 – £18.50 it's a very important target species for the fishery. Although potting activity occurs throughout the district, it is particularly prevalent along the North Norfolk coast; an area with long standing historical and cultural traditions of fishing for these species.

Historically, the fishery was an inshore mixed species creel fishery operating within 2nm of the coastline (MAFF, 1975), primarily due to limitations of the vessels and equipment. The introduction of larger vessels and the capability to store and transport live animals in subsequent years has increased the range in which potters operate, enabling fishing grounds further afield to be utilised (Turner et al. 2009). During this period, the introduction of hydraulic pot haulers has improved the efficiency and speed at which pots can be deployed and hauled from a vessel. Coupled with the development of new markets for European lobster, allowing greater sales opportunities, these technological changes have resulted in a substantial increase in landings and effort as expressed by number of pots deployed in the fishery over the past 50 years. Due to these changes, the fleet is comprised of vessels with a range of varying capabilities, and a significant number still fish in close proximity to the shore on the historic fishing grounds around Cromer Shoal. While many of the fishers have replaced their traditional open-decked cobles and skiffs with larger boats, the majority of vessels targeting this fishery within the EIFCA District are still categorised as <10m. The small beach-launched cobles and skiffs that have been retained predominantly target inshore grounds, while the larger vessels, some of which are still beach-launched, have the capability to access stocks further offshore.

Potting fisheries use static gear consisting of strings, or *shanks*, of 20-30 baited pots which are typically left to soak for 24-48 hours before being hauled. Pots have changed in size and efficiency as fishing practices have developed. Creels were historically used, however the mid-20th century saw the introduction of larger parlour pots increasing the yield per pot (figure 1). Catch is sorted at sea, with any undersize or poor-quality individuals returned immediately, whilst the remainder is sold to processors, restaurant outlets and local fishmongers once landed.

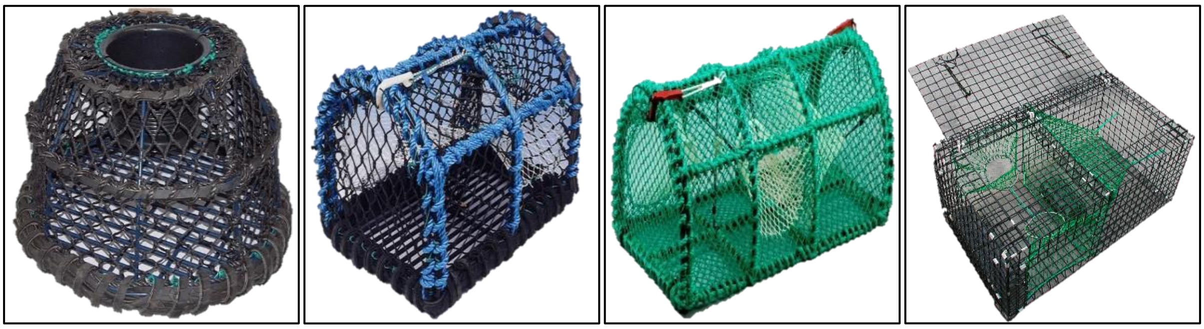

Figure 1. Various pot designs from traditional inkwell and creels to modern parlour and PVC coated wire.

European lobster – Biology and Ecology

Figure 2. European lobster (H.gammarus).

The population range for European lobster extends from Scandinavia to North Africa, however, they are mainly centred around the British Isles where a large proportion of annual landings occur (Cefas, 2020). *H. gammarus* is one of the most commercially exploited shellfish species found in UK waters and has one of the highest value/Kg. They occupy solitary shelters in rocky substrate and crevices between rocks and boulders and availability of suitable habitat of this type has been suggested as a key driver in influencing the carrying capacity and size structure of *H. gammarus* populations. Moulting occurs in summer approximately once a year for adults, becoming less frequent in older animals, and mating occurs soon after the female has moulted. After the eggs hatch the larvae are in the water for 3-4 weeks before the first juvenile stages settle on the seabed. Larval distribution depends on local hydrographical conditions and the behaviour of individuals. With significant time spent in the plankton, the probability of individual larvae surviving is low and consequently recruitment levels are highly variable. Both sexes are considered fairly sedentary, although some inshore/offshore and longshore migration is known to take place at some locations (Cefas, 2020).

Current fisheries management

The EIFCA district extends from Saltfleet in Lincolnshire, through Norfolk and down to the southern limits of the District in Harwich and 6nm out to sea. Within this area, the European lobster fishery is subject to local management in the form of EIFCA byelaws, as well as national and European legislation (table 1). The European lobster fishery is currently managed nationally through Marine Management Organisation (MMO) licensing and regionally by IFCA byelaw. International EU regulations set limits on minimum landing size (MLS). EU minimum landing size restrictions of 87mm carapace length for European lobster are reflected in UK law by statutory instrument. In the Eastern IFCA District vessels fishing for lobster and brown crab must have a licence with a shellfish entitlement issued by the MMO. The quantities that are permitted to be landed are not restricted. Owners of vessels that are 10m and under with a shellfish entitlement were previously required to complete Monthly Shellfish Activity Returns (MSARs) for all landings of lobster and crab and submit them on a monthly basis to the Marine Management Organisation (MMO), however this has now been replaced by an electronic reporting system. Vessels over 10m in length are exempted from MSAR recording but their fishing activities must be recorded in an EU logbook and submitted to the MMO. The lobster and crab fishery is not subject to EU TAC regulations or national quotas. Details of the regulations relevant to the fishery are outlined below in table 1.

Table 1.Regulations relevant to trap fisheries targeting European lobster in the Eastern IFCA district.

Regulation	Effect	Intent
MMO Vessel Licencing shellfish permit	Prohibits the fishing for shellfish without relevant permits	Limits entry into the fishery as no new additional permits are being issued.
Council Regulation 850/98 ANNEX XII for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms.	Prohibits landing of organisms below minimum legal landing sizes (115mm CW for brown crab, 87mm CL for European lobster)	Prevents removal of organisms from the fishery before reproductive maturity is reached.

Lobster and Crawfish (Prohibition of Fishing and Landing) Order 2000	Prohibits fishing for, and landing of, lobsters and crawfish bearing a V notch or mutilated in such a manner as to obscure a V notch.	Protects brood stock that has been marked for protection using a V notch cut into the tail of the animal.
EIFCA Byelaw 6: - Berried (egg-bearing) or soft-shelled crab (*C. pagurus*) or lobster (*H. gammarus*)	Prohibits removal from the fishery any edible crab or lobster that is soft-shelled or bearing eggs.	Protection of current and future brood stock and prevention of poor practice in landing low quality catch.
EIFCA Byelaw 7: - Parts of shellfish	Prohibits landing of edible crab (*Cancer pagurus*), Velvet crab (*Necora puber*) or lobster (*Homarus gammarus*) or parts thereof which cannot be measured to ensure compliance with MLS.	Closes a loophole where parts of undersized animals could be landed potentially removing immature organisms from the fishery.
EIFCA Byelaw 9: - Redeposition of shellfish	Requires that any shellfish, the removal of which is prohibited, be returned to the sea immediately and as near as possible in the place from which they were taken.	Ensures that organisms are returned the habitat from which they were taken, thus ensuring a greater chance of their survival on return to the sea.

The Authority's Strategic Assessment identified management of the District's crustacean fishery as a high priority based on limited regulation to address effort, gear or catch control combined with low confidence in activity data. This prompted the consideration of management needs driven by the following points:

- Assessments indicating that stocks are approaching or exceeding exploitation rates that would be required to achieve Maximum Sustainable Yield (MSY).
- Requests from the industry to consider revised management.
- Obligations under the Marine and Coastal Access Act 2009 (MaCAA) to manage the exploitation of sea fisheries resources in its district
- Duties under Section 153 of the Marine and Coastal Access Act (2009) to ensure the sustainable exploitation of sea fisheries resources and;
- Achieving good environmental status in all EU marine waters by 2020 set by the Marine Strategy Framework Directive (2008).
- Descriptor 3: Commercial Fish and Shellfish, as described in the Marine Strategy Framework Directive (MSFD), implies that stocks should be:
    1. exploited sustainably consistent with high long-term yields
    2. have full reproductive capacity in order to maintain stock biomass and;
    3. the proportion of older and larger fish/shellfish should be maintained (or increased) being an indicator of a healthy stock

Furthermore, the EIFCA Strategic Assessment 2019 outlines assessing the impact of fishing activities on the Cromer Shoal Chalk Beds (MCZ) and delivering management measures (if required) as a high priority, providing a concurrent driver to establish management measures for the fishery.

Commercially exploited stocks should be in a healthy state and exploitation should be sustainable, yielding the Maximum Sustainable Yield (MSY). This increases the pressure to ensure that management measures are in place to support the sustainability of commercially exploited stocks. Based on this, and in line with duties under MaCAA and MSFD, requirement for the introduction of technical measures[1] may be necessary to address issues identified within the fishery.

The benefits of introducing technical measures include (depending on the technical measure used) some or all of the following:

- increasing population size
- affording protection to a higher proportion of mature individuals
- reducing incidental mortality on immature individuals in the stock and;
- improve spawning and subsequent recruitment within the stock.

Some potential impacts of introducing technical measures include:

- Increases in MLS will result in a reduction in retention for some time
- Associated costs of gear changes needed

[1] Fisheries technical measures are rules that determine the way fishermen are allowed to fish e.g. mesh size, minimum landing size and gear size.

Assessment Areas

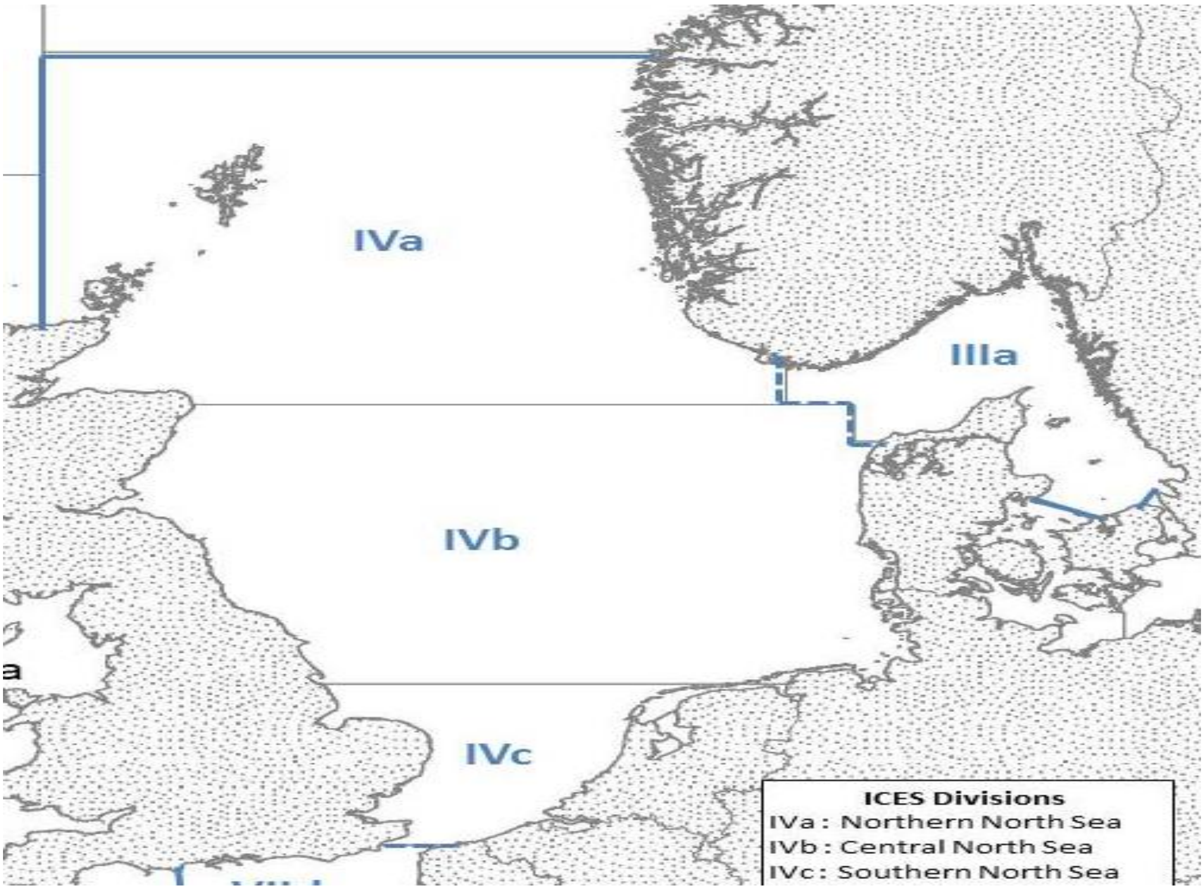

Figure 3. ICES subdivisions of the North Sea including IVc, classed as the Southern North Sea in which the Eastern IFCA district is located.

To facilitate the analysis and assessment of fished stocks in the North Sea, the International Council for the Exploration of the Sea (ICES) divide the North Sea into 3 broad areas (figure 3); IVa, classed as the Northern North Sea, IVb classed as the Central North Sea and IVc classed as the Southern North Sea; the latter inclusive of the area for which EIFCA is the relevant Authority. These are further divided into gridded Statistical Rectangles providing greater resolution. Statistical Rectangles are used to define boundaries of grounds fished by operators in the district, enabling analysis on a site-by-site basis (figures 4-8). Assessment of the fisheries is supported by the requirement of fishers to submit either electronic reports, replacing MSAR forms or EU logbooks, clearly stating which ICES Statistical Rectangle has been fished in. Effort and catch are unevenly distributed throughout the fishing grounds within EIFCA's jurisdictional boundary (heavier black line) and are concentrated in certain areas, corresponding closely with the position of major ports associated with the fishery and key production areas located off the North Norfolk coast.

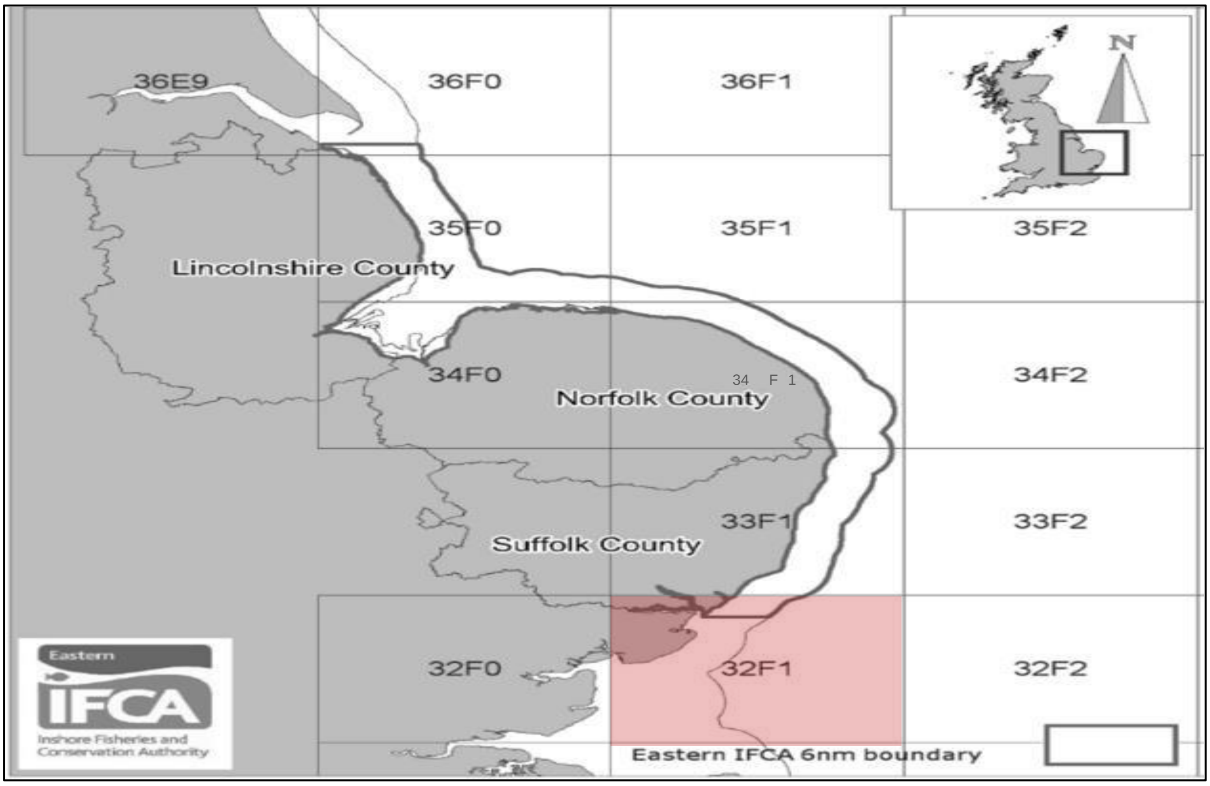

Figure 4. ICES Rectangle 32F1, located at the southern extremity of the district, overlaps with Kent and Essex IFCA and is fished by a small number of vessels from the EIFCA district, reflected by relatively low levels of reported effort and landings.

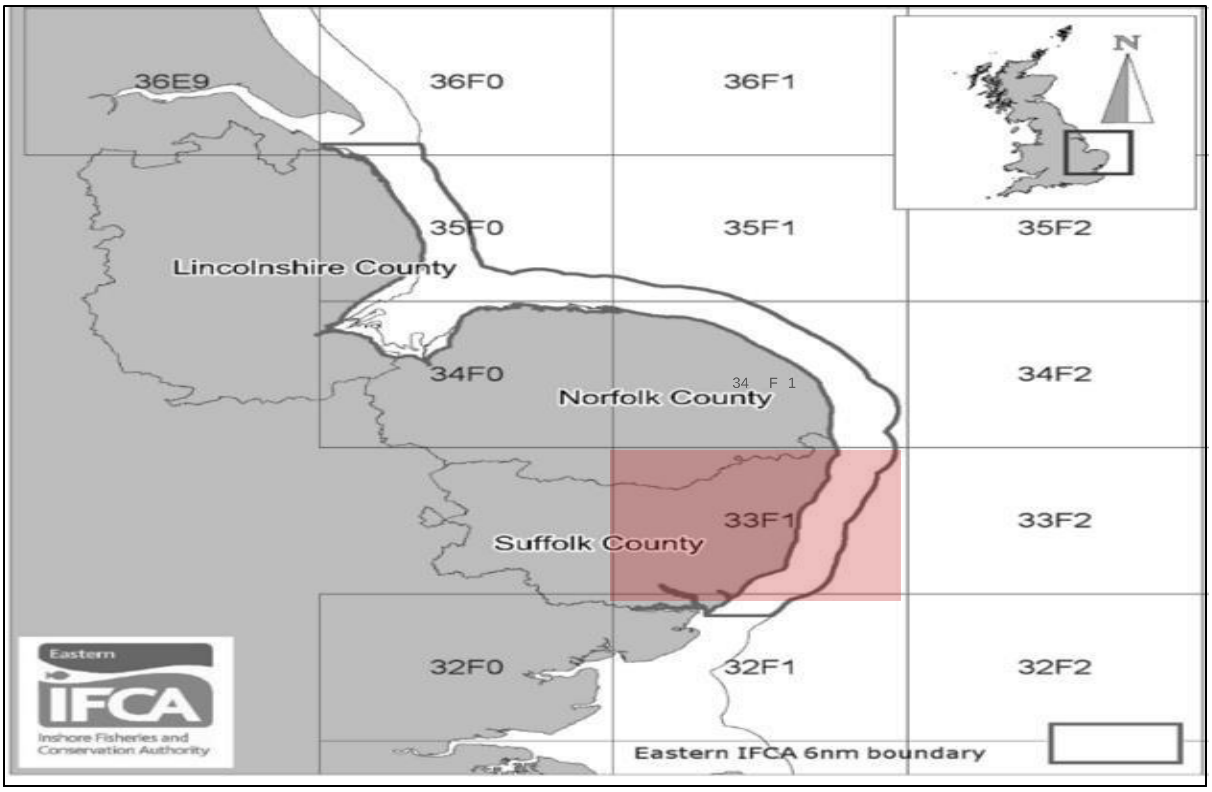

Figure 5. ICES Rectangle 33F1, situated off the Suffolk coast, covers an area between the Orford and Lowestoft. A comparatively small number of vessels fish this area, reflected in the relatively low landings and effort compared to the Norfolk coast.

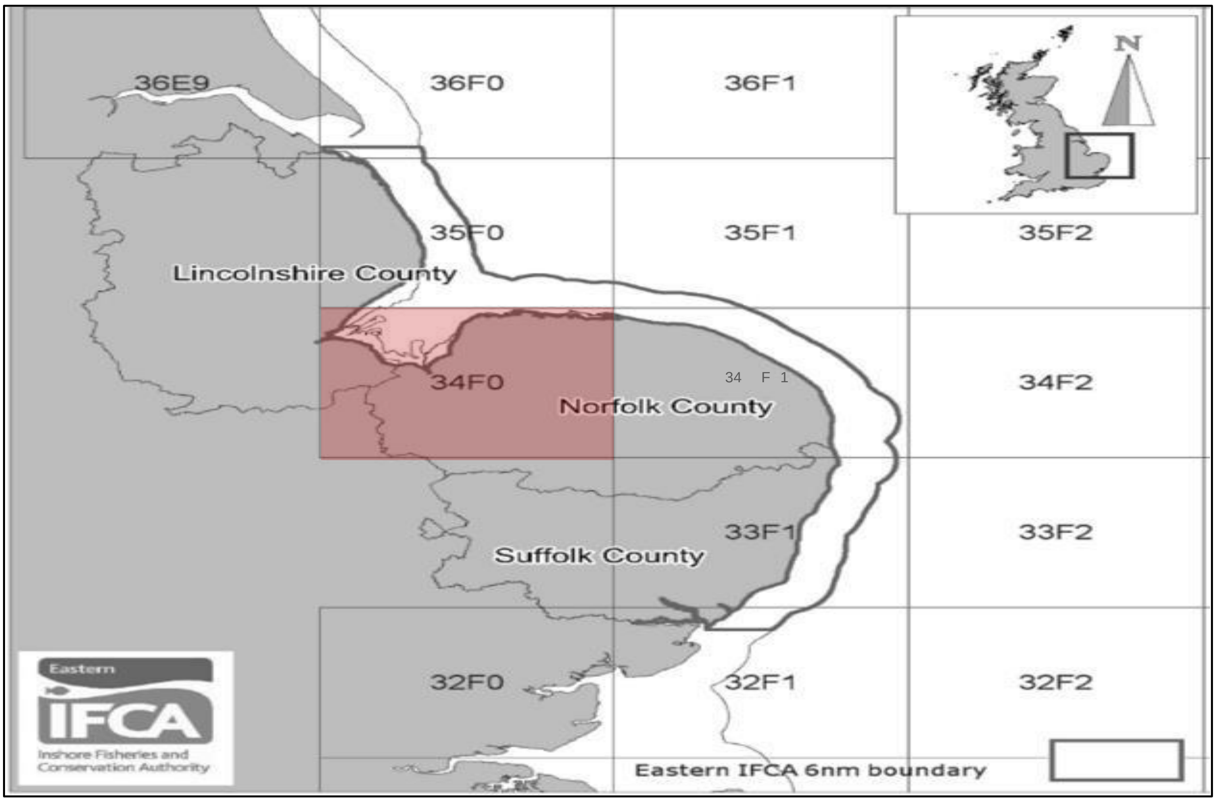

Figure 6. ICES Rectangle 34F0 straddles the Norfolk/Lincolnshire border, including the Wash and a partial section of the North Norfolk Coast. Relatively low effort is currently dedicated to crab and lobster fishing in the area.

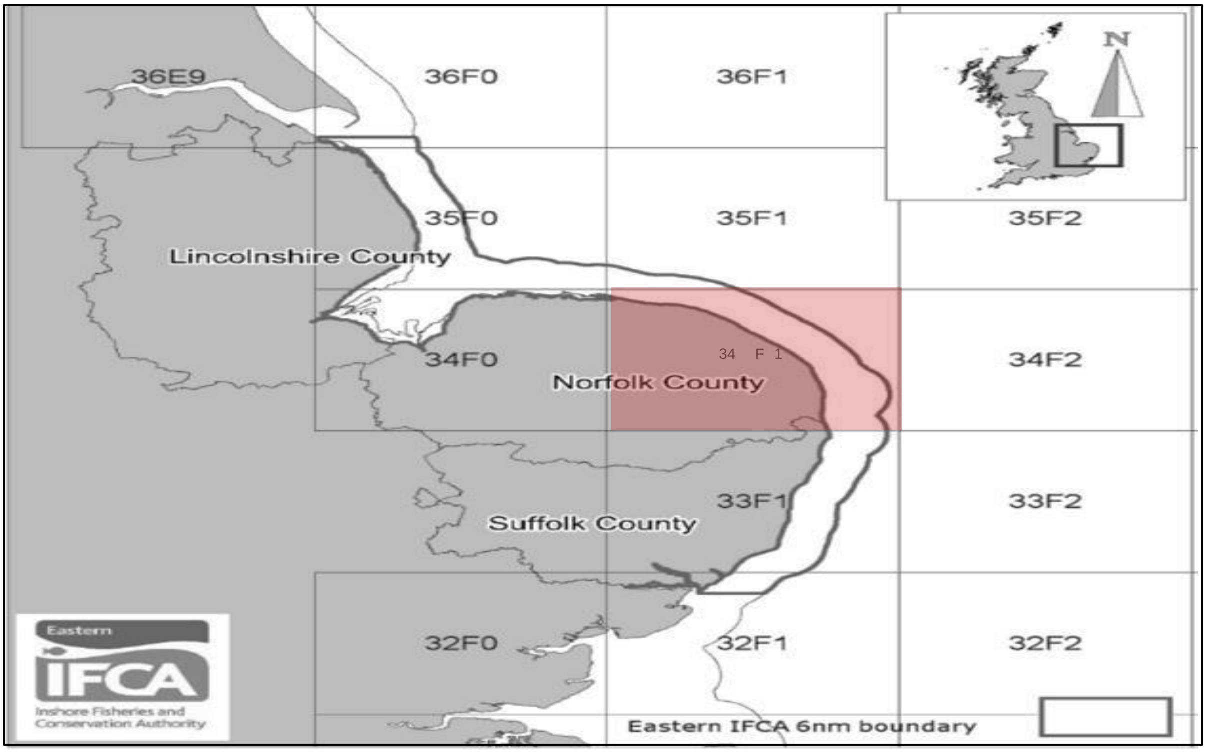

Figure 7. ICES Rectangle 34F1 contains the primary fishing grounds for vessels operating out of Cromer and is fished by many vessels from ports along the North Norfolk coast.

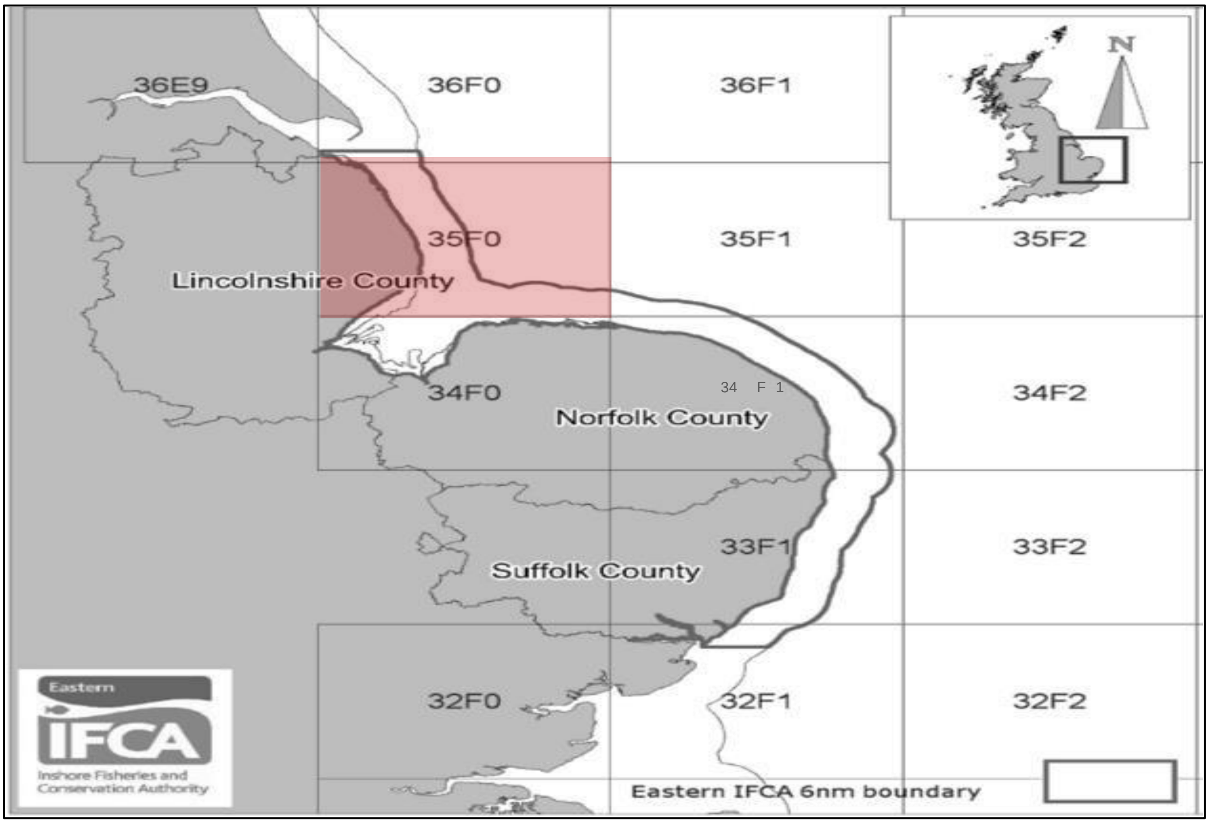

Figure 8. ICES Rectangle 35F0 is the main offshore potting ground fished by vessels operating out of Wells and Lincolnshire.

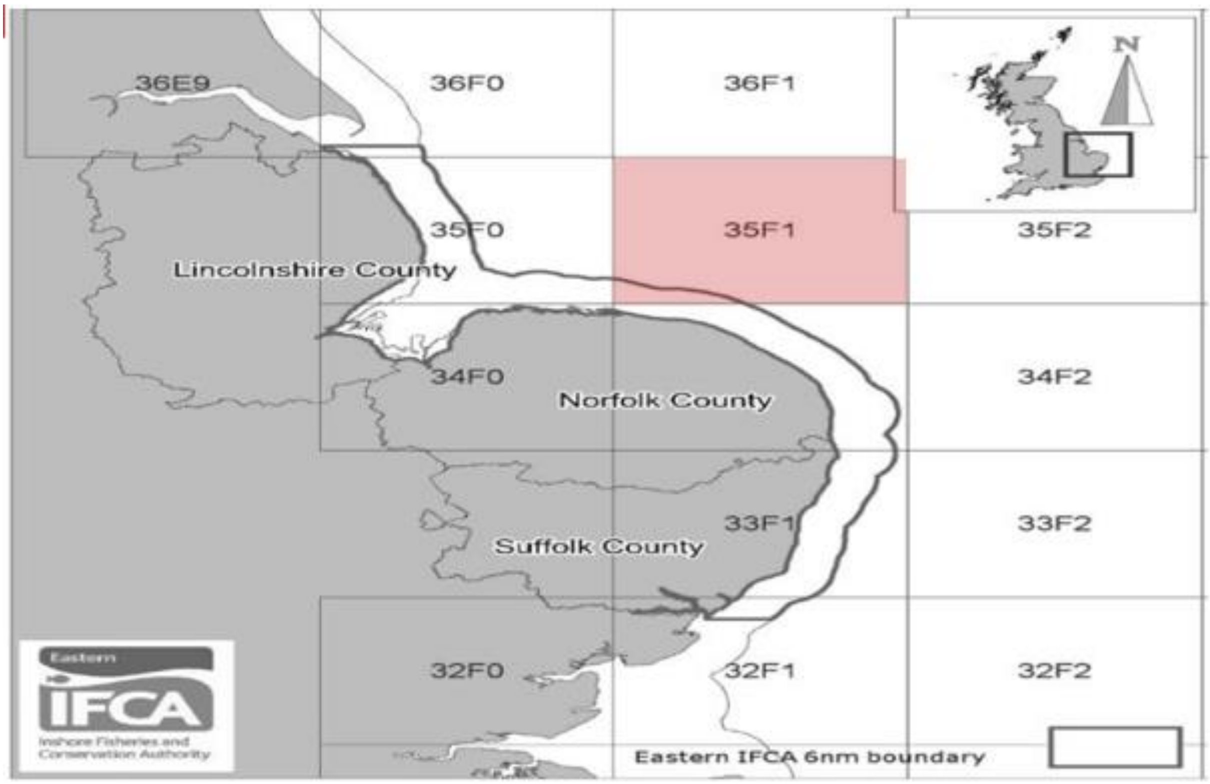

Figure 9. ICES Rectangle 35F1 is fished by larger offshore vessels from around the district.

Data sources utilised for assessing stock metrics

Landings and Effort Data – Monthly Shellfish Activity Returns (MSARs)

Monthly Shellfish Activity Returns (MSARs) are standardised forms in which fishers report their catch to the Marine Management Organisation, with a copy going to Eastern IFCA. They form a foundation dataset which arrives primarily in paper format. These data are entered into a bespoke Access database, which can be queried to extract particular components. Submission of MSARs has been obligatory for shellfish entitlement holders operating vessels <10m since 2006, providing daily records of fishing activity including; areas fished (by ICES Statistical Rectangle), landings (kg), effort (number of pots hauled) and port of landing. MSAR data are used to generate statistics on landings and effort annually, monthly or daily; by port, area fished or vessel. This information provides an overview of the fishery; highlighting productive grounds, relative port activity and concentrations of fishing activity. Landings and effort data can be further utilised to determine LPUE by ICES rectangle. LPUE can be used conservatively as a proxy for stock abundance, potentially highlighting areas with higher LPUE as having higher population densities (Welby 2016).

The Marine Management Organisation (MMO) has now launched the catch recording (e-reporting) service for the under 10m fleet. The service was implemented across all under 10m vessels in a phased approach between November 2019 and January 2020 and will replace the current paper MSAR method, enabling more accurate digital records for all under 10m vessels and will be a future licence condition. Importantly, the data gathered will also benefit the industry and be critical in providing better science to inform stock assessments and support future sustainable management. At the time of writing (February 2021), Eastern IFCA currently doesn't have access to the data from the catch reporting service, therefore, these data have not been included in the overall landings and effort reported below.

MMO UK fisheries statistics

UK fisheries statistics, published annually by the government, provide data on annual landings figures by fishery for the 10m and under and the over 10m vessel categories. However, they do not provide information on fishing effort in terms of pot hauls from which LPUE calculations can be calculated. Landings figures are very different when comparing MSAR and MMO landings statistics data for the under 10m fleet. This is primarily due to the method used to capture the data within each database. It is compulsory for all under 10m vessels to submit details of their catches in MSAR forms, so in theory, the MSAR database should contain details of all catches made by this sector of the fleet (albeit, landings weights are estimated by the fishermen). By contrast, the MMO landings data are derived from sales notes generated when fishermen sell their catch to a registered buyer or seller. Critically, sales notes are not required to be submitted when catch is sold directly to the public, or for individual sales smaller than 25kg. Because of the nature of this fishery, where much of the catch is sold in small quantities and/or direct to the public, possibly via their own shops, these landings are not captured by the MMO database. Landings figures from these two data sources are, therefore, non-comparable, but it is important to understand these differences when looking at landings figures for the fishery as a whole.

In addition to under 10m landings data gleaned from both MSARs and MMO landings data, the MMO landings data, based on sales notes, also provides data for vessels over 10m. Figure 10 highlights the total annual landings attributable to the over 10m fleet when compared with landings gleaned from the MSAR data for the under 10m fleet. This provides an overview of the total landings by vessels of both categories within the district. Because effort data, in terms of pot hauls, is not included within the MMO landings data, however, these additional landings data are not comparable with the LPUE calculation made in this report based on pot haul data obtained from MSAR data. It should always be remembered, however, when viewing trends in LPUE derived from MSAR data alone, that they do not incorporate data from the entire fleet.

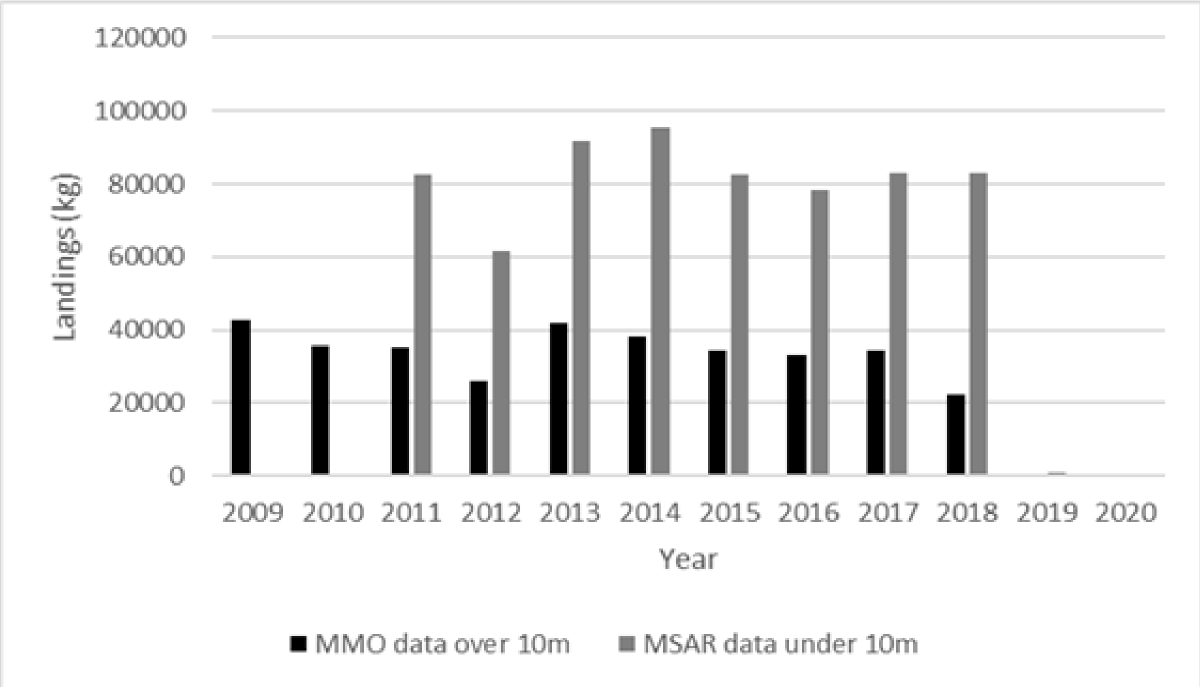

Figure 10. Comparative data for landings from vessels >10m (MMO data) and <10m (MSAR data).

Analytical tools for assessing crustacean stocks

Catch Per Unit Effort (CPUE) and Landings Per Unit Effort (LPUE) are measures that are both commonly used to assess the abundance of stock by looking at the size of catch or landings in relation to the amount of effort (in this case, pot hauls) that was used to catch them. There are known issues with these metrics, however, as they both assume the catches seen within pots (for CPUE) or landed (for LPUE) are representative of those species on the ground. However, in reality, several mechanisms may influence catchability, reducing the linkage between these metrics and the stock on the ground. These include the biological and behavioural aspects of the lobster, for example females not feeding when brooding and therefore not being caught. Changes to the efficiency of fishing vessels and gear, and the experience and knowledge of the crew when deploying gear in the fishing grounds generally result in greater efficiency, resulting in improved CPUE and LPUE values that could mask an overall decline in stock. Seasonal variability in the behaviour of the target species during breeding and spawning times that affects their vulnerability to be captured will also have seasonal impacts on CPUE and LPUE. There are also inter-specific and intra-specific behaviours that can affect the number of animals that are likely to enter a pot. CPUE is invariably calculated without reference to the targeting behaviour of the fishing fleet or the behaviour of individual animals in and around the pots, and with limited understanding of the selectivity and sampling efficiency of baited pots. Baited pots selectively sample portions of target species and although some of this selectivity is intentional, for example through the use of escape gaps, crustacean mobility and behavioural interactions that contribute to catchability is not. Therefore, numbers and distributions of individuals within pots may not be representative of relative abundance and distribution of the larger population leading to complex and interchangeable relationships between CPUE and abundance (Skerritt et al. 2020).

Skerritt et al. 2020, in a study to improve understanding the interactions associated with the simultaneous capture of European lobster and brown crab found that the proportions and quantities of the species fished within a mixed-species fishery varies seasonally, diurnally, spatially and with vessel targeting behaviours, noting that competitive interactions between individuals of the same species (intra-specific) and different species (inter-specific) is likely to affect the observed catch. When looking at the impacts of inter- and intra-specific interactions on CPUE and LPUE values affecting crustacean trap fisheries and their implications for management, they identified that the accurate measurement of CPUE based on catch and effort data collected from a mixed species potting fishery, is influenced by underlying species interactions.

In addition to factors that influence both CPUE and LPUE, there are further ones specific to LPUE. While LPUE is commonly used as a proxy for CPUE because it is much easier to measure landings than the catch at sea, LPUE can only quantify the landed component of the catch and does not account for the unknown fraction that may have been discarded at sea. Provided discard rates remain relatively consistent over time, LPUE is a reasonable proxy for CPUE. However, that assumption cannot be guaranteed, particularly as changing market demands may affect how much of a catch is landed, possibly resulting in more or less discards. There are also compounding issues that arise from mixed fisheries if any seasonal, temporal or biological variables that impact either species cause the fishers to redirect the usual focus of their target species.

While it is important that the implications of all of the above factors are understood when utilising CPUE or LPUE to assess a stock, it is nevertheless difficult to quantify them. While they make CPUE and LPUE unusable as tools for calculating the actual size of a stock at any given time, if the assumption is taken that these limitations will remain roughly stable from year to year, they can provide insight into how stable the fishery is over time. A steadily declining LPUE over successive years would be cause for concern that the stocks were declining, while a stable trend in LPUE would indicate the fishery was either operating sustainably or had reached equilibrium at a sub-optimal plateau. For all their limitations, CPUE and LPUE are still among the most commonly used tools for assessing crustacean stocks. LPUE has been used in this assessment due to the availability of landings and effort data provided by the MSAR forms.

Assessing LPUE from MSAR data

Some fishers use MSAR forms to record other species than crustacea. It is important, therefore, when analysing the data that such records are removed as failure to remove effort targeting other species (e.g., whelk) would inflate the apparent effort with no respective gain in landings. During the data-cleaning process, outliers were also sought that indicated errors had either been made on the original recording form or while being entered into a digital format. These included instances in which crustacea landings were recorded but had zero associated effort, or effort was recorded but had no landings data. Other data were removed where the resultant LPUE appeared impossibly high for that weight of lobsters to be present in a pot.

In some cases, lobster and whelk were recorded for the same trip, indicating fishers were probably targeting both fisheries the same day with different pots. As it could not be discerned from the forms, however, what proportion of the effort had been targeted at each species, these records were also removed from the LPUE calculations. Because the crab and lobster fishery is a mixed fishery, many reports contained landings of both species.

In most cases the volume of crab compared to lobster indicated that crab was the main target species, but in a small number of cases, it appeared lobster may have been the primary target. LPUE for European lobster has been calculated with the assumption that effort targeted both species simultaneously, therefore all pots that fished mostly crab and a small proportion of lobster have been included in LPUE calculations.

For the analysis of trends in landings and effort, consistent data is available since 2012. Data for the years preceding 2012 are not reliable due to very low numbers of records within EIFCA's digitised database, so have been removed from the following analysis.

Based on the MSAR returns for vessels fishing within the Eastern IFCA district, landings of European lobster peaked at 98.4 tonnes in 2015, decreasing to 82.4 tonnes through 2016 and 2017 and then climbing to approximately 87 tonnes through 2018 and into the 2019 fishery (figure 11). The number of pot hauls in the EIFCA district over the same time period has fluctuated and in 2019 totalled 671,001 from a peak of 717,818 in 2012 (figure 12). Landings per unit effort (LPUE) has remained relatively stable across the data reporting period of 2012 – 2018, fluctuating annually between 0.13 Kg/pot haul and 0.14 Kg/pot haul. LPUE increased slightly in 2019 to 0.16 Kg/pot haul whilst landings and effort remained relative stable. Although landings of *H.gammarus* are significantly lower than *C.pagurus,* a much higher market value for the species makes it an important element of this mixed species fishery.

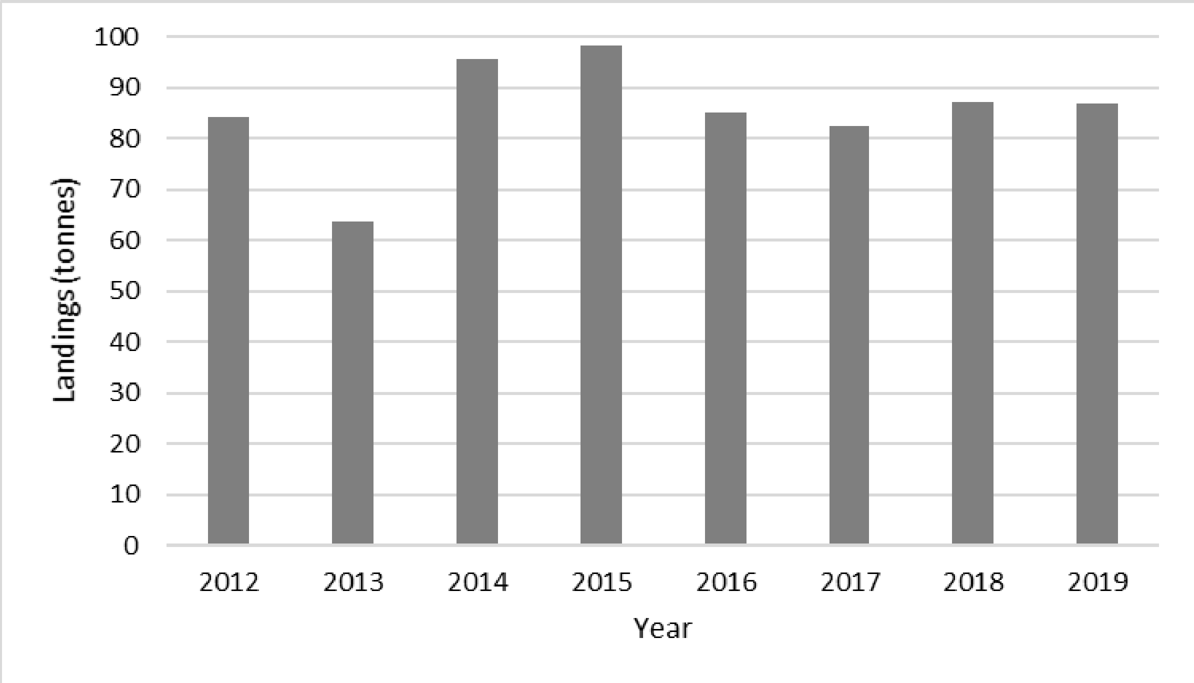

Figure 11. Annual European lobster landings (tonnes) in the district between 2012 and 2019.

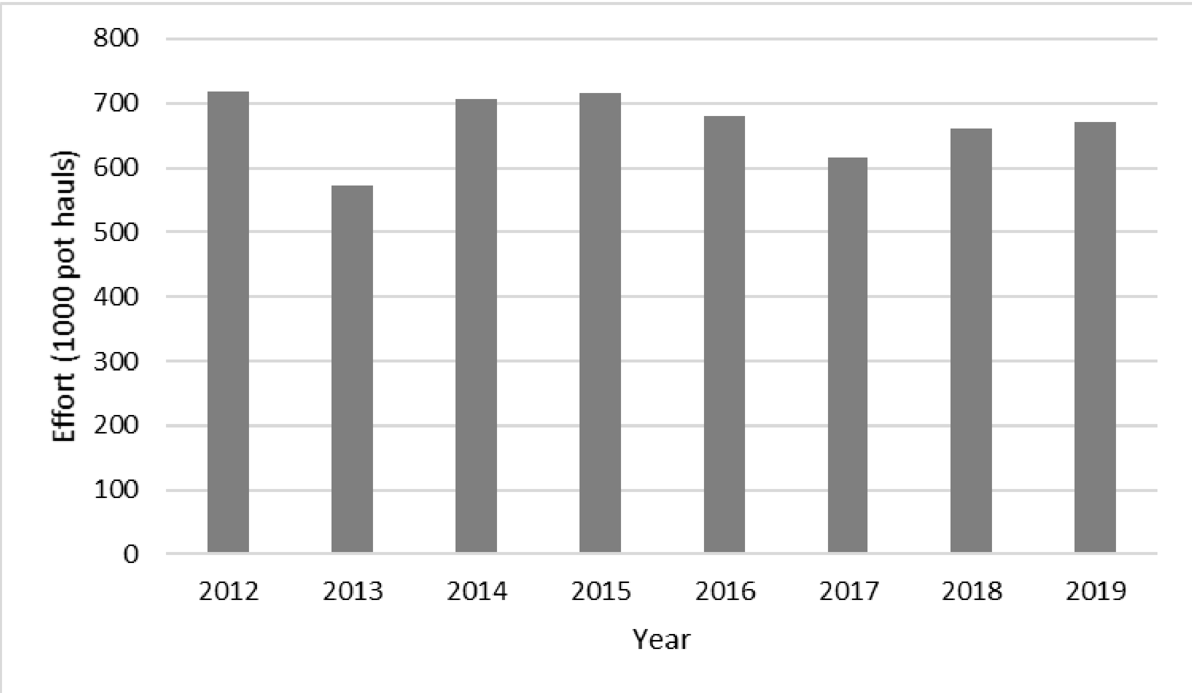

Figure 12. Annual European lobster effort (number of pot hauls) in the district between 2012 and 2019.

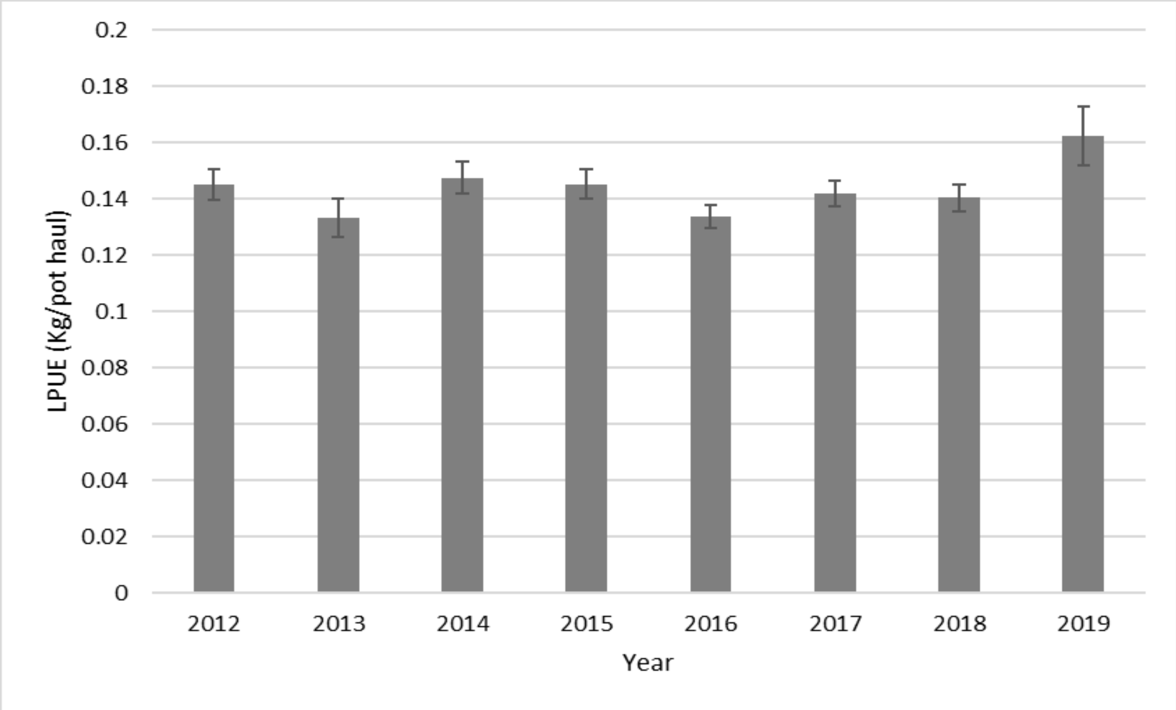

Figure 13. Annual LPUE for European lobster including 95% confidence intervals in the district between 2012 and 2019. LPUE has been calculated for each individual MSAR entry and the mean determined from the averaged values combined.

Table 2.Summary statistics for European lobster in the district wide fishery.

Year	Effort (number of pot hauls)	Lobster Landings (tonnes)	LPUE (kg/pot haul)
2012	717,818	84.3	0.14
2013	571,963	63.6	0.13
2014	706,781	95.6	0.14
2015	714,911	98.4	0.14
2016	680,316	85.2	0.13
2017	616,315	82.4	0.14
2018	660,903	87.2	0.14
2019	671,001	87	0.16

The 95% confidence intervals (figure 13) indicate a narrow margin of error for 2012 to 2019. This is most likely due to the large number of data entries that were averaged to form each year's LPUE calculation. The margin of error increases considerably for 2019, most likely attributable to reduced numbers of data entries.

Analysis of individual ICES statistical rectangles between 2012 and 2019

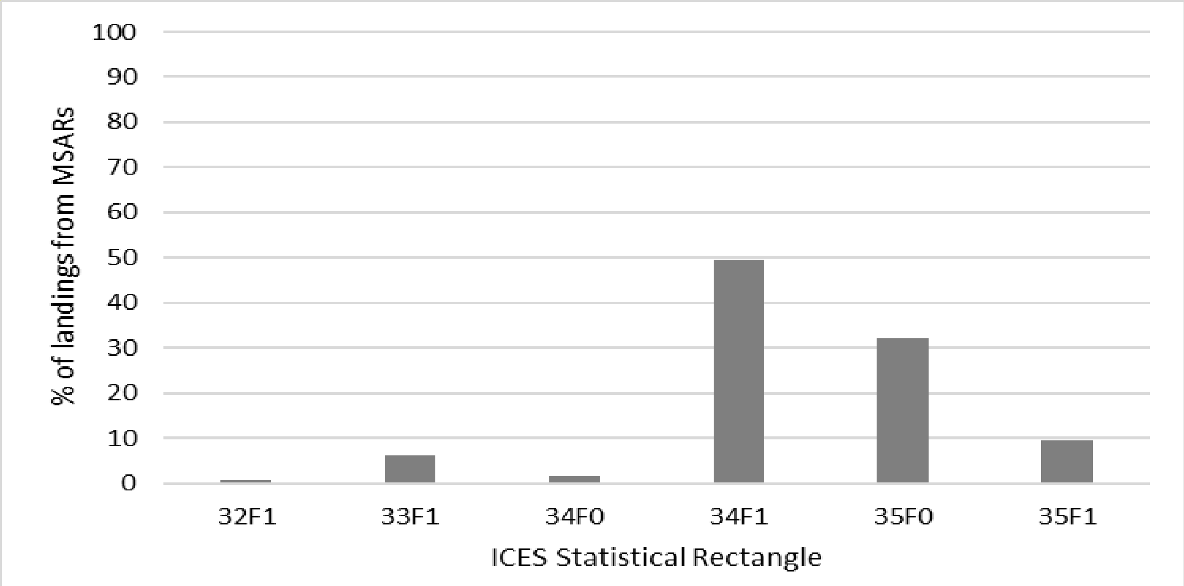

Figure 14. Percentage of landings for European lobster attributable to each of the individual ICES statistical rectangles.

The largest amount of landings and effort are in 34F1 and 35F0, making up 49.5% and 32.2% of total annual landings, respectively. Annual landings and effort in ICES statistical rectangles 32F1, 33F1 and 34F0 are appreciably lower. Because of the relatively high levels of effort directed towards 34F1 and 35F0, and the known importance of 35F1 for the larger offshore vessels in the district, these three areas have been explored in more detail below.

__ICES statistical rectangle 34F1__

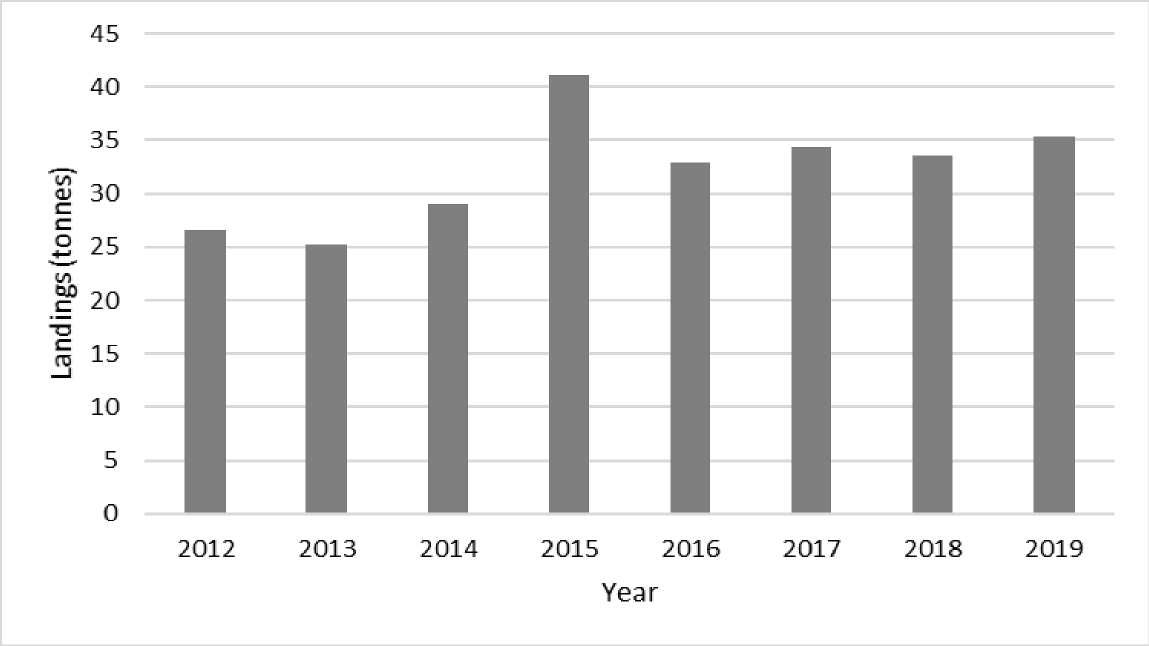

Figure 15. Annual European lobster landings (tonnes) derived from MSARs in ICES statistical rectangle 34F1.

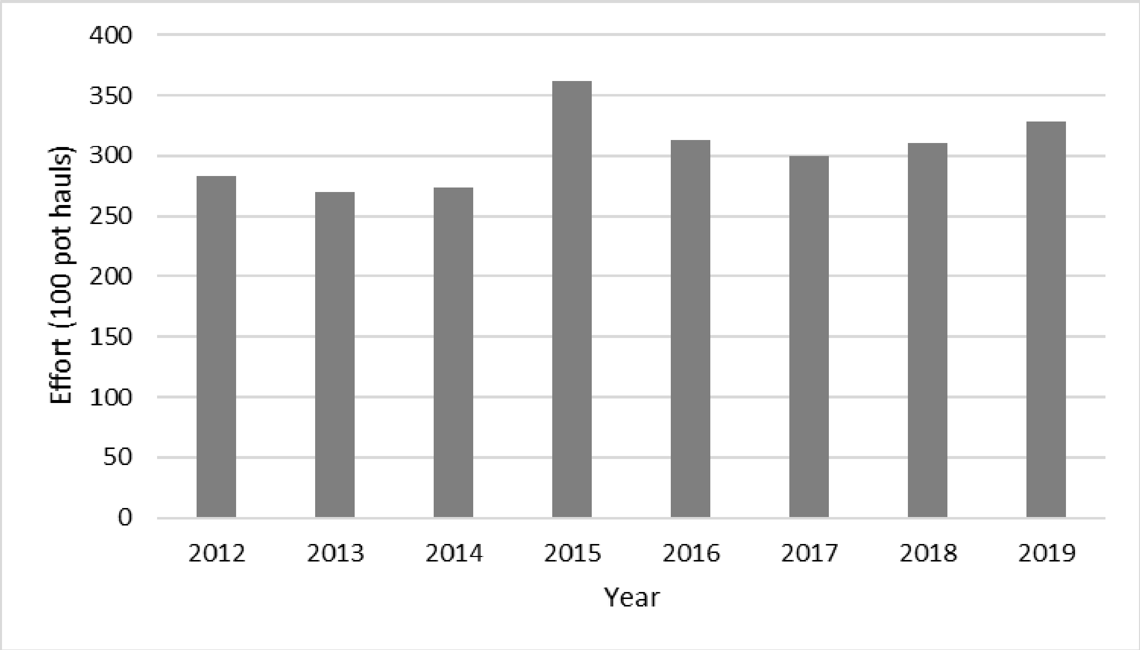

Figure 16. Annual European lobster effort (number of pot hauls) in ICES statistical rectangle 34F1.

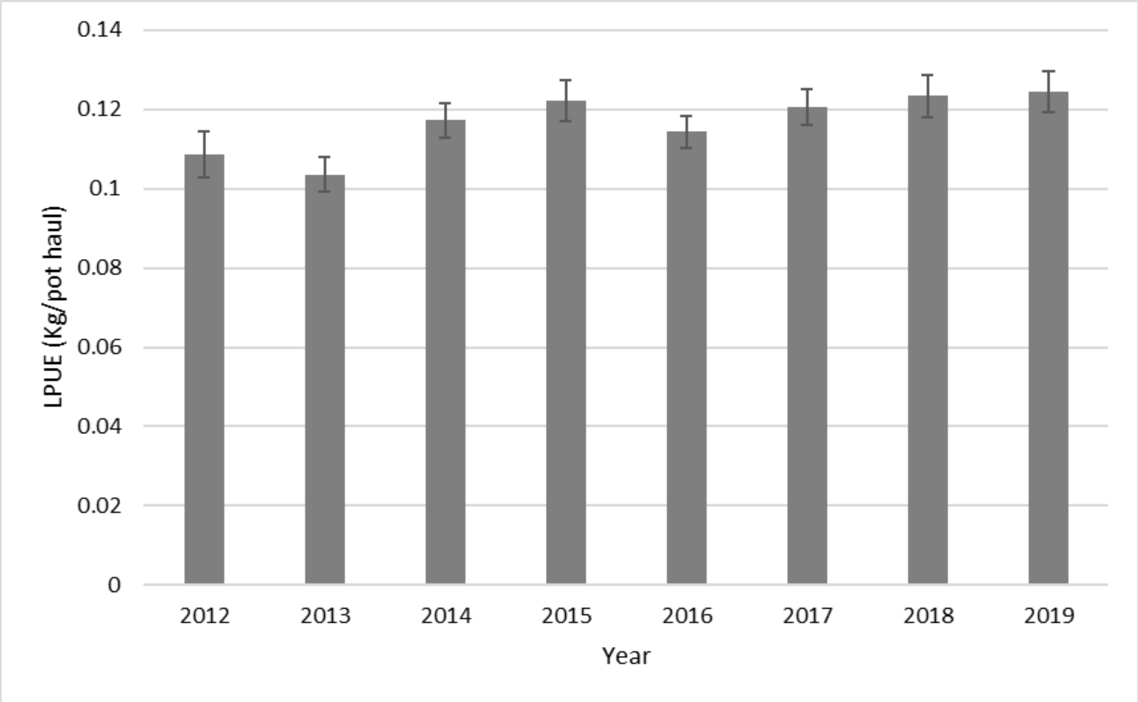

Figure 17. Annual LPUE for European lobster including 95% confidence intervals in ICES statistical rectangle 34F1. LPUE has been calculated for each individual MSAR entry and the mean determined from the averaged values combined.

Table 3. Summary statistics for European lobster in ICES statistical rectangle 34F1.

Year	Effort (number of pot hauls)	Lobster Landings (tonnes)	LPUE (kg/pot haul)
2012	282,506	26.6	0.11
2013	269,554	25.2	0.1
2014	273,745	29.1	0.12
2015	361,706	41.1	0.12
2016	313,006	32.9	0.11
2017	300,243	34.4	0.12
2018	310,753	33.6	0.12
2019	328,267	35.3	0.12

ICES statistical rectangle 35F0

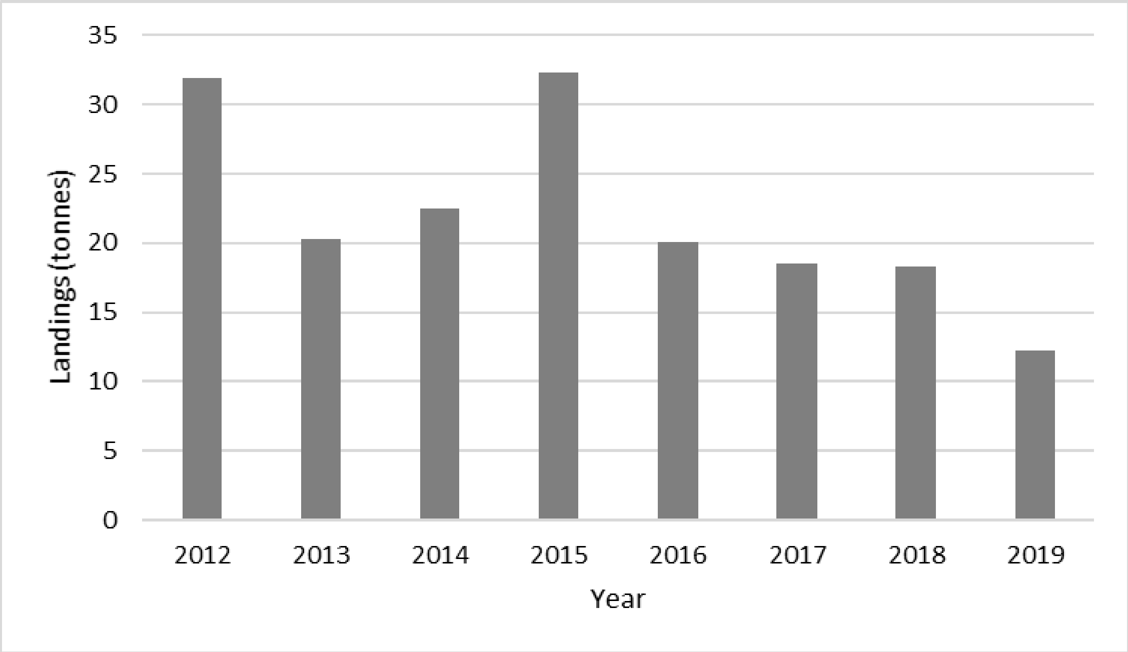

Figure 18. Annual European lobster landings (tonnes) derived from MSARs in ICES statistical rectangle 35F0.

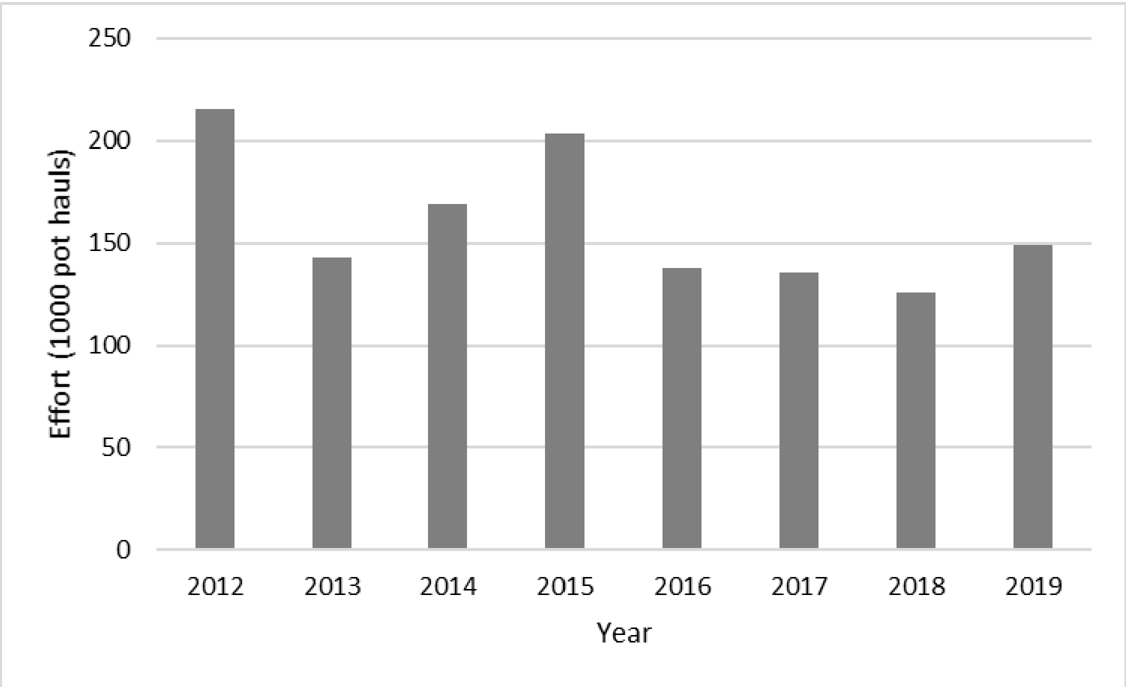

Figure 19. Annual European lobster effort (number of pot hauls) in ICES statistical rectangle 35F0.

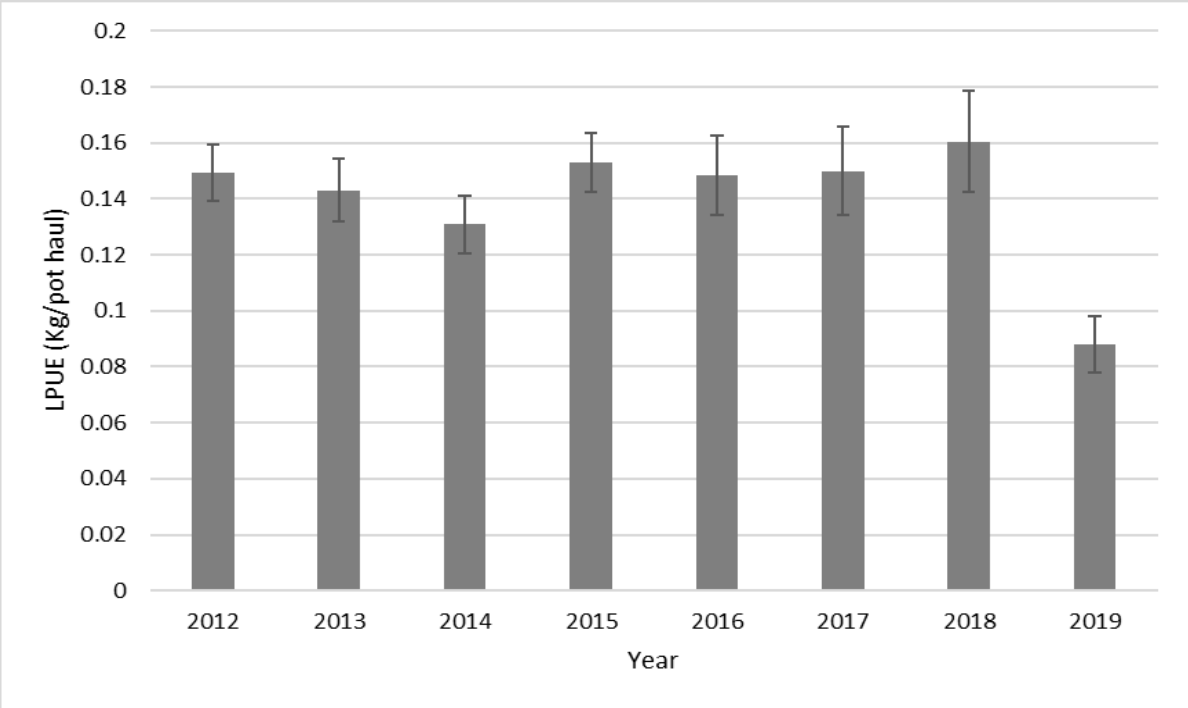

Figure 20. Annual LPUE for European lobster including 95% confidence intervals in ICES statistical rectangle 35F0. LPUE has been calculated for each individual MSAR entry and the mean determined from the averaged values combined.

Table 4. Summary statistics for European lobster in ICES statistical rectangle 35F0.

Year	Effort (number of pot hauls)	Lobster Landings (tonnes)	LPUE (kg/pot haul)
2012	215,743	32	0.15
2013	143,260	20.3	0.14
2014	168,820	22.5	0.13
2015	203,612	32.4	0.15
2016	137,895	20.1	0.15
2017	135,501	18.5	0.15
2018	125,565	18.3	0.16
2019	149,030	12.2	0.09

ICES statistical rectangle 35F1

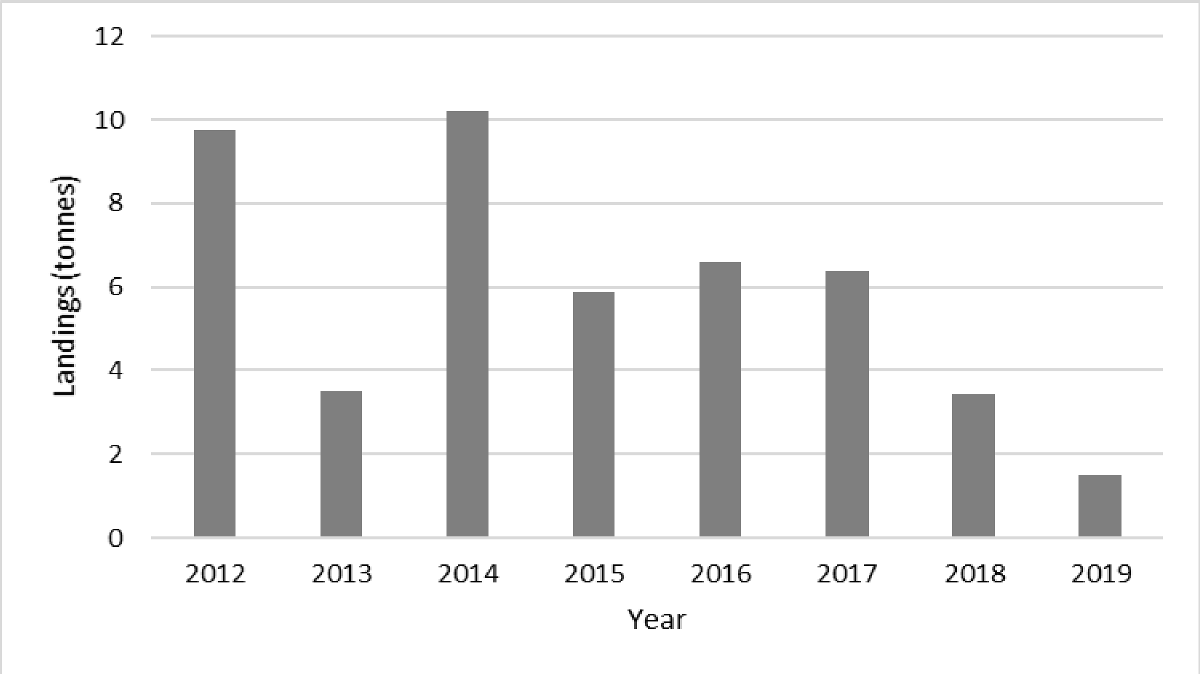

Figure 21. Annual European lobster landings (tonnes) derived from MSARs in ICES statistical rectangle 35F1.

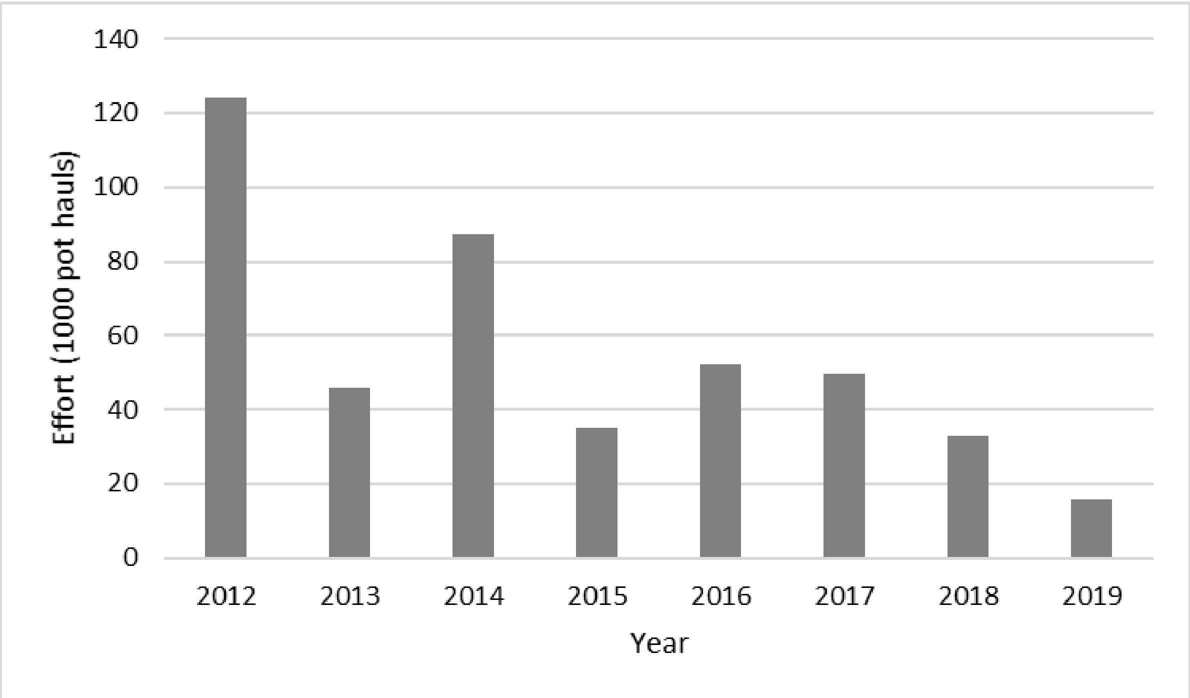

Figure 22. Annual European lobster effort (number of pot hauls) in ICES statistical rectangle 35F1.

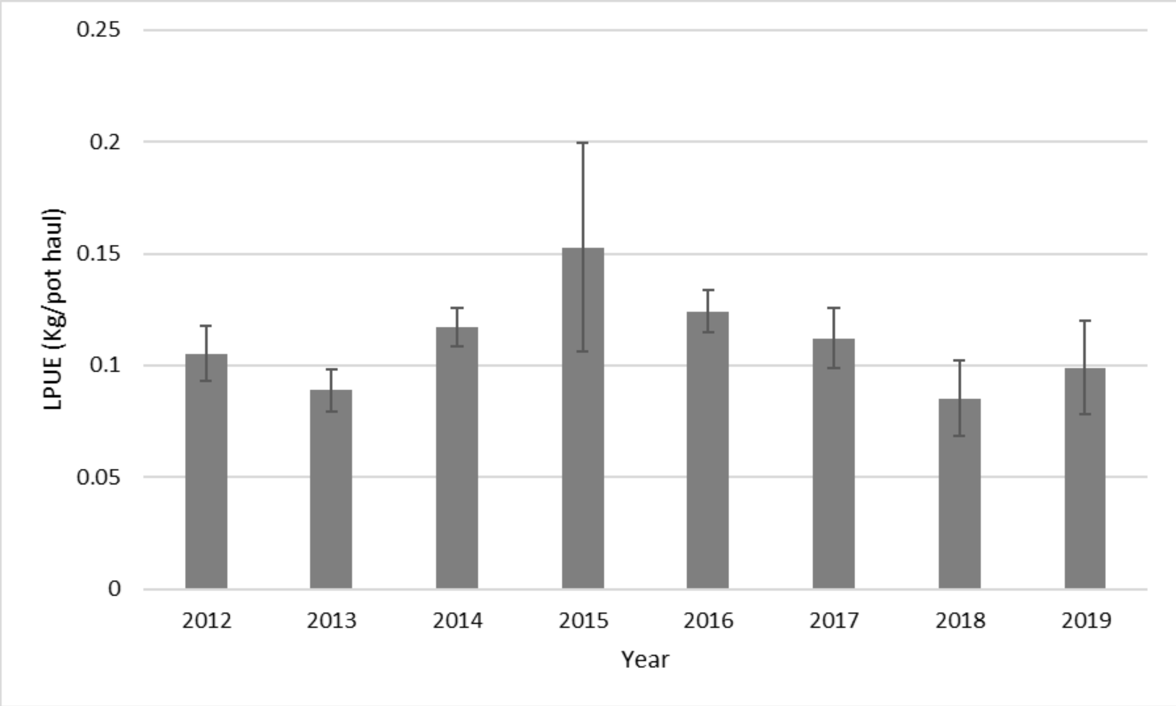

Figure 23. Annual LPUE for European lobster including 95% confidence intervals in ICES statistical rectangle 35F1. LPUE has been calculated for each individual MSAR entry and the mean determined from the averaged values combined.

Table 5. Summary statistics for European lobster in ICES statistical rectangle 35F1.

Year	Effort (number of pot hauls)	Lobster Landings (tonnes)	LPUE (kg/pot haul)
2012	124,078	9.8	0.11
2013	45,910	3.5	0.09
2014	87,200	10.2	0.12
2015	34,975	5.9	0.15
2016	52,360	6.6	0.12
2017	49,745	6.4	0.11
2018	33,000	3.4	0.09
2019	15,955	1.5	0.1

Population biometrics

Biological Data – Bio-sampling at ports and processors

In addition to analysing MSAR data, European lobster length-frequency data were collected by Eastern IFCA officers from ports and processors within the district as part of its biometric sampling program (bio-sampling). Sampling effort is currently targeted at ports and processors on a proportion of catch from selected vessels at the point of landing or once catch has been distributed to local processors. Carapace length (CL) is measured from the eye socket, at the base of the rostrum, to the base of the thorax and recorded with sex, area fished (ICES statistical rectangle), weight sampled and total vessel landing weight.

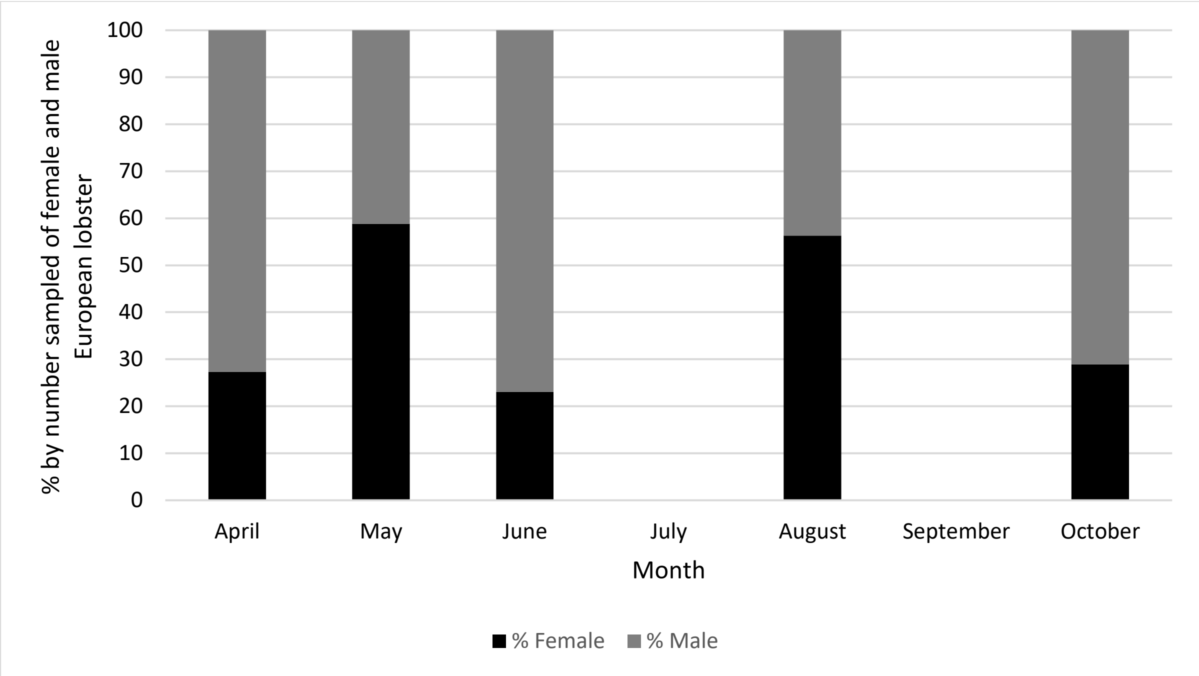

Figure 24. Percentage by number of male and female European lobster fished per month in 2019 from biometric data sampling. There were no individuals available to be sampled in the months of July and September.

Sampling of European lobster has proved challenging since the inception of the bio-sampling program with consistently lower landings and subsequently fewer individuals to sample when compared to brown crab. In comparison, 443 lobster individuals were sampled in the 2019 bio-sampling season, only approximately 6% of the number that were measured in the brown crab population. Furthermore, saltwater tank storage enables mixing of individuals making sampling difficult with the potential for erroneous results. This is reflected in figure 24 which shows that the months of July and September provided no individuals to be sampled. Through biometric sampling a better understanding of the current population status of European lobster within the EIFCA district was established. However, this was confined to only the landed catch; from the minimum landing size of 87mm upwards and those individuals returned to the sea for other reasons. There was a high degree of variation in animal sizes for both male and female individuals, varying from 87-146mm for males and 87-147mm for females (figure 34 and 35). Overall, males and females comprised 63% and 37% of sampled individuals, respectively. There was less temporal variation between months for lobsters than for brown crab. Sampled males peaked in June at 77%, dropping to 41% in May. Sampled females peaked at 59% in May, dropping to 23% in June. In comparison, brown crab male abundance peaked at 92% in August, dropping to 0.5% in October. Female brown crab abundance was lowest at 8% in August, peaking in October to 99.5% of total catch for the month.

Figures 25 and 26 present the population structure for European lobster, based on all individuals sampled during the biometric sampling program in 2019.

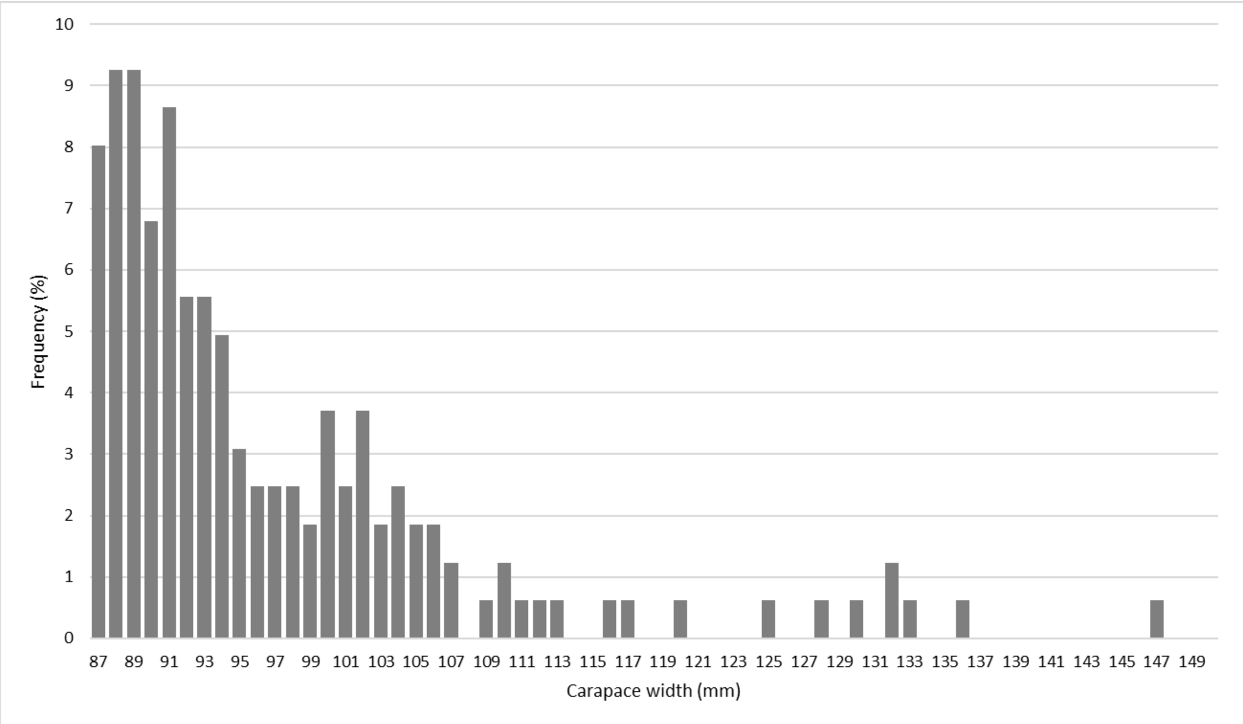

Figure 25. Population histogram for female European lobster derived from the 2019 biometric sampling dataset.

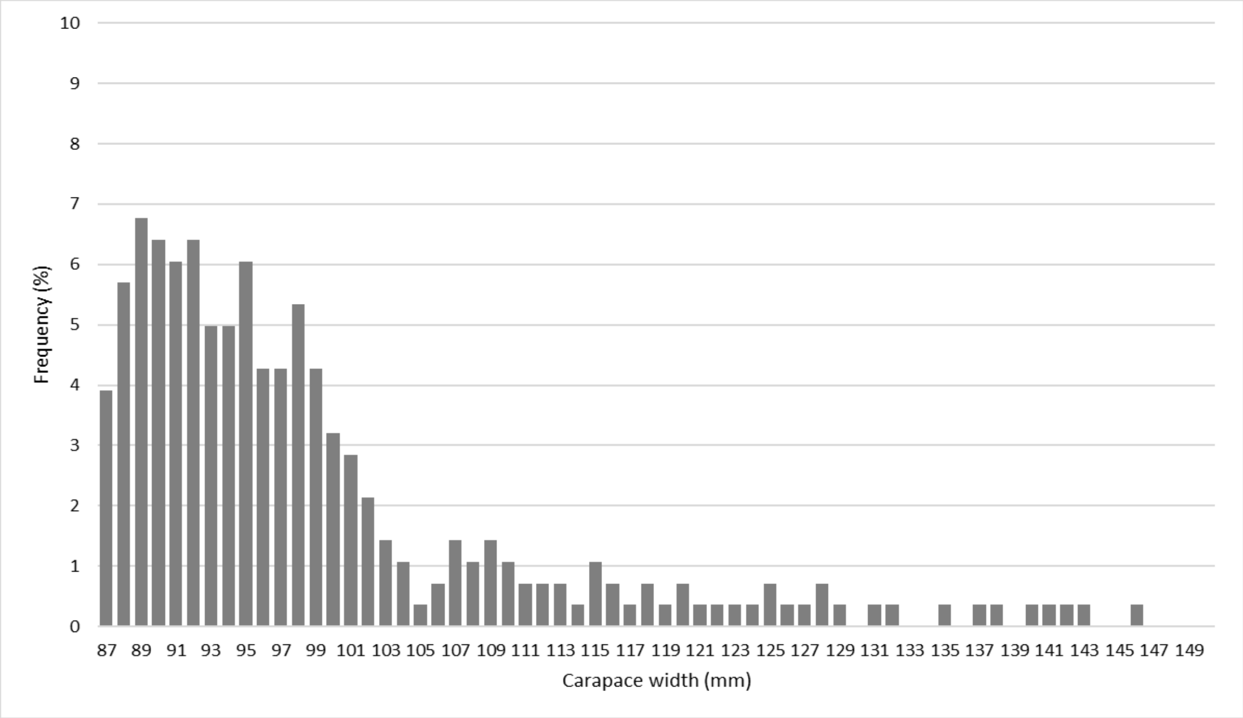

Figure 26. Population histogram for male European lobster derived from the 2019 biometric sampling dataset.

Discussion

The population structure of *H.gammarus* stocks, both in the southern North Sea and nationally are better understood than *C.pagurus*, primarily through tagging studies that have identified lobsters as being more sessile, appearing to make relatively limited movements throughout their life cycle. *C.pagurus* are known to undertake extensive seasonal migrations, thus increasing the catchability of the species. As a mixed fishery, the catchability of lobster varies temporally across the season and the effects of intra and inter specific competition impact the number of lobsters fished (Skerritt et al. 2020).

It is very difficult to discern between effort that has been applied to specifically target lobster and crab. Effort data in the form of number of pots hauled provided in MSAR reporting for this target both crab and lobster, therefore with significantly less lobster being landed than crab, but the same amount of effort being applied to both species in the LPUE calculations, lobster LPUE will likely be artificially decreased. Although this has implications for assessing true LPUE within the fishery, consistency in applying the same calculations across the data reporting period ensures that results are comparable year on year.

LPUE has remained relatively stable in the district wide fishery between 2012 and 2019, with marginal fluctuations around the annual average mean of 0.14 kg/pot haul. This indicates that the abundance of lobster on the fishing grounds appears to be both spatially and temporally stable, suggesting that the stock currently recovers from annual depletion with recruits maintaining LPUE. While this indicates that fishing activity is not influencing recruitment to the point of reducing contemporary levels of stock biomass, it does not necessarily mean it is not inhibiting the potential increase in species' abundance through recruitment overfishing. Importantly, similar caveats to the *C.pagurus* fishery apply with *H.gammarus* when considering stable trends in LPUE. A stable LPUE may indicate that prior fishing pressure has already reduced the stock to a stable plateau that is below its optimum capacity. We are unable to identify whether this has been the case in the current study, and as the fishery predates associated fishery records, would be difficult to discover without restricting fishing effort and observing the effects on LPUE.

ICES statistical rectangles 34F1 and 35F0 represent 49.5% and 32.2% of all lobster landings within the Eastern IFCA district indicating their importance for the districts fishermen. ICES rectangle 35F1 has been explored further due to its importance for the larger offshore vessels in the district, constituting 9.8% of the districts landings. The remaining 3 ICES statistical rectangles, although important localised fishing grounds for communities that fish these areas constitute considerably less to the districts fishery representing 8.5% of total annual landings combined. Trends in LPUE in individual ICES rectangles represent localised characterisations of the fishery, in terms of effort, individual sizes of lobsters and distribution of individuals on the fishing grounds. Unlike crab, which at times move appreciable distances, lobsters tend to be more sessile which reduces the area in which a lobster fishery can occur. Fishing for lobster depends a lot more on the positioning of pots close to areas that lobster frequent, in this case the complex chalk structures found in ICES statistical rectangle

34F1 and this may be why 34F1 represents approximately 50% of all lobster catch in the district. The complex reef structure found in the inshore area of this ICES rectangle provides ideal habitat for lobster and with the majority of vessels targeting this area of chalk provides greater catch rates indicating that this remains the most productive area in the district for the lobster fishery.

ICES statistical rectangle 34F1 is the predominant fishing ground for European lobster within the district with >49% of reported landings from MSARs from this rectangle alone. The majority of vessels fishing this area are 10m and under and generally target the inshore coastal area of the rectangle in which the exposed chalk feature of Cromer Shoal Chalk Beds MCZ is situated.

Figure 15 indicates that landings from this area peaked at 41.1 tonnes in 2015. Following this peak, landings dropped to 32.9 tonnes in 2016 and maintained an average of approximately 33 tonnes through to the 2019 fishery. Following a dataset low of 0.1 kg/pot haul in 2013, LPUE has remained stable at 0.11 – 0.12 kg/pot hauls into 2019 despite annual fluctuations in both effort and landings.

Situated off the Lincolnshire coast, ICES statistical rectangle 35F0 is the second most fished area for European lobster landed into the district with >32% of reported landed weight from this rectangle. Landings peaked in 2015 at 32.4 tonnes, however declined steeply in 2016 to 20.1 tonnes and continued to drop through the 2019 fishery where a data reporting period low of 12.2 tonnes can be seen. Effort also dropped considerably in 2016 following the peak in 2015, however as effort has stabilised between 2016 and 2019 landings have continued to reduce. Despite changes seen in landings and effort between 2015 and 2018 LPUE remained stable at approximately 0.15 – 0.16 kg/pot haul, however LPUE declined steeply in 2019 to a data reporting period low of 0.09 kg/pot haul whilst effort increased slightly from the preceding year and landings dropped considerably potentially indicating a decrease of available lobster to be fished on the ground.

In terms of MSAR data, ICES statistical rectangle 35F1 represents only 9.8% of total landed weight for European lobster in the district; a relatively small contribution to overall annual landings when compared with the more heavily fished ICES rectangles 34F1 and 35F0. ICES rectangle 35F1 is further offshore, beyond the inshore fishery of ICES rectangle 34F1 and is targeted mainly by larger vessels with the capacity to reach the offshore fishing grounds.

Although much of this data won't be captured in the MSARs, the data we do have for vessels under 10m that target the area indicates that effort has generally decreased in the area from a peak of 124,078 pot hauls in 2012 to a data reporting period low of 15,955 pot hauls in 2019. Landings have also shown a general trend of decrease across the period from 9.8 tonnes in 2012 to 1.5 tonnes in 2019, with some fluctuation from year to year. LPUE has decreased from a data reporting period high of 0.15 kg/pot haul in 2015 to 0.1 kg/pot haul in 2019. Interestingly, despite the disparity between effort in 2012 and 2019 of approximately 108,000 pot hauls, LPUE has only decreased by 0.01 kg/pot haul.

LPUE results for brown crab (Bridges, 2021) indicated an appreciable drop in LPUE in the fishery in 2018 which was potentially attributable to the 'Beast from the East' climatic event of the same year. This was supported by anecdotal reports of reduced catch from fishermen in this year and local media (www.northnorfolknews.co.uk, 2018) reported widespread beaching of crustacean and mollusc species, including brown crab and lobster. Fishermen from both Cromer and Wells also reported that crab and lobster appeared to be behaving differently during this event, in terms of catchability and location with catches of brown crab reduced by up to 60% when compared to the 2017 fishery. LPUE remained relatively stable for European lobster in 2018 and 2019, indicating that the same effects of this climatic event may not have impacted lobster stocks as much as they did brown crab.

The MMO are currently in the process of administrative changes, replacing MSARs with electronic reports. This may result in an absence of data available to EIFCA, impacting on our ability to analyse and assess the fishery for a number of years. A similar trend was seen when MSARs were introduced and it took a number of years to obtain reliable consistent data. This change has come at a critical juncture in management of the fishery and may present problems when assessing the effects of any management measures introduced, including potential impacts on assessing progress of the Fisheries Improvement Plan (FIP), the potting assessment in Cromer Shoal Chalk Beds MCZ and any economic impacts of management.

Biometric sampling

Whilst sampling effort and subsequent quantity of individuals to measure has increased for brown crab through access to processors, increasing acquisition of biometric data, this approach has not been as beneficial for European lobster as sampling effort has remained low in 2019. Lower landings of lobster, coupled with saltwater tank storage enabling mixing of individuals, makes sampling difficult with the potential for erroneous results. This presents fewer opportunities to measure individuals, with approximately 15 times as many brown crabs sampled consistently when compared with lobster. Cefas also appear to suffer similar problems when assessing lobster stocks. Their recent stock assessment (Cefas 2020) of the species in East Anglian waters highlighted that inconsistencies in sampling, coupled with insufficient data are making confident analysis of current stock levels difficult.

Although the data is caveated due to limited access to individuals to sample and increased selectivity by fishermen before catch reaches the processors, some inferences can be drawn from the population structure based on the biometric sampling data. The data shows that male lobsters make up the largest contribution to landings overall in 2019 represented by 63% of all sampled individuals. There were, however, a number of months in the 2019 fishing season in which more females were landed than males, particularly where females are not egg bearing and sessile.

A number of factors affect catchability throughout the season. During courtship the male and female form a brief pair bond before mating. The female moults and mates in the shelter of the hard-shelled male, remaining with him in the shelter whilst recovering from moulting. This reduces the amount that both will feed, thus reducing their likelihood of being caught in baited pots. Once mating has occurred the female will move out of the shelter with a voracious appetite while her shell continues to harden and the male will resume his usual foraging behaviours, making them more susceptible to being fished. Once the female has hardened her shell, she will release her fertilised eggs to her abdomen and brood them, reducing her movements and again reduce her susceptibility to being fished. Newly moulted individuals have an increased vulnerability to predation and will remain hidden until the shell has hardened, a process which can last a few hours or several weeks depending on the size of the individual and calcium availability. Juvenile lobsters will moult up to 25 times in their first five years, gradually reducing in adulthood to as little as once every two years.

The population structure for the district wide fishery indicates a peak at 89mm for both male and female European lobster. Relative abundance then falls with increasing size. This is potentially due to fisheries exploitation and natural mortality. Although these factors are likely to influence the population structure curve to some degree, it is also likely that the selection of particular individuals for market sale will influence the shape of the size distribution curve when compared with natural population curves for the stock still in the sea.

Importantly, this doesn’t represent the overall peak in abundance for the whole population, only those that are landed. Data captured during biometric sampling provides the opportunity to measure a broad range of catch without the risk of recapture which may skew the data and not show an accurate representation of the population. However, sampling at sea may risk recapture but provides a better representation of the population as a whole as those individuals usually returned as undersize provide a better understanding of population trends below the 87mm minimum landing size. Sampling at ports is less dependent on external factors such as weather, enabling a consistent dataset to be compiled whereas sampling at sea is very much dependent on availability to join fishermen on trips. Many of the vessels involved in the fishery are small with restricted space to sample which creates additional difficulties with sampling at sea. A limitation with our approach of heavily bio-sampling at processors is the risk that some of the catch may be sorted at sea before landing and selectively diverted to shops rather than going to the processor, preventing us from measuring the whole catch or a sub sample that accurately reflects the overall component each fisher has in the whole catch. Particularly large or healthy individuals are usually selected from the catch, or a specific sex which has the potential to skew the data towards an increase in the smaller end of the range of catch. Another limitation of the sampling method is the spatial distribution of sampling effort. Surveys are currently conducted at two locations on the north Norfolk coast, where catches tend to have originated from ICES statistical rectangles 34F1 and 35F1. As a consequence, no recent bio-metric data have been collected from lobster that have been landed from Lincolnshire or Suffolk, two very different fisheries, targeting different fishing grounds and potentially different size lobster.

Data gap analysis

The current stock assessment has identified a need to examine our approach to crab and lobster sampling in terms of the data collected and the location from which it was sampled in order to provide an assessment that is representative of the fishery as a whole. Limited sampling locations and access to catch that has been sorted before reaching the point of sampling mean that the introduction of bias into our sampling method is something that could be influencing results. Prior to the 2019 lobster stock assessment, Eastern IFCA trialled a multi-metric approach to crustacean stock assessments including LPUE and Length Converted Catch Curve (LCCC) fisheries models. LCCC is used to assess how the fishery effects stock structure, population dynamics and age (size) classes. Fishing mortality estimates derived from the LCCC model consider the frequency of sizes within a population to estimate the depletion over time of individuals, represented as mortality rate. This is based on the difference between how many small (young) and big (old) individuals are in the population. LCCC models were originally developed to overcome issues with conducting stock assessments on tropical finfish that, like crustacea, do not produce distinctive growth rings in their hard-skeletal structures from which they can be aged. LCCC determines age (pseudo age) from size using known (estimated) growth parameters, but also has the assumption that recruitment and natural mortality occur at steady rates and that there is no emigration from the population. These assumptions, and the fact that crustacea grow in steps rather than at a steady rate, mean the LCCC model is less than ideal for crustacean stock assessment. Nevertheless, while this method is not tailored to the specifics of crustacean biology it is commonly used for estimating fishing mortality for this stock; providing an indication of stock health and a means of monitoring and quantifying any changes resulting from management actions.

The LCCC modelling method is currently under internal review at Eastern IFCA to determine whether local conditions make its continued use appropriate for stock assessments in the district. Its continuation will require improvements being made to improve sampling techniques, to ensure the whole stock is proportionally represented in assessments

This stock assessment forms part of a group of current projects focussed on potting fisheries in the Eastern IFCA district and the wider southern North Sea. A commercial fisheries assessment is currently under way to assess the impacts of potting fisheries on the designated features of Cromer Shoal Chalk Beds MCZ and an industry led Fisheries Improvement Plan (FIP) with the aim of improving the sustainability of the fishery.

Cefas publish reports describing the status of the European lobster stocks every 2 years. The most recent report (Cefas, 2020) indicates that the exploitation status for lobster in East Anglia is high for both male and females, although decreasing since 2017. Fishing pressure is particularly high around the Minimum Landing Size of 87mm. The spawning stock biomass of both sexes is low. Cefas recognise that low sampling levels make the uncertainty on stock status high for the lobster stock and inconsistencies in data inhibit a more refined analysis of stock exploitation driven primarily by a lack of data on population dynamics such as recruitment into and migration out of the fishery.

Conclusions

LPUE results for the district-wide fishery indicate that populations of European lobster have plateaued at a dataset peak, suggesting that stocks are stable and currently recover from annual depletion with recruits maintaining LPUE. While this indicates that fishing activity is not influencing recruitment to the point of reducing contemporary levels of stock biomass, it does not necessarily mean it is not inhibiting the potential increase in the species’ abundance through recruitment overfishing. Within a limited dataset, a stable LPUE can also be achieved where prior fishing pressure has already reduced the stock to a stable plateau that is below its optimum capacity. We are unable to identify whether this has been the case in the current study, and as the fishery predates associated fishery records, would be difficult to discover without restricting fishing effort and observing the effects on LPUE. Through much of the district, the lobster fishery forms part of a mixed fishery with brown crab; in which the fishers use the same gear in the same area to concurrently catch both species. Candidate management measures will need to be proportionate. Any measures implemented for one species has the potential to impact on the other, potentially causing unnecessary detrimental effects on the fishery.

Recommendations

The stock assessment indicates that from a purely population sustainability perspective the European lobster fishery in the Eastern IFCA district is currently not under immediate threat.

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