

Third Report
of the implementation of the FIP
Spanish crayfish, *Procambarus clarkii*, with fyke nets &
traps in Andalusia and Extremadura

Isla Mayor - Andalusia



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1 Executive Summary

FIP activities in Andalusia continued in September 2022, with field work and data collection carried out in the Andalusia basin using fyke nets, a typical gear used in the rice fields. Delay in the start of the sampling in Andalusia was due to the lack of rain, water and the heat wave felt, delaying the crayfish life cycle and fishing to occur. Field work was carried out in two site visits in September at Andalusia rice fields. Sampling data from Alfocan and South Ocean were also provided and analysed. Results shows a 1:1 sex ratio, and usually a normal distribution of crayfish length frequencies. This preliminary assessment also showed the low proportion of bycatch of common carp juveniles and blue crab at Andalusia rice fields. In order to fully assess the Spanish crayfish fishery, further work and additional data needs to be collected, specifically more data collection from different fishers in both Andalusia (and Extremadura) regions.

2 Introduction

The following document represents the thirds report of the Spanish crayfish (*Procambarus clarkia*) FIP. In the first report (December 2021) a description of the fishery, its socio-economic importance, but also biological and ecological aspects of crayfish were presented. The report also included a summary of the current legislation in Andalusia and Extremadura regions. The second report focused on the fishing and sampling activities carried out in Extremadura region.

This third report presents the results for the two site visits to sample the crayfish fishery with fyke nets in Andalusia (September 2022); a comparison with the previous 2021 fishing season in Andalusia region; and producer data analyses with a comparison of the results for 2021 and 2022 seasons.

2.1 Crayfish fishery in Andalusia region.

The crayfish fishery in Andalusia is regulated and managed by Order of 3 of August 2016¹ on the species control plan for Marisma del Guadalquivir on the control plan for this region and supplies 50% of the national crayfish production. There are no fisher's association or other business organisations associated to the crayfish fishery, and the exact number of fishers operating in the area is still unknown. The fisher accompanied during 2021 and 2022 seasons was the same, which is not enough to assess data such as fishing area covered and number of fishing gears, crucial to do fishery assessment.

¹ https://www.juntadeandalucia.es/boja/2016/152/BOJA16-152-00030-14325-01_00096695.pdf, downloaded 20/10/2021

Fishing activity in Andalusia is characterized by the use of fyke nets (Fig. 1) that are set in the rice fields of Isla Mayor, during a period of 48 hours, without using bait.



Fig. 1 – Fyke net used to catch crayfish at Isla Mayor Rice fields in Andalusia region.

3 Work plan

The 2022 FIP activities started in May, with a 2 months delay of what was initially planned (March), mainly due to the lack of rain and water, and the consequence delay in the beginning of the fishing season. The following planned FIP tasks were carried out:

Experimental planning (Started May 2022 – September 2022)

- Defining sampling areas and methodology (first visit), adapt methods (second visit)
- Preparing sampling material

Data collection *in situ* (Started June 2022 – September 2022)

- Collecting biological data (size, total weight, sex, behavior, habitat, geographic position) from crayfish and bycatch

Data analyses (Started June 2022 – December 2022)

- Biological data compilation and analysis
- Review of sampling planning
- Bycatch identification and characterization.



Stakeholder mapping and engagement (Started May 2022 – December 2022/January 2023)

- Fishers' engagement and participation in data collection.
- Contacting government authorities in Junta de Andalusia and Junta the Extremadura to follow-up FIP progress activities and start scheduling objectives for the following months of 2023.

Reporting and project management (Started May 2022 – January 2023)

- Drafting report
- Managing activities
- FIP reporting (August, January)

4. Results

4.1. Fisheries characterization *in situ*

The experimental design drafted included the collection of data from sets of fyke nets of different fishers in order to have catch composition in the different fishing locations. However, it was only possible to follow one fisher and the area covered by him. The fisher was the same one accompanied for the 2021 samples, operating within the same fishing area, and collecting around 100 fyke nets per fishing day, after a 48 hours period of fishing. This fisher have 200 fyke nets displaced in a 1,67km perimeter around a rice field (Fig. 3). It was only possible to sample around 5% of fyke nets in each site visit due to the time required to measure each crayfish, while trying minimise interference in the fisher normal activity, and considering a 2 persons team (one person measuring and one person writing the lengths). The fyke nets sampled in both visits were placed in the same local as it is showed in figure 3.



Fig. 3 – Fishing area covered by one fisher in Andalusia region.

4.1.1. First Site Visit – 23/09

During the first visit one fisher was accompanied, and 5 of the 100 fyke nets collected were sampled, corresponding to a total of 402 individuals measured during, approximately, 2 hours.

i) *Sex Ratio*

Overall, the number of females and males was rather balanced, with a total of 49.5% of females' sampled (199 individuals) and 50.5% males (203 individuals).

When analysing each trap in detail, the proportion of females were higher in 3 fykenets. However, in fyke nets number 1 and 2 the quantity of males were slightly higher (3% and 4%, respectively), and in the fyke nets number 4 and 5 the ratio were lower than 1%, in spite of fyke net number 3 having the highest number of females (5% higher than the number of males). (Fig. 4).

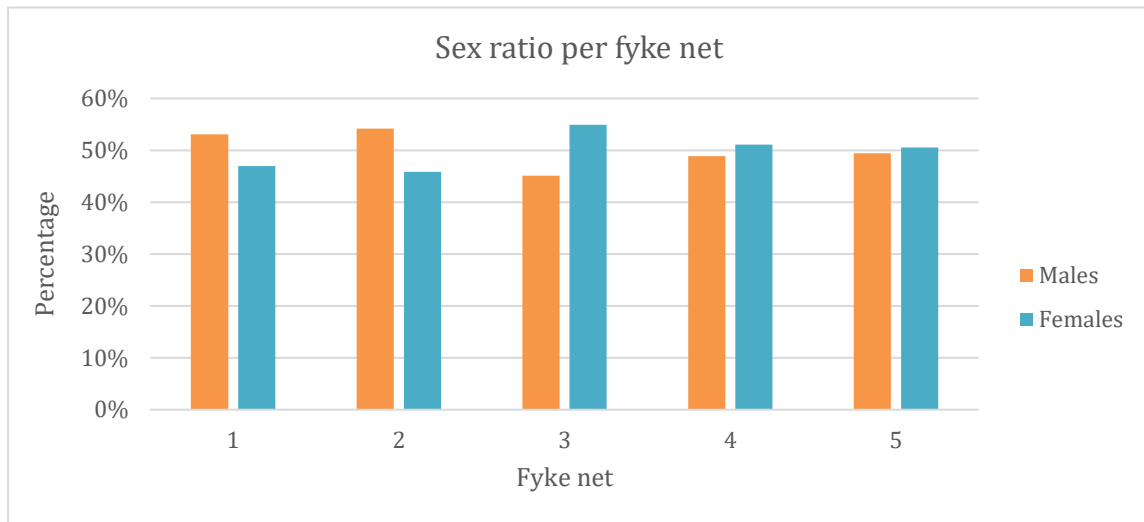


Fig. 4 – Sex ratio for each fykenet sampled.

ii) *Catch per Unit of Effort – CPUE*

The catch at each fyke net shows that in average each one caught approximately 80 individuals (Fig.5). Furthermore, knowing the number of fishers and fykenets operating in the area it will be possible to estimate total crayfish catch for the Andalusia region.

a) *CPUE in number*

$$CPUE(number) = \frac{\text{total number of individuals}}{\text{total number of fyke nets}}$$

Total number of individuals sampled = 402

Total number of fyke nets sampled = 5

CPUE = 80.4

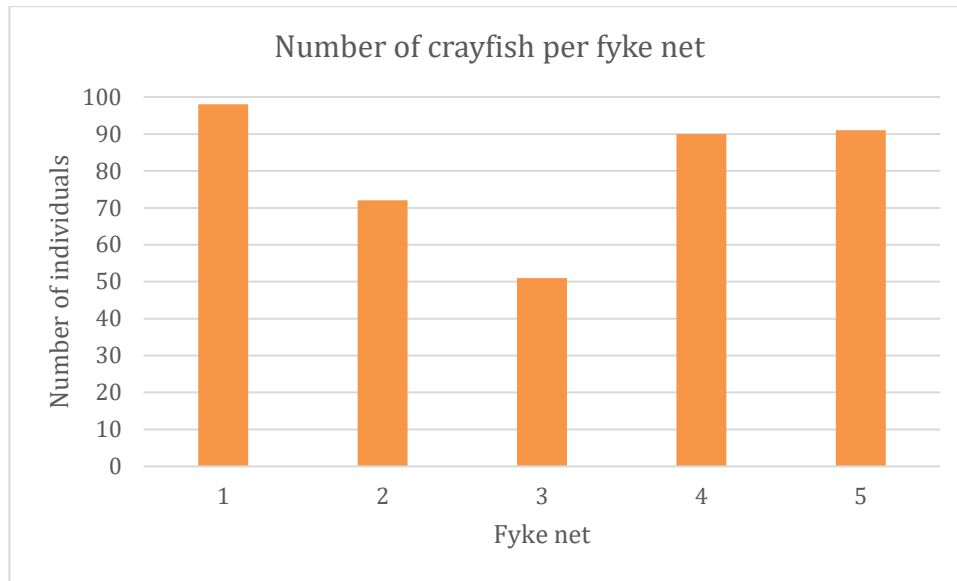


Fig. 5 – Number of individuals per fyke net.

Results shows that each fyke net harvest in average more than 80 individuals during the 48 hours fishing at the rice fields, with a peak in fyke net number 1 with almost 100 individuals caught (98 individuals). Fyke net number 3 correspond to the smallest catch with 51 individuals caught followed by fyke net number two with 72 individuals.

b) CPUE in kg

$$CPUE(Kg) = \frac{\text{Catches weight}}{\text{Number of Fyke nets}}$$

Catches weight = 135,5 kg → 100 fyke nets

$CPUE (Kg) = 135,5 / 100$

$CPUE (Kg) = 1,355 Kg$

Results shows that this fisher catch approximately 1,35 kg of crayfish per fyke net operating 48 hours.

iii) Length frequency

Catches were distributed between 24 and 46 mm, with the majority of the individuals around 30 and 40 mm, indicating that the catch was mainly composed of adult individuals, aged

above 300 days. Lengths from fyke net number 4 and 5 were more wide-ranging, with fyke net number 4 displaying more larger individuals (between 40 and 46 mm), and fyke net number 5 more smaller individuals, likewise fykenet number 3 (between 24 and 30 mm).

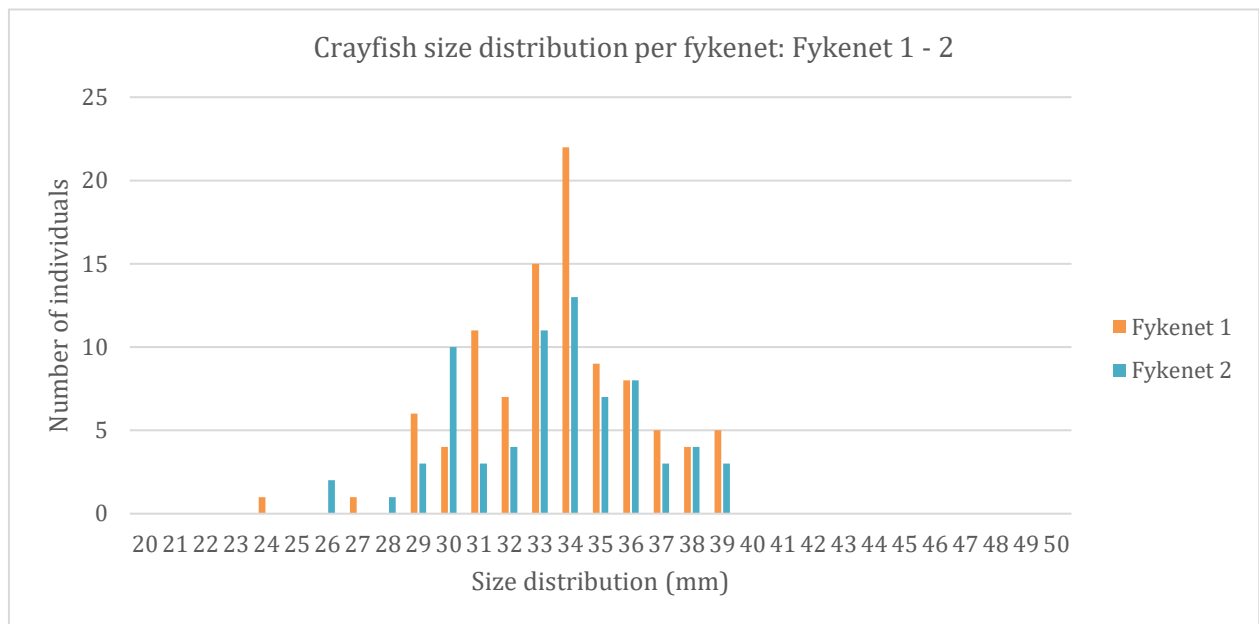


Fig. 6 (a). Crayfish length distribution per fykenet: 1 – 2.

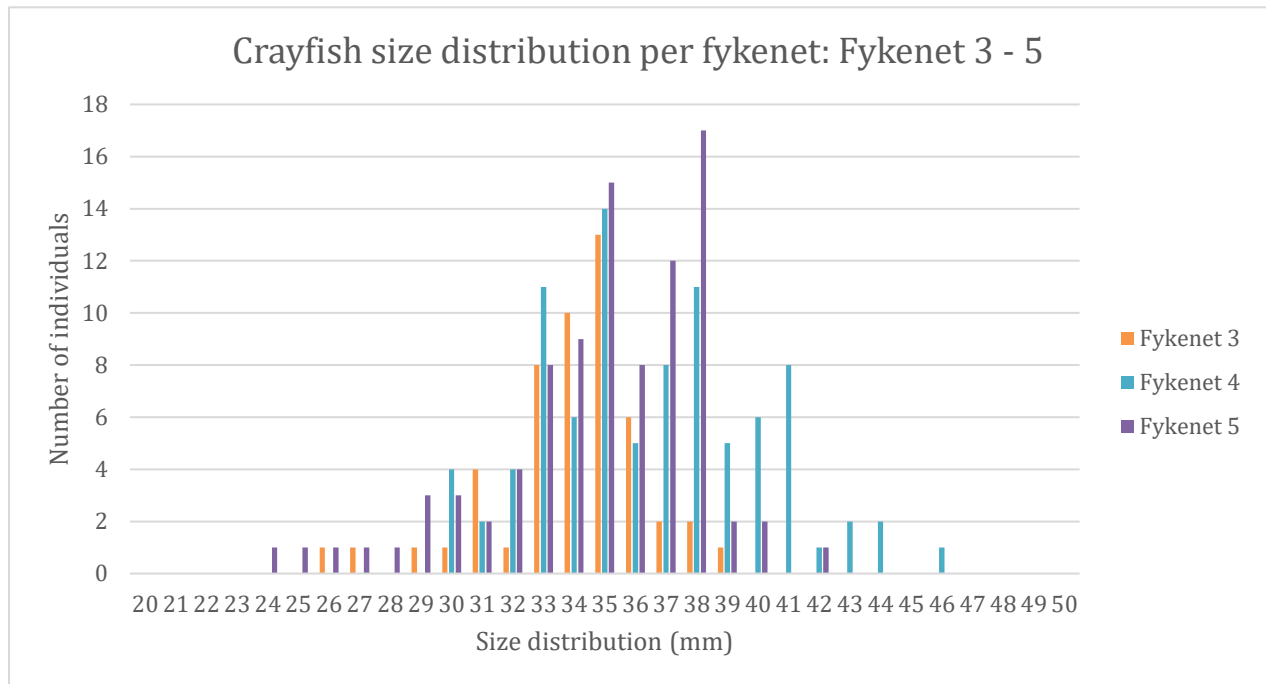


Fig. 6 (b). Crayfish length distribution per fykenet: 3 – 5.

4.1.2. Second Site Visit – 30/09

The second visit occur one week after the first one, and on the last fishing day of the fisher followed. During this week there was a considerable increase in rainfall. The methodology used during the first visit was replicated: same sampling team, same fisher accompanied, same location where the fyke nets were sampled, which allowed for the impact of the rain in the species to be assessed. Therefore, 5 of 100 fyke nets collected were sampled, corresponding to a total of 752 individuals measured.

i) Sex Ratio

Overall the number of crayfish males sampled are slightly higher than the number of females, with a total of 50.8% of male sampled (382 individuals) and 49.2% females (370 individuals).

When analysing each fyke net in detail, the proportion of males were higher in 3 fykenets - 1, 4 and 5 – with a greater difference registered in fyke net number 4 with 58.6% of males (99 individuals) versus 41.4% of females (370 individuals). Fyke nets number 2 and 3 revealed a higher proportion of females, 56.5% and 57.3%, respectively (Fig. 7). Furthermore, two spawning females were collected in fyke net number 5 (Fig. 8).

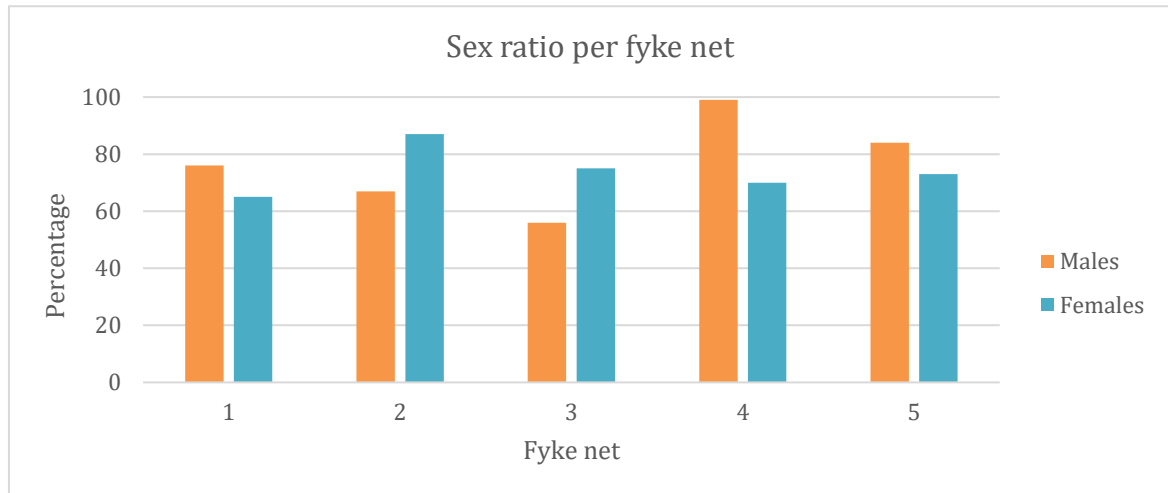


Fig. 7 – Sex ratio for each fyke net sampled.



Fig. 8 – Spawning female collected in fyke net number 5.

ii) *Catch per Unit of Effort – CPUE*

The catch at each fyke net shows that there is a predominance of traps with approximately 150 individuals (Fig.7).

a) *CPUE in number*

$$CPUE(number) = \frac{\text{total number of individuals}}{\text{total number of fyke nets}}$$

Total number of individuals sampled = 752

Total number of fyke nets sampled = 5

CPUE = 150.4

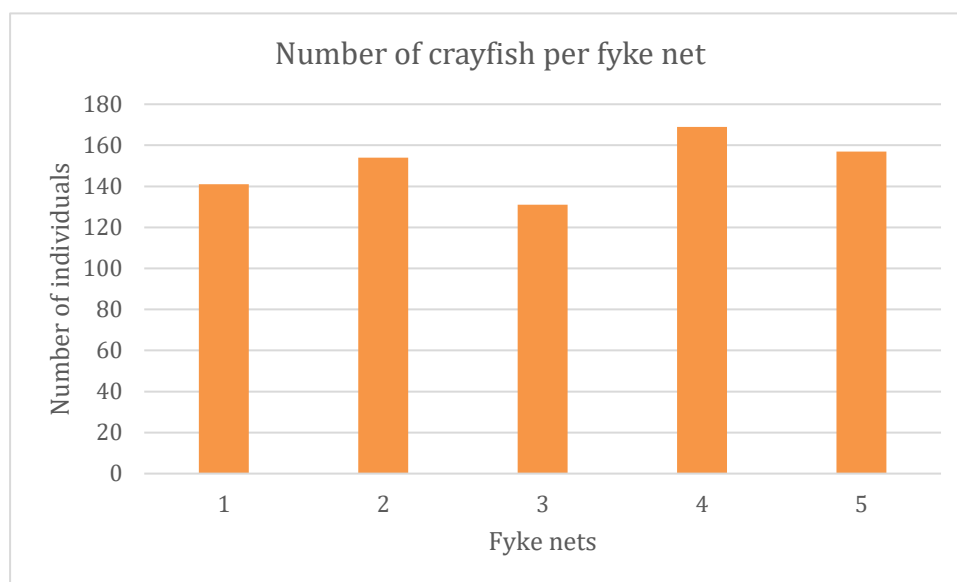


Fig. 9 – Number of individuals per fyke net.

Results shows that each fyke net harvested in average 150 individuals during the 48 hours fishing at the rice fields, with a peak in trap number 4 with 169 individuals caught, representing an increase of approximately 70 individuals per fyke net when compared with the sampling from the previous week (CPUE in number = 80.4).

b) CPUE in kg

$$CPUE(Kg) = \frac{\text{Catches weight}}{\text{Number of fyke nets}}$$

Catches weight = 190 kg → 100 fyke nets

$$CPUE (Kg) = 190 / 100$$

$$CPUE (Kg) = 1.9 Kg$$

Results shows that this week the catch was approximately 1.9 kg of crayfish per fyke net operating 48 hours, corresponding to an increase in 0.6 kg of crayfish per fyke net.

iii) Length frequency

Catches were distributed between 22 and 41 mm, with the majority of individuals with sizes between 29 and 38 mm, indicating that the catch was mainly composed of young adult individuals, aged under 250 days. The spawning females collected in fyke net number 5 had 31 and 41 mm length, similar with the results from the previous week with a slight increase in the number of smaller individuals, although not significant.

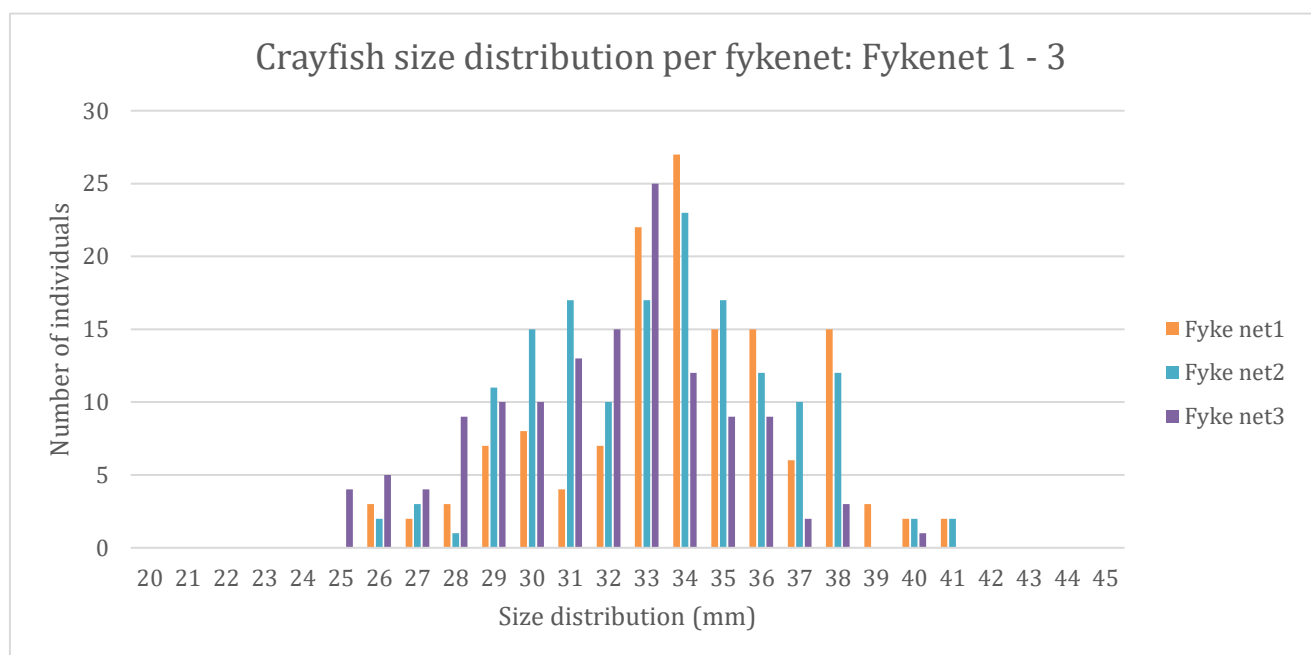


Fig. 10 a) Crayfish length distribution per fyke net: 1 – 3.

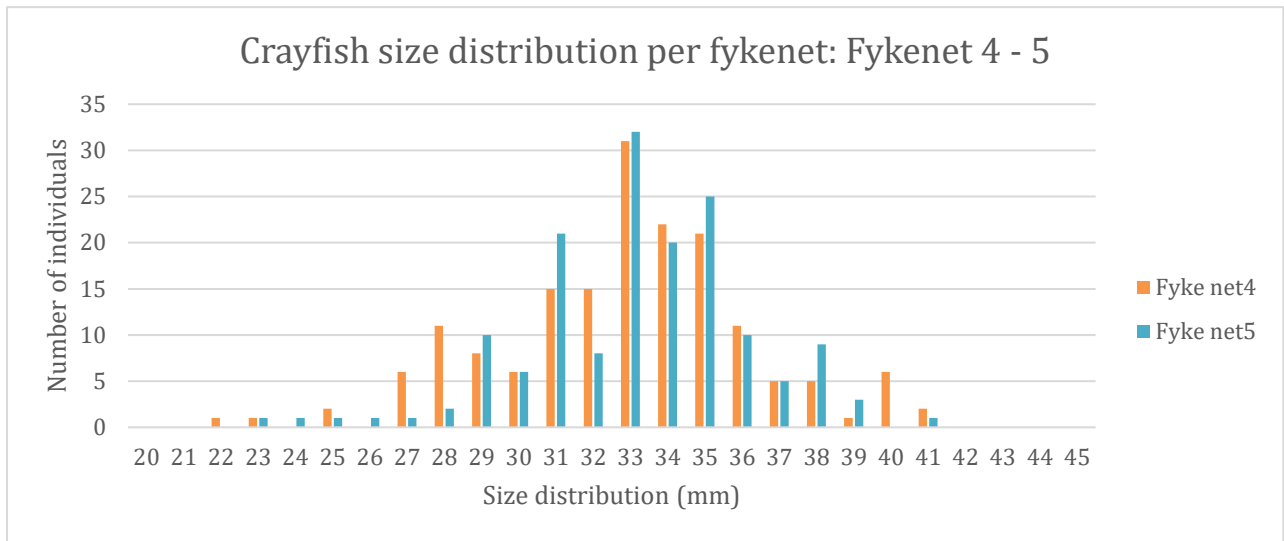


Fig. 10 b) Crayfish length distribution per fyke net: 4 – 5.

4.1.3. Bycatch characterization

Bycatch was identified and measured for the total of fyke nets collected (200 fyke nets, 100 in each visit). In the first visit in the fyke net number 4 a blue crab was caught (*Callinectes sapidus*), with 262 mm length (Fig. 11), which is an invasive species, and kept by the fisher for personal consumption. This species is native to the western Atlantic, and its distribution ranges from Cape Cod (USA) to northern Argentina, including the Gulf of Mexico, and it has been reported in several areas across the globe, including Iberian Peninsula, as invasive species [1].



Fig. 11 – Blue crab (*Callinectes sapidus*) collected during the field work.

In both visits juveniles of common carp (*Cyprinus carpio*) (Fig. 12), which is also an invasive species, were found in fyke nets. . A total of 100 common carp were measured in both visits for a total of 200 fyke nets collected, with an estimated CPUE of 0.5, although all fyke nets sampled (10 in total) caught common carp.

$$CPUE = \frac{\text{Number of common carp caught}}{\text{Number of fyke nets}}$$

CPUE = 0.5 individuals caught per fyke net.

In the first visit 29 individuals were sampled, corresponding to a proportion of 1.4% of the total crayfish caught. A considerable increase in the second visit was registered, with 71 individuals collected, corresponding to a proportion of 1.9%. Similar to what happened for crayfish, rain played an important role in the abundance of the species, in average in the first visit 5.8 individuals were caught in each fyke net, and in the second visit 14.2 individuals were registered, corresponding to an increase of 2.45 individuals. Size varied between 5.8mm and 12.4 mm, with a clear cohort of individuals with 6.5 mm (Fig. 13). Furthermore, the majority of individual's length registered was between 6.4 mm and 6.9 mm.



Fig. 12 - Common carp (*Cyprinus carpio*) juvenile.²

² <https://portal.ct.gov/DEEP/Fishing/Freshwater/Freshwater-Fishes-of-Connecticut/Common-Carp>, accessed 20/12/2021

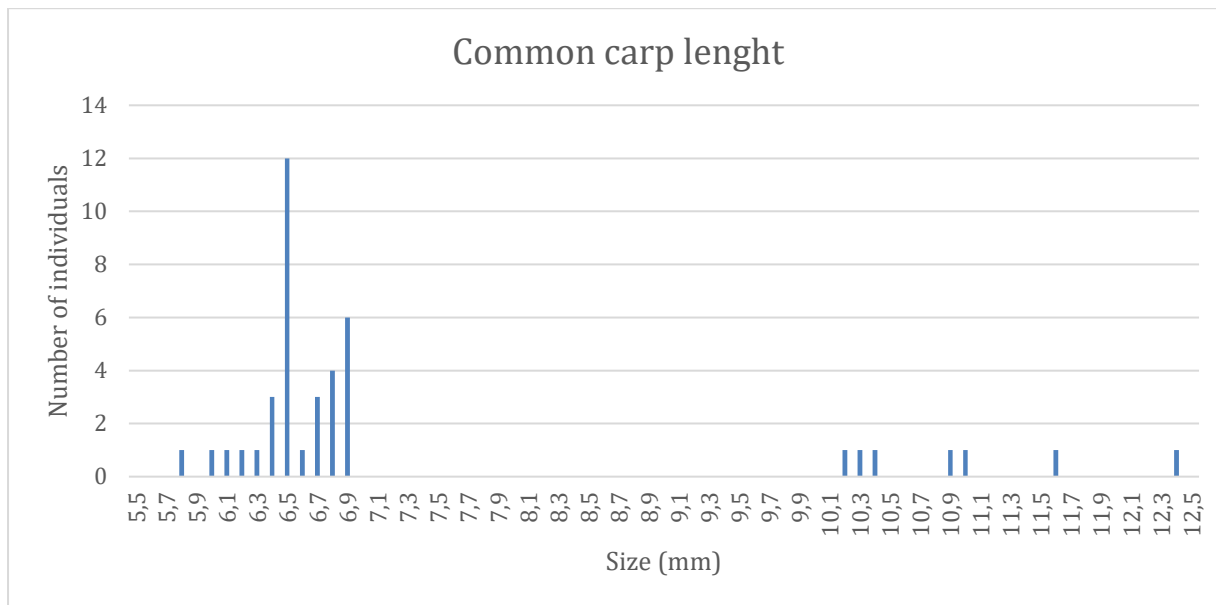


Fig. 13 - Common carp length distribution for 200 fyke nets.

Bycatch was very low, 100 common carp individuals and 1 blue crab for a total of 1154 crayfish caught.

4.1.4. Comparison between Andalusia 2021 and 2022 results

In 2021 only one site visit for sampling was carried out. Measurements were taken randomly from several fyke nets with a total of 175 individuals measured. In 2022 two site visits were carried out, as described in this report, with a total of 1154 individuals measured (402 in the first visit and 752 in the second). The results for both seasons shows that the crayfish population have a balance sex ratio close to 1:1 female and male proportion. Also, individual's size were similar between the two years. However, CPUE in kg estimated for 2021 season was 3 kg per fyke net, and 1,9 kg in 2022.

4.2. Production characterization

Data collected by two producers, Alfocan and South Ocean, from the middle until the end of the 2022 season was made available. Both producers continued to have different methodology regarding their sampling process. Alfocan samples weekly (two or three samples per sampling day) while South Ocean samples once every month. Data from 26th September until 18th November were provided by Alfocan (weeks 34 – 46), while the data made available by South Ocean only includes three sampling days/month (31st August, 10th September and 31st October).

After the last season site visit (September 2021), Alfocan started to take POCL measurements as recommended in the first FIP report (Fig. 14). Regarding South Ocean, data were provided with PBRT measurements, contrary to what was recommended. Despite the fact that data from both producers cannot be compared, length frequency and sex ratio were assessed.

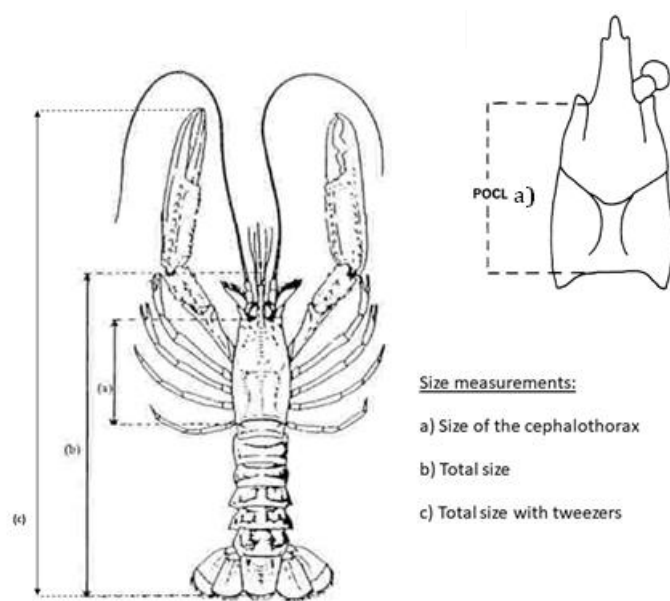


Fig. 14 - Size measurements for crayfish, shrimps and lobsters: a) measure recommended for crustaceans' species (POCL – postorbital carapace length); b) South Ocean measurement (PBRT - point of the rostrum until the base of telson); c) Alfocan measurement (total length with tweezers).

Total catch data was made available by the two producers, Alfocan and South Ocean, for the weeks 34 – 46 of the 2022 season. Both producers only provided total weight data for each week, for weeks 14 to 30, analysed in the second FIP report, August 2022. Thus, the results from the previous report cannot be compared with the following results.

4.2.1. Alfocan data analysis

The results shows that there are no apparent significant differences between the measurements taken in the same sampling days, and there are slight differences between the weeks, similar to the 2021 season. For this reason, the results were treated considering the number of individuals measured per sampling day and size distribution compared by week.

i) Sex ratio

Sex ratio was assessed using the total number of individuals sampled by Alfocan between week 35 and 45. The distribution is homogeneous between both sexes (Tab. 1), with the number of females and males balanced in proportion near 1:1.

Table 1. Sex ratio of individuals sampled at Alfocan

	<i>N</i>	%
<i>Total Sampled Individuals:</i>	2827	100
<i>Number of females:</i>	1389	49
<i>Number of males:</i>	1438	51

i) Length frequency

Length frequency of individuals was calculated using data between week 40 and 45, where POCL measurements are available. A total of 2827 individuals were sampled. The length frequency reveals a normal distribution, with a minimum POCL size of 20 mm and a maximum of 65 mm, and a peak at 35 mm, excepted for week 39 with a 30 mm peak. There are slight differences between the weeks, with larger individuals appearing more frequently after October. The number of individuals sampled was different between the weeks, according to the number of measurements taken in the sampling day. Furthermore between week 34 and 38, two measurements were taken per sampling day (4 kg); between week 39 and 45, three samples were collected (6 kg); and in the week 46 only one measurement was taken in the sampling day (2 kg).

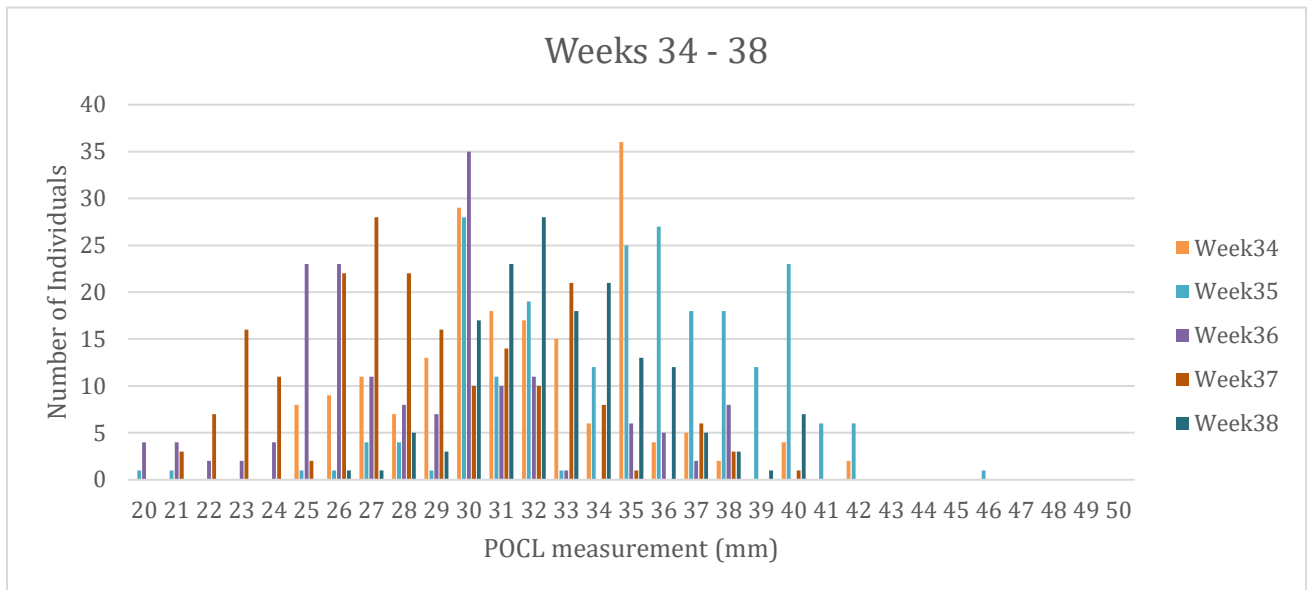


Fig. 15 (a) – Crayfish length frequency week 34 to 38

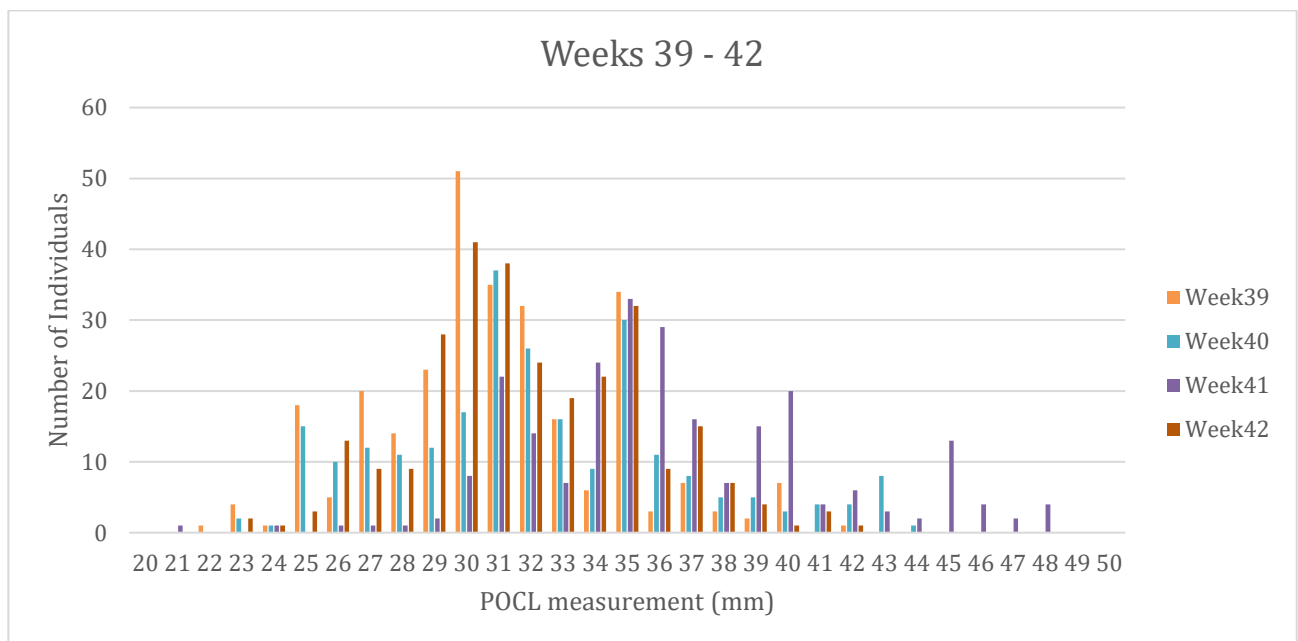


Fig. 15 (b) – Crayfish length frequency week 39 to 42

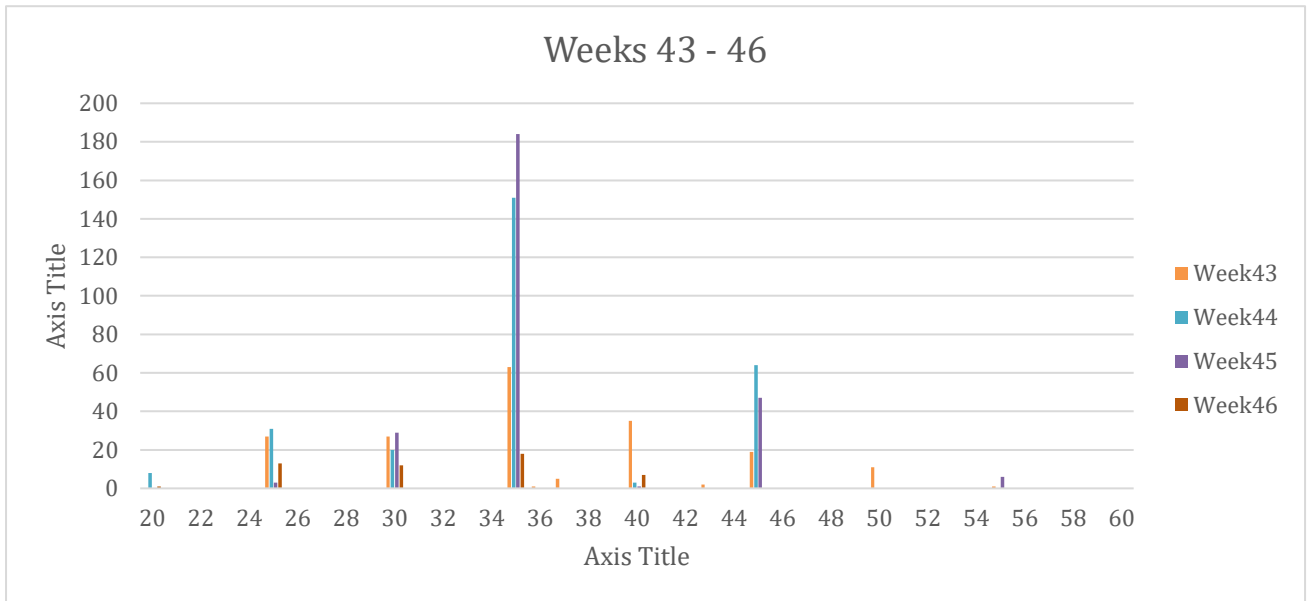


Fig. 16 (c) – Crayfish length frequency

4.2.2. South Ocean data analysis

Since South Ocean only samples once a month, and the data provided concerns only three months (August, September and October), only three days were assessed. A total of 284 individuals were sampled for size and sex distribution.

At South Ocean, sex ratio is similar with previous samples with a 1:1 proportion between females and males (Tab. 2). Also, length frequency is close to a normal distribution, as observed for previous samples. Maximum size registered was 110 mm and minimum 35 mm, with the majority of individuals within 40 and 70 mm of total length, and a peak at 50 and 60 mm.

Table 2. Sex ratio of individuals sampled at South Ocean

	N	%
<i>Total Sampled Individuals:</i>	284	100
<i>Number of females:</i>	152	54
<i>Number of males:</i>	132	46

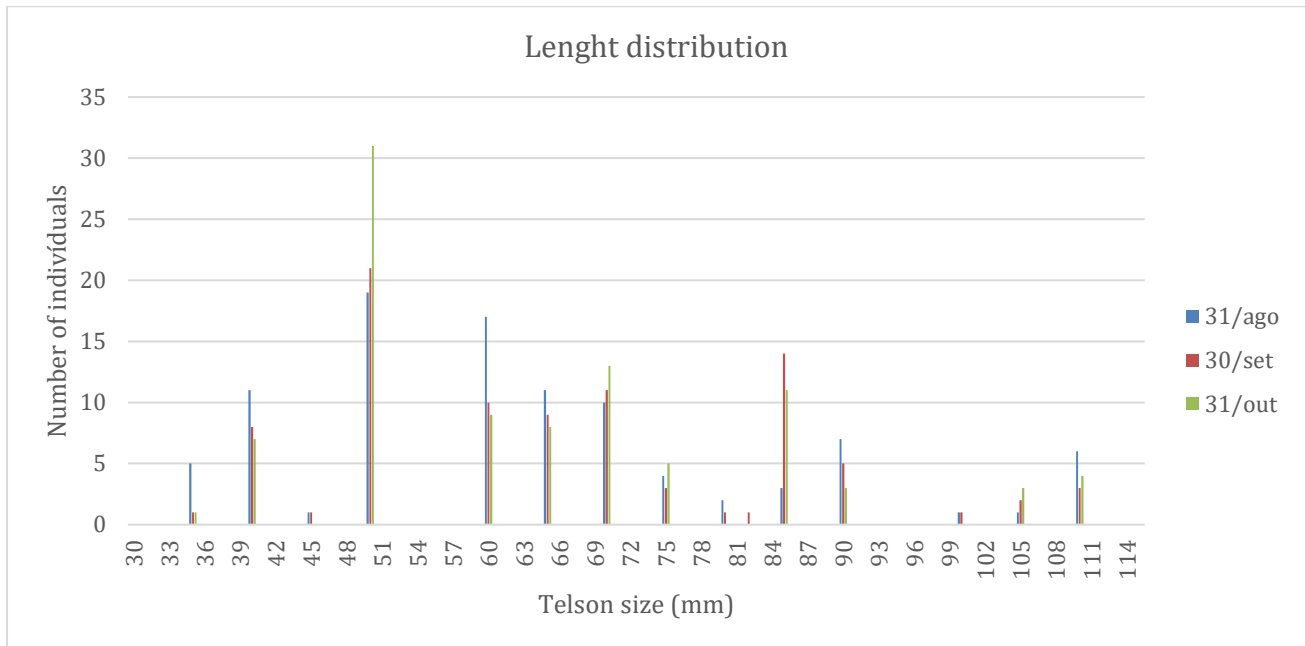


Fig. 12 – Length distribution, using Telson measurement.

4.3. Stakeholder mapping and engagement

Stakeholder mapping and engagement activities were focused on contacting government representatives in Junta de Extremadura and Junta de Andalucía to initiate a round of meetings in 2023 to follow-up the FIP progress and its results so far

5. Discussion

2022 FIP activities started with a two month delay due to the lack of rain and water, and also due to the heat wave felt earlier in the year. Field work and data collection was carried out in Andalusia rice fields sampling commercial fyke nets in the Guadalquivir basin. Data was collected in order to do an analysis of the catch composition and bycatch characterization of the fishery in Andalusia, and compared with the results for 2021 in the same region.

Fishers from Andalusia (and Extremadura, see previous FIP report) reported that the 2022 catches' were the lowest they remember and the catches have been dwelling for the last few years, especially in the dry years, due to the lack of rain and water. The importance of the rain was highly notable from the first to the second site visit in Andalusia, with almost twice of

individuals sampled in the 30th of September than in the 23th of September, for the same number of fyke nets (752 and 402 individuals, respectively for 5 fyke nets each).

For the first visit on the 23 September, CPUE in numbers shows that each fyke net caught around 80 individuals of crayfish during the 48 hours operating. The CPUE in weight was estimated to be 1.35, which means this fisher caught approximately 1 kg of crayfish per fyke net, i.e. in 48 hours.

CPUE estimated for each trap of the second visit with the same fisher were almost twice than the CPUE assessed in the first visit, 150. Regarding CPUE by weight they were considerably higher than on the first visit, with a CPUE of 1.9, which means that the same fisher caught approximately 2 kg of crayfish per fyke net. This represents an increase of almost 50% compared with the first visit in the week before, which represents an increase in the number of individuals available for fishing despite being the end of the fishing season in Andalusia for this year. This could be explained by the rainfall that occurred during the week within visits, as it rained the entire week, which could contribute to the increase in the numbers of crayfish and also common carps. The individuals were the same size (average between 30 and 40 cm).

The differences between the 2021 and 2022 seasons in Andalusia for CPUE in weight was approximately 2 kg less in 2022 than in 2021 ($\text{CPUE}_{\text{kg } 2022} = 1.35 \text{ kg}$ and $\text{CPUE}_{\text{kg } 2021} = 3 \text{ kg}$), which could be related to the lack of rain and also the heat waves felt during 2022, which was also corroborated by the results of the second visit.

Regarding the sex ratio of the crayfish sampled, the proportion of males were slightly higher than the males for both visits (49% and 51%, respectively), and the size distribution were similar between visits and seasons, showing that the population were mainly composed by adult individuals approximately 1 year of age.

Bycatch was assessed from all 200 fyke nets hauled during the two visits and it is very low. Only 1 individual of blue crab, a prolific invasive species in the region, was found caught in the fyke nets. A total of 100 common carps were collected in all 200 fyke nets, less than in the 2021 season with 167 individuals, with an average size of 6.5 cm, corresponding to an early age of juvenile phase [2] and probably from the last spring spawning season, although smaller than in the

previous season (7.9cm). CPUE was estimated for all 200 fyke nets at 0.5 which means that only one individual is caught in two fyke nets, corroborating what was observed by the team during the site visits that bycatch was not found in all fyke nets. However, it was not possible to assess which fyke nets registered the higher number of common carps individuals, due to the fact that during the visits the fisher was keeping the individuals aside whilst the team was measuring the crayfish, and the bycatch was only measured at the end of the fishing activity to cause minimum impact to the fisher.

In order to get a deeper knowledge of bycatch distribution among the fishing area, more fieldwork is needed to study in detail each fyke net catch and also different fishers and fishing areas. Nevertheless, both assessments show that fyke nets bycatch is considerably low especially bearing in mind that common carp is also a prolific invasive species in the same region, with an estimated proportion of 1% of common carp caught for the total crayfish catches.

The length data provided by both companies Alfocan and South Ocean continue to be of different measurements, and these need to be aligned, although both have equal sample size (2kg). It is unclear if national legislation requires a specific measurement as no specific requirement was found in legislation. Furthermore, it is also unclear if a measurement procedure was detailed and agreed in the communications between the administrations and the companies. Nevertheless, the European legally required measure is postorbital carapace length - POCL, while for example in the Portuguese legislation for freshwater species is PRBT, which is also the measurement that South Ocean have been taking. Therefore, it is recommended that both companies align their measurement and choose either PRBT or POCL, following what was already suggested in the first FIP report: *“it is recommended that both companies align their measurement and choose either PRBT or POCL, although we recommend for comparison with international studies that POCL is chosen”*. Thus, a comparison between size distributions of the two companies was not possible. In relation to the sampling frequency, one company samples 2 or 3 times in one day on a weekly basis, and there seems to be no significant differences between daily measurements. This leads to the conclusion that there is little need to sample several times within a day. On the other hand, the other company samples only once monthly a few individuals and the resulting length frequencies do not provide sufficient information and therefore the sampling should be increased.

Finally, regarding a comparison between fishing activity in Andalusia and Extremadura regions (Extremadura results can be found in the previous FIP report), the regions have differences regarding fishing areas, gears and operation. Catch compositions are also different regarding number and size of the individuals: individuals from Extremadura were smaller with the majority of individuals measuring between 25 and 35 mm, whilst in Andalusia the average sizes extends to 46 mm. In addition, the number of individuals caught by fyke nets (Andalusia) is higher than the individuals caught by traps (Extremadura), with the CPUE in numbers in average for both visits 115 individuals/fyke net and 40 individuals/trap. The number of individuals caught is the most significant difference between gears/areas, likely reflecting the fact that fyke nets operate during 48 hours and traps only 24 hours. Regarding sex distribution, populations from both sites showed a balance between the number of males and females, and only in Andalusia was there two spawning females found. Regarding bycatch, in both regions is considerably low, the proportion of none target species was under 0.5% and the species caught are reported as invasive: pumpkinseed in Extremadura; common carp and blue crab in Andalusia.

6. Conclusions and Recommendations

From this assessment fewer conclusions can be taken regarding stock status and the characterization of the fishery, particularly regarding fishing effort and fishing area since only one fisher was followed in Andalusia.

Nevertheless, there are some preliminary points that can be highlighted, namely the lower proportion of bycatch, and the impact the rain have in the species abundance. In order to fully assess the Spanish crayfish fishery, the following recommendations ought to be considered:

1. More data regarding fishers, fishing areas and number of fishing gears should be collected and /or made available;
2. A common reference measurement needs to be agreed between the producing companies and also with the Spanish administrations;
3. Producers sampling effort should be refocused on different measurement procedures instead of daily frequency;
4. Producers data should continue to be transmitted in clear electronic format in editable format (word, excel);



5. The engagement of fishers should be promoted to allow for fishery data to be collected.

7. References

- [1] Morais et al. (2019). The Atlantic blue crab *Callinectes sapidus* Rathbun, 1896 expands its non-native distribution into the Ria Formosa lagoon and the Guadiana estuary (SW-Iberian Peninsula, Europe). *Bio Invasions Records*, 8(1), 123–133.
- [2] Lorenzo Vilizzi (2018). Age determination in Common-carp, *Cyprinus carpio*: history, relative utility of age structures, precision and accuracy. *Rev Fish Biol Fisheries*, 28, 461-484.