Isles of Scilly Stock Status Report 2023: Brown Crab (Cancer pagurus)

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Suggested citation format:

Morcom, S., Hooper, T., Pender-Frazer, C. and Stamp, T. (2023) Isles of Scilly Stock Status Report 2023: Brown Crab (Cancer pagurus). Isles of Scilly Inshore Fisheries and Conservation Authority.

Acknowledgements

The authors thank all the fishers who contributed to data collection.

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Table of Contents

List of Figures

List of Tables

Contents

Executive Summary

The brown crab (Cancer pagurus), also referred to as edible crab, is distributed throughout the UK coastline. It inhabits a range of habitats and depths over its life cycle and is found widely in the Isles of Scilly Inshore Fisheries and Conservation Authority's (IoSIFCA) six nautical mile limit. The crab fishery in the Isles of Scilly accounted for 48 percent of landings in 2022 and is targeted by 50% of boats in the current fleet. It is worth around £200,000 annually.

Brown crab are found from Norway through the North Sea and English Channel to the coast of Portugal. Their reproductive cycle is estimated to be around 7 years, with individuals becoming sexually mature ~4 years old. Females move inshore in the summer months to moult and mate before migrating offshore to incubate eggs for 6-9 months, larvae hatch and females return to shallow inshore areas once again. Brown crabs have a wide-ranging diet and will both predate and scavenge food sources including hard shelled bivalves and fish. Brown crabs inhabit a range of habitats, preferring complex, inshore areas during juvenile stages and a range of deeper habitats when they are older.

Brown crab was the third most valuable species landed into the UK in 2021 worth £59 million. Despite the importance of this fishery to the UK, research and stock assessments have been lacking, with brown crab currently regarded as a data poor species. The latest stock assessment in the UK was carried out in 2018 (published 2019), over 4 years ago. It is widely recognised that stocks of crab are in decline in the UK, however there is limited data available to support this.

People have likely been harvesting crab on the Isles of Scilly for as long as the islands have been inhabited. The first official landings records are from the early 1900's. Management is a minimum size of 160mm carapace width (CW) for males and 140mm CW for females, with the return of berried individuals.

Vessel onboard catch monitoring will be continued every 3 years in the Isles of Scilly to improve data on the fishery and develop indicators from which the fishery can be more effectively monitored and managed.

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
MMO	Marine Management Organisation
CMR	Catch-mark-recapture
CW	Carapace width –– measured across widest part of carapace, above midline
MLS	Minimum landing size – 160mm CW male/140mm CW female in the District
SOM	Size at sexual maturity
BRUVS	Baited remote underwater video systems

1 Species Description

1.1 Life History

Brown crab (Cancer pagurus), also known as edible crab, are a relatively fast growing crustacean. Mating occurs over the late summer months with males guarding females until they moult. Copulation occurs sternum to sternum (Edwards, 1966) with the male releasing sperm inside the female, the female then produces a fluid which hardens on contact with seawater creating a plug which retains the sperm inside and prevents seawater entering (Pearson, 1908). Males will then continue to mate guard for up to 2 days. Sperm can be retained by females and has been shown to be able to fertilise up to 3 years of successive egg broods (Pearson, 1908). Broods are single paternity (McKeown and Shaw, 2008).

After mating females migrate offshore to spawn eggs (Bennett and Brown, 1983, Hunter et al. 2023). There is no data on the period of time between insemination and spawning and it is likely this varies. It has been suggested these offshore migrations are to allow the females to be in warmer (deeper) water over the winter months, or to allow currents to carry larvae in a particular direction after spawning (Bennett and Brown, 1983, Thompson et al. 1995, Hunter et al. 2013, Eaton et al. 2003). However, migration may also be caused by females trying to find soft, sandy sediment in which to bury themselves whilst incubating, as some females have been found brooding in inshore sandy areas (Woll, 2003). Once females ovulate, they bury down into deep, sandy sediments and reduce their movement, feeding and heart rate (Hunter et al. 2013, Naylor and Taylor, 1997). Females incubate eggs for 6 – 9 months depending on water temperature, with faster incubation likely in the Western English Channel due to warmer temperatures (Hunter et al. 2013, Bennett, 1995), before releasing the hatched larvae into the water column.

The pelagic larval phase lasts at least 60 days in water temperatures between 15 and 20 degrees Celsius (Nichols et al. 1982, Thompson et al. 1995). Genetic studies suggest that dependant on prevalent ocean currents, some populations may be self-seeding (Eaton et al. 2003) but the majority are interlinked (Ungfors et al. 2009, McKeown et al. 2017). There is little known about settlement and early life stages, however juveniles are found in shallow, complex, coastal habitats (Mesquita et al. 2021). Complex habitats are often selected by juvenile species as they offer more protection than open habitats, improving growth and survival (Lefcheck et al. 2019). The life cycle takes around 7 years.

Although it has been suggested that females are less likely to enter pots when they are carrying eggs, berried females do still occur in pots in the Isles of Scilly. Only 3 were recorded in 2023 due to onboard catch recording starting beyond the period at which berried females are usually found. Berried females entering pots on a small scale has been reported elsewhere (Haig et al. 2015).

1.2 Size at Maturity

The literature on size at sexual maturity (SOM) shows that this can vary between areas, with some regional areas showing differences (Easton et al. 2023) and others not (Bakke et al. 2018). Size at maturity can be behavioural, physiological, function or morphometric. In the UK behavioural SOM for females ranges between 105- 211mm CW (Brown and Bennett, 1980), physiological SOM ranges 120 -133.5mm CW for females (Tully et al. 2006 and Tallack, 2007) and 104.3 - 110mm CW for males (Edwards,1979, Tallack, 2007 and Easton et al. 2023) and functional SOM ranges 116 – 196mm CW for females (Haig et al. 2015 and Tallack, 2007).

As catch data was not collected at the correct time of year for berried females we are unable to improve our understanding of size of maturity in the District. The minimum landing sizes (MLS) in the Isles of Scilly District is 140mm CW for females and 160mm CW for males and it is highly likely these allow crabs to breed before entering the fishery.

It is worth noting that males often have smaller SOM (Easton et al. 2023, Tallack 2007) and yet have larger MLS than females. Females are also targeted more heavily than males in the fishery due to seasonal movements. Females are genetically monogamous, retaining sperm from only one male, with the ability to retain sperm for multiple brood fertilisations, this makes the population more susceptible to overfishing females (McKeown et al. 2008).

1.3 Growth

Growth rate in Cancer pagurus has not been extensively studied due to difficulties rearing in captivity and recapturing tagged individuals in the wild. Males and females grow at similar rates when below 100mm CW, as crabs mature their growth rate slows down. Post sexual maturity females grow more slowly than males, this is likely due to reproductive trade-offs, this causes males to grow to much larger sizes than females in the SW UK (Bennett, 1974). Male growth rate is initially about 10mm CW a year, this then slows to 2mm a year and for females growth rate is about 5mm a year initially, slowing to 1mm a year CW (Bennett, 1979).

Discovering the relationship between growth and age is challenging in crustaceans. Advances in technology have allowed neurolipofuscin-based ageing techniques to be used to improve our understanding of age in brown crab. They suggest the average time for a crab to reach MLS is 4.1 years for females and 4.8 years for males. Mean maximum age was 9 years. This suggests that large males might represent the upper extreme of growth variability rather than living for a long time (Sheehy and Prior, 2008).

1.4 Movement

Research has shown that females tend to follow a westward migration in the English Channel, most likely in order to brood and release larvae, although there was no set breeding area (Bennett and Brown, 1983, Hunter et al. 2013). This movement only appears to happen in the English Channel. This migratory movement seems to only occur in females, with males moving much less (Ungfors et al. 2007). Males that do travel long distances are more likely to be large individuals (Bennett and Brown, 1983).

Recapture rates tend to be slightly higher for crab than they are for European lobster and spiny lobster at around 30% (Karlsson et al. 1996, Hunter et al. 2013). Anecdotal evidence from Scillonian fishers suggests that brown crabs in Scilly perform seasonal migrations.

1.5 Distribution and Habitat

Brown crab are distributed across the NE Atlantic, from Norway through the North Sea and English Channel to the coast of Portugal. In the Isles of Scilly IFCA District Brown crabs inhabit a wide variety of habitats from shallow, inshore intertidal areas such as rockpools to deeper offshore rocky and sandy habitats. The target fishery is located offshore in deep waters around 90 metres over sand, mud and reef habitats. Juvenile crab are frequently bycaught in lobster pots that are fishing in shallow inshore water.

There is limited research on habitat preference in brown crab, however unpublished research from the University of Bangor suggests juvenile crab in the Isle of Man prefer complex habitats that contain kelp and macroalgae (May, 2015).

1.6 Diet and Predators

Brown crab are both active predators and scavengers. They consume a wide variety of crustaceans, molluscs and echinoderms, including their own species. The most likely predators of crab in the Isles of Scilly are nursehounds (Santoro et al. 2023) and other crabs.

1.7 Parasites and Disease

Blackspot is the most common disease seen in brown crab. It is caused by a bacterial infection that causes black lesions on the exoskeleton (Ayres & Edwards 1982). It is thought to mostly affect older crabs that moult less frequently (Stentiford, 2008), however Haig et al. in 2016 found infections in crabs as small as 72mm CW.

In Cornwall's inshore shellfish stock survey 2003 – 2006 they found the presence of 'pink' or 'bitter' crab disease, the latter seen predominantly on the south coast from Mount's Bay to the west (Davis and Trundle, 2006). This disease is fatal to edible crabs and has not been

studied in detail in the UK. There are no signs of it in Scilly, but it remains something to be aware of.

For the latest review please see Stentiford, G.D., 2008. Diseases of the European edible crab (Cancer pagurus): a review. *ICES Journal of Marine Science*, *65*(9), pp.1578-1592.

1.8 Inherent vulnerability

The life history of brown crab gives them a low vulnerability rating (10/100) with a high resilience (sealifebase, 2023). Cancer pagurus have high fecundity. They also have a highly dispersed planktonic larval stage which creates a panmictic population in the Atlantic (McKeown et al. 2019). Age of maturity is unknown and currently stock estimates only use size at maturity. There is limited research on brown crab reproduction, the information available suggests breeding may be highly variable between individuals and populations depending on differing environmental factors.

Brown crab is an R selected species, this means they are characterised by fast maturation, numerous offspring, exponential population growth and short lifespans (~9 years). They have been found to have a high mortality rate (0.48) (Sheehy and Prior, 2008).

1.9 Behaviour

Research using electronic reporting systems and gear in gear out technology has suggested that in mixed lobster and crab fisheries the increase in capture of one species in a pot may cause a decline in the capture of the other. When there were increased captures of lobster beyond a threshold (~ one MLS lobster) there was a decline in capture of crab. Water temperature increase also increased crab capture (Emmerson et al. 2022).

There are a number of studies which have investigated the effect of electromagnetic fields on the behaviour and reproduction of crabs in relation to the developments of offshore windfarms. Although brown crab showed a lower rate of deformities than European lobster, exposure to electromagnetic fields during embryo development still caused decreased carapace height, total length, and maximum eye diameter. These could go on to have a significant impact on the population in the long term (Harsanyi et al. 2022).

Pit digging feeding behaviours by crab can cause changes in sediment characteristics and abundances of meiofauna and macrofauna (Newburgh, 1991).

2 Fishery

2.1 Gear and Methods Used

Fishing effort for crab is mostly offshore, in deep sandy habitat, although rough ground is also targeted. Fishing largely remains within the six nautical miles of the IFCA boundary. String length (total length of pots deployed at one time) varies depending on vessel size and pot size (range 1 - 50). The size of pot and type of bait used varies both within and between vessels. The number of strings set depends on boat size and capability. Soak times vary with weather and tide and ranges from 2 to 14 nights. Crabs are removed from pots as they come aboard. Undersize, berried, soft or poor quality individuals are returned, and fish are nicked before being placed in a container or vivier.

2.2 The Current Fishery

There are 26 registered vessels is in the Isles of Scilly, ranging from 11 to 4 metres in length, with 23 boats operating regularly in 2023, 13 of these target brown crab. There is one vessel for which crab is the main source of income. Crab is targeted year round, with fishing limited by weather over the winter months. Most crab is landed from early summer to autumn, this corresponds to the movement of females to inshore areas to breed.

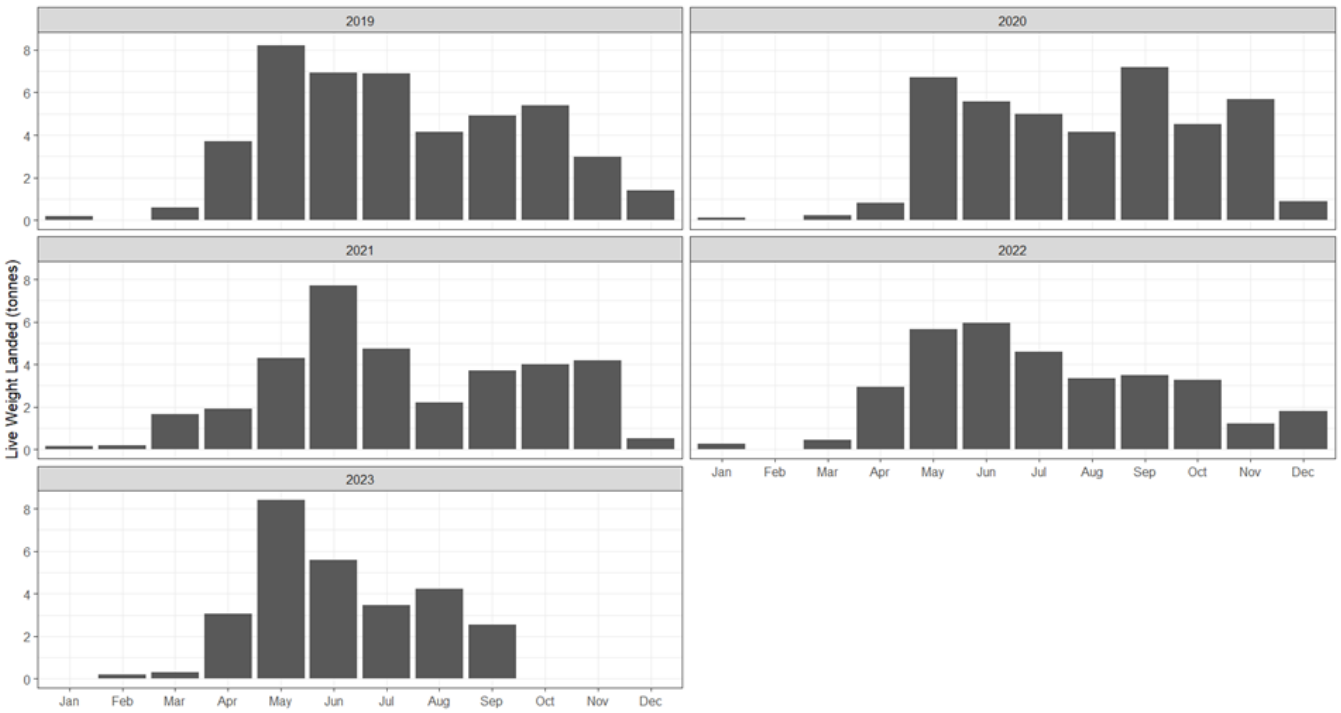


Figure 1. The live weight of crab (t) landed to the Isles of Scilly from 2019 to September 2023 separated by month and year.

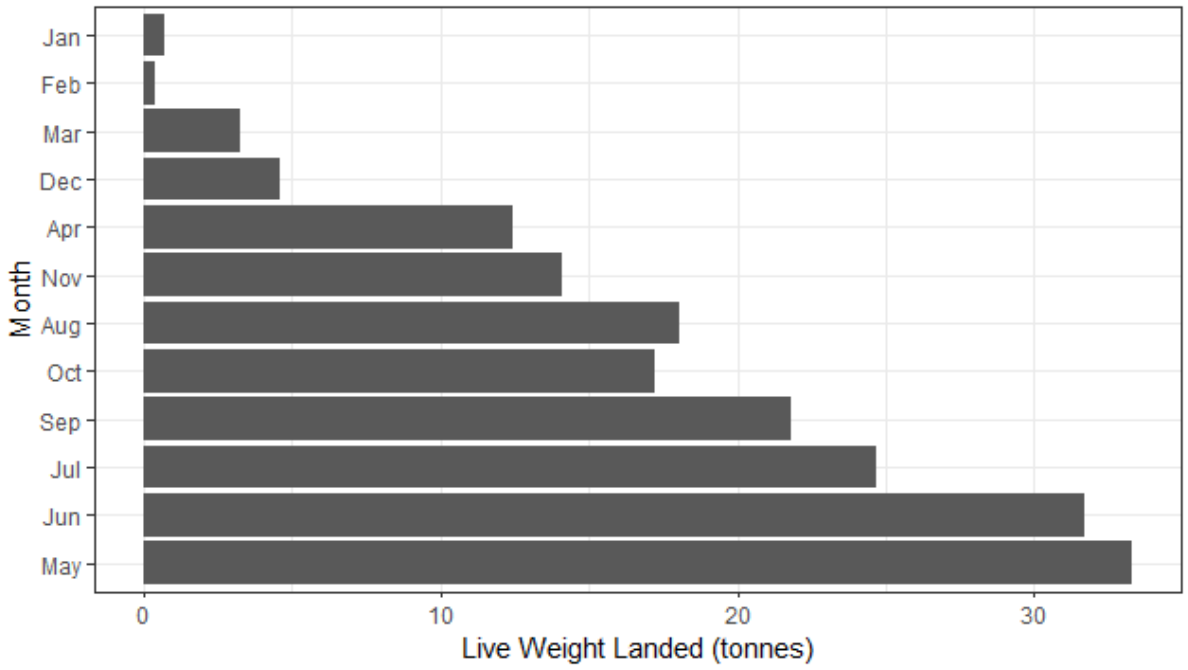


Figure 2. Live weight of crab landed in tonnes from the Isles of Scilly for each month from 2019 to September 2023.

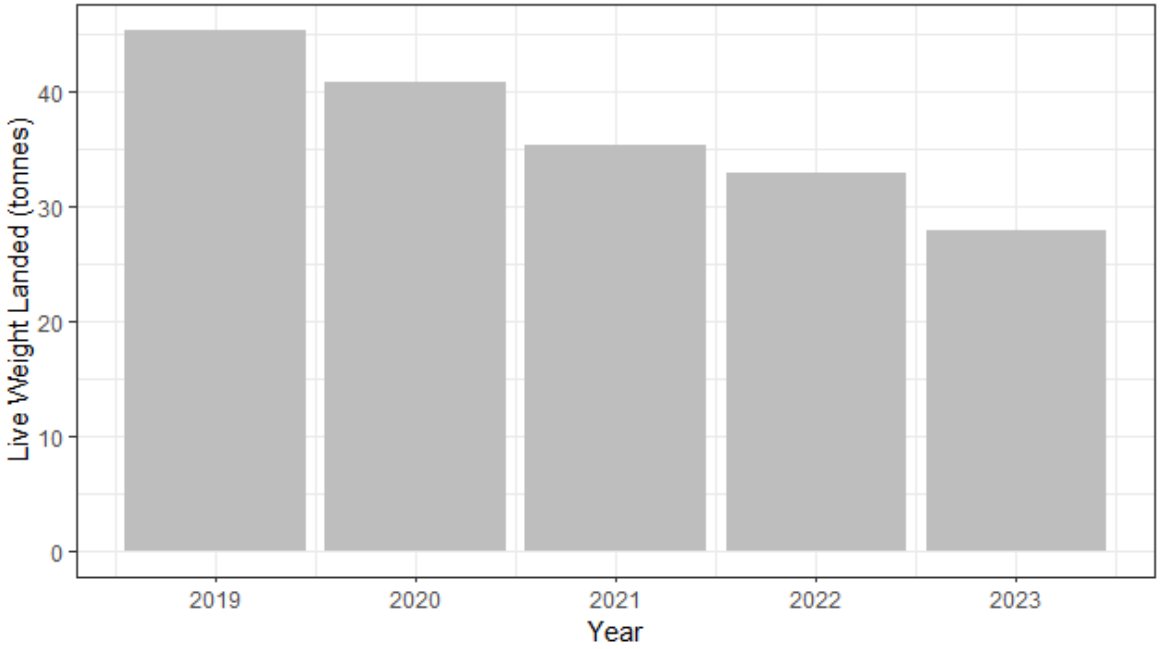
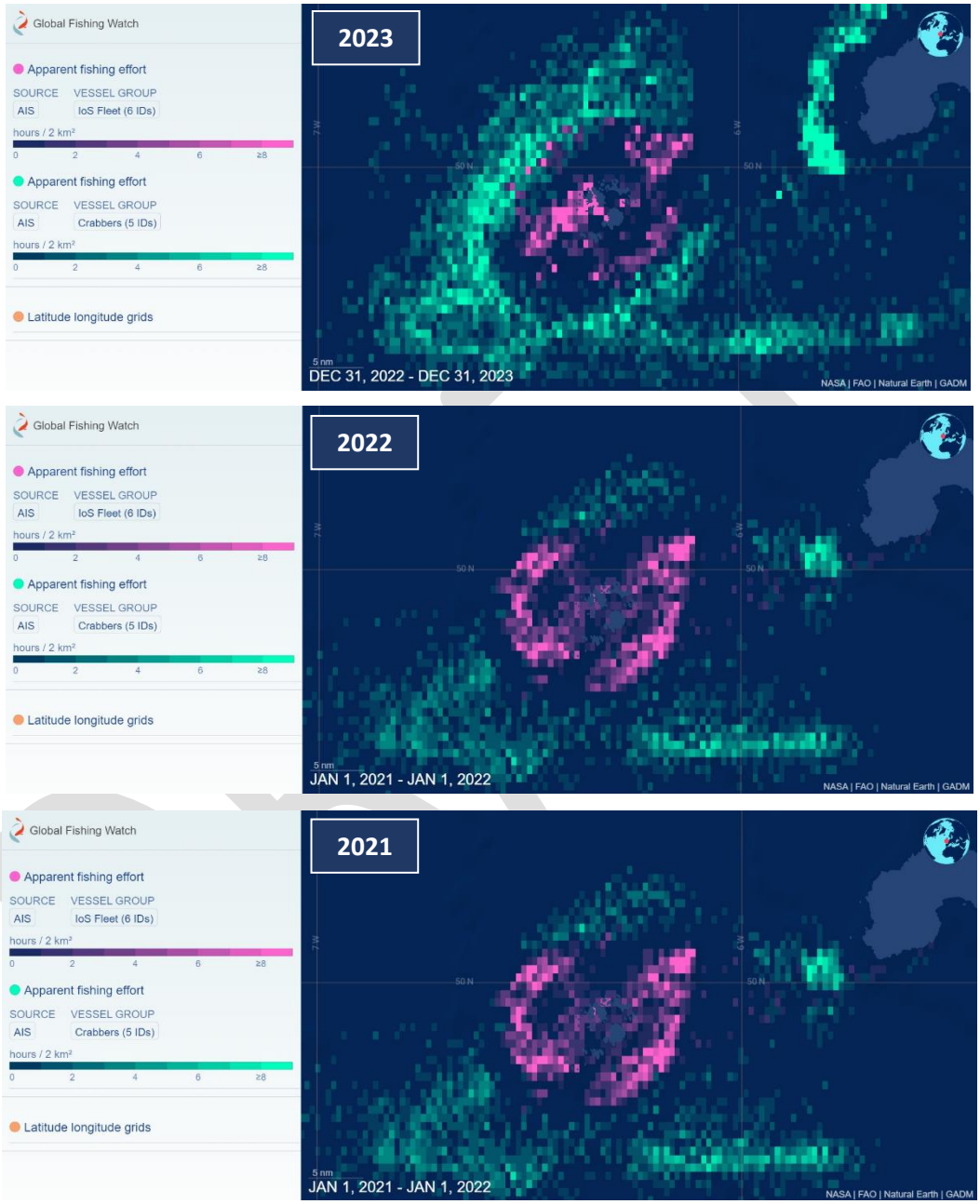


Figure 3. Crab landings (live weight, tonnes) into the Isles of Scilly from 2019 to September 2023.

Crab landings have been slowly declining in the Isles of Scilly from 45,365kg in 2019 to 32, 708kg in 2022 (Figure 3). Crab landings are also declining more widely in the South West (Street et al. 2022). Although the reasons for this aren't clear, it is likely due to an increase in pressure from large vivier fishing vessels that have grown in number over the last two decades. This view is reinforced within the Fisheries Management Plan responses that increases in effort by larger, offshore vessels outside 6nm were 'compromising the sustainability of the inshore fishery.' The Isles of Scilly IFCA District has a size and length limit

on vessels allowed to fish within the District (11 metres and 10 tonnes, Fishing Gear Permit Byelaw 2013), although this limits large vessels operating within the District, it does not prevent migratory female crab being targeted when leaving and entering the District. There is a high amount of effort from large crab vessels surrounding the District, and it is likely this is impacting the abundance of crab within the District (Figure 4, 5 & 6- see Appendix 1).



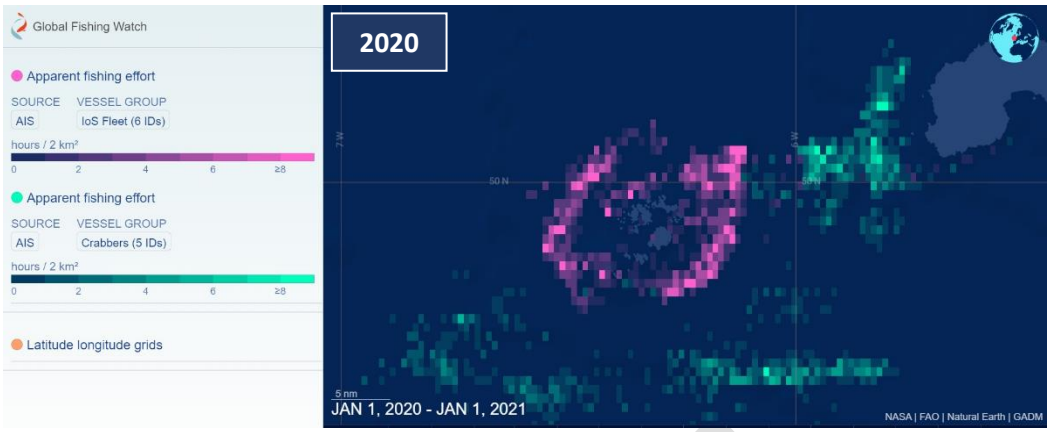


Figure 4. Global Fishing Watch data showing apparent fishing hours per 2 square kilometres from 2020 to 2023. Pink squares indicate Isles of Scilly vessel, green squares indicate crabbing vessels over 11 metres/10 tonnes (See appendix 1 for further information).

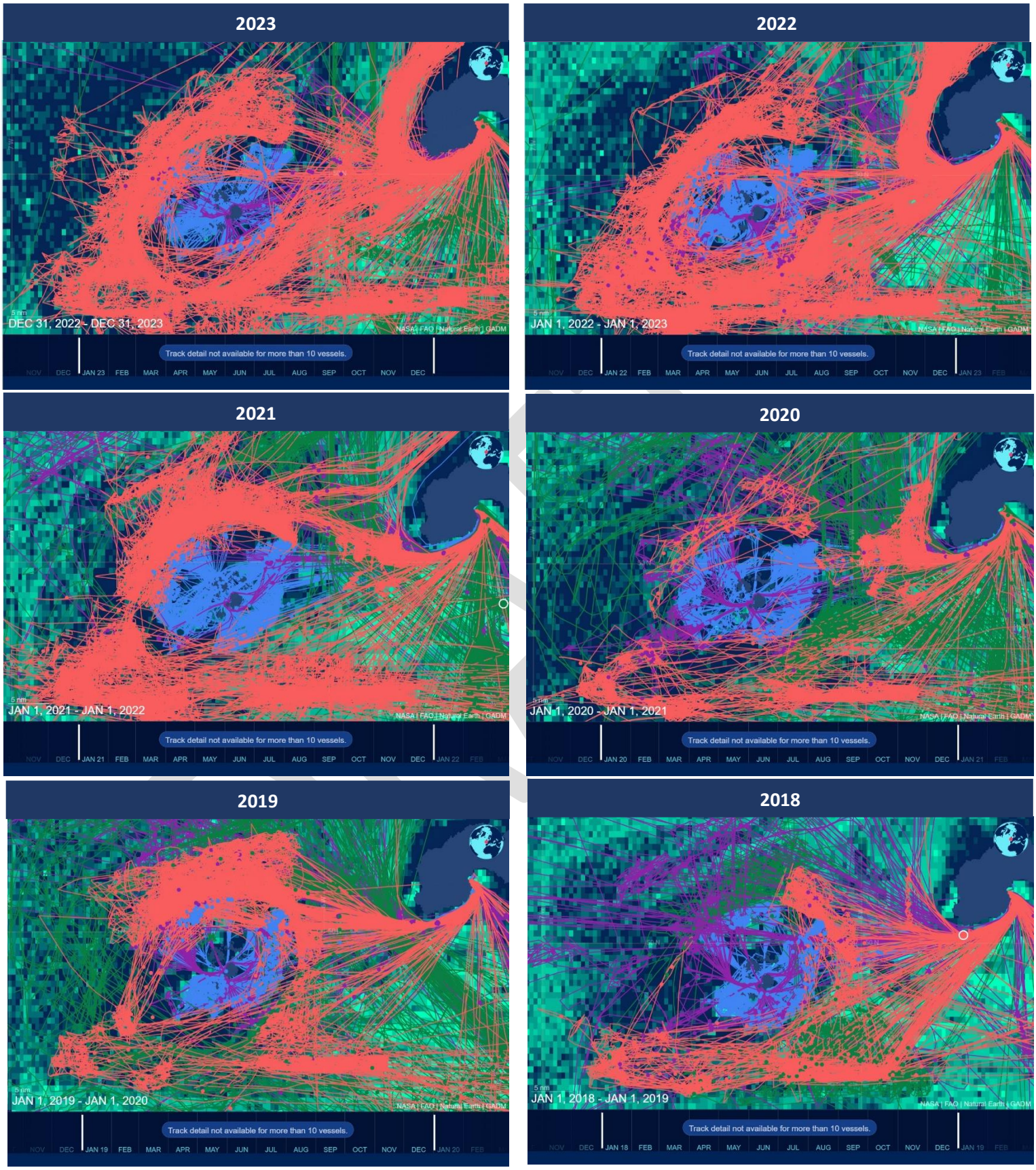


Figure 5. Global Fishing Watch data showing apparent fishing track data of crabbing vessels over 11 metres/10 tonnes in red, trawlers in green, netters in purple and the local Isles of Scilly fishing fleet in blue (See appendix 1 for further information).

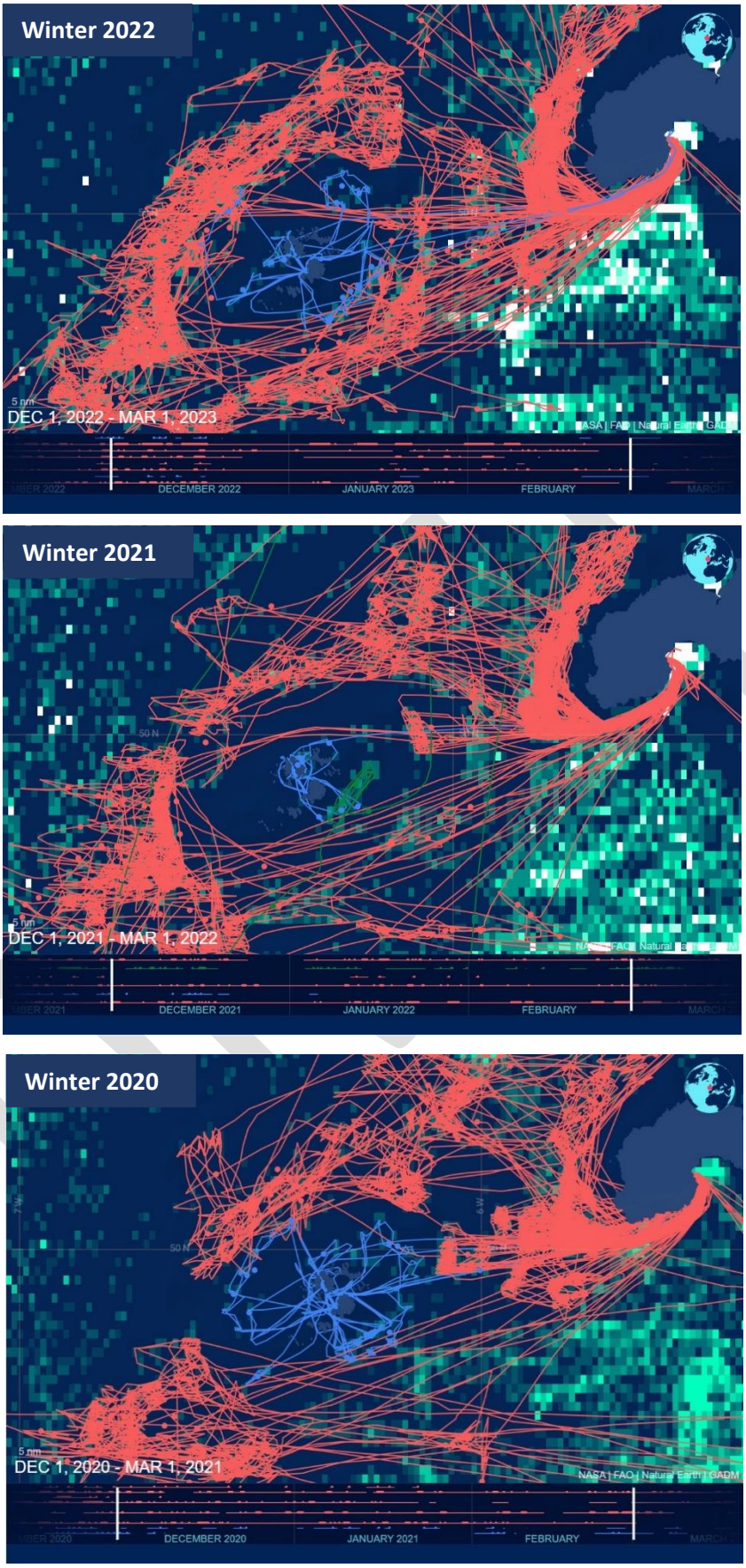


Figure 6. Global Fishing Watch data showing apparent fishing tracks for the past 3 winters (2020, 2021, 2022). Crabbing vessels over 11 metre/10 tonnes are shown in red, Isles of Scilly fleet are show in blue (See appendix 1).

2.3 Susceptibility

Pots are used to target crab across the IoSIFCA 6 mile District. During the summer months females migrate inshore to breed with resident males, they then migrate back offshore to brood in the autumn. These long-distance movements make female crabs more susceptible to entering pots. Females have a smaller minimum landing size than males, but mature at a large size than males, this may also have an impact on the breeding female population. In the Isles of Scilly most crab fishers only keep large crabs well over MLS, and therefore the impact of MLS on females is likely to be minimal.

2.4 Conclusion

Crab stocks within the Isles of Scilly are highly likely to be influenced by fishing activity throughout the Western Channel due to their migratory movements. The continual, steady decline of LPUE suggest that effort needs to be limited to enable the population to recover and become sustainable. Landings have declined within the Isles of Scilly District.

3 Fishery Management

3.1 Management measures

Regulations in Scilly are currently a minimum landing size (MLS) of 140mm CW for females (ICES Divisions VIId, e and f) 160mm CW for males (The Undersized Edible Crabs Order 2000). All berried individuals must be returned.

3.2 Objectives and principles

The objectives and principles of the fishery need to be developed from the information collected in 2023, from 2019 research and from MMO landings data. Management of the fishery needs to be established at a wider level than the IoSIFCA District due to the movements of females. Effort within the District should be monitored and impacts of other fisheries (such as tangle netting or trawling) on the crab population should be considered.

4 Research and Monitoring

Research on the crab population was initiated in 2019 with a month of data collected in the summer. We have compared this to data collected in 2023. Onboard monitoring of catch will be carried out every 3 years to ensure management is effective and proportionate.

4.1 Fishery research

Only fishery dependant data has been collected for the crab fishery. There is currently no additional reporting required of fishers, other than that required national by the MMO in their catch app, which includes the ICES sub rectangle area caught, live weight estimate and gear used. There is no effort data for the District. The introduction of iVMS in 2024 should improve estimates of area use and effort.

4.1.1 Onboard catch monitoring

Onboard recording of commercial catch reported in this report was carried out in 2023. Prior to this data was collected from June to July over a 4 week period in 2019. Data in 2023 was collected onboard 3 different vessels, over 6 trips totalling 515 pots over 22 strings, collecting data on 889 crabs from April to September (*n*=1568 including bycaught individuals).

Information on each individual is recorded: length of carapace to nearest mm, sex, breeding condition (berried, 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, string length, soak time, and position. The same data was collected for any non-target species caught.
Data was not collected on pot size, number of entrances or bait type due to the variability in these factors both day to day on the same vessel and between vessels. These factors were included in notes where possible.

4.1.2 Spatial pattern of fishing activity

The spatial data collected in this study and the study in 2019 only represents the areas fished when observers are onboard and does not show the full extent of fished areas within the District. The addition of iVMS data in future years will hopefully be able to increase our insight into the effort distribution of this fishery.

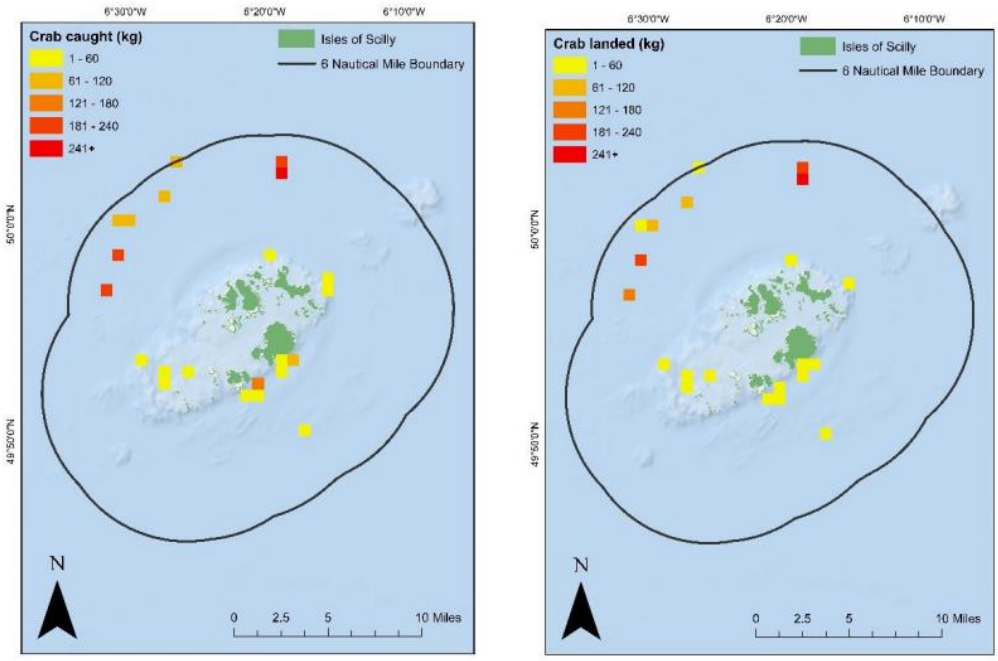


Figure 7. Spatial pattern of effort for crab from onboard catch recording in 2019 in the Isles of Scilly District.

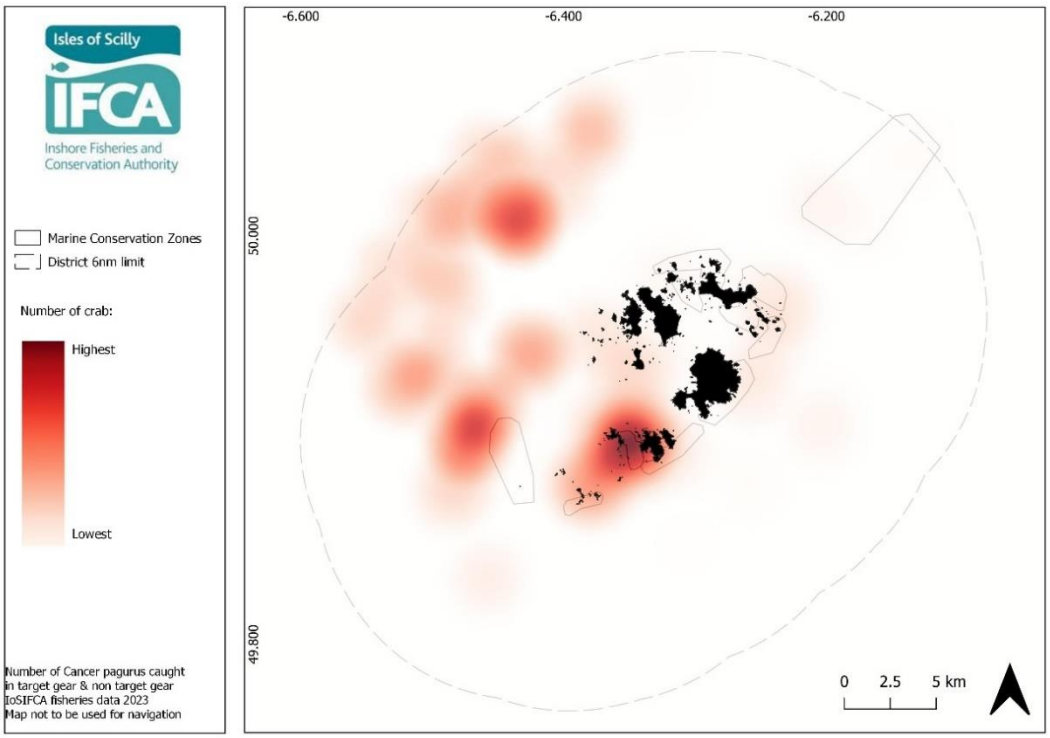


Figure 8. Heatmap showing 3km radius of crab occurrences in catch data in the Isles of Scilly fleet. This data includes both target and bycatch data occurrences of crab.

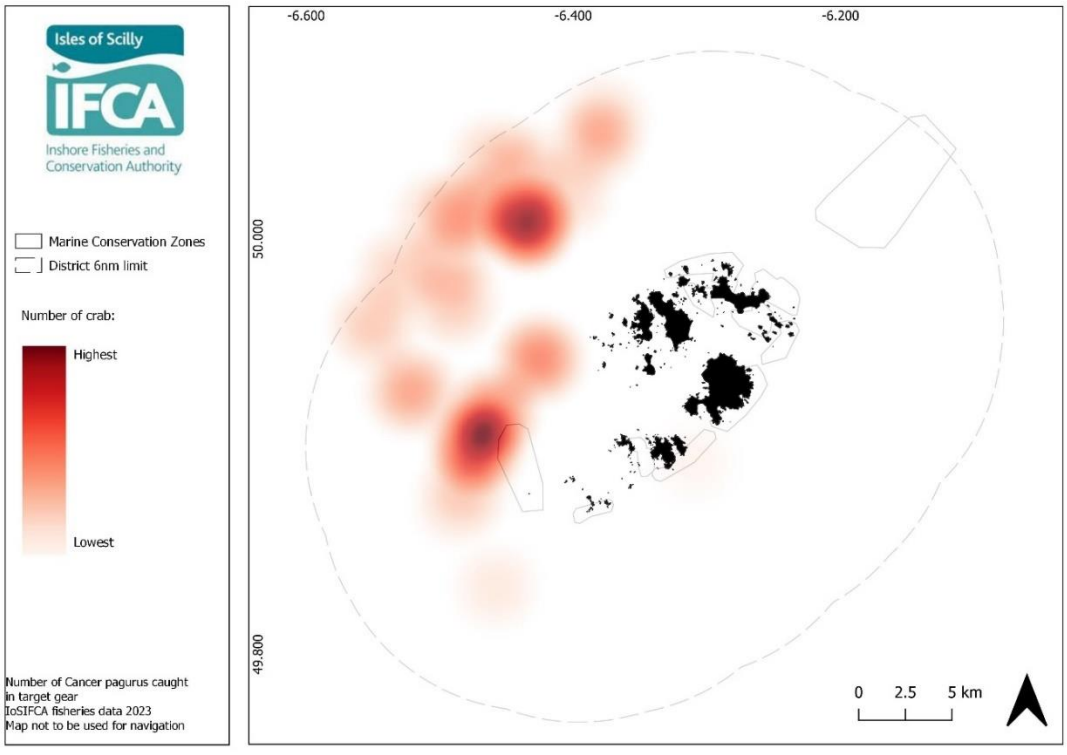


Figure 9. Heatmap with a 3km radius showing crab target effort in the Isles of Scilly of onboard catch data 2023.

Most effort for crab when observers were onboard targeted the north west of the District. When compared with the heatmap showing occurrences of crab in catch data in the District, we can see there is a high number of crab also caught close inside the District in non-target gear. These crabs were often juveniles. The spatial layout of both effort and occurrence show the range of habitats that are important for the brown crab throughout its life cycle.

4.1.3 Bycatch

Bycatch was recorded on all fishing trips, wherever possible bycatch was measured and sexed. There were 138 non target (bycatch) individuals caught in the 6 trips, this was 12.8% of the total catch. Of this 12.8%, 89.2% were commercial species (table 1). Commercial species were considered as species targeted in the SW UK commercially, not all species considered commercial are landed in the Isles of Scilly (crawfish, spider crab and lobster).

The most commonly bycaught commercial species was European lobster, followed by spider crab and crawfish. The most commonly caught non-commercial species were nursehounds and pouting, although these were still rare. The majority of bycatch was returned to the sea alive (58%), 39% was landed and 2.9% was kept for bait. None of the bycatch was dead in the pots.

Species Group	Species	Number caught	Commercial	Non commercial
Demersal fish	Ling *Molva molva*	1		●
	Three bearded rockling *Gaidropsarus vulgaris*	2		●
Crustacean	Crawfish *Palinurus elephas*	2	●	
	Spider crab *Maja squinado*	15	●	
	European lobster *Homarus gammarus*	106	●	
Elasmobranch	Nursehound *Scyliorhinus stellaris*	5		●
Semi pelagic fish	Pouting *Trisopterus luscus*	4		●
Eels	Conger eel *Conger conger*	1		●
Worm sp.	Seamouse *Aphrodita aculeata*	1		●
	Edible sea urchin *Echinus esculentus*	1		●
	Starfish sp.	Unrecorded small number		●
Total individuals		**138**	**123**	**15**

Table 1. Bycatch species and abundance caught in crab target gear in the Isles of Scilly 2023 onboard recording.

4.2 Ecological research

There has been minimal fishery independent research. Future research could include control pots used by the IoSIFCA within the District to monitor control CPUE across years and sites.

4.2.1 Baited Remote Underwater Video Systems

Isles of Scilly IFCA, in partnership with the University of Exeter, Natural England, Plymouth Marine Lab and NERC GW4+ Doctoral Training Partnership, are supporting a 4 year PhD carried out by Owen Exeter. Data collection was completed in 2023. The PhD aims to assess the ecological value of, and threats to, marine protected areas in 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.

Future analysis will determine whether BRUVS can be used in future years as a fishery independent measure to monitor the brown crab population.

5 Stock Health

There is currently no formal stock assessment in place for brown crab in the Isles of Scilly. The data from 2019 and 2023 provide 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 crustaceans, including crab. 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. This data is challenging to gather due to environmental conditions around the Isles of Scilly.

In the UK Length Cohort Analysis is currently used to assess crustacean stock health for lobster and crab. This method uses a number of assumptions, if these are incorrect the outcomes of the models could be limited in their ability to help visualise the stock. For example, the mortality rate found by Sheehy and Prior (2008) (0.48) is substantially larger than that currently used in CEFAS stock assessments (2019 report used a mortality rate of 0.2). This highlights the lack of data on brown crab and the importance of understanding basic life history traits.

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

5.1 Length frequency distribution

The total number of brown crabs sampled in 2023 is 1568. These were collected from 6 pot targeted fishing trips equating to 515 pots and includes incidental captures in pots from trips targeting lobster and from nets targeting crawfish.

The catch was split 58% female, 38% male and 3.7% unidentified sex (*n*=910 females, *n*=599 males, 59=NA). There was a skew in favour of females being landed (n=443, 84.8% of landed catch) likely due the time of year (Bennett, 1980) and their migratory patterns, as well as their smaller landing size. In 2019 the percentage of the catch which was female was 59%, only 1% different to 2023.

Just over a third of the catch, 33%, was landed (n=522), 1.1% was dead and 65.5% released. The percentage of catch below maturity (< 140mm CL) was 36%. 68% of crabs above MLS were landed. Crab above MLS was returned if it had black spot, was soft, damaged or missing claws.

The mean carapace width for brown crab was 146.9mm (± 25 SD, range 30 -265), for males 139mm (± 24.4 SD range: 73mm – 265mm), and for females 152mm (± 24 SD range: 30mm – 215mm).

These figures are very similar to those from 2019, where overall mean carapace width was 146.75mm, males were 137mm CW and female mean CW was 152mm. The range of sizes was larger in 2023 likely due to increased sampling effort.

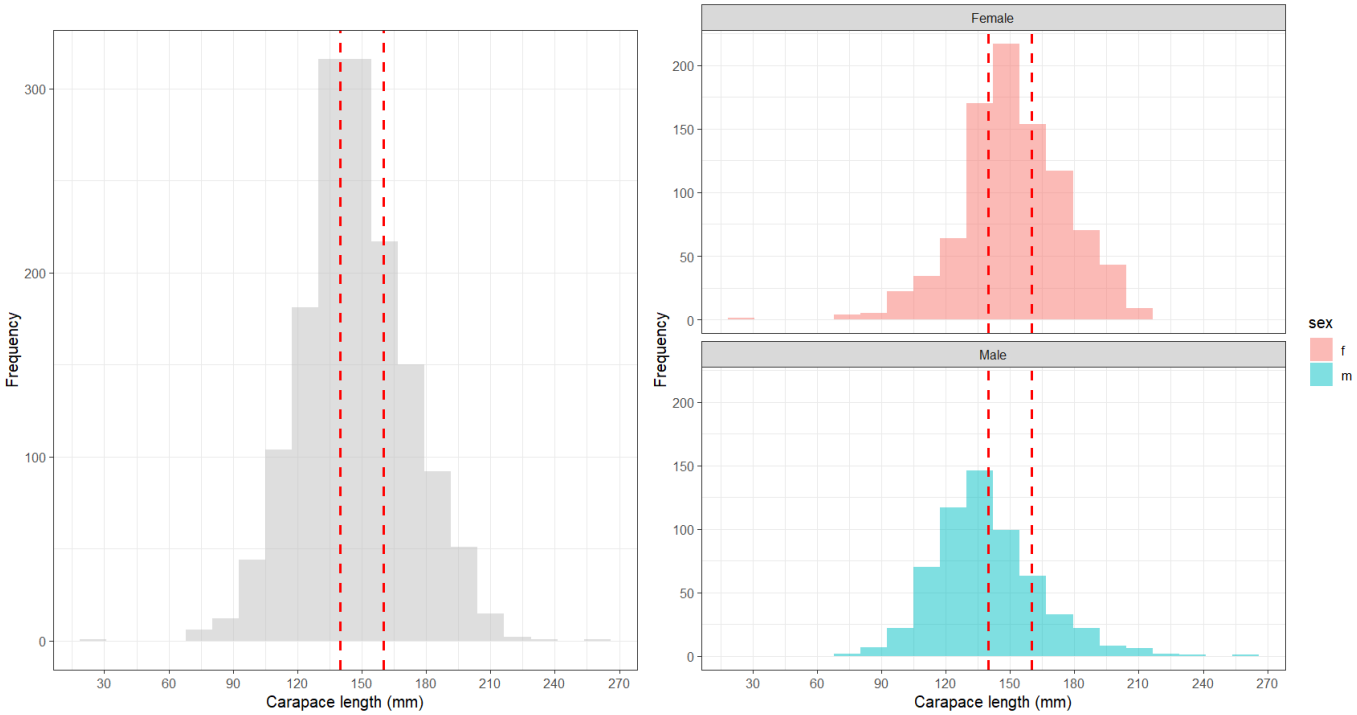


Figure 10. Length frequency distribution of brown crab carapace widths from onboard catch recording 2023 in the Isles of Scilly. There is a red dashed line at 140mm CW which indicates female MLS and a red dashed line at 160mm CW which indicates male MLS.

5.2 Catch per unit effort trends

Catch per unit effort data was taken from 6 potting trips on 3 different vessels from April to September 2023. This data provides an initial indication of CPUE over the course of the summer, it is not comprehensive and does not account for differences which may arise seasonally or between different vessels. CPUE is an indicator of change in population biomass, however it cannot account of factors such as varying catchability between years or changes in sex ratio or size of fish. Overall CPUE in the District was calculated as 0.27 crabs per pot per night (±0.27 SD). This should act as a comparison for future data collection when taken from a range of vessels from April to September.

5.3 Functional sexual maturity

There were only 3 berried individuals recorded in 2023. These were 162, 182 and 190mm CW. This may suggest that current MLS (140mm CW) is too small, however there would need to be further data collection on a larger number of individuals to understand this.

6 Stock Health Summary

Brown crab carapace width taken from fisheries samples have remained the same in 2023 as they were in 2019. The spread of size classes also seems very similar to that in 2019, although with a smaller abundance. Although the stock is likely being overfished, this does not appear to be driving any change in average crab size.

6.1 Summary

Category	Status
Landings	Landings have decreased in recent years, this is likely due to an increase in effort from large vessels working West of the English Channel. Effort controls across all vessels would need to span the English Channel and Western Approaches in order to be effective due to large scale adult female movements.
Catch distribution	Current spatial distribution can only be inferred from onboard catch recording and anecdotal evidence. Effort is concentrated further towards the edge of the District in deep water. Both soft sediment and rocky reefs are targeted. The inclusion of iVMS data in future reports will give a clearer understanding of effort distribution.
Catch rates	CPUE in 2019 was recorded in kg and without a rate included (ie per night), this makes it hard to compare with 2023 CPUE which was recorded as number of individuals per pot per night. CPUE in 2019 was 0.8kg per pot, in 2023 CPUE was 0.27 crabs per pot per night. If we infer than soak time was similar for pots sampled in 2019 and estimate a crab to weigh around 1kg, we can estimate that CPUE has decreased slightly. This would be in line with other evidence such as landings from Scilly and LPUE in Cornwall.
Ecological research	Not currently carried out. Preliminary BRUVS data suggests that BRUVS may be an effective way to help monitor crawfish abundance in the future.
Vulnerability	Brown crab life history means they should be resilient to fishing pressure. to overfishing. However, there are no effort limits currently and this leaves the stock vulnerable to over exploitation. The migratory movements of females also increases their vulnerability to exploitation.
Size/sex composition	Mean carapace length is currently higher than minimum landing size for females, and lower than minimum landing size for males. There appears to be minimal change in the past 4 years to the average size of individuals. Juvenile fish currently make up 36% of catch. The fishery currently has a female predominance of 58%, likely due to seasonal movement. The composition of catch does not appear to have changed in the past 4 years.
Fishing mortality	Unknown. Natural mortality likely 0.48 (Sheehy and Prior, 2008).
Spawning biomass	Unknown – further research needed.

Table 2. Brown crab stock health summary for the Isles of Scilly IFCA District 2023.

6.2 Isles of Scilly IFCA crab management

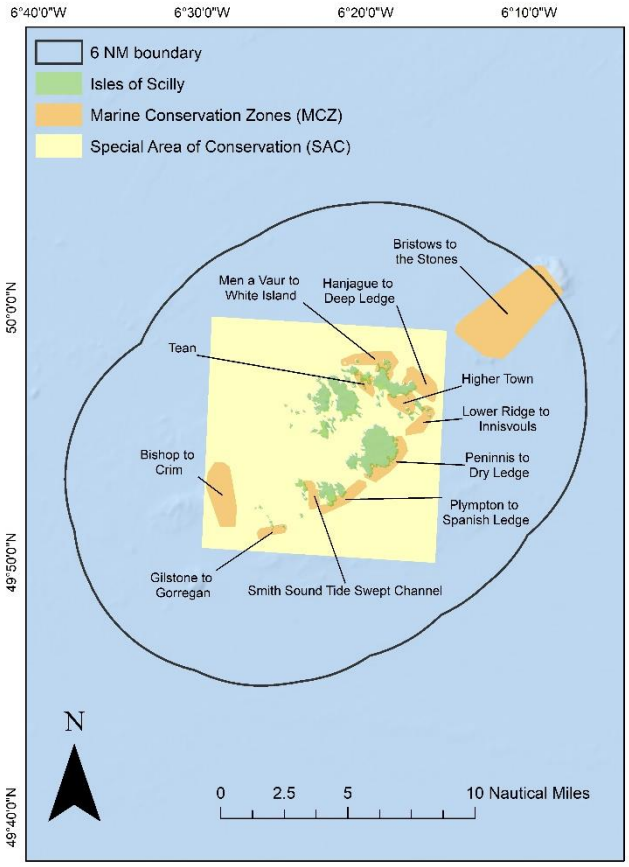


Figure 11. Map of the Isles of Scilly IFCA District including Marine Protected Areas.

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^2. The IFCA has not introduced any Byelaws specifically related to crab management.

Under the Marine and Coastal Access Act, 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 three are most relevant to the management of brown crab. 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 GES and does not compromise the capacity of marine ecosystems to respond to human induced changes.

The Crab and Lobster Fishery management Plan was published in December 2023 and includes the following fisheries management objectives for brown crab:

1. Develop and pilot an improved data collection programme for crab fisheries
2. Establish methods to better assess stock status that reflect the life history of the target species and fishery exploitation patterns
3. Assess the impact of crab fishing activity on the wider marine environment
4. Improve the understanding of interactions between the crab fishery and other fisheries
5. Devise and implement a short to medium term management approach proposal that considers the external regulatory environment
6. Establish a long-term management approach for crab fisheries in line with improvements in data collection and stock assessment
7. Explore trade-offs between access arrangements for crab fisheries that will ensure both long-term environmental sustainability and economic profitability

The Government response to the Consultation on crab and lobster Fishery Management Plans shows that there was support to ban the use of soft-shelled crab for bait and to pilot effort management and catch limits in specific areas. The report also notes that management measures should be 'implemented at pace to reduce pressure on the stocks'; however there was not agreement on the mechanism. The Government response states that they will consider introducing regional MCRS for brown crab and explore effort restrictions such as pot limits within a 3 to 5 year period. Over a longer term (over 5 years) Government will 'develop and introduce measures to achieve…sustainable and profitable fisheries' including seasonal closures, other fishing effort limits, catch limits, landing restrictions based on sex, and gear design measures.

The FMP proposal for finer scale management would involve exploring the use of 'locally appropriate input controls (such as pot limits or days at sea limits) or output controls (such as catch limits). The Western English Channel Crab Fishery Unit (CFU) has a stock size that is near to MSY and an exploitation rate that was 'moderate' in 2019, however there are concerns about 'significant increases in fishing effort in the area in recent years, which are not yet reflected in stock assessment data.'

6.3 Recommendations

Sampling should occur throughout the year to improve our understanding of seasonal sex fluctuations.

All berried females seen in pots were above MLS for females. This suggests that the current minimum landing size for females, may be smaller than the size at which 50% of females are

sexually mature. Increasing the landing size of females could help enhance the reproductive stock, particularly if this was introduced in a widescale across the South West. Further research into size at sexual maturity would improve our understanding and should also be carried out when opportunity allows.

Improve cohesion and collaboration regionally in how data is collected, analysed and collated.

Reinforce need for effort controls outside 6nm implemented through FMP.

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Appendix 1 - Global Fishing Watch Data

Below is guidance from globalfishingwatch.org on how to interpret Global Fishing Watch data.

'Global Fishing Watch uses data about a vessel's identity, type, location, speed, direction and more that is broadcast using the Automatic Identification System (AIS) and collected via satellites and terrestrial receivers. AIS was developed for safety/collision-avoidance. Global Fishing Watch analyzes AIS data collected from vessels that our research has identified as known or possible commercial fishing vessels, and applies a fishing presence algorithm to determine "apparent fishing activity" based on changes in vessel speed and direction. The algorithm classifies each AIS broadcast data point for these vessels as either apparently fishing or not fishing and shows the former on the Global Fishing Watch fishing activity heat map. AIS data as broadcast may vary in completeness, accuracy and quality. Also, data collection by satellite or terrestrial receivers may introduce errors through missing or inaccurate data. Global Fishing Watch's fishing presence algorithm is a best effort mathematically to identify "apparent fishing activity." As a result, it is possible that some fishing activity is not identified as such by Global Fishing Watch; conversely, Global Fishing Watch may show apparent fishing activity where fishing is not actually taking place. For these reasons, Global Fishing Watch qualifies designations of vessel fishing activity, including synonyms of the term "fishing activity," such as "fishing" or "fishing effort," as "apparent," rather than certain. Any/all Global Fishing Watch information about "apparent fishing activity" should be considered an estimate and must be relied upon solely at your own risk. Global Fishing Watch is taking steps to make sure fishing activity designations are as accurate as possible. Global Fishing Watch fishing presence algorithms are developed and tested using actual fishing event data collected by observers, combined with expert analysis of vessel movement data resulting in the manual classification of thousands of known fishing events. Global Fishing Watch also collaborates extensively with academic researchers through our research program to share fishing activity classification data and automated classification techniques.'

See also - Kroodsma, D.A., Mayorga, J., Hochberg, T., Miller, N.A., Boerder, K., Ferretti, F., Wilson, A., Bergman, B., White, T.D., Block, B.A. and Woods, P., 2018. Tracking the global footprint of fisheries. *Science*, *359*(6378), pp.904-908.

Appendix 2 – Data collection form

Shellfish recording form

Date		**Vessel code**	
Observer		**Weather (beaufort 0-5)**	

String Number		**Pots on string (total)**		**Pots sampled (total)**	
Location	**Start Lat:**	**Lon:**	**End Lat:**	**Lon:**	
Soak time		**Habitat/depth**			

Species	**Length** (mm)	**Sex** (M/F)	**Notes** (berried, v notch, disease, claws, fate)	**Species**	**Length** (mm)	**Sex** (M/F)	**Notes** (berried, v notch, disease, claws, fate)