Supporting Sustainable Sepia Stocks

Report 3: Assessing the efficacy of egg receptors within fishing traps used to target common cuttlefish (*Sepia officinalis*)

Daniel Davies
Kathryn Nelson
Sussex IFCA
2018

Contents

Summary

The structure and netting of a cuttlefish trap may be used by cuttlefish as a site for egg laying, often resulting in the trap becoming covered in cuttlefish eggs. In this study, there was an average of 184 eggs per trap (*range* = 0-813). These eggs can be difficult to remove and represent a potential loss to the recruitment of the population.

The aim of this study was to trial three different artificial egg laying substrates within the operational cuttlefish traps of Hastings fishers. The additional egg laying substrates were: 45cm lengths of 8 mm polypropylene rope, willow whips and trap entrance fingers. Each substrate was reviewed on a number of criteria; the percentage of eggs deposited on the egg laying substrate, the time and effort required by fishers to remove the eggs from the trap, the number of cuttlefish in the traps, and the preferences of the participating fishers.

The most efficacious egg laying substrate trialled was the lengths of 8 mm rope. On average, this modification had 50% eggs on the modification relative to the total number of eggs laid on the trap. The 8 mm rope also required the least time and effort to remove eggs deposited on it and was the preferred modification of the participating fishers. The addition of 8 mm rope also improved the average number of cuttlefish per trap. The average catch rate of the unmodified traps was 0.86 cuttlefish per trap, whereas the addition of the rope to the traps raised the average catch rate to 1.5 cuttlefish per trap.

This report describes efficacy of egg receptors within fishing traps used to target common cuttlefish. This report was written as part of the Fisheries Local Action Group (FLAG) funded project; Supporting Sustainable Sepia Stocks. The other outputs from this project are:

- The biology and ecology of the common cuttlefish (report).
- The English Channel fishery for common cuttlefish (report).
- Egg survival and maternal investment (report).
- Mitigating cuttlefish egg mortality post fishing activity (poster).
- Supporting sustainable sepia stocks (presentation).

Acknowledgements

Funding for this project was provided by the European Union's European Maritime Fisheries Fund (EMFF) and was accessed through the Hastings Fisheries Local Action Group (Hastings FLAG). The project was a collaboration between the Sussex Inshore Fisheries and Conservation Authority, the University of Brighton and the Hastings Fishermen's Protection Society. We would like to thank all of our collaborators for all their effort toward the completion of this project. Our thanks also goes to the skippers and crews of the participating vessels for welcoming us aboard their vessels and for suppling both data and knowledge on their fishery.

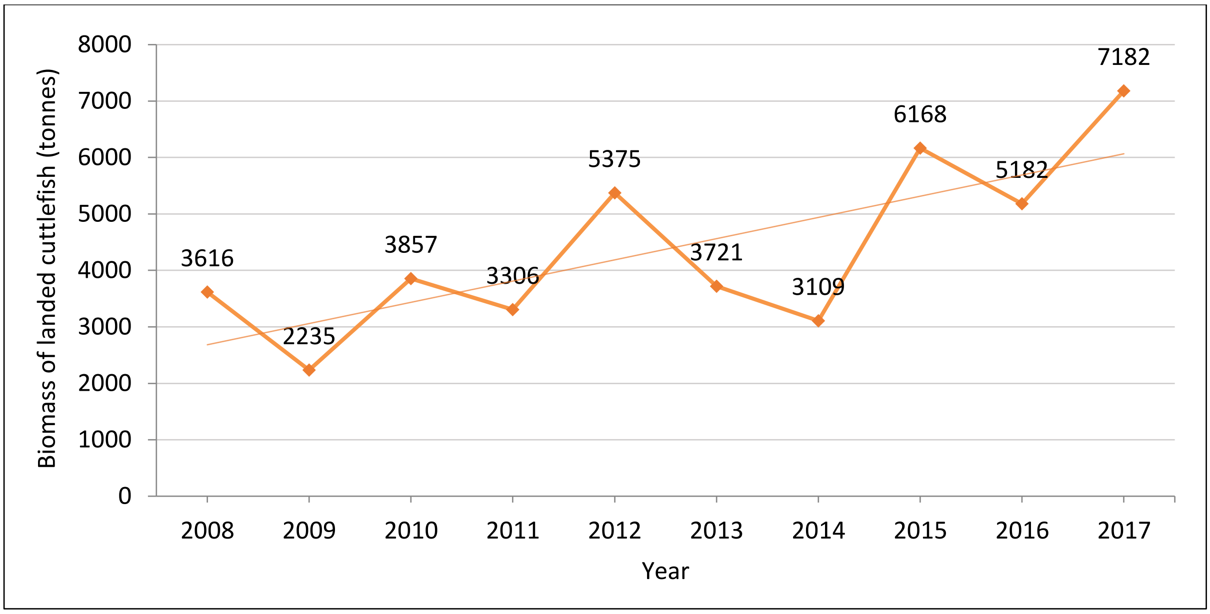
Introduction

The common cuttlefish (*Sepia officinalis*) is a marine mollusc within the class of cephalopoda. Members of the class cephalopoda can be found in all major marine environments around the world (Reid *et al,* 2005). Historically, the English Channel population of the common cuttlefish *S. officinalis* was considered a non-target species for commercial fishers with low values and insignificant effort expressed on the stock. This position has dramatically changed in recent years (Dunn 1999). *S. officinalis* now represent an important commercial fishery to many European nations (Bloor, 2012; Bloor, *et al,* 2013a; Keller, *et al*, 2014).

UK Cuttlefish fishery

The English Channel represents one of the most important fishing grounds for cuttlefish in Europe, with 60% of all catches between 1993 and 2003 occurring in the English Channel (ICES areas VIId and VIIe) (Royer *et al,* 2006). In the last decade, the UK cuttlefish fishery has nearly doubled its exploitation rate (Figure 1).

Until recently, the trend observed in the UK cuttlefish fishery was mirrored in the Sussex cuttlefish fishery, with years of high catches across the nation correlating with high catches in Sussex. The peaks and troughs seen in the annual landings of cuttlefish, at both scales of observation, is the result of periods of high and low abundance produced by the cyclic nature of the English Channel cuttlefish population caused by environmental variables (Dunn, 1999; Gras *et al*, 2014; Guerra, 2006). In 2017, at the same time the UK cuttlefish fishery recorded a ten year high with landings of 7182 tonnes, the Sussex cuttlefish fishery recorded a ten year low with landings of 157 tonnes (Figure 1).



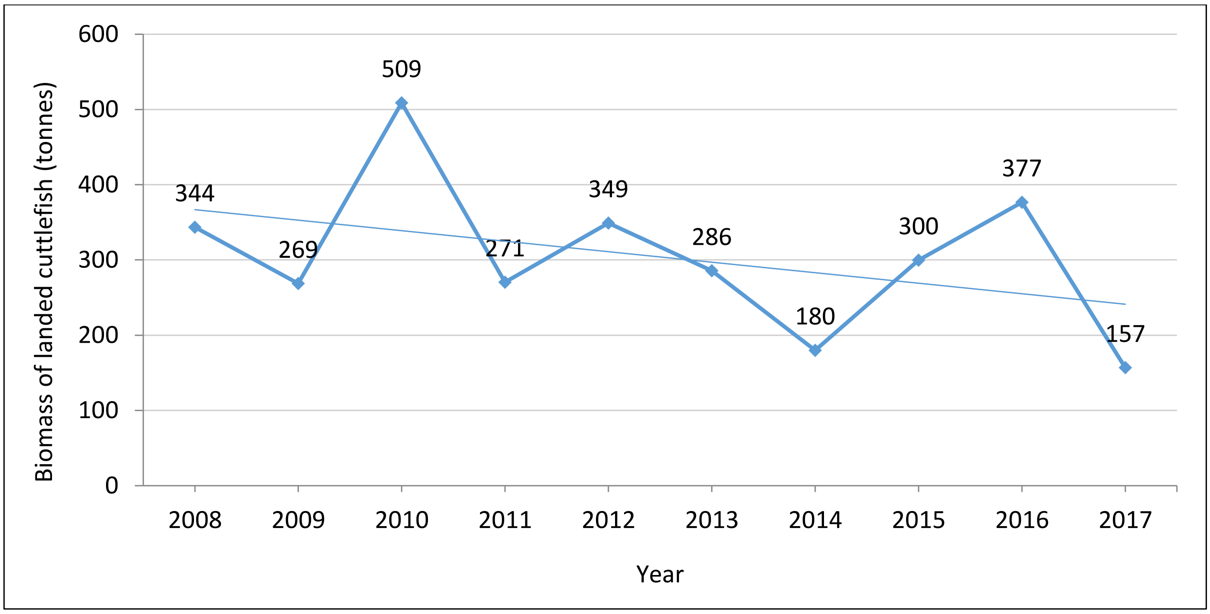


Figure 1. Total landings in tonnes of cuttlefish across all UK ports (orange) and Sussex ports (blue) between 2008 and 2017 (MMO landings data 2008-2017).

Cuttlefish trap fishery

The cuttlefish trap fishery is considered highly sustainable, as the fishers target fully grown cuttlefish at or near the end of their lives and as such, the fishing mortality is close to natural mortality (Bloor, 2012). The cuttlefish trap fisheries are also highly selective for the target species with very low rates of bycatch (Dunn, 1999).

During standard operating practices, the traps used by artisanal fishers to target cuttlefish often become egg laying sites for the breeding adults (Figure 2). Although many fishers try to remove and return these eggs to sea, it is not always possible to remove all eggs while at sea (Joy *pers comm,* 2017). Due to the method of egg attachment used by maternal cuttlefish, the removal of eggs from fishing gear sometimes requires harsh cleaning techniques such as scrubbing with a stiff brush or the use of jet washes (Blanc and Daguzan, 1998). These aggressive cleaning techniques are likely to reduce the survival rate of the eggs and the subsequent loss of these eggs from the recruitment to the population is likely to cause deleterious impacts on the future population size (Barile *et al* 2013; Belcari *et al,* 2002; Blanc and Daguzan, 1998; Bloor, 2012; Bloor *et al,* 2013; Dunn, 1999; Melli *et al,* 2014; Watanuki and Kawamura, 1999).

Figure 2. Photographs of cuttlefish traps with eggs attached.

Mitigating egg mortality

Whilst using traps to catch cuttlefish is considered to have less impact than using towed gear, many cuttlefish traps become covered in eggs and these eggs are likely to be lost from the population. Improvement in the sustainability of the inshore cuttlefish trap fishery may be achieved by determining an efficient technique that will facilitate fishers in the removal of a higher proportion of the eggs deposited on the traps in a way that will allow them to survive.

A number of studies have been conducted into different mitigation strategies to reduce the mortality of cuttlefish eggs post trap fishing effort. Abecasis *et al* (2013) reviewed the impact of a marine protected area (MPA) which restricted fishing activity on and around the breeding grounds of the local cuttlefish population. This study showed that small MPAs do not produce a positive effect on the abundance of local populations of cuttlefish. This is probably due to the low site fidelity and large seasonal migrations of cuttlefish (Abecasis *et al,* 2013). Therefore, other conservation measures could be more beneficial than MPAs in supporting a sustainable cuttlefish population.

Another mitigation strategy involves fishers leaving the traps in suitable areas after the end of the fishing season to allow the eggs on the traps to hatch. Although this would allow the eggs that are laid later in the season to hatch, it does not protect the eggs laid earlier in the season as the majority of fishers clean their traps intermittently throughout the fishing season, causing some egg destruction. This measure would also not prevent egg destruction when traps are brought ashore in anticipation of bad weather conditions (Melli *et al,* 2014). There is also a risk of gear conflict with the pots being damaged by towed fishing activity and of the pots being lost in stormy conditions.

A mitigation measure trialled in Morbihan Bay, France, was to deploy on to the seabed iron grids with ropes of different diameters and lengths attached to it. The grids were placed at locations remote from any fishing activity. The study showed that maternal cuttlefish had a strong oviposition (egg laying) preference for ropes of 8 mm in diameter and 50 cm in length, although lengths of between 30 and 90 cm were also used. Although eggs were laid on the 90 cm ropes, as they became laden, the additional weight resulted in the ropes lying on the seabed and none of the eggs hatching due to smothering. Different coloured ropes were also considered. Ropes of mixed colour initially had more eggs laid on them, but as the ropes became fouled with a biofilm the preference towards them became less pronounced (Blanc and Daguzan, 1998).

Barile *et al*, conducted a similar study off the Molise coast in Italy. This study also showed that maternal cuttlefish had a significant preference of ropes of 8 mm in diameter. The study also considered two structures for the ropes to be attached to. The first was a flat grid, similar in design to the ones used by Blanc and Daguzan, and the second was the frame of a cuttlefish trap. They found that the trap frames were cheaper to produce and easier to handle, and that they also suffered less from the impacts of siltation and oxidation. The incidence of egg laying was significantly higher on ropes attached to trap frames than ropes on the flat grids. During the study, small batches of eggs were collected and reared under laboratory conditions. Generally high levels of embryogenesis (hatching) were observed during the experiment and optimal conditions were found to be 21°C and salinity of 30 PSU (Barile *et al,* 2013).

A recent study conducted in the north western Adriatic Sea used the cuttlefish traps of fishers active within the local fishery. This study, informed by the work of Blanc and Daguzan, only used ropes of 8 mm diameter and 40 cm length but two different types; elastic and hemp. These ropes were attached to the inside of cuttlefish traps that were deployed during routine fishery operations. No significant difference was observed between the two rope materials as oviposition sites in the number of ropes with eggs or the maximum number of eggs laid. There was also no significant difference between the use of yellow or blue ropes. No discernible differences in the catch rates were observed between traps with elastic or hemp ropes and the controls. The results of this study indicated that this mitigation strategy was quite effective, allowing over 20% of eggs deposited on the traps to be easily removed, while having no impact on the efficacy of the traps (Melli *et al,* 2014).

Aims

This part of the Supporting Sustainable Sepia Stocks project focussed on a fieldwork trial involving Hastings fishers using cuttlefish traps. Three different egg receptors were attached to the inside of traps with the aims of:

- Devising a mitigation method to reduce post-fishing egg mortality by 15%
- Determining the impact of attaching egg receptors to cuttlefish traps on the fishing effort (number of cuttlefish caught)
- Determining the impact of attaching egg receptors to cuttlefish traps on the workload of the fishers

In addition, eggs were collected for laboratory trials at the University of Brighton to determine the survival rate of cuttlefish eggs removed from the receptors. Also the egg receptors were trialled on frames at a site independent from the fishing activity.

Methods

The beach-launched fishing fleet of Hastings is the largest of its kind in the UK with 28 vessels active within its fleet. The Hastings fishing fleet is not only vital to the local economy, but also has important cultural and historic relevance, as Hastings has hosted an active fleet of fishing vessels for over a thousand years (Peak, 1985). Hastings is situated on the south coast of England in the county of East Sussex (Figure 3).

Data was collected in collaboration with three vessels from the Hastings cuttlefish trap fishery. These vessels represented all of the operational vessels fishing within the cuttlefish trap fishery of Hastings for the 2018 season. The collection of data took place alongside the routine operational practices of each of the vessels. Potting took place within 2 nautical miles of the coast to the west of the centre of Hastings (Figure 3).

Two techniques of data collection were undertaken; 1) direct at sea observations with a researcher onboard the fishing vessel and 2) indirect observation with participating fishers taking photographs of the cuttlefish traps when a research was not onboard. All directly observed fishing efforts occurred between 14th May and 3rd July 2018. The indirect observations occurred between 8th June and 28th June 2018.

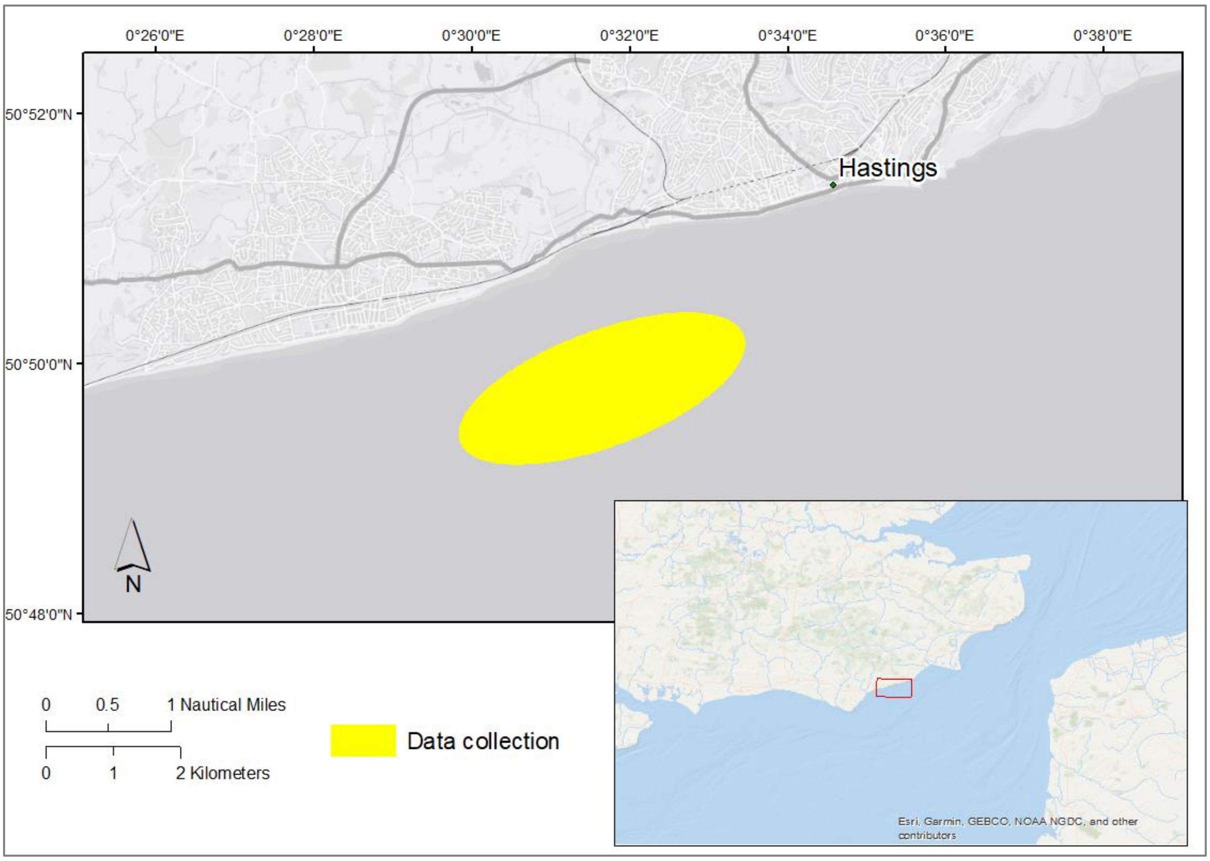


Figure 3. Study area.

Modifications

A single string of ten cuttlefish traps deployed from each vessel was modified to provide increased ovipositioning (egg laying) sites for maternal cuttlefish. All three vessels used parlour traps that measured 120 x 90 x 30 cm with three or four entrances. The capture netting was formed of 50 mm square mesh. Three different egg receptors were replicated three times on each modified string and one trap was left unmodified to act as a control. The modifications were: trap entrance fingers, 7-10 mm diameter willow whips and 8 mm diameter blue polypropylene rope (Figure 4). These structures were chosen following consultation with local fishers and an extensive review of scientific literature (Blanc and Daguzan, 1998; Barile *et al,* 2013; Melli *et al,* 2014; Joy *pers comm,* 2018).

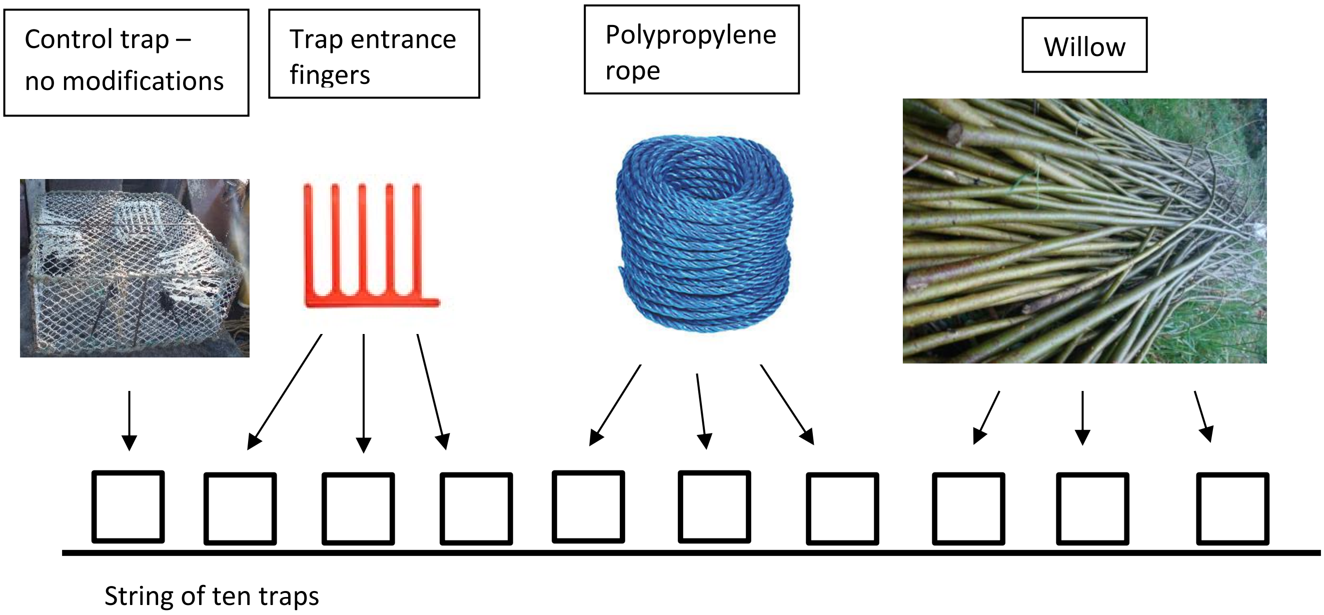


Figure 4. Diagram of the modified string.

Fourteen units of trap entrance fingers were attached to the internal structure of the trap. Each unit consisted of five prongs, with each prong measuring 13.5 cm. This provided an additional 945 cm of potential egg laying substrate (Figure 5).

Eight 110 cm lengths of rope were tied to the bottom of each trap. The rope was tied in a fashion to provide sixteen 45-50 cm lengths of rope and increased available ovipositioning sites by 800 cm per trap (Figure 5).

Two 95-100 cm lengths of black maul willow whips were tied in the middle to form a cross structure. A single length of the same willow was twisted together to form a rough circle with a circumference of approximately 80 cm. Both the circle and cross structures of willow were placed into the trap, but not attached to the trap structure in any way. The willow provided an additional 280 cm of ovipositioning substrate (Figure 5).

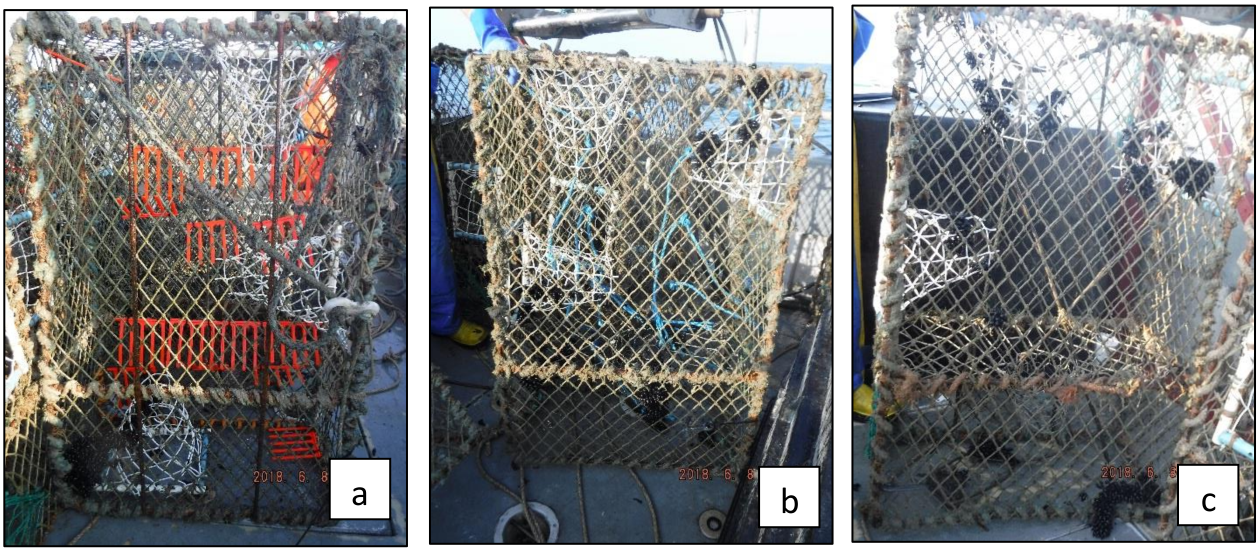


Figure 5. The cuttlefish traps showing the modifications: a. trap entrance fingers, b. rope, c. willow.

At sea observations

Sussex IFCA research officers were onboard for a total of twelve fishing trips. The weather, wind speed and direction as well as the sea state for each trip was recorded.

As the string of modified traps was hauled, the onboard observer collected information on the number cuttlefish and bycatch species in each trap. Estimates of the percentage of the trap covered in cuttlefish eggs were made. Throughout the hauling, working and reshooting of the modified traps, video footage of the modified string was recorded on a GoPro (Hero 3) camera. After the catch was counted and removed, the observer took a number of photographs of each trap. These images recorded the density and location of cuttlefish eggs laid on the trap and egg receptors. After all data and images were collected, the fishers then removed any eggs from the trap and the egg receptors as possible. The observer also recorded the time taken by fishers, to haul, work and redeploy the whole string.

During the hauling of the unmodified strings, observations were also recorded to act as further controls. The number of cuttlefish and bycatch per trap was recorded, as well as estimates of the percentage of the trap covered in eggs. Photographs of one trap in each unmodified string were taken. The time taken by fishers to haul, work and redeploy the string was also recorded. During analysis, two unmodified strings from each fishing trip were selected at random to enable comparative analysis between the controls and the modified traps.

As the fishers removed the eggs from the traps, some were retained in an aerated bucket of sea-water for survival studies, and biochemical and histological analysis.

Fisher observations

The fishers took photographs of every trap on the modified string and of one pot on the unmodified strings during seven trips. These supported the data collected by the onboard researchers.

Test strings

Two test strings were manufactured to review the efficacy of the different egg laying substrates added to the fishers' traps when not incorporated within an active fishery, therefore avoiding any influence this may have had on egg laying. Each string contained three metal frames measuring 90 x 90 x 45cm, similar to cuttlefish trap frames. The three different egg laying substrates (trap entrance fingers, polypropylene rope and willow whips) were attached to each frames, with each frame containing a single type of substrate (Figure 6). A bespoke holding pen measuring 61 x 34 x 19 cm and separated into six equally sized compartments was also attached to the test string. Each frame and the holding pen were attached to the main lead-line at 8 m intervals. Two replicate strings were fabricated.

Both strings were deployed from Sussex IFCA's Fisheries Patrol Vessel 'Watchful' in Pevensey Bay, approximately 10km south west from the data-collection-with-fishers area. Before the test string was deployed, approximately 100 eggs were placed into each of the compartments within the holding pens. These eggs were used to determine the survival rate of eggs returned to sea by fishers post fishing activity. The test strings were deployed on the 23rd May 2018.

On the 10th July, the test string was hauled onto the deck of FPV 'Watchful' and the numbers and locations of cuttlefish eggs deposited onto the different substrates was recorded. The number of remaining eggs within the holding pens was also recorded. After all data was collected the test strings were redeployed on to the seabed at the same location. After the cuttlefish fishing season had finished, both test strings were collected and brought ashore on the 5th September 2018. The number and location of eggs was recorded alongside the number of remaining eggs within the holding pen.

Figure 6. The three egg laying substrate types: a. trap entrance fingers, b. rope, c. willow and d. the bespoke holding pen.

Fisher questionnaire

All active fishers associated with each of the participating vessels were interviewed at the end of the project. Each interview contained three main sections; personal details, their opinion of the current inshore cuttlefish trap fishery and their opinion on the three different modifications trialled during this project (Appendix 1). The questions about the modifications required fishers to score each adaptation one to three, best to worst, in term of various criteria including; the efficacy of the modification (amount of eggs laid), the impact on the catch rate of the traps (number of cuttlefish), the time and effort required to remove both cuttlefish and cuttlefish eggs and an overall opinion of the modified traps.

Data analysis

The photographs collected during both direct and indirect observations were reviewed using Microsoft Paint. Each image was magnified to the appropriate magnification to enable the eggs to be accurately counted. As each egg was counted, a single red dot was placed on the image, ensuring an accurate count was maintained. The eggs were separated into two populations, those laid on the trap and those laid on the egg receptors (Melli *et al,* 2014). Other more advanced image analysis software were tested but they were not as effective as this simple method.

All numerical data was compiled into a Microsoft Excel spreadsheet for the calculation of mean values with the corresponding standard deviations. MiniTab 17 was used to conduct statistical analysis: Kruskal Walis and Mann Whitney U tests were applied to the numbers of cuttlefish caught within modified and unmodified traps and the abundance and distribution of deposited eggs.

Results

Egg receptors

Rope had the most eggs laid on it, followed by willow. The least amount of eggs were laid on the fingers, despite them providing the greatest additional egg laying area. 50% of the total amount of eggs laid on the trap and receptor, were laid on the ropes (Figure 7 and 8).

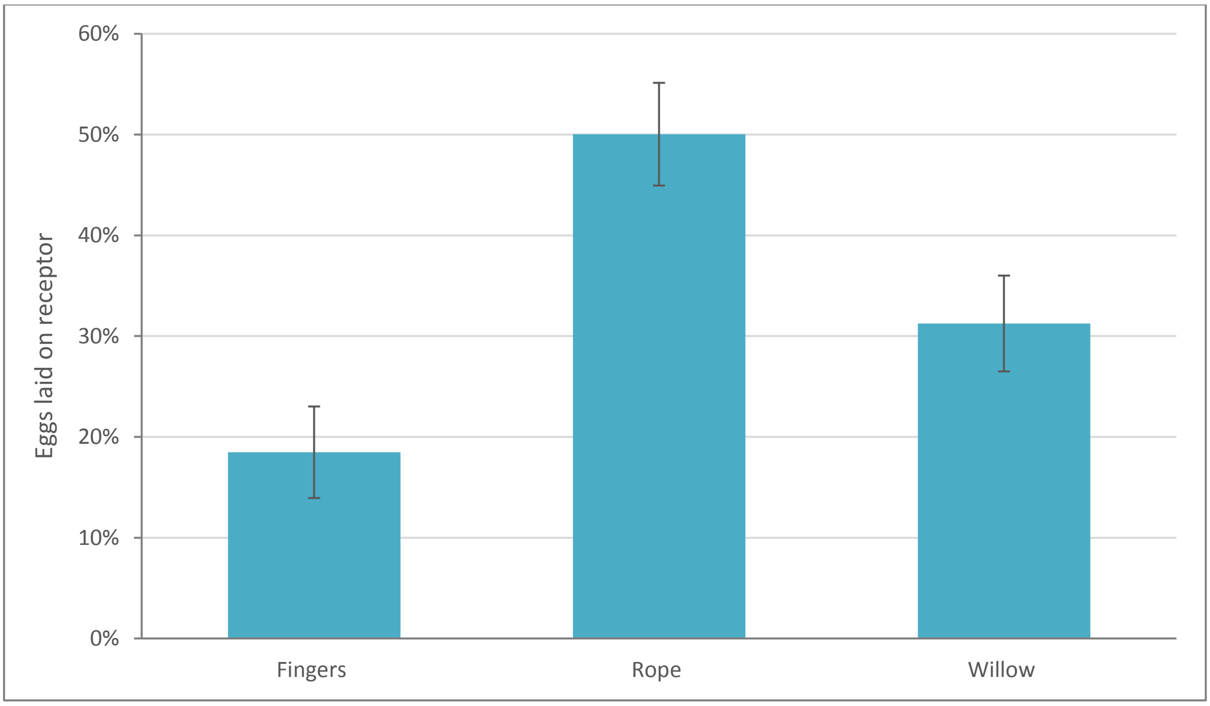


Figure 7. The average percent of total eggs laid on receptor. The error bars indicate the standard error of mean.

Figure 8. The cuttlefish eggs attached to the receptors; Left: fingers, Middle: rope, Right: willow.

Egg laying on traps

There was an average of 160 eggs laid on the unmodified traps (Figure 8). This was lower than the number of eggs laid on the traps with willow (220) or those with ropes (200) but higher than the traps with fingers (130). This was specifically the number of eggs laid on the traps, not including the egg laying substrates.

Most of the eggs were laid on the frame of the traps with some eggs also around the entrances and on the netting between the main and parlour sections of the trap. Most of the traps had 5-20% egg coverage.

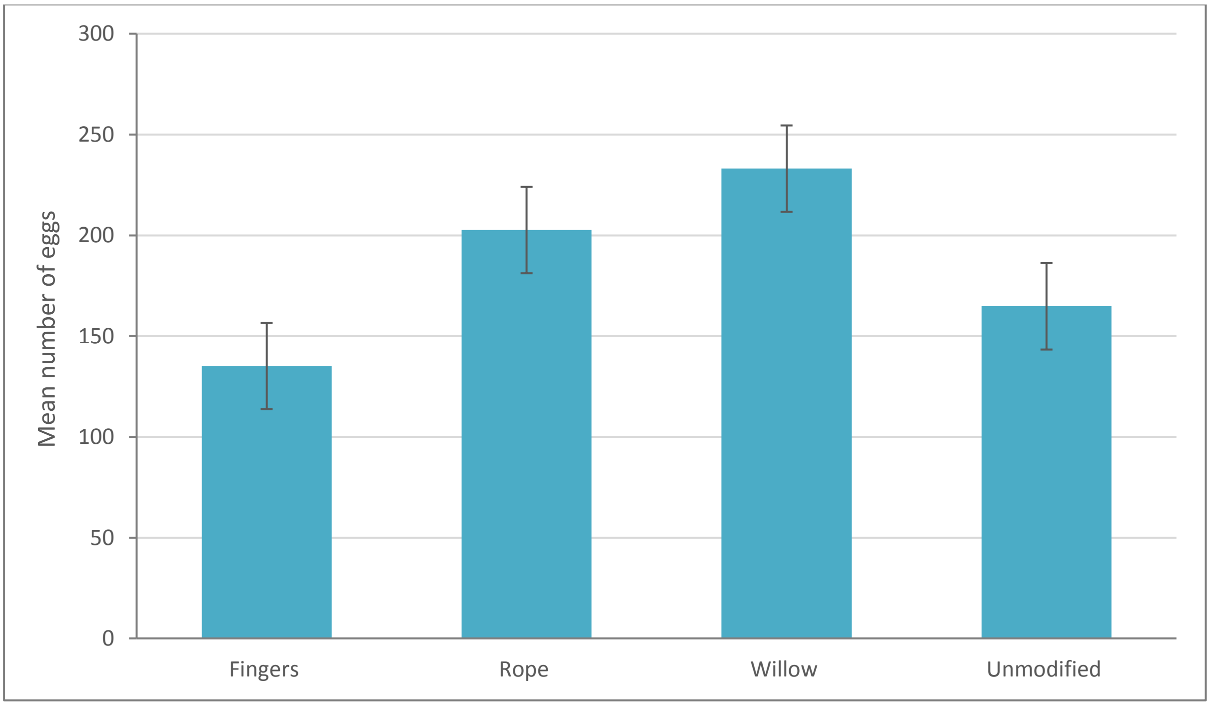


Figure 9. The average number of eggs deposited per trap for modified and unmodified traps. The error bars indicate the standard error of mean.

Number of cuttlefish per trap

In the unmodified traps, the average number of cuttlefish per trap was 0.8. The traps which had the addition of ropes had a much higher average number of cuttlefish (1.5) and the traps with willow also had more than the unmodified traps (1.0). Only the traps with the entrance fingers had less cuttlefish (0.7) (Figure 9). This suggests that the addition of egg receptors could be beneficial for the trapping of cuttlefish.

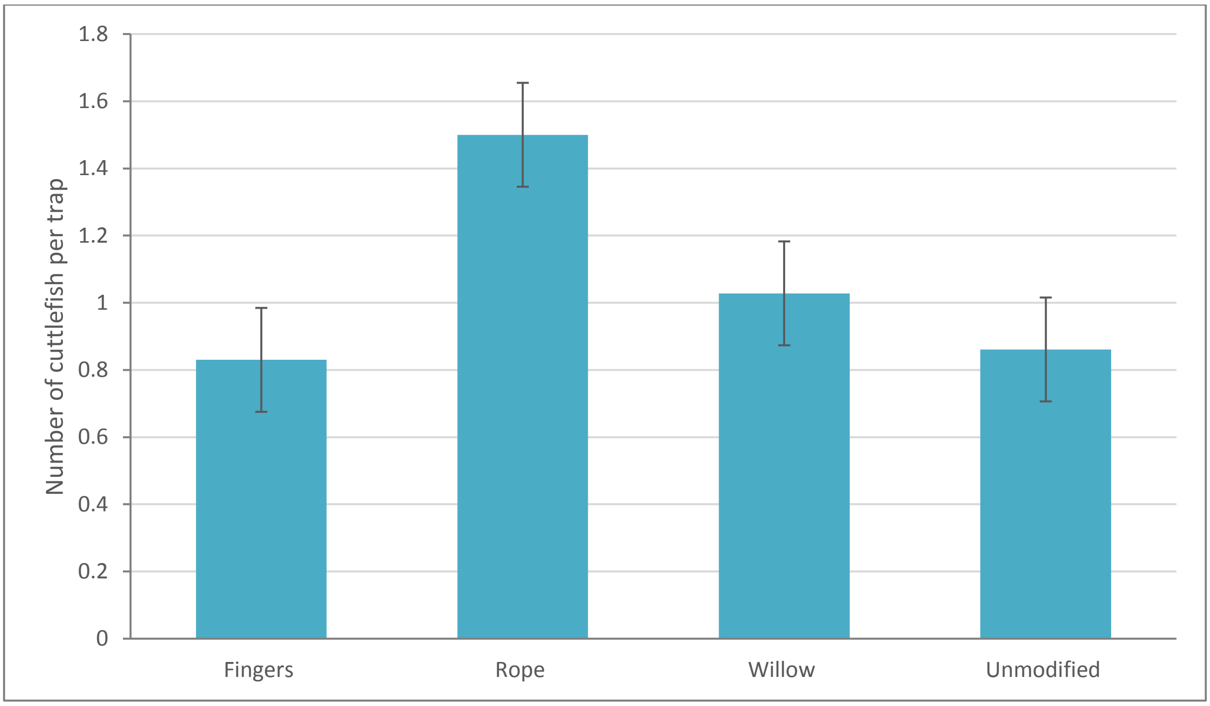


Figure 10. The average number of cuttlefish per trap for the modified and control traps. The error bars indicate the standard error of mean.

Bycatch

29% of the traps contained bycatch. The most common species (84%) was spider crab (*Maja squinado*) (Figure 10). Other species included edible crab (*Cancer pagurus*), common starfish (*Asterias rubens*), bib pout (*Trisopterus luscus*), European bass (*Dicentrarchus labrax*), plaice (*Pleuronectes platessa*) and lesser spotted dogfish (*Scyliorhinus canicular*) (Figure 7). The bycatch was returned to the sea.

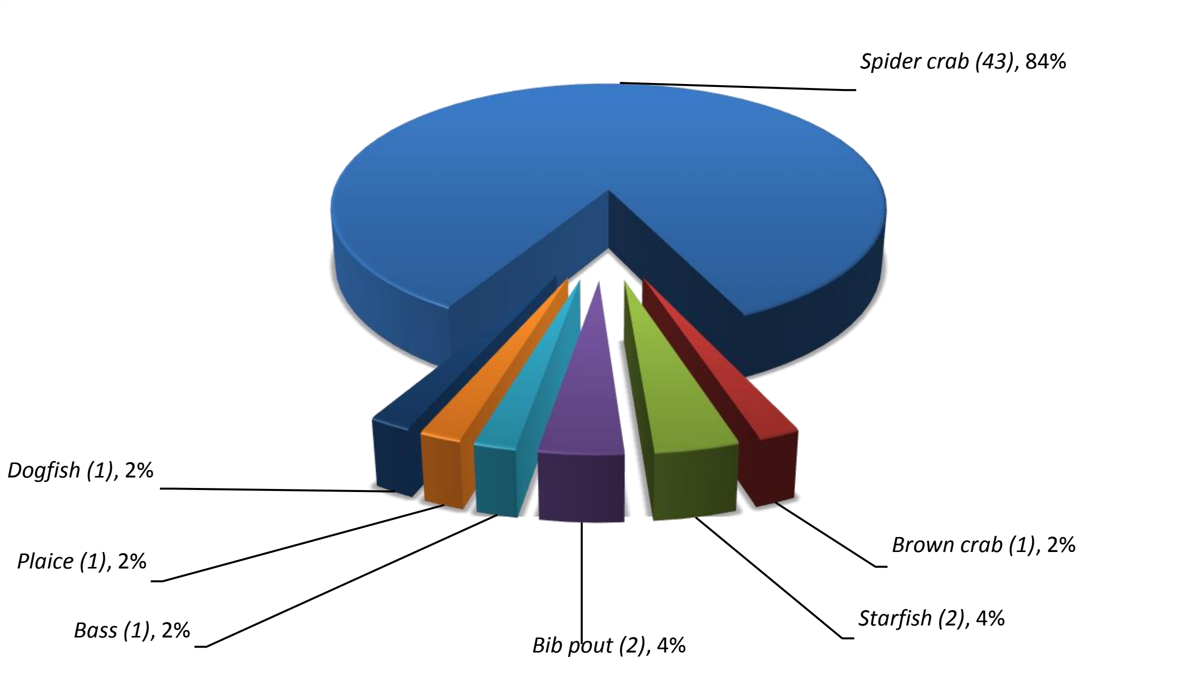


Figure 11. The bycatch recorded across all observed modified strings (120 traps). Number of individuals (n) in parenthesis.

Test string observations

When inspected in July, eggs had been laid on all three egg laying substrates attached to the test frames. The highest number of eggs were laid on the fingers (188) and the least on the rope (46), contrary to the observations of the modified traps in the fishery. 101 eggs were laid on the willow. In September, there were no eggs remaining on the fingers but there were still 34 (74%) on the ropes and 145 (77%) on the willow. These eggs looked as if they had not developed properly; they were flaccid and easily damaged.

No eggs remained in the holding pens in September. There was concern that they had been asphyxiated due to a thick algal bloom decaying near the seabed in May and June. In July, some of the eggs had looked healthy but others were smothered with silt and were decaying. This has implications for the survival of the eggs removed from egg laying substrates. Work package 3 of this project – a laboratory study of egg survival post fishing activity – will provide further information.

Fisher interviews

The trap entrance fingers were the least favoured of the modifications for all of the fishers interviewed. Six of the fishers stated a clear preference for the polypropylene rope followed by the willow whips. While one fisher, preferred the willow over the rope.

When fishers were asked about the importance of the cuttlefish fishery to their annual income, all fishers stated it was either essential or important. Five of the interviewed fishers reported that this season had a lower catch than last year. 71% of interviewed fishers cited the offshore trawl fishery in the western English Channel as the biggest threat to the local trap fishery as they considered the current fishing pressure sustainable. All fishers reported that the biggest impact on their daily catch was the wind speed and direction. Other influential factors included the presence of spiny spider crabs (*M. squinado*), the soak time and the size of the tide.

Discussion

Egg receptors

The modifications trialled during this study, were specifically designed to allow fishers to easily remove any cuttlefish eggs deposited on them. The reduced effort required by fishers to remove the eggs will enable fishers to return a larger number of eggs to sea, while reducing the requirement of aggressive and potentially damaging cleaning techniques to remove the eggs (Belcari *et al,* 2002; Bloor, 2012).

All three egg laying substrates had over 15% of the total eggs laid on the trap deposited on them. All cuttlefish eggs deposited on the modifications could, with differing degrees of difficulty, be removed from the trap with minimal damage to the egg cluster and quickly returned to sea, increasing the probability of survival. Although all three modifications could be utilised to increase the number of eggs returned to sea, the results of this study indicate that the 8 mm polypropylene rope was the most effective modification, both in terms of the percentage of eggs deposited and the ease of egg removal.

Fishers were asked to remove all eggs deposited on the receptors. While removing eggs deposited on the rope and fingers, fishers inserted their arms into the trap through the small opening used to remove the catch. When removing eggs from the willow, fishers would often remove the willow from the trap, replacing it after the eggs had been removed. It was noted that fishers required less time and effort to remove the eggs deposited on the rope. Although the eggs could be easily removed from the fingers, accessing the fingers was at times quite difficult and required more time and effort than either of the other two modifications. The fishers' preference was for the ropes.

Egg laying on traps

There was large variation in the number of eggs laid on both modified and unmodified traps throughout the fishing season. There was a slight increase in the average number of eggs laid on traps with rope and willow modifications (233 and 203 eggs per trap respectively) compared to the control (160). This may be a result of an increased number of cuttlefish being attracted into the trap. It was hoped that the addition of egg laying substrates would reduce the number of eggs laid on the trap, as the substrates were designed to be easier for egg removal than the trap. However, this has not been the findings of this study, although high percentages of the total number of eggs were laid on the receptors.

Number of cuttlefish per trap

The increased number of cuttlefish in the traps modified with both the rope and willow, compared to the unmodified traps, suggested that the addition of these substrates was an attractant to cuttlefish. The addition of egg receptors increased the structural complexity of the traps, perhaps serving as an attractant to female cuttlefish. This is supported by a number of studies that have suggested that maternal cuttlefish prefer areas of increased structural complexity for egg laying (Bloor, 2012; Bloor *et al,* 2013a; Guerra, 2006; Guerra *et al,* 2016). The increased attraction and resulting abundance of female cuttlefish is likely to serve as an attractant toward male cuttlefish seeking a mate (Bettoso *et al,* 2016; Bloor, 2012; Naud *et al,* 2005).

The preference seen toward the traps modified with rope correlates with the work of two previous studies, one in Morbihan Bay, France and the other, off the Molise coast in Italy. Both studies found a significant preference toward 8 mm ropes of a similar length to the ones used during this project (Barile *et al,* 2013; Blanc and Daguzan, 1998). However, if this solution were to be developed further, an alternative to plastic would be sought to avoid pollution caused by degrading polypropylene rope.

The relatively low numbers of cuttlefish in the traps with fingers is likely due to the length of the fingers, as the naturally occurring egg laying sites selected by female cuttlefish are often longer than the length of the trap entrance fingers. This resulted in the trap entrance fingers serving as less of an attractant to female cuttlefish (Guerra *et al,* 2016).

Bycatch

The inshore cuttlefish trap fisheries are selective for the target species with low rates of bycatch (Dunn, 1999). This is supported by the data collected during this project. Of the 120 traps directly observed, 29% had bycatch. When compared to other fishing methods, trap fisheries also have generally high survival rates for discarded specimens, further reducing the ecological impact of the capture of bycatch (Suuronen *et al,* 2012). The most common species recorded as bycatch, spider crab, occurs inshore in large numbers during the summer months. This species is considered a pest by many of the participating fishers, reporting that the presence of spider crabs in or around the cuttlefish traps can act as a strong deterrent to the cuttlefish and have a negative impact on the catch rate of the trap.

Test string observations

The eggs in the holding pens had a very low survival rate. Four of the twelve chambers had 100% mortality within 48 days of deployment. Five of the remaining chambers also experienced very high mortality (>80%) during the same time frame. Only two chambers had relatively low mortality at 21% and 25%. It remains unclear why these eggs experienced such low survival rates. Cuttlefish eggs held under laboratory conditions had far higher survival rates (see work package 3 report; Egg survival and maternal investment). After 105 days, all of the remaining eggs had either hatched or perished. This was expected as the gestation time for cuttlefish eggs laid in the English Channel is between 80-90 days (Bloor *et al,* 2013a).

The three frames that had the different egg laying substrates attached to them had a small number of eggs on each of the three substrates. This indicated that breeding cuttlefish were present in the area between 23rd May and 10th July. Increases in the number of eggs deposited on the willow between 10th July and 5th September indicates the presence of breeding cuttlefish at that time.

The low number of eggs across all three substrates was not mirrored when the modifications were applied to the operational cuttlefish traps of active fishers. The average number of eggs deposited across all of the frames was 43 eggs per frame. When the egg laying substrates were added to operational cuttlefish traps, the modified traps had a higher average number of eggs (184). The test strings were deliberately placed away from the main fishing area and therefore potentially further away from the main cuttlefish aggregations.

Fishery sustainability

All fishers interviewed stated that they were highly reliant on the cuttlefish trap fishery and that the revenue generated from this fishery was highly important to their annual income and their ability to run an economically viable business.

Most of the fishers interviewed (71%) reported a drop in their landings of cuttlefish over the last couple of years. The reduction in landings of cuttlefish to Hastings reported by the interviewees correlates with the landings data collated by the Marine Management Organisation (MMO) for all vessels landing cuttlefish to UK ports. MMO landings data shows a large drop in the landings of cuttlefish for fishers operating traps across the whole UK. The reported drop in local landings is in contrast to an increase to overall UK catches.

Five of the seven fishers interviewed expressed concern over the growing offshore fishery and felt that it represented the biggest threat to the inshore fishery. The offshore fishery for cuttlefish is dominated by otter and beam trawlers. These fishers target the over wintering aggregations of cuttlefish that form in the deeper waters in the western English Channel. In 2017, the otter and beam trawlers landing to Brixham, Devon, accounted for over 60% of all cuttlefish landed to UK ports, with landings of 1575 and 2740 tonnes respectively. Between 2013 and 2017, both the otter trawlers and the beam trawlers operating from Brixham have seen increases in their landings of cuttlefish (47% and 32% respectively).

The current exploitation rate of the offshore cuttlefish fishery is likely to prove unsustainable (Denis and Robin, 2001; Royer *et al,* 2006; Gras *et al,* 2014; Gras *et al,* 2016). The threat this offshore fishery represents to the inshore trap fisheries is highly plausible as the inshore trap fisheries are sensitive to the exploitation of the population by the offshore fleet. This is due to the catches of the trap fishers being dependent on the proportion of cohorts that evade offshore exploitation and return to the inshore breeding grounds (Royer *et al,* 2006). There is further information in the report: The English Channel fishery for cuttlefish, as part of the Supporting Sustainable Sepia Stocks project.

Conclusion

This part of the Supporting Sustainable Sepia Stocks project focussed on a fieldwork trial involving Hastings fishers using cuttlefish traps. Three different egg receptors were attached to the inside of traps with the aims of:

1. Devising a mitigation method to reduce post-fishing egg mortality by 15%
2. Determining the impact of attaching egg receptors to cuttlefish traps on the fishing effort (number of cuttlefish caught)
3. Determining the impact of attaching egg receptors to cuttlefish traps on the workload of the fishers

The key results addressing these aims were:

1. All three egg receptors had greater than 15% (of the total number of eggs) attached to the receptor. These eggs were able to be more easily removed from the fishing gear and returned to sea, compared to unmodified traps. Whilst all three egg receptors trialled during the study increased the amount of eggs returned to the sea, the efficacy of the 8 mm polypropylene rope exceeded the other modifications in all aspects. The rope had the highest percentage of eggs deposited on it, it required less time and effort to remove the eggs, it was the preferred modification of the participating fishers, and there was an increased number of cuttlefish in those traps.
2. The traps modified with rope and willow had a higher number of cuttlefish than the unmodified traps.
3. There was a small additional time and effort burden associated with the modifications. However, the fishers stated how important the cuttlefish trap fishery is to them locally so were willing to support measures which help the long term sustainability of the fishery.

References

Barile, N., Cappabianca, S., Antonetti, L., Scopa, M., Nerone, E., Mascilongo G., Recchi, S. and D'Aloise, A. (2013). New protocols to improve the deposition and hatching of *Sepia officinalis'* eggs. *Veterinaria Italian,* 49 (4), pp. 367-374.

Belcari, P., Sartor, P., Sanchez, P., Demestre, M., Tsangridis, A., Leondarakis, P., Lefkaditou, E. and Papaconstantinou, C. (2002). Explotation patterns of the cuttlefish, *Sepia officinalis* (Cephalopoda, Sepiidae), in the Meditteranean Sea, *Bulletin of Marine Science,* 71(1), pp. 187-196.

Bettoso, N., Borme, D., Faresi, L., Aleffi, I., Orlando-Bonaca, M. and Lipej, L. (2016). New insights on the biological parameters of the exploited cuttlefish *Sepia officinalis* L. (Mollusca: Cephalopoda) in the northern Adriatic Sea in relation to the main fishing gears employed. *Mediterranean Marine Science,* 17(1), pp. 152-162.

Blanc, A., and Daguzan, J. (1999). Young cuttlefish *Sepia officinalis* (Mollusca: Sepiidae) in the Morbihan Bay (south Brittany, France): accessory prey of predators. *Journal of the Marine Biological Association of the United Kingdom,* 79(6), pp. 1133-1134.

Bloor, I. (2012). The ecology, distribution and spawning behaviour of the commercially important common cuttlefish (*Sepia officinalis*) in the inshore waters of the English Channel. PhD Thesis, University of Plymouth.

Bloor, I., Attrill, M., and Jackson, E. (2013a). A Review of the Factors Influencing Spawning, Early Life Stage Survival and Recruitment Variability in the Common Cuttlefish (*Sepia officinalis*). *Advances in Marine Biology*, 65, pp. 1-65.

Denis, V. and Robin, J. (2001). Present status of the French Atlantic fishery for cuttlefish (*Sepia officinalis*). *Fisheries Research*, 52(1-2), pp. 11-22.

Dunn, M. (1999). Aspects of the stock dynamics and exploitation of cuttlefish, *Sepia officinalis* (Linnaeus, 1758), in the English Channel. *Fisheries Research,* 40, pp. 277-293.

Essington, T., Beaudreau, A. and Wiedenmann, J. (2006). Fishing through marine food webs. *Proceedings of the National Academy of Sciences,* 103(9), pp. 3171-3175.

Gras, M., Roel, B., Coppin, F., Foucher, E. and Robin, J. (2014). A two-stage biomass model to assess the English Channel cuttlefish (*Sepia officinalis* L.) stock. *International Council for the Exploration of the Seas Journal of Marine Science*, 71 (9), pp. 2457–2468.

Gras, M., Safi, G., Lebredonchel, H., Quinquis, J., Koueta, E. and Robin, J. (2016). Stock structure of the English Channel common cuttlefish *Sepia officinalis* (Linnaeus, 1758) during the reproduction period. *Journal of the Marine Biological Association of the United Kingdom,* 96(1), pp. 167-176.

Guerra, A. (2006) Ecology of *Sepia officinalis. Vie et Milieu,* 56(2), pp. 97-107.

Guerra, A., Hernández-Urcerab, J., Garcia, M., Sesteloc, M., Regueiraa, M., Gilcotod, M. and F. Gonzáleza, A. (2016). Spawning habitat selection by the common cuttlefish Sepia officinalis in the Cíes Islands (Northwest Spain). *Fisheries Research,* 183, pp. 44–54.

James, C., Pearce, B., Coggan, R., Leivers, M., Clark, R., Plim, f., Hill, J., Arnott, S., Bateson, L., De-Burgh, T. and Baggaley, P. (2011). *The MALSF synthesis study in the central and eastern English Channel. British Geological Survey*. [Online]. Available at: http://nora.nerc.ac.uk/14031/1/OR11001.pdf (Accessed on 29th September 2018).

Keller, S., Valls, M., Hidalgo, M., and Quetglas, A. (2014). Influence of environmental parameters on the life-history and population dynamics of cuttlefish *Sepia officinalis* in the western Mediterranean. *Estuarine, Coastal and Shelf Science*, 145, pp. 31–40.

Melli, V., Riginella, E., Nalon, M. and Mazzoldi, C. (2014). From trap to nursery. Mitigating the impact of an artisanal fishery on Cuttlefish offspring. *Public Library of Science ONE* 9(2): e90542. doi:10.1371/journal.pone.0090542

Molfese, C., Beare, D. and Hall-Spencer, J. (2014) 'Overfishing and the replacement of demersal finfish by shellfish: an example from the English Channel.', *Public Library of Science One*, *9*(7), doi: 10.1371/journal.pone.0101506.

Naud, M., Shaw, P., Hanlon, R.and Havenhand, J. (2005). Evidence for biased use of sperm sources in wild female giant cuttlefish (*Sepia apama*). *Proceedings of the Royal Society B: Biological Sciences,* 272(1567), pp. 1047-1051.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. and Torres Jr, F. (1998). Fishing Down Marine Food Webs. *Science*, 279(5352), pp. 860-863.

Pauly, D. and Palomares, M. (2005). Fishing down marine food web: It is far more pervasive than we thought. *Bulletin of Marine Science,* 76 (2), pp. 197-212.

Pauly, D., and Watson, R. (2005). Background and interpretation of the "Marine Trophic Index" as a measure of biodiversity. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 360 (1454), pp. 415–423.

Payne, A., Agnew, D. and Pierce, G. (2006). Trends and assessment of cephalopod fisheries. *Fisheries Research,* 78, pp. 1-3.

Reid, A., Jereb, P. and Roper, C. (2005). Family Sepiidae. In: Jereb, P. and Roper, C. (eds), *Cephalopods of the World. An Annotated and Illustrated Catalogue of Cephalopod Species Known to Date. Volume 1. Chambered Nautiluses and Sepioids (Nautilidae, Sepiidae, Sepiolidae, Sepiadariidae, Idiosepiidae and Spirulidae)*. Rome: Food and Agriculture Organisation of the United Nations.

Royer, J., Pierce, G., Foucher, E., and Robin, J. (2006). The English Channel stock of Sepia officinalis: Modelling variability in abundance and impact of the fishery. *Fisheries Research*, *78* (1), pp. 96–106.

Suuronen, P., Chopin, F., Glass, C., Løkkeborg, S., Matsushita, Y., Queirolo, D. and Rihan, D. (2012). Low impact and fuel efficient fishing—looking beyond the horizon. *Fisheries research,* 119-120, pp. 135-146.

Watanuki, N and Kawamura, G. (1999). A review of Cuttlefish basket trap fishery. *South Pacific Study*, 19 (1-2), pp. 31-48.