

# Isles of Scilly Stock Status Report 2023: European spiny lobster (*Palinurus elephas*)

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### **Acknowledgements**

The authors thank all the fishers who contributed to data collection. We would also like to thank Defra for funding this report.

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## Executive Summary

The European spiny lobster (*Palinurus elephas*), referred to as 'crawfish' throughout this report, is distributed across the Southwest of the UK, along the west coast of Ireland and into Scotland. A large number inhabit rocky ground in the Isles of Scilly Inshore Fisheries and Conservation Authority's (IoSIFCA) District. The crawfish fishery in the Isles of Scilly accounted for 12 percent of total fish landings in 2022 and is currently targeted by 60% of boats in the fleet. Landings have increased by 275% in the past 4 years, with yearly value increasing by 241%, from just under £67,000 in 2019 to £162,000 in 2022.

Crawfish are an omnivorous crustacean, with a wide-ranging global distribution in northern temperate waters in the Eastern Atlantic Ocean and the Mediterranean Sea. They live in reef habitats at depths ranging from 15 to 90 metres. They have a long planktonic larval phase which lasts ~ 9 months in the Atlantic before settling. It is believed they take around 7-8 years to become sexually mature, however data on growth and settlement is lacking in the Atlantic populations. Studies have found individuals mostly remain within a few kilometres of their home reef, however some undertake long distance movements. The reasons for this are still unclear.

Crawfish are a non-quota, commercially valuable species. There has been a targeted fishery for over 100 years, which saw a collapse in the late 1900's across its range.(2013), due to reductions in the population based on historical abundance and exploitation levels. The Isles of Scilly crawfish fishery was first recorded in the 1920's, with overfishing depleting the population in the 1920's and 1950's. The species has been slowly recovering throughout South West England. Landings on Scilly remained steady from 1998 to 2018 and have since increased by an average of 40% a year (30% in 2020, 75% in 2021 and 20% in 2022). Management in the IoSIFCA District in 2023 is through a minimum size of 110mm, which was brought into effect in 2020 and a prohibition on landing of berried females.

This crawfish report is based on catch recording onboard commercial vessels in the Isles of Scilly fleet. Beyond this there is scope to continue onboard catch recording every 3 years, with the aim to increase data on the fishery to develop indicators from which the fishery can be more effectively monitored and managed.

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## List of Abbreviations

IoSIFCA	Isles of Scilly Inshore Fisheries and Conservation Authority
IoS	Isles of Scilly
District	Refers to Isles of Scilly IFCA 6 nautical mile boundary
CMR	Catch-mark-recapture
CL	Carapace length – from the tip of the rostrum to mid-point of distal edge
MLS	Minimum landing size – 110mm CL in the District
BRUVS	Baited remote underwater video systems
CL50	Carapace length at which 50% of females are mature.
MMO	Marine management organisation

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## **1. Species Description**

### **1.1 Life Cycle**

European spiny lobster (*Palinurus elephas*), also known as crawfish, begin life hatched at 2 -3 mm (Kittaka and Ikegami, 1988), and at this planktonic stage drift in the ocean currents, taking approximately a year in the Atlantic to reach juvenile stage (Goñi and Latrouite, 2005; Hunter 1999). These post settlement and juvenile stages are rarely seen in the wild, with little research published since Díaz et al. 2001 used scuba divers to investigate settlement habitats in the western Mediterranean Sea. They found settlement occurred at around 7-8mm carapace length (CL) in small crevices over the warmer spring and summer months (Díaz et al. 2001). They settle at shallow depths, likely around 5 to 15 metres (Yeap et al. 2022). Research by Mercer in 1973 in the Atlantic suggests they grow ~12mm per moult. Once settled crawfish take approximately 4 years in the Mediterranean to become sexually mature (Goñi et al. 2003). Opinions differ on whether growth takes slightly longer in the Atlantic, including in cooler locations such as the Southwest of the UK and Ireland (Hunter, 1999), or whether in fact they grow faster and larger in the Atlantic (Goni & Latrouite, 2005).

Previous research shows mating in the Atlantic occurs between June and October (Mercer, 1973). Females will mate when moulted, sternum to sternum, with the males depositing two spermatophores below the females genital opening. Spermatophores can remain on the female for up to 10 days. Oviposition will occur shortly after mating, the female then uses her 5th walking leg to scratch the spermatophores and fertilise the eggs. Females incubate the eggs for 6 – 10 months (Mercer, 1973).

### **1.2 Size at Maturity**

The literature on size at sexual maturity suggests the smallest berried females seen in the Southwest UK were 90mm CL, two females measuring 79mm CL had immature ovaries (Hunter et al. 1996). In the Mediterranean females with carapace lengths as small as 71.5mm had eggs and 70% of 80mm CL females were sexually mature, indicating faster development in warmer temperatures (Goñi et al. 2003). Female crawfish from Ireland were seen to reach sexual maturity between 70mm and 95mm CL, with 50% having mature ovaries at 82mm CL (Mercer, 1973a). Size at maturity can be defined as behavioural, physiological, functional or morphometric. The scope of current research has only allowed us to study functional sexual maturity, estimated from carapace lengths of berried females caught in nets and pots.

We can be confident that the use of 110mm is well above the size at maturity and enables reproduction before they become vulnerable to fishing. Research in Portugal found that although only 5% of the females caught were larger than the size at which 50% were sexually mature (110mm CL), that 5% of females contributed 59% of egg production (Garhardo et al. 2006). Similar figures have been found in the Mediterranean (Goñi et al. 2003). This indicates the importance of large females in the population.

### **1.3 Growth**

Crawfish are recorded to live for up to 15 years (Marin, 1987), with maximum sizes varying from 175mm Carapace Length (CL) and 160mm CL for males and females respectively, in the Mediterranean (Campillo & Amadei, 1978), 200mm CL and 170mm CL in Brittany (Latrouite & Noel,

1997) and 190mm and 153mm in Ireland (Mercer, 1973). Larger females produce five-fold more eggs than smaller females (Goni et al. 2003) and larger larvae (Kittaka and MacDiarmid, 1994).

In Ireland growth rates were found to be around 12.2mm CL per year for males, and 12mm CL for females (Mercer, 1973a), however this varies greatly with geographic location and size, with larger individuals growing more slowly and more likely to increase weight than length (Hunter, 1999). This was seen by Hepper (1977) who found growth rates of 0 – 3mm CL per moult/per year, likely because the crawfish being monitored were at the top end of their growth limit. Marin (1985) suggests crawfish are 7 – 8 years old when they reach 110mm CL.. Moulting occurs less frequently as crawfish age, moulting once a year for females of 6 -7 years old and once a year for males over 11 years (Marin, 1985).

There have been no direct studies so far on crawfish age. Developing a growth model will help us understand how crawfish size relates to age is critical in helping understand the age structure of the stock, and therefore enabling more effective management.

Catch-mark-recapture studies in the IoSIFCA District have yielded little information to help us understand growth rates due to the lack of recaptured individuals. Only 1% of individuals tagged were recaptured. We are hopeful this will increase over the next 12 months as recently tagged fish begin to reappear, however a low recapture rate is normal for crawfish (Mulas et al. 2022, Follesa et al. 2011). Mark recapture rates in the fishery off south west Ireland are also sufficient to eventually provide growth data (Marine Institute 2022).

#### **1.4 Movement**

The movement patterns of crawfish in the Atlantic are understudied, especially when compared to studies carried out on other palinuridae species in Australia and the Mediterranean. Movements are split between the movement of larvae in the water column after hatching, small-scale foraging movements and large-scale migrations.

It has been suggested crawfish may carry out a premating migration into shallower waters in the spring/summer and then post mating migration back into deeper waters in the winter (Ansell and Rob,1977; Mercer 1973a). However, previous tag recapture studies conducted in both the Atlantic and Mediterranean indicate that adult movement is restricted, with most crawfish moving less than 5 km and rarely up to 20km after 1 – 8 years (Hepper, 1967, Marin 1987, Goni et al. 2001b, Cuccu 1999, Marine Institute 2022). Studies have shown 60.4% of individuals move less than 2km from release site, 79.9% less than 5km. There were some long distance migrations, an 80mm CL female travelled 134km over 2 years, and a male travelled 45.9km over 4 years, however research suggests these movements are likely to be carried out by juveniles (Follesa et al. 2009, 2011).

In the Isles of Scilly a modelling study undertaken in 2018 by Cefas (Whomersley et al. 2018) to look at how crawfish larvae might be distributed from a selected network of MPAs around South West England, including the Isles of Scilly. A General Individuals Transport Model was used and the model was run over a 16 month period for 1996, 1997, 2006 and 2010. Release locations were within the Isles of Scilly SAC, Skerries Bank and Surrounds MCZ, the Lizard Point SAC and Padstow Bay and Surrounds MCZ. The results for Scilly showed a general trend of dispersal to the north into the Irish Sea and clockwise around the south and west of Ireland and ultimately to the west of Wales (Whomersley et al. 2018).

Capture-mark-recapture (CMR) studies carried out in 2013 in the District had limited success, with



less than 1% recapture rate (1 tagged crawfish return). Further to this, sixteen data storage tags were deployed on crawfish in 2015, none of which were recovered. We have found marginally improved return rates over the last 2 years of 1.5%, described in detail further in this report (*table 3*). In 2022 there was a recapture of a crawfish over 110mm CL with a floy tag from a French research group (IFREMER) and in 2023 a further 2 French male individuals over 110mm CL were caught in the District.

An ultrasonic telemetry study of crawfish in the Isola delle Femmine protected area in Sicily found lobsters display homing instincts, with 5 individuals moving back to their capture site within 20 hours of being released. The 5 individuals that stayed within range of the receivers ranged within 1.6 and 8.6km (Giacalone et al. 2019).

Two years of telemetry research have been ongoing in the IoSIFCA District in partnership with FISH INTEL, to improve understanding of crawfish movement in the Atlantic and locally in Scilly. Most tagged individuals were found to remain in a spatially restricted area and did not show a homing instinct, for further details see section 4.2.1. We have also carried out 2 years of streamer tag research which has also found a limited range of movement in recaptured crawfish.

## **1.5 Distribution and habitat**

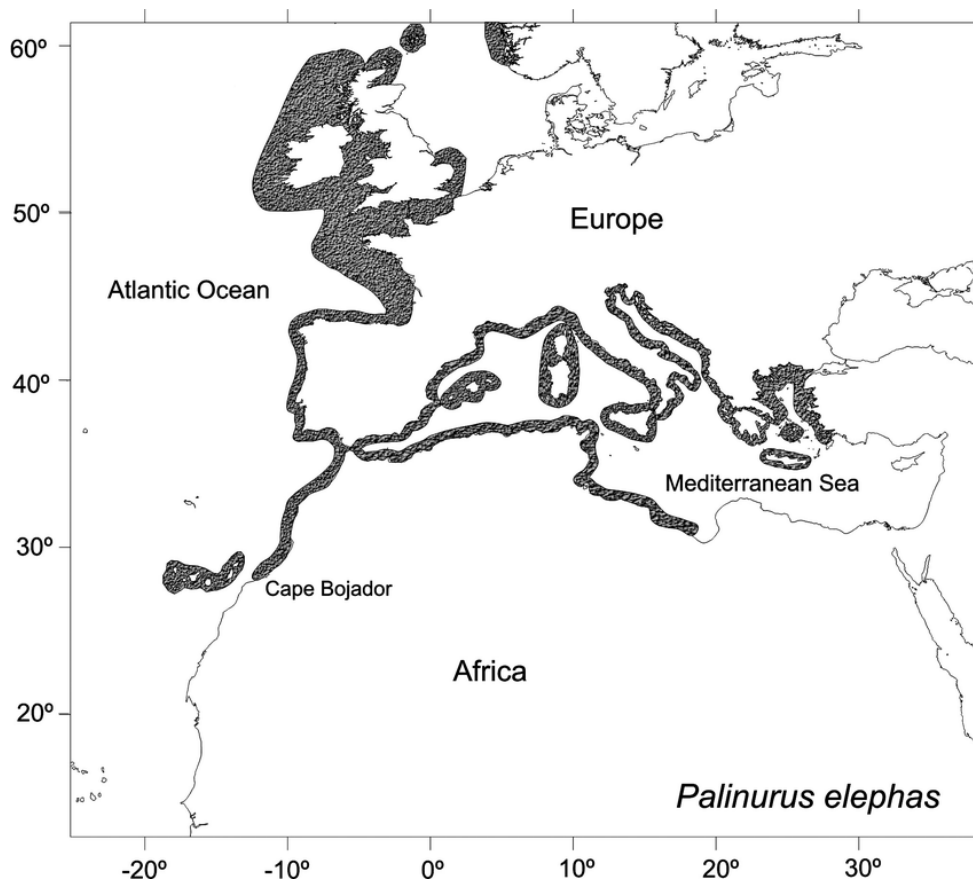


Figure 1 - Geographic distribution of *Palinurus elephas*. Source: Goñi, R. and Latrouite, D., 2005

Crawfish are found in the Mediterranean Sea and Eastern Atlantic Ocean. The map above shows potential distribution, but with very few records from the Irish Sea and Scotland. Commercial distribution with more significant populations in the Atlantic ranges from west and south coast of Ireland, south west England to northern France and West coast of Portugal. There is a small genetic distinction between Mediterranean and Atlantic populations of crawfish. Crawfish are effectively panmictic throughout the Atlantic, this means that there are no restrictions for genetic mixing, due to their long larval phase (Ellis et al. 2022).

Studies suggest that the correct habitat is an important factor to enable crawfish to settle, with crawfish needing complex, rough, rocky ground.

### 1.6 Diet and Predators

Crawfish are opportunistic omnivores, their diet ranging from crustaceans, molluscs and sea urchins in the Mediterranean (Goni et al. 2001, Quetglas et al. 2001), although no studies have been carried out in the Atlantic it is likely the diet is similar. High microplastic load has been found in crawfish in Sardinia (Cau et al. 2023).

Predators of crawfish in the Isles of Scilly include nursehounds (*Scyliorhinus stellaris*) and the common octopus (*Octopus vulgaris*). Quetglas et al. found only a 23.5% predation efficiency of common octopus on crawfish in pots in the Mediterranean, therefore the predation efficiency in a natural environment with shelter for the crawfish is likely to be much lower. Predation events of

nursehounds on crawfish have not been investigated, however baited remote underwater video system (BRUVS) data shows both nursehounds and crawfish present, without any predatory interactions (pers. Comms. Owen Exeter). On board catch data showed less than 1% of crawfish are lost in nets or pots to predation.

### **1.7 Parasites and Disease**

There is limited research on parasites and disease in Atlantic populations of crawfish, with existing research carried out on Caribbean and Mediterranean specimens (Ross et al. 2019). There is only one report of bacterial and fungal caused shell disease in spiny lobsters from Alderman (1972), a year later in 1973 Alderman reported a fungal induced gill infection. The lack of reported disease on these lobsters is most likely due to a lack of research as opposed to a lack of the presence of disease and parasites.

### **1.8 Inherent vulnerability**

Studies on other similar species such as the western rock lobster (*Panulirus cygnus*) have demonstrated that sustainable fisheries are possible (Bellchambers et al. 2016). Historical Crawfish records have however showed a clear cycle of population increases followed by declines. The reasons for populations increases are poorly understood. As a result of the Crawfish life history, the vulnerability of populations to decline has been assessed as “moderate”, with a “medium” resilience to fishing pressure (sealifebase, accessed 2023). Crawfish are also classed as “vulnerable” under by the International Union for Conservation of Nature (IUCN), meaning that it is neither endangered nor critically endangered but is facing a high risk of extinction in the wild in the medium-term future. The data comes from 2013 and notes that there are threats from fishing and harvesting, but without any systematic monitoring schemes. The justification is because the species has declined by 30-50% over the last 27 years and pressure on the species in the Mediterranean is increasing. Tje, age of maturity in the Atlantic is unknown but is likely to be between 5 and 10 years, and the minimum landing size used across England, France and Ireland is above size at maturity. There is open and widespread larval dispersal and recruitment, so local declines would be subvented by recruitment and inward migration of sub adults. On the other hand they also have a long gestation period and long planktonic larval stage and , settlement within an area may be highly reliant on highly variable/stochastic hydrological and oceanographic processes.

### **1.9 Behaviour**

Understanding crawfish behaviour is important, not only to predict and understand threats to the population, but also for the initiation of breeding or re-introduction programmes. Studies have shown that boat noise increases stress hormone levels, and alters behaviour by increasing movement, whilst also reducing immunity levels in crawfish (Celi et al. 2014, Filiciotti et al. 2014). Research has also shown crawfish learn from experience and display predator avoidance behaviour. (Gristina et al. 2011).

Adults live in individual holes, but they are not defensive or territorial and share habitat; however juveniles are gregarious and tend to be in groups (Mercer 1973a). It has been suggested migrations may take place in groups to increase vigilance to predators (De Vincenzi et al. 2015). It is noted by some fishermen that juveniles tend to be caught in clusters, which would indicate support for the idea that they travel in groups.

Telemetry studies in the Mediterranean suggest that contrary to previous thoughts Crawfish are active, likely foraging, during the day rather than the night (Giacalone et al. 2006). Crawfish scavenging behaviour may explain high microplastic load found in stomach and intestines in Sardinia (Cau et al. 2023).

## **2. Fishery**

### **2.1 Development of the fishery**

The crawfish fishery in the Isles of Scilly has been present likely since the 1800's, with catches at their highest on record in the early 1920's. Marine Management Organisation (MMO) data records over 48, 000 crawfish landed in 1920 (~48 tonnes). After this, landings of crawfish were combined with landings of lobsters when recorded, which makes it hard to know how many crawfish were landed from Scilly during this period. When looking at the whole of the UK, we can see that landings were around 50 tonnes in the 1950's (almost the whole total of Scillonian landings 30 years previously) and then a consistently high effort from 1964 to 1976 peaking at around 150 tonnes landed in 1971 (Whitley, 2020). After this the fishery declined and fishermen moved to targeting other species. Predecessors to the MMO with responsibility for sea fisheries management (Ministry of Agriculture and Food and Fisheries) stopped recording crawfish landings separately for all of the UK in 1977 with landings being grouped together under 'other crustacean'.

Outside of these peaks, a small population of crawfish has remained, with a small but steady number landed each year. In 2014 fishermen and divers noticed that the numbers of crawfish were increasing. Fishing effort across their range then began to increase from this point.

Historical research would help develop an understanding of the baseline for the crawfish population in the Isles of Scilly. By extracting information on the number of fish landed per gear effort we can create historical landings per unit of effort (LPUE) in the Isles of Scilly, these can then be compared to modern day LPUE. Understanding the size of spiny lobster landed and the size frequency of the population will further increase our knowledge on their recovery status. This could be achieved via historical records such as the 'weigh ins' at The Mermaid pub. By building a baseline of what the stocks of spiny lobster in the Isles of Scilly looked like before exploitation rates increased, we can develop an understanding of historical populations around the archipelago.

### **2.2 Current fishing activities**

Crawfish are fished from the west coast of Ireland, south west coasts of England and the Atlantic coasts of France and Portugal. The two main fisheries in the South West of the UK are Cornish and Scillonian netting and potting fisheries.

There are 26 registered vessels in the Isles of Scilly, ranging from 11 to 4 metres in length, with 23 boats operating regularly in 2023. Of these 23, 14 target crawfish, an increase of 20% from the 12 in 2022. The crawfish fishery in Scilly was worth £162,000 in 2022 and £272,000 up to September 2023.

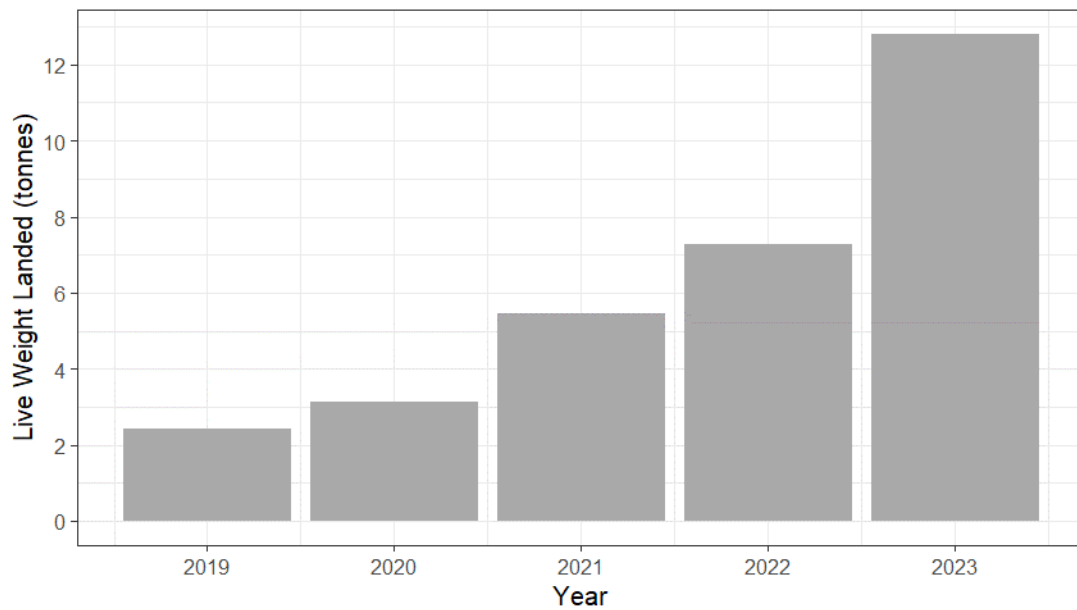


Figure 2- Total sum of crawfish landed in tonnes (live weight) from the Isles of Scilly from January 2019 to September 2023.

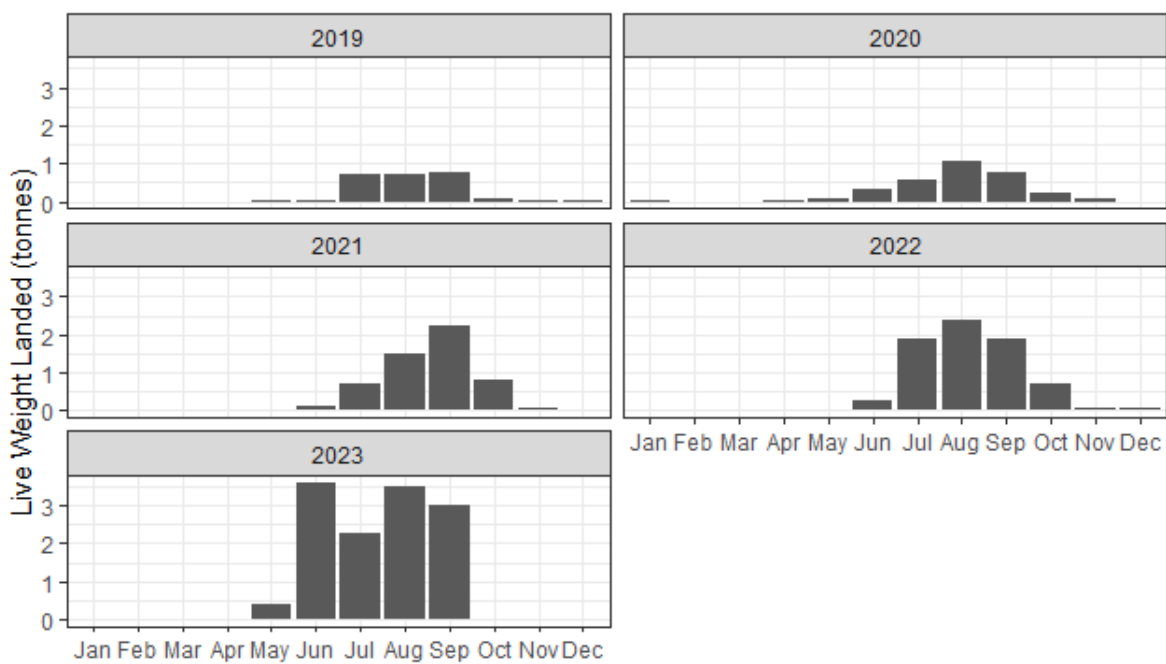


Figure 3 - Live weight (tonnes) landed of crawfish, in the Isles of Scilly, each month, each year from 2019 to September 2023.

Vessels from the nearby harbour of Newlyn also fish for crawfish in the District. Inshore VMS data in the future will inform the extent of fishing activity.

Crawfish netting begins regularly towards the end of May and continues through until November, with a handful of irregular landings between December and April.

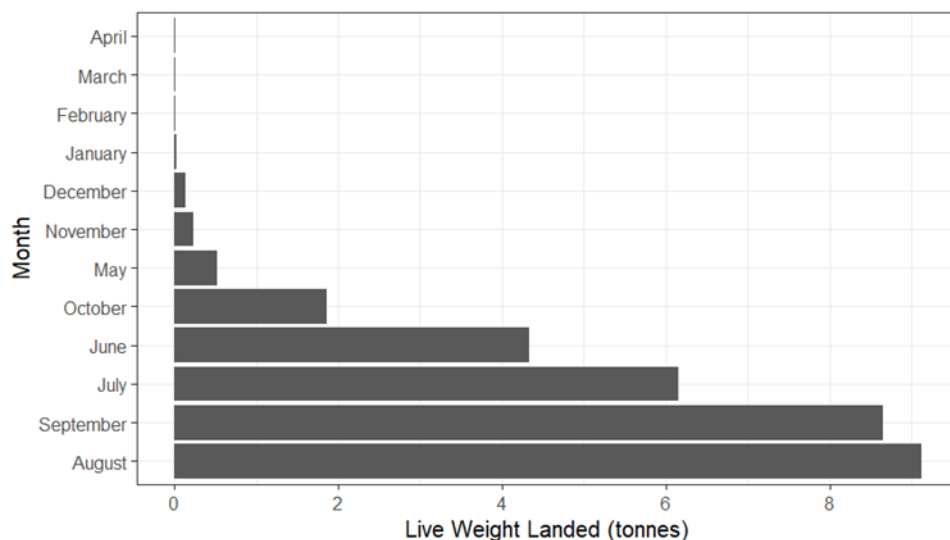


Figure 4 - Live weight (tonnes) of landed crawfish in the Isles of Scilly, grouped by month, from January 2019 to September 2023.

Fishing for crawfish tends to take place further offshore than lobster potting, but remains over rough ground and largely within the six nautical miles of the IFCA boundary.

The crawfish are removed from the net both as the net comes aboard and after the entire net has been hauled. Undersize and berried individuals are returned, and fish are placed in a container or vivier tank.

There is one local dive operator who have a policy of not allowing divers to catch and land crawfish; there are very few visiting dive operators and the IFCA have taken a proactive approach to ensure that they are aware of the voluntary agreement not to remove crawfish from MCZs.

Within the IoSIFCA District both pots and nets used to target crawfish. Individuals that are just pre or post moulting are more susceptible to being caught in pots and appear to be more drawn to bait. During mating individuals are more susceptible to being caught in nets as they move around the sea floor. The last two years have seen an increase in the number of vessels targeting crawfish and the amount of gear being used, the increase in has led to accidental gear conflict in some areas, where nets are shot too close to other gear in the water and this can cause tangles and gear damage.

### 2.3 Gear and Methods Used

Crawfish are mainly targeting using monofilament, tangle or gill net. The gauge and mesh size varies, with small gauges catching smaller fish and larger gauge only catching larger fish. The nets are tied in lengths called tiers, the length of tiers depends on the size and capability of the boat. End weights, usually comprised of 50kg chunks of chain are attached to the start and end of the tier to prevent it drifting. The net will sit vertically in the water column. This method aims to capture the crawfish as they are moving across the seabed.

Tier length (total length of nets tied together), number of tiers, size of mesh, soak time and onboard storage all vary. Number of tiers depends on boat size and capability, ranging from 3 to ~10 deployed at one time, however this also varies over the season depending on how well the tiers are doing. Soak times varied with weather and tide and is usually 2 nights, however some vessels leave

nets soaking over a spring tide and these can be deployed for up to 18 nights.

A small number of fishers target crawfish using inkwell pots. These are baited and attract the crawfish to the pot. These are deployed in string lengths relative to the size of the vessel. This method is potentially less damaging to crawfish. Both methods target deep, rocky reef areas.

## **2.4 Management and regulation**

In January 2024, the MMO introduced an increase in MLS in English waters of ICES area 7 from 95mm to 110mm. The increase was recommended in letters sent by Cornish inshore fishermen (including Isles of Scilly Fishermen's Association) in July and August 2023. The concerns centred around the increase in the numbers of large vessels that had started to target crawfish in waters outside 6nm. MMO figures confirm that the number of vessels has risen from 3-5 between 2010 and 2020 to 8-9 vessels in 2021-2022. As noted in the consultation document, 'large vessels have a far greater increase in effort since these vessels are capable of carrying between 400 and 1,000 nets, whereas small netters are limited to less than 100 nets'. The consultation document also notes that the increase was proposed 'as it will likely increase the reproductive output of the population, by increasing the likelihood that crawfish can spawn at least once before they reach a harvestable size. Evidence also suggests that larger crawfish have a higher reproductive potential.'

There are also proposals for a seasonal closure. The MMO consultation document notes Cefas scientific advice that MLS may not offer enough protection to the stock if catch levels are not also controlled and other measures should be considered including closures or limits on total landings.

Management measures in the IoSIFCA District are currently a MLS of 110mm CL, a measure that was put forward by fishermen in 2017. The return of berried females and individuals that are already V notched individuals is a requirement within national law (although currently V notching of individuals is not widespread). The introduction of the MLS byelaw came into effect in 2020, raising the MLS from the EU size of 95mm CL to 110.

## **2.5 IFCA and crawfish management**

Isles of Scilly IFCA has responsibility for management of Fisheries and the impact of fisheries activities on Marine Protected Areas within a District of 912km<sup>2</sup>.

Under the Marine and Coastal Access Act 2009 (MACAA), the IFCA is required to 'seek to balance the social and economic benefits of exploiting the sea fisheries resources of the district with the need to protect the marine environment from, or promote its recovery from, the effects of such exploitation.' (Section 153 paragraph 2b) and seek to ensure that the conservation objectives of any MCZ in the district are furthered.

The Fishery Act (2021) has led to the development of Fisheries Management Plans (FMP) and eight objectives that are required to be met, of which two are most relevant to the management of crawfish. These include the 'Sustainability Objective' that fish and aquaculture activities are managed so as to achieve economic, social and employment benefits and contribute to the availability of food supplies, but does not overexploit marine stocks. The sustainability objective is intended to highlight the need to draw together these three strands: environmental, social and economic; and over the long-term balance those related to fisheries (social and economic) and the environment on which they depend.

The ecosystem objective defines an approach in which the collective pressure of human activities is kept within levels compatible with the achievement of Good Environmental Status (GES) and does not compromise the capacity of marine ecosystems to respond to human induced changes. In the context of crawfish fisheries, this objective would mean that bycatch would need to be minimised as well as any direct interaction between the fishing gear and protected habitats and other species.

Crawfish are included within the crab and lobster FMP as a ‘data limited species’ with an approach to monitor trends to identify whether further management is required. In comparison to crab and lobster, available data and understanding for crawfish remains poor.

11 Marine Conservation Zones were designated within the Isles of Scilly District in 2013. 9 of the 11 have crawfish listed as a feature with a ‘recover’ conservation objective. Isles of Scilly fishermen were closely involved in the design of these MCZs through a series of meetings co-ordinated by the Sea Fisheries Committee as part of the ‘Isles of Scilly Local Group inputs’. Records (official sightings) of crawfish at the time had been obtained from diver surveys (Dipper 1981, Seasearch 2004). These records were sparse and generally in shallow water and ultimately no ‘formal’ records were submitted, but provided as local knowledge. The MCZ boundaries were drawn using local knowledge and in general followed the 50m bathymetric line, and encompass the reef areas around St Martins, St Marys and the western rocks as well as Bristows to the Stones. It was not until 2014 that crawfish started to return. The vulnerability assessment undertaken at the latter stages of the MCZ process identified the potential that crawfish were likely to be a ‘recover’ conservation objective, but local stakeholders were not involved at this point.

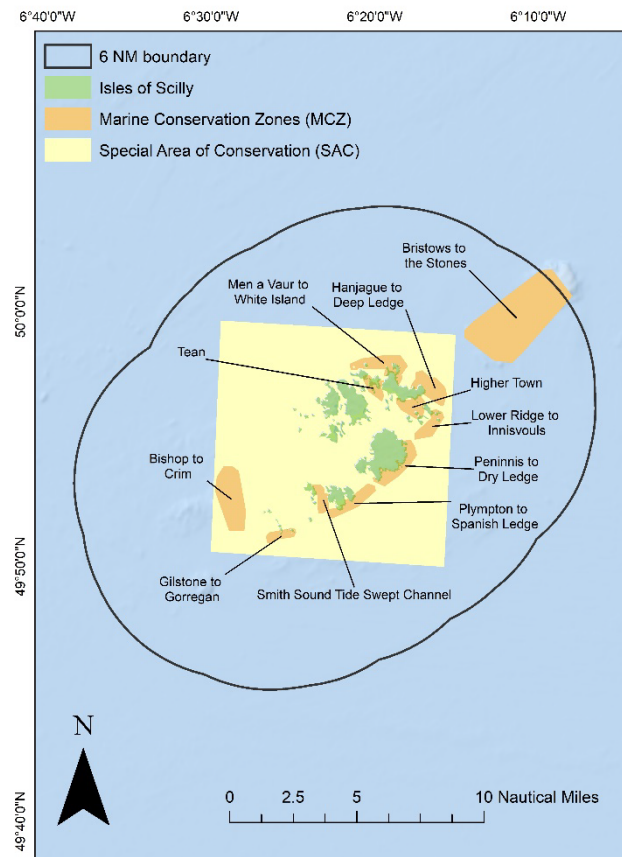


Figure 5 Isles of Scilly IFCA boundary and protected areas.



In the context of crawfish this creates an unusual situation in which a species is being managed both as a fishery and a conservation feature of the Marine Conservation Zones (MCZ). A healthy crawfish population is an important requirement for a healthy and sustainable fishery. The use of diver surveys and baited video technology can be used to inform knowledge of crawfish populations, but are more limited in being able to determine size. On board catch and landings data can be used to gather data on populations and ensure that the catch per unit effort and size distribution are stable. Fishing data cannot provide reliable information on whether there are healthy male and female populations. It is important therefore that all these data are drawn together to provide an insight into the health of a population, irrespective of whether the root of the question comes from a conservation management or fishery management perspective.

The same applies to any measures which are used to ensure populations remain healthy into the future. The causes of crawfish vulnerability and cycles of increase and decrease are not well understood; there may well be oceanographic factors as well as unsustainable levels of fishing activity. The rationale behind these historical patterns may well remain clouded and uncertain; but the current priority is to consider how the current resurgence can be sustained. For all those with a stake in the future of crawfish, it is right to consider what management tools are most appropriate to ensure both the population is healthy and the fishery is sustainable; and for these discussions to be informed by incremental improvements in data gathering and shared understanding between fishermen, regulators, scientists and conservation advisors.

It is important that the Isles of Scilly crawfish fishery is seen in a regional and international context. As noted in section 1.5, crawfish are distributed across the Mediterranean, North Africa, Iberian peninsula and the Celtic Sea. The extent to which local fisheries are dependent on larval movement and settling versus adult migration is still not understood. The telemetry study and small number of tag recaptures suggests a high proportion of residency, but with some individuals tagged in France being caught in Cornwall and the Isles of Scilly there are also individuals that move considerable distances. Research by Tully (2022) in Ireland has similar findings with tag recaptures predominantly local, but variable size distributions suggesting migration.

Research has been undertaken on the crawfish fishery in Brittany, France for the past 15 years and has included tagging and research to gather fishing data. Over this time there has been an increase in the numbers of crawfish with more males and a high number of juveniles (M. Laurens, IFREMER). Management measures introduced are an increased MLS to 110mm in 2009; a winter closure in 2012; fishery closure for females in 2014 and 2015 and a closed area in 2007. In Ireland there are 112 inshore boats targeting crawfish to a varying degree, with annual landings of 20-30 tonnes and a value of E1 million<sup>1</sup>. The principal management mechanism is the use of a 110mm MLS. Areas closed to fishing with nets (west Galway and Kerry) have been in place since 2006 to limit seal and elasmobranch bycatch. Research on growth, population estimates from mark recapture and monitoring catch and by-catch rates in the fishery is ongoing (Marine Institute 2022)

With the implementation of this measure, there will be a standard MLS across the Celtic Sea. Smaller sizes still exist in Portugal (95mm) and the Mediterranean (ranging from 80 to 107mm). A prohibition on berried females exists in Spain and Portugal.

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<sup>1</sup> [https://bim.ie/wp-content/uploads/2021/02/BIM\\_Review\\_of\\_Crawfish\\_Technical\\_Conservation\\_Measures\\_Nov2012.pdf](https://bim.ie/wp-content/uploads/2021/02/BIM_Review_of_Crawfish_Technical_Conservation_Measures_Nov2012.pdf)

### **3. Research and Monitoring**

Over the last decade there have been three research projects that have focused on crawfish on Scilly:

- a) Between 2014 and 2015, crawfish were included in the capture mark recapture tagging research project (Holt & Fletcher, 2016). 745 crawfish were sampled to provide catch data analysis, 283 were tagged and only one was recaptured. The report provides data on the distribution of crawfish within the district, and the catch composition.
- b) In 2018 a study undertaken in collaboration with Cefas used a model to examine how crawfish larvae might be distributed from a selected network of MPAs around South West England (Whomersley et al 2018).
- c) As part of a partnership project led by the University of Plymouth, the Isles of Scilly IFCA installed a network of 14 telemetry receivers at a study site to the north of St Martins and attached 87 transmitter tags to crawfish in 2021 and 2022 to study small scale movement within and around an MCZ.

This report draws on the findings of this research in combination with two years of data gathering on board six fishing vessels in 2022 and 2023. Additional on-board catch research took place in 2019, however this included a limited number of opportunistic crawfish captures from as crab and lobster bycatch, that does not provide enough information to compare with other data so is not discussed further within this report.

Data collated by the MMO from landings data supplied by fishermen through the catch app includes the ICES sub rectangle area caught, live weight estimate and gear used. Local knowledge indicates that there are some anomalies within this data set.

The introduction of iVMS in 2024 should improve estimates of area use and effort.

#### **3.1 Onboard catch monitoring**

In 2022 and 2023, catch data was collected onboard 57% of the local IoS crawfish fleet (8 of the 14 active vessels). Information on each individual crawfish was recorded: length of carapace to nearest mm, sex, breeding condition (berried, spermatophores present, recently moulted) and any notes on health to gain an understanding on the demography of the catch. Alongside this, data was recorded on vessel, weather conditions, depth, tier length, gauge size, mesh size, soak time, and position. The same data was collected for any non-target species caught.

In 2022 data was collected over 9 netting trips from July to September recording 504 individual crawfish. In 2023 data was collected over 12 netting trips and 2 potting trips from May to September with 1109 individual crawfish measured.

#### **3.2 Spatial pattern of fishing activity**

The spatial data collected in this study and Holt & Kelly-Fletcher (2016) only represents the areas fished when observers are onboard and does not show the full extent of fished areas within the District. These fishing locations are however included within this report to show that sampling was

conducted across a range of locations. The addition of iVMS data in future years will be able to increase our insight into the effort distribution of this fishery.

IoSIFCA crawfish report

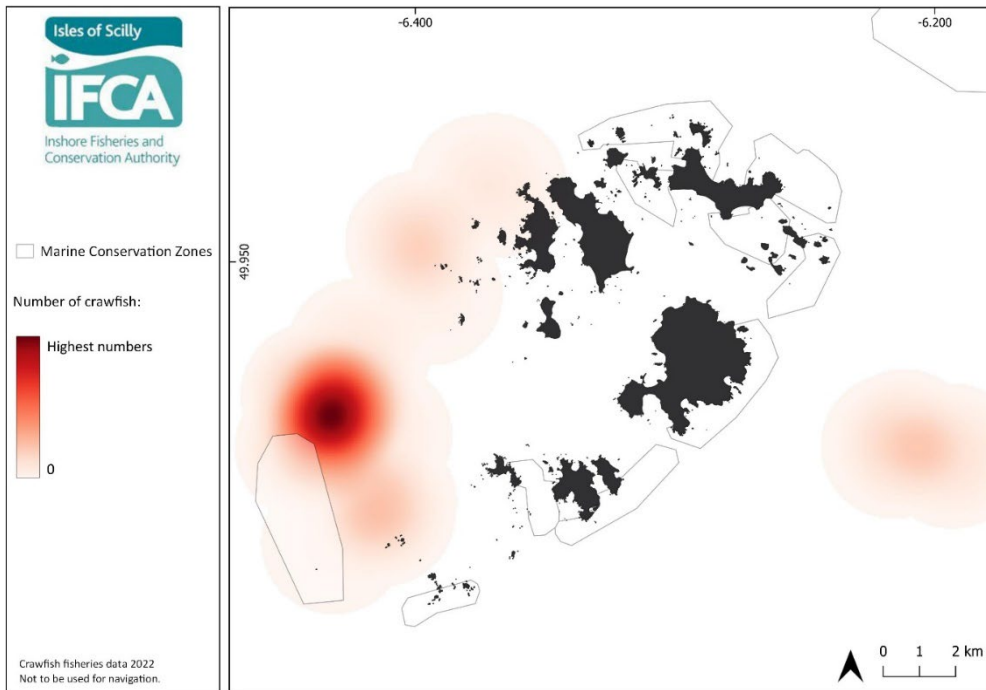


Figure 8 Spatial distribution of effort from catch data in 2022 (Heatmap 2km)

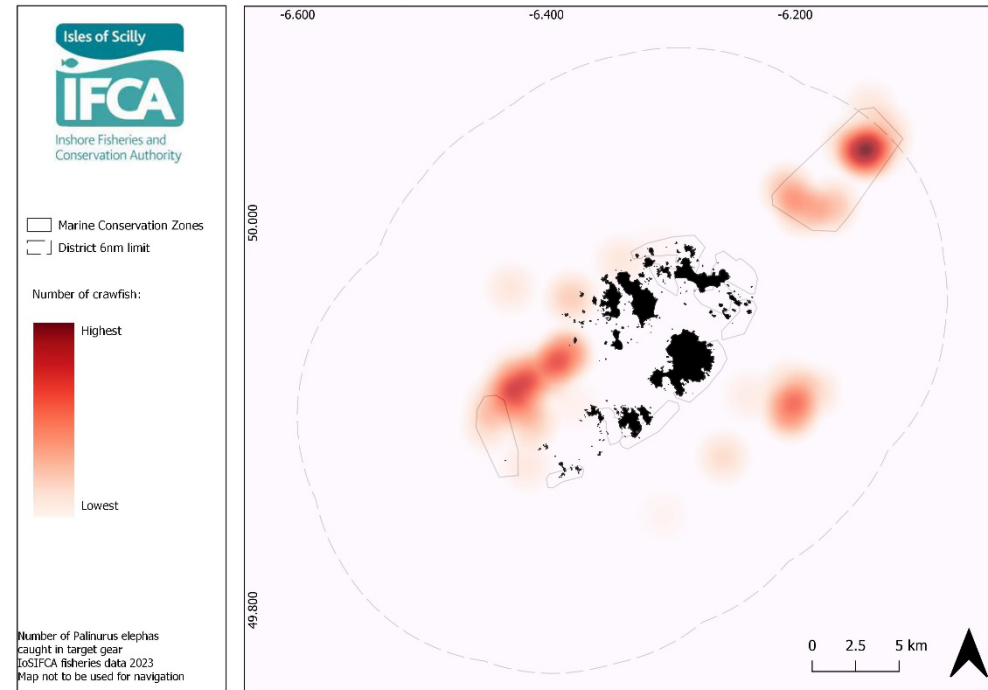


Figure 7 Spatial distribution of effort from catch data in 2023 (Heatmap 2km)

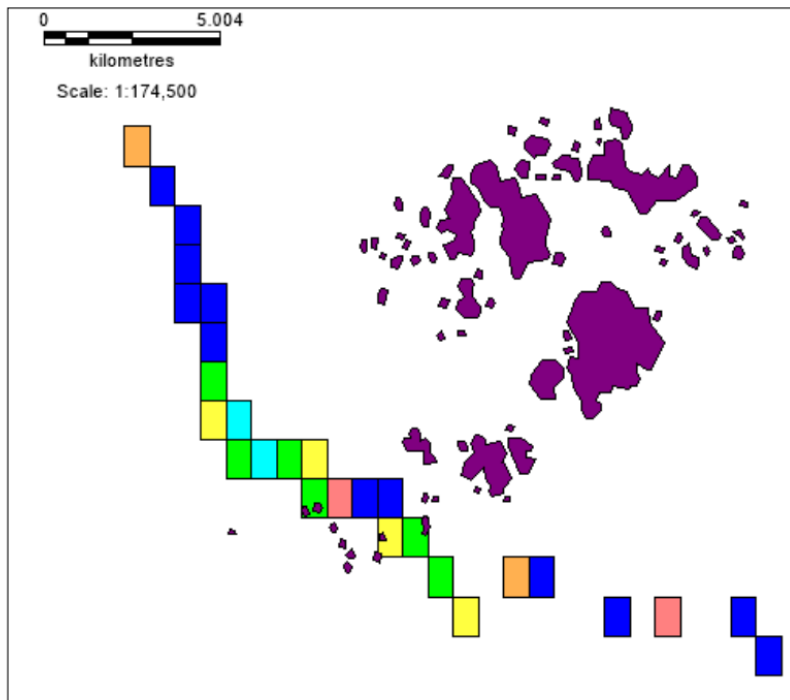


Figure 22. Distribution of crawfish within the Isles of Scilly district

Figure 9 - Spatial distribution of catch data from 2014-15 (Holt and Kelly-Fletcher, 2016).

### 3.3 Tagging

Table 1 - Floy tagged crawfish from 2022-23

Year	Month	Number of Tags
2022	July	8
	Aug	13
	Sept	79
2023	April	3
	May	18
	June	9
	July	27
	Aug	41
	Sept	131
<b>Total</b>		<b>330</b>

There have been 330 individuals tagged since the start of 2022, 117 females and 213 males. Although females were preferentially tagged, due to the sex skew in catch there were significantly more males tagged. There has been a 1.5% recapture rate so far.

Previous tagging research in 2016 had only one return, a male increasing from 98 to 108mm CL over 348 days, travelling a distance of 8.68km (Holt & Fletcher, 2016).

Throughout data collection in 2022 and 2023 crawfish captured below MLS have been tagged to help improve understanding of dispersal and growth in the District. Floy Tag® polythene streamer tags (100mm x 3mm) which read 'IOSIFCA' and have a unique number were inserted dorsally using a needle into soft tissues visible between the end of the carapace and the first or second tail segment, with the needle subsequently discarded to leave the two ends of the tag visible.

Not all crawfish were tagged, the number tagged depended on condition of the fish and ability during the haul. Hauling of the net was prioritised at all times to ensure safety of the boat and convenience of the skipper.



Figure 10 - Blue floy IFCA tag inserted dorsally into crawfish tail.

Table 2- Recaptured crawfish 2022-23

Sex	Date tagged	Tag number	Initial tag position	Date re-captured	Position recaptured	Distance moved	CL when tagged (mm)	CL when recaptured (mm)	Growth rate	Growth period
M	19/09/202	3741	49 53.203 006 24.660	26/07/203	49 53.203 -6 24.660	0km	104	<110	Less than 6mm	10 months
M	28/05/203	3270	49 55.033 006 26.373	23/08/203	49 55.193 -6 26.075	400m	105	=/>110	5mm	3 months
M	13/07/203	3299	50 00.438 006 12.711	28/07/203	50 00.101 -6 12.623	450m	105	<110	<5mm	2 weeks
M	01/09/203	3350	49 58.598 006 16.248	09/09/203	Near the crim	~19km	104	104	0	8 days
M	13/07/203	3291	49 59.719 006 10.899	07/10/203	49 59.328 006 10.604	100m	103	109	6mm	3 months

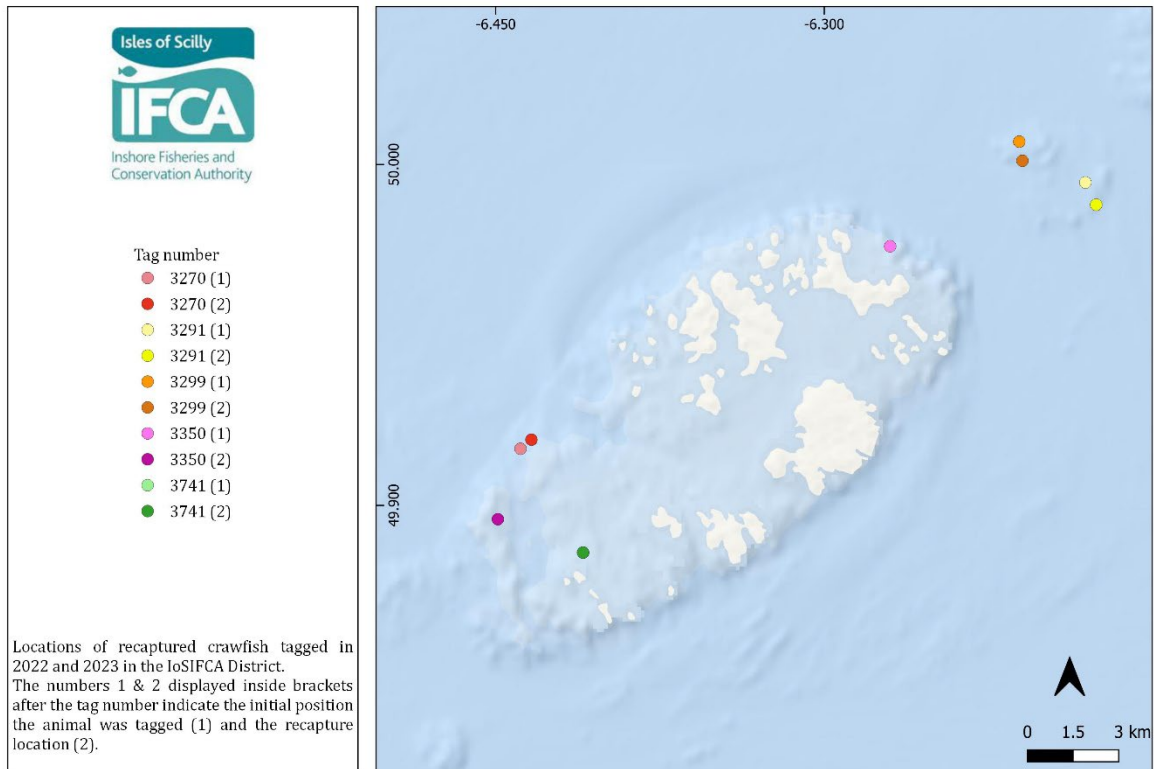


Figure 12- Initial tag and recapture locations of crawfish in the Isles of Scilly from 2022 to 2023.

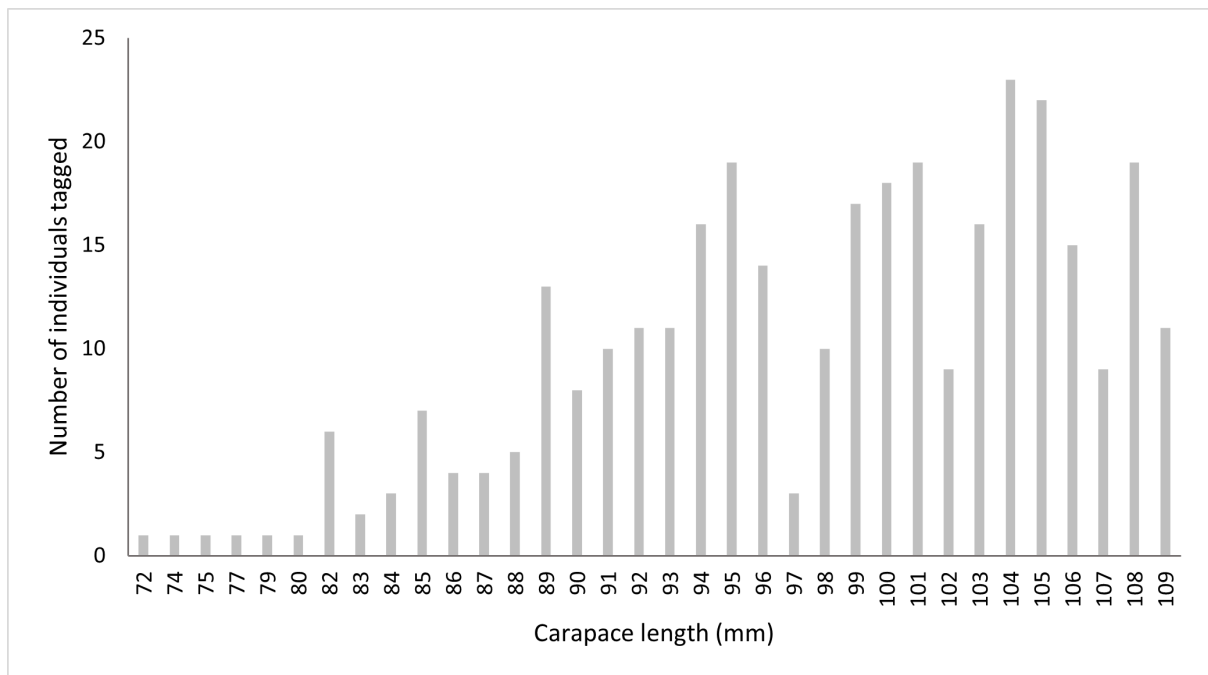


Figure 11 - Length frequency of tagged crawfish in 2023

there were also 2 French tagged crawfish captured in 2023 and 1 French crawfish captured in 2022. Crawfish tag 3006 was a male tagged south of Brest (48° 03 01 N, 5°05,20 W WGS 84.) on the 9<sup>th</sup> of September 2019 at 91mm. He was recaptured on the 17<sup>th</sup> of August 2023 at 122mm CL at 49 52.234,



006 16.261, travelling a distance of around 150 miles in 4 years and growing approximately 10mm a year. We do not have the data available from IFREMER for the remaining 2 tags.

Although tagging research has improved our knowledge of crawfish movement in the District, indicating similarly to other research carried out in the Mediterranean (Follesa et al. 2009), there is strong site fidelity with a small number of individuals travelling further, the sample size is too small to draw any full conclusions. The returned sample size has also been unable to provide much clarity on growth rates in the District. Results from the 5 recaptures suggest that crawfish may be more likely to moult in the summer than the winter and that crawfish may increase CL ~5mm per moult.

Future tagging needs to consider using T bar tags used by other research teams on *Palinurus elephas* (France, Mediterranean, Australia), that are ventrally inserted with a tag gun. Although these are more costly and require some training, they have more longevity than floy tags.

### **3.4 Ecological research**

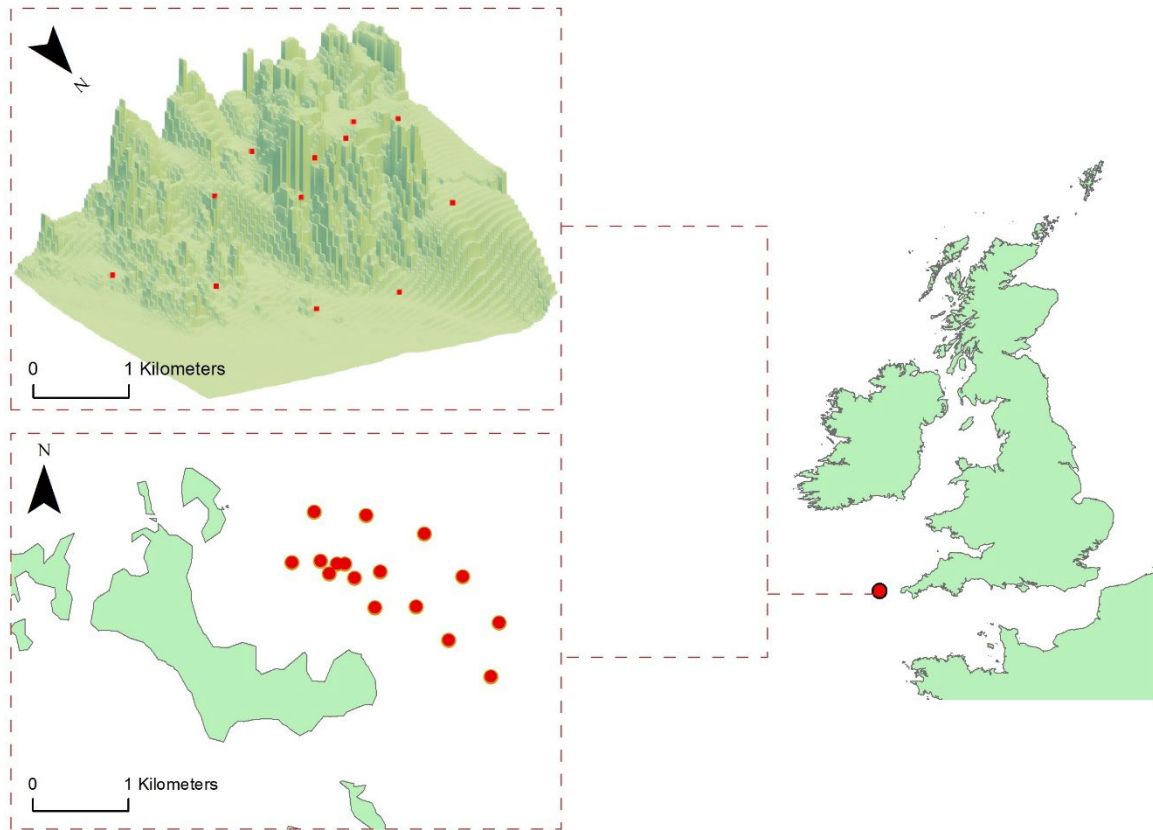
Data to inform species records and conservation status for crawfish has generally relied on volunteer diver records (Jackson, 2021). Although the data can be modelled and extrapolated, it is generally biased towards shallow depths and to some extent observer biased. Over the past two years our ecological understanding has been expanded through the use of telemetry research and Baited Remote Underwater Video (BRUV) data gathered as part of a PhD with the University of Exeter.

In future years the capabilities of local divers could also be used to collect further juvenile settlement data, identify sex ratios or provide population estimates at key sites.

#### **FISH INTEL acoustic tracking**

Isles of Scilly IFCA have been a partner in the FISH INTEL project led by the University of Plymouth with partners from the UK, France and Belgium. Using an array of 14 receivers the aim was to help us learn more about the movement and migration of crawfish.

Receivers were set in both a small scale array, able to detect movements down to a 10m radius and a broad scale array that could detect movements of 1 to 2km.



*Figure 13 - Position of acoustic receivers (red points) in the Isles of Scilly as part of the FISH INTEL network, shown on 3D depth (top left) and 2D map (bottom left) in relation to the UK (right)*

There were 87 individuals tagged (26% female, 74% male) with acoustic transmitters (v9) ranging from 60 to 140mm CL. These were caught by divers and fishers, both adjacent to the network and relocated from across the District.

Over the course of the study there were 1.9 million detections from 82 crawfish. The longest track was 10 months and the shortest 1 day, mean detections per individual of 23 000.



Figure 14 - Abacus plot displaying detections received from crawfish on FISH INTEL receivers arranged by sex and the year captured. Each animal is represented by a row, each detection is represented by a point on each row. The colour of the point represents the receiver that detected the animal.

Further analysis of this data will occur in 2024, however telemetry data currently suggests that individuals have relatively small home ranges. Most tagged animals have been recorded remaining within spatially restricted areas, with core activity areas measuring approximately 100-200m with a maximum extent of movements contained within 1-2km. The telemetry data also highlights differences in male and female movement patterns (Figure 13), with females being detected at a lower rate than males. This is thought to be due to females spending a high proportion of time within rocky crevices where they aren't detected by the receivers. This would suggest that females are more sedentary than the males and further highlights that spatial management such as MCZ's would be an effective management tool if deemed appropriate within the Isles of Scilly.

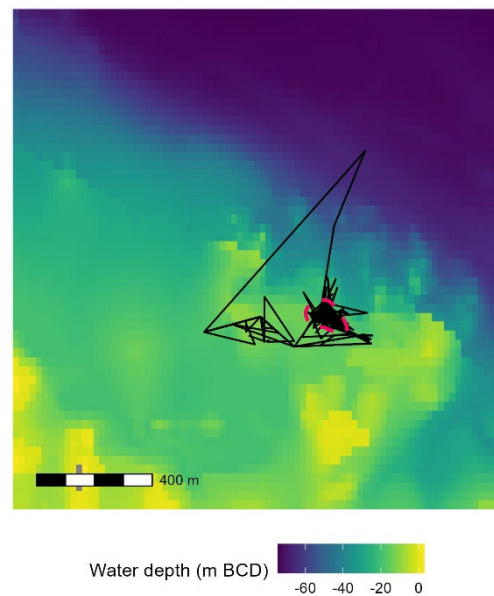


Figure 15 - Example figure of acoustically tagged Crawfish (ID: 34977; Male; 108mm CL) movements 21/09/2022 – 30/05/2023. Black line represents animal path. Pink boundary represents animal core activity area

### 3.5 Baited Remote Underwater Video Systems

Isles of Scilly IFCA, in partnership with the University of Exeter are supporting a 4 year NERC Doctoral Training Partnership PhD carried out by Owen Exeter. Data collection was completed in 2023. The PhD aims to monitor ecological changes within the Isles of Scilly and is supervised by Dr. Kristian Metcalfe and Professor Annette Broderick. Research is carried out largely by using baited remote underwater video systems (BRUVS). The system holds cameras at one end of a bait pole, able to record any individuals which appear to investigate the bait, or which pass the camera by chance. BRUVS are placed on the seabed, or to float in the water column for a set period of time. The footage is analysed to determine species diversity, abundance and for some species sex ratio within 200m radius of the deployment site. They are stereo BRUVS which means they are able to measure the length of individuals seen on the cameras.

Preliminary analysis of this data suggests BRUVS may be an effective tool for measuring crawfish distribution and relative abundance (Figure 9). Further analysis will determine whether BRUVS can be used in future years as a fishery independent measure to monitor the crawfish population.

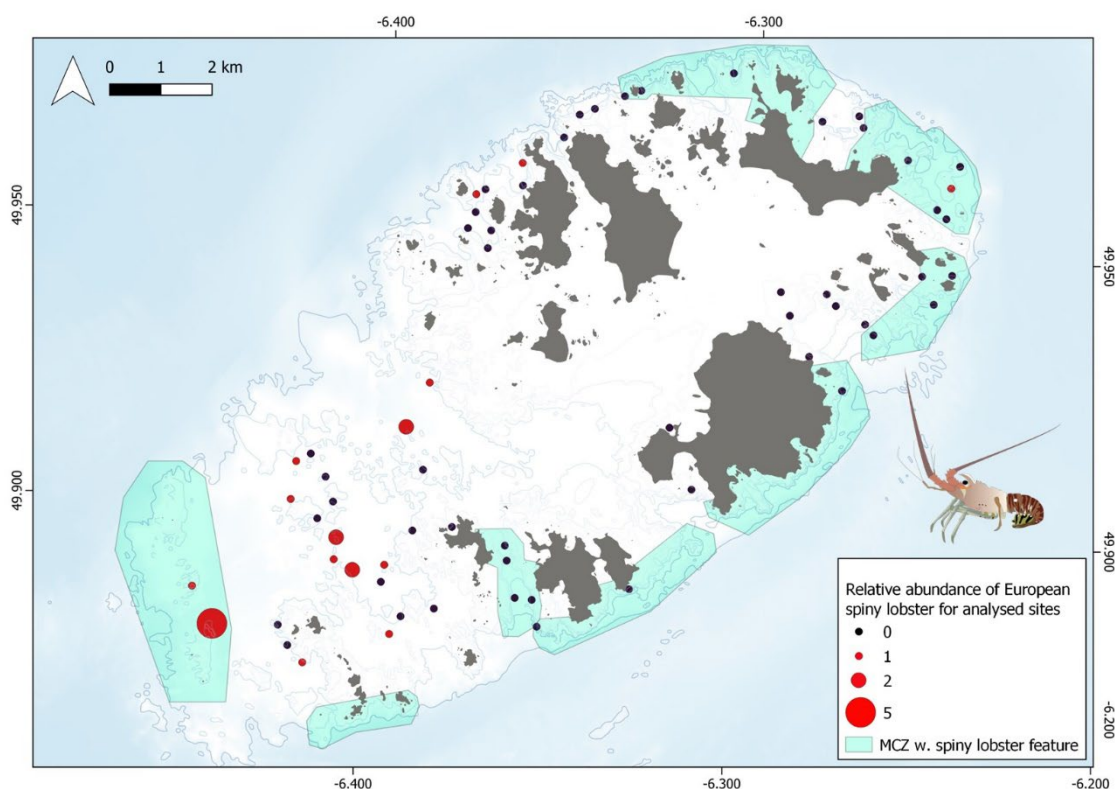


Figure 16- Preliminary results using a sample (71 of 300 deployments) of analysed BRUVS survey data showing A. crawfish occurrence at each survey site and B. a kernel density estimate of crawfish occurrence using a 100 x 100 m grid cell resolution with a 1 km search radius.

### 3.6 Population health

There is currently no formal stock assessment in place for crawfish in the Isles of Scilly. The following data from 2022 to 2023 provides a baseline from which to develop future assessments. In order for a

stock assessment to be developed there needs to be adequate information on abundance, mortality, reproduction and growth. There are challenges associated with gathering this information on crawfish. Creating accurate ageing methods is difficult due to the loss of tissue during moults. There is also very limited data on mortality and larval movement.

In the UK Length Cohort Analysis is currently used to assess crustacean stock health for lobster and crab. This relies on a number of assumptions and models which need less data input and could be used for crawfish, however due to the high number of assumptions uncertainty with model outcomes is likely to be high.

Future data collection efforts to help create stock assessments are included in the recommendations section of this report.

### **3.7 Length frequency distribution**

For 2023 the total number of crawfish caught was 1196, with 1190 measured. These were collected from 12 net targeted fishing trips made of 37 tiers equating to 15.13 miles of net, 2 pot fishing trips of 126 pots and includes incidental captures in pots from trips targeting lobster and crab. The majority of crawfish caught were male, making up 79% of catch ( $n=206$  females,  $n=984$  males). The mean carapace length for crawfish was 112mm, for males 113mm (range: 79mm – 150mm), and for females 106mm (range: 72mm – 155mm).

The percentage of undersize (<110mm CL MLS) catch was 39.5% ( $n=472$ ), with 60.5% ( $n=724$ ) of catch above MLS. The percentage of catch landed follows the number of fish above MLS closely with 58.9% landed, 1.8% dead and 39.7% released. Crawfish above MLS were released if they were soft or berried.

### **3.8 Catch per unit effort trends**

This is the first time that commercial catch and effort in the Isles of Scilly crawfish fishery has been recorded. Catch per unit effort data was taken from 12 netting trips in 2023 on 6 different vessels, consisting of 37 tiers from May to September. Only netting data was included for catch per unit of effort (CPUE) due to lack of pot data. This data provide an initial indication of CPUE over the course of a summer, it is not comprehensive and does not include differences in CPUE that may occur seasonally or between different areas or vessels. CPUE is an indicator of change in the population biomass, however it does have caveats and cannot account for other factors such as varying catchability between years, or changes in sex or size of fish. Developing a standardised index that accounts for differences in catchability, that are unrelated to changes in population size, would be a next step in this process.

The average (mean) soak time for nets was 6.3 nights, with a mean of 3 nights (range 2 – 18 nights). The large range is due to some nets being left out over spring tides and others being taken out the water. Overall CPUE in the 2023 fishery was calculated as 26 ( $\pm 21.4$  SD, SE 3.5) crawfish per mile of net, per night. This should act as a comparison for future data collection when taken from a range of vessels in the fleet over the 6 month summer season. In 2022 CPUE was 28 ( $\pm 24.5$  SD, SE 5.5)

crawfish per mile of net, per night, although this should be taken with caution due to the small sample size ( $n=504$ ). In comparison catch rates of crawfish varied from 5-25 fish per mile of net between 2017 and 2022 (with the majority within the 10-20 range) in Ireland (Marine Institute, 2022)

### 3.9 Functional sexual maturity

Size at sexual maturity is still relatively understudied in the Atlantic population of crawfish. Estimates include work from Hunter finding in the early 1990's mean CL for berried females was 138.5mm (Hunter et al. 1996) and later berried females ranged 90 – 121mm CL (Hunter et al. 1999). In the Mediterranean functional maturity is thought to occur around 77.2mm CL (Goni et al. 2003) and in Portugal at 110mm CL (Galhardo et al. 2006).

We were unable to find L50 due to small sampling numbers (1% of catch,  $n=12$ ), however the mean size of berried females was 117.8mm CL (range 90 – 152,  $\pm 19$  SD). We have found a greater range in size at functional maturity in 2023 than in 2022, where mean was 123.2 mm CL ( $\pm 9.6$  SD, 0.9% of catch,  $n=5$ , range 117 -140). All sample sizes are small.

Not included in analysis of functional maturity, but recorded are hens with spermatophores present (2022 and 2023,  $n=3$ , 101 – 137mm CL).

Data collected from the past 2 years does not provide much clarity on whether the current MLS of 110mm CL allows females to breed before entering the fishery. In future larger sample sizes will be needed to be able to determine L50 (carapace length at which 50% of females are mature).

### 3.10 Comparison with previous assessments

A comparison was made in the size-length frequency of male and female crawfish captured within the IoS IFCA district in 2023, 2022, 2015 (Holt & Kelly-Fletcher, 2016) and 2014 (Holt & Kelly-Fletcher, 2016). Across the four years the minimum and maximum carapace length for males and females was 75 – 152mm & 66 – 155mm respectively.

The mean carapace length of males has increased by almost 4mm, from 108.4 mm CL to 113mm CL in 2023. Whereas for females the mean CL has decreased by almost 6mm, from 112.1 to 106mm CL. When visually inspecting the size frequency distribution (Figure 17), a disproportionately high number of small individuals were captured in 2014 and 2015. In 2022 and 2023 the same pattern is not observed, suggesting that in 2014 and 2015 a relatively high number of smaller animals were recruiting/moving into the isles of Scilly district.

Using an Analysis of Variance (ANOVA), a statistically significant difference was observed for male and female carapace lengths by year (Table 4 and Figure 17). Using a pairwise comparison significant differences were observed for years 2022 (F: 51.36, P: 0.01) and 2023 (F: 51.36, P: <0.001), where, males were observed to be 4.5mm and 7.2mm larger than females (Figure 17). The biological significance of differences in size between years is not fully understood. However, across all years the size range of the adult population was thought to be healthy, due to the approximately bell

curved shape in size distribution of captured crawfish. If significant fishing pressure was applied to the population, which was selecting/removing specific size class(s), size frequency plots would show highly irregular patterns.

Variables	Sum squares	Mean squares	F value	P
Sex	2860	2859.54	14.293	<0.001
Year	3504	1167.87	5.838	<0.001
Sex * Year	7279	242648	12.129	<0.001

Table 3– ANOVA table showing statistical significance of year, sex and their interaction (sex \* year) on carapace length

A high proportion of male animals were captured across all the years. The percentage of catch that was male was approximately 70% in 2014 and 2015 (Holt & Fletcher, 2016). In 2022 and 2023 the proportion of males captured varied from 89% to 82%. Similar patterns have been observed by fishers in Cornwall, where the catch was 78%, 84%, 85%, 81% Male in 2020, 2021, 2022 and 2023 (pers. Comm C. Daniels, Scientific Officer CIFCA). The high domination of male animals within the fishery is thought to be a result of sex-dependent differences in movement characteristics (section 4.1.1), however further work is required to qualify this.

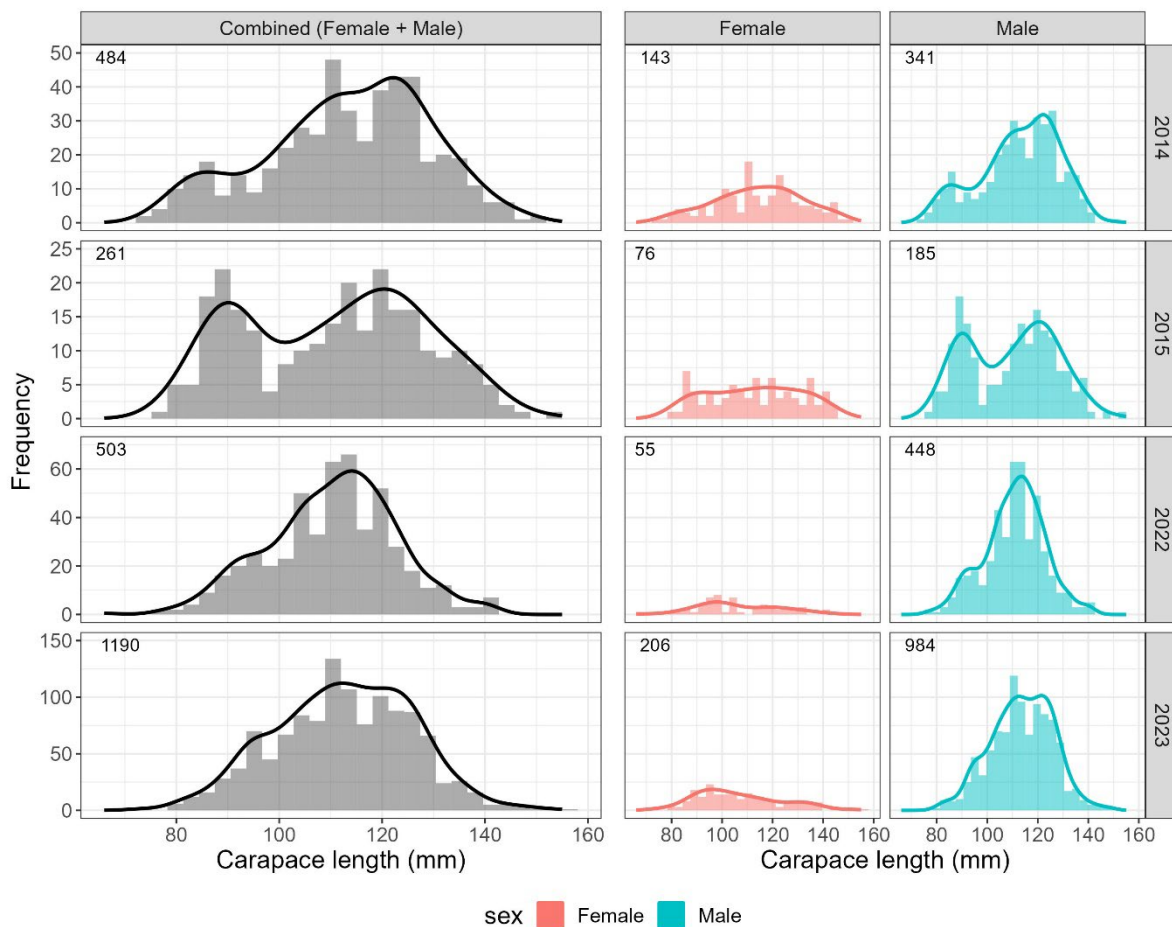


Figure 17- Length frequency of crawfish from onboard catch data 2023, 2022 (collected by IoS IFCA), 2015 & 2014 (Holt & Kelly-Fletcher, 2016). Number in top left shows sample size



### 3.11 Summary

This table gives a summary of the current status of the crawfish population and fishery in the Isles of Scilly.

**Table 4** - Summary of the current status of the crawfish stock in the Isles of Scilly

Category	Status
Landings	Landings have increased in recent years due to the increase in crawfish (241%), and consequently an increase in effort, both in fleet size (20% increase) and number of tiers.
Spatial effort	A broad picture spatial activity can only be inferred from onboard catch recording, but does not represent a comprehensive picture. Effort is concentrated on rocky reefs surrounding the islands, these include those to the west and south of the islands and further to the east, including Bristows to the Seven Stones reef. There appears to be limited targeted fishing to the north of the islands. This is likely due to a lack of suitable ground. The inclusion of iVMS data in future reports will give a clearer understanding of effort distribution.
Catch rates	This is the first year a CPUE has been created for the fishery. CPUE is currently at 26 crawfish per mile of net per night. This is hard to compare regionally but appears to be similar to other areas of the SW UK.
Fishery independent monitoring	Movement studies in partnership with the FISH INTEL team supports research from the Mediterranean which shows males have small home ranges. Preliminary BRUVS data suggests that BRUVS may be an effective way to help monitor crawfish abundance in the future.
Size/sex composition	Mean carapace length is currently higher than minimum landing size. There appears to be no decline in the size of males. There is a decline in the size of females. Juvenile fish currently make up 39.5% of catch. The fishery currently has a male predominance of 79%, the cause of which are unknown.
Fishing mortality	Unknown – further research needed.
Spawning biomass	Unknown – further research needed.



### **3.12 Future objectives and recommendations for the fishery**

Some overall objectives and principles of the fishery need to be developed from the information collected over the past two years (2022 & 2023). Information on the stock is still limited, however some basic principles can be established which can act as shared and transparent boundaries for future governance.

The overall objective should be for a co-management approach in which fishermen and regulators are working in tandem with scientists and using knowledge collected to determine whether and what management intervention is required.

Crawfish research over the last two years in collaboration with fishermen provides a first and basic indication that the population is healthy. Catch Per Unit Effort is increasing; there is an even population size distribution and the average size of males increasing by 4mm since 2015. However, average size of females is decreasing and this species is known from history to be vulnerable to sudden declines. Although effort has increased rapidly within the district over the past three years, there are no signs that would indicate effort is unsustainable. However, the study is still at a very early stage and sample sizes are very small to have high confidence in CPUE and size distribution. It is important to note that it is not possible, with two years of data to determine a trend.

Based on this knowledge, it would be sensible to ensure annual onboard research with a target of 20-30 trips a year and to continue to use baited video to replicate our understanding of populations on the ground. Diver surveys have been used in the past, but it would be beneficial to incorporate an additional element to record the sex of individuals.

In collaboration with fishermen, the development of some target indicators or 'warning lights' would be useful – for example if the number of boats or tiers increases by 20%; the number of immature fish declines by 20%; catch per unit effort declines by 15% or the average size of individuals declines by 15%. Any of these would be a point that would initiate meetings with fishermen and IFCA to discuss whether any further measures would be necessary.

Research should aim to achieve a higher rate of sampling over greater time in order to smooth the data and reduce any short term anomalies.

Any future management intervention should be based on scientific knowledge and using proportionate measures, that have strong evidence that they are necessary, effective and enforceable.

Specific objectives should be linked to requirements under the Fisheries Act.

There is a need for regional and international co-ordination. The IFCA should be active in working with neighbouring IFCAs, the MMO and management and research organisations in England, Wales, Ireland and France.

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Appendix 1 – Data collection form

<b>Date</b>		<b>Vessel ID code</b>	
<b>Observer</b>		<b>Weather/Sea state</b>	

<b>Net Number</b>			<b>Mesh size:</b>			<b>Gauge size:</b>			<b>Tier length</b>			<b>Soak time</b>		
<b>Start Location</b>	<b>Lat:</b>		<b>Lon:</b>			<b>End location</b>		<b>Lat:</b>		<b>Long:</b>				
	<b>Habitat/depth</b>													
<b>Length (mm)</b>	<b>Sex (M/F)</b>	<b>Notes (berried, disease, parasite)</b>		<b>Tag</b>	<b>Bycatch species</b>	<b>Bycatch length (mm)</b>	<b>Bycatch sex</b>	<b>Notes</b>		<b>Bycatch fate</b>				