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RESEARCH ARTICLE

Influence of soak time on catch performance of commercial creels targeting Norway lobster (*Nephrops norvegicus*) in the Mediterranean Sea

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Abstract – Creel catch performance is known to be affected by the soak time in many fisheries. If creels maintained their efficiency over longer periods, increase in soak time should lead to proportional increase in catch quantity. However, the exact shape of this relationship is unknown for creel fisheries targeting Norway lobster (*Nephrops norvegicus*). If it was known fishermen could adjust their fishing strategy accordingly and maximize their net earnings. We compared catch performance of creels targeting Norway lobster soaked for one and two days in the Adriatic Sea. Results were obtained for three crustacean species, Norway lobster (*N. norvegicus*), mantis shrimp (*Squilla mantis*), and blue-leg swimming crab (*Liocarcinus depurator*) and two fish species, poor cod (*Trisopterus minutus*) and blotched picarel (*Spicara flexuosa*). Doubling the soak time from one to two days did not double the catches and for Norway lobster no increase was found. For the other crustaceans, a slight but not significant increase was estimated. Catches of blotched picarel were significantly lower for the longer soak time, while the results were inconclusive for the poor cod.

Keywords: *Nephrops norvegicus* / Soak time / Unpaired catch comparison

1 Introduction

Norway lobster (*Nephrops norvegicus*) is economically the most valuable crustacean species caught in EU waters. Annual landings in the Mediterranean area were 2470 t in 2015 (EUROSTAT: http://ec.europa.eu/eurostat/data/database). Bottom trawling accounts for approximately 95% of Norway lobster catches (Ungfors et al., 2013). However, creel fisheries that account for the remaining volume are considered to have a smaller ecological footprint (Ungfors et al., 2013), and to produce much less discards compared to bottom trawls (Morello et al., 2009). Although various bottom trawl modifications such as including escape panels (e.g. Krag et al., 2016) or square mesh panels (e.g. Santos et al., 2016) have been trialled and some of them implemented to reduce unwanted bycatch of undersized individuals, their efficiency remains variable. Since one of the EU Common Fisheries Policy objectives is to ensure minimisation of the negative impacts of fishing activities on the marine ecosystem (Regulation (EU) No. 1380/2013), increased use of creels as an alternative to trawling could be relevant in certain areas. Therefore, it is important to explore ways of maximizing creel catch performance.

Creel catch performance is known to be affected by the soak time in many fisheries. If creels maintained their efficiency over longer periods, an increase in soak time should lead to a proportional increase in catch quantity. However, the actual shape of this relationship is generally unknown for creel fisheries targeting Norway lobster. Knowing the influence of soak time, fishermen could adjust their fishing strategy accordingly to maximize their net earnings. Bjordal (1986) found that only 6.1% of Norway lobster individuals that approached the creel actually entered. This might indicate that Norway lobster could have difficulties finding the entrance. If the bait maintained its attractiveness, an increase in soak time should allow Norway lobster more time to circle around the creel, find the entrance and enter. The problem is that Norway lobster is not the only species attracted by the bait (most creel fisheries use oily fishes as bait, including horse Mackerel). According to Adey (2007), the presence of other crab species in and around the creel reduces the number

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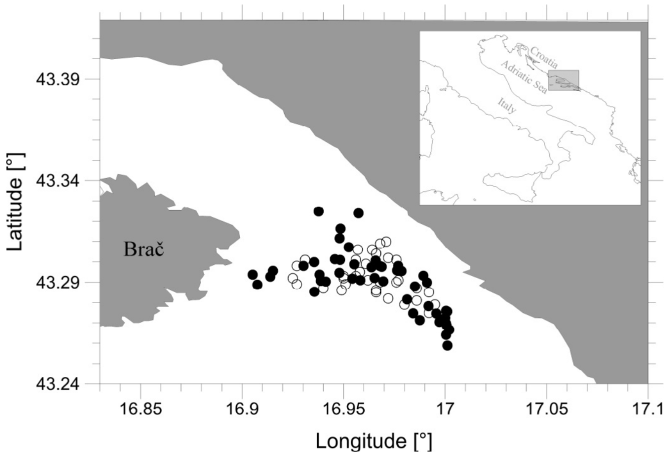

Fig. 1. Map of the survey area showing the position of the creel longlines with one day (solid circles) and two day soak times (open circles).

of Norway lobsters entering the creel. The scavenger species in the area can also consume the bait, negatively influencing creel catch performance over time. This has been observed in the Adriatic Sea by Morello et al. (2009) and Panfili et al. (2007), who estimated that up to 50% of creel bait is consumed within 12 h and up to 100% within 24 h. This could imply that soak times longer than 24 h do not increase creel catches. Furthermore, Bjordal (1986) showed that small Norway lobsters are usually chased off by bigger individuals. This implies that the presence of larger individuals inside the creel could incite smaller specimens to escape from it, or deter them from entering. Similarly, individuals of the opposite sex are known to either attract or repel each other, depending on the first individual entering the creel (Ungfors et al., 2013).

The above considerations illustrate how the behaviour of Norway lobster and other species during fishing could potentially affect the influence of soak time on creel catch performance in different directions, making it difficult for creel fisherman targeting Norway lobster to predict the optimal soak time. Therefore, the main objective of this study was to investigate the influence of soak time on the catch performance in creel fishery targeting Norway lobster in the eastern Adriatic Sea. Specifically, we addressed the following questions:

– Does doubling the creel soak time lead to a proportional increase in catches?
– If not, is there any difference in creel catch performance by extending soak time from one to two days?
– Does an increase in creel soak time affect catch performance in a similar way for different species and sizes?

2 Material and methods

2.1 Experimental fishing

The experimental fishing was conducted in the Adriatic Sea (Fig. 1) between 26th of May and 5th of July 2016 using a commercial fishing vessel (LOA 6.90 m, 84 hp). The investigation was based on a typical commercial creel design and deployment practice commonly used in the study area. The creels used in this study were made of a rectangular metal frame (700 × 450 × 265 mm) with 41.04 mm knotless polyamide diamond netting stretched over the frame in a way to obtain a square mesh shape, as prescribed by the regulations. The two entrances made of the same netting material were positioned opposite each other on the short sides of the creel (Fig. 2). Before fishing, the creels were baited with 43.29 ± 11.33 g (±SD) of fresh Mediterranean horse mackerel (*Trachurus mediterraneus*), hooked halfway between the entrances without any bait protection device. The bait was renewed on every hauling occasion.

The creels were deployed in a longline system, each comprising 30 creels (further in text referred to as "longline") (Fig. 2). The longlines were deployed following typical commercial practice in the area. They were set in the early morning hours and retrieved after one or two days. Longlines deployed with one day soak time are hereafter labelled as 1-day, while longlines deployed with two-day soak time are labelled as 2-days longlines. Due to low catches per individual creel, the catch of one longline (30 creels) was considered as a base unit in the subsequent analysis. Upon retrieval, the total catch of each longline was sorted and species and size distributions were recorded. Norway lobster and mantis shrimp carapace length, and blue-leg swimming crab carapace width were measured to the nearest mm, and poor cod and blotched picarel total length were measured to the nearest cm. Sex was determined only for Norway lobster.

2.2 Estimation of the catch comparison curve

The data were analysed using the software tool SELNET (Herrmann et al., 2012) following the method described below. Owing to the experimental design, the catch data from the longlines deployed with, respectively, 1-day and 2-day soak times were not collected in pairs and can be regarded as unpaired catch data. Since there is no obvious way of pairing the catch data from 1-day and 2-days deployments, the average relative catch performance was estimated by adopting the catch comparison analysis method for unpaired data described by Herrmann et al. (2017), and applying it for the first time to a creel fishery. The catch comparison was carried out based on total catches per deployment type by minimizing the following expression:

$$-\sum_l \left\{ \sum_{i=1}^{q1} n1_{li} \times \ln(1.0 - cc(l, \boldsymbol{v})) + \sum_{j=1}^{q2} n2_{lj} \times \ln(cc(l, \boldsymbol{v})) \right\}, \quad (1)$$

where $\boldsymbol{v}$ are parameters of the catch comparison curve $cc(l, \boldsymbol{v})$, and $n1_{li}$ and $n2_{lj}$ are the number of crustaceans and fish of length class l caught in the ith deployment of a 1-day longline and jth deployment of a 2-day longline. $q1$ and $q2$ represent the total number of deployments of 1-day and 2-day longlines, respectively. The outer summation in expression (1) is the summation over length classes l. Minimizing expression (1) is equivalent to maximizing the likelihood for the observed data based on a maximum likelihood formulation for binominal data. As a result, estimated model parameters are those that make the experimental data most likely.

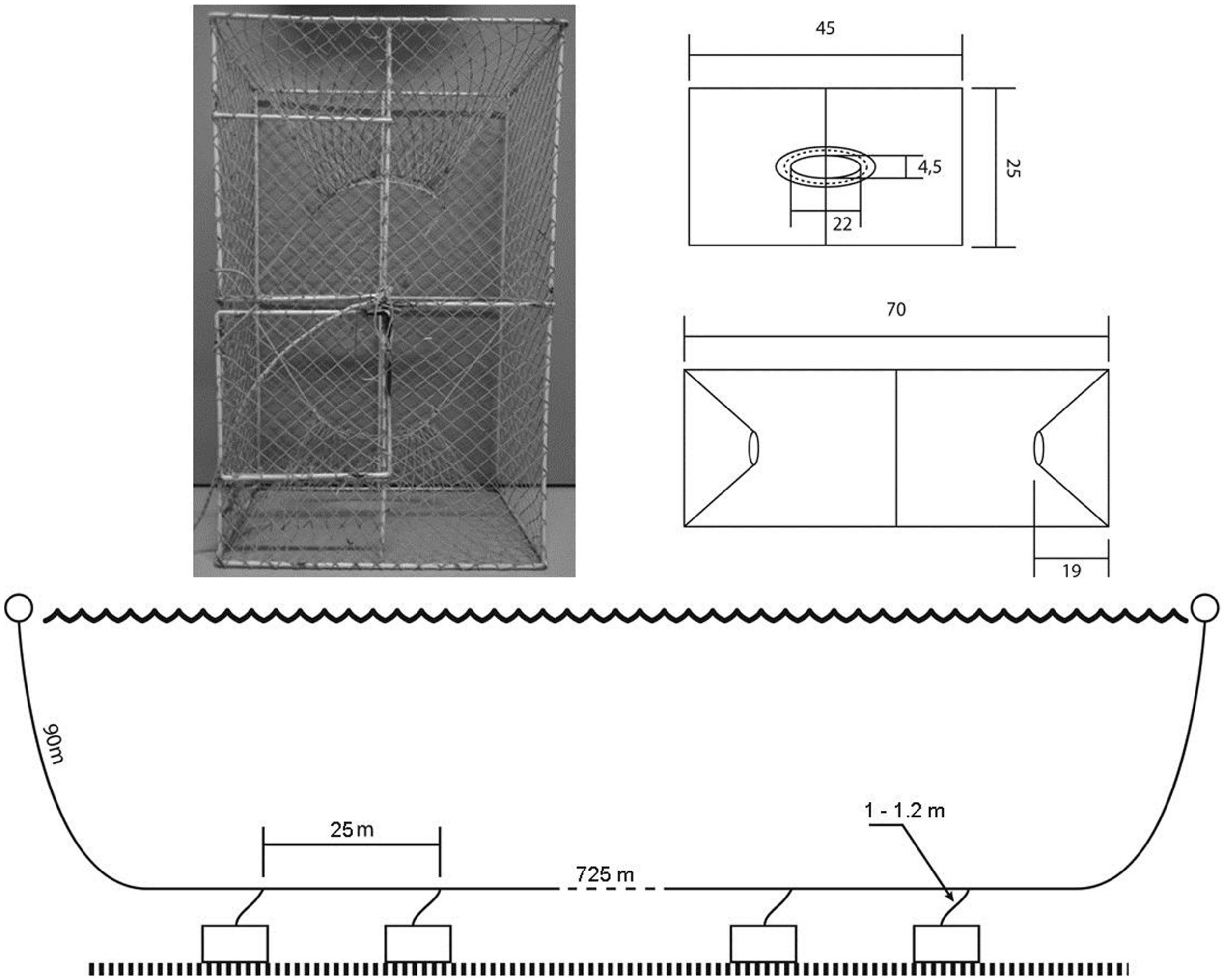

Fig. 2. Photo and technical drawing of the creel used in the study and schema view of the deployment in the longline system.

The average experimental catch comparison rate, cc_l, where l denotes crustacean carapace length or width, or fish total length, is estimated as:

$$cc_l = \frac{\sum_{j=1}^{q2} n2_{lj}}{\sum_{i=1}^{q1} n1_{li} + \sum_{j=1}^{q2} n2_{lj}}. \qquad (2)$$

When the catch performance for 1-day and 2-day deployments and the number of deployments are equal ($q1 = q2$), the expected value for the summed catch comparison rate is 0.5. In the case of unequal number of deployments, $q2/(q2 + q1)$ would be the baseline to judge whether there is a difference in catch performance between 1-day and 2-day soak time for the creels. The experimental cc_l is modelled by the function $cc(l, \boldsymbol{v})$ which has the following form (Herrmann et al., 2017):

$$cc(l, v) = \frac{\exp(f(l, v_0, \ldots, v_k))}{1 + \exp(f(l, v_0, \ldots, v_k))}, \qquad (3)$$

where f is a polynomial of order k with coefficients v_0 to v_k. Thus $cc(l, \boldsymbol{v})$ expresses the probability of finding an individual of length l, in the catch of one of the deployments with 2-day soak time, given that it is found in the catch of either deployments. The values of the parameters $\boldsymbol{v}$ in $cc(l, \boldsymbol{v})$ are estimated by minimizing expression (1). We considered f of up to an order of 4 with parameters v_0, v_1, v_2, v_3 and v_4. Leaving out one or more of the parameters v_0, v_1, v_2, v_3 and v_4, led to 31 additional models that were also considered as potential models for the catch comparison $cc(l, \boldsymbol{v})$ between 1-day and 2-day deployments. To combine estimates from the 31 models multi-model averaging was used (Burnham and Anderson, 2002) following the procedure described in Herrmann et al. (2017). We use the name combined model for the results of this multi-model averaging.

The ability of the combined model to describe the experimental data was evaluated based on the p-value, which quantifies the probability of obtaining by coincidence at least as big a discrepancy between the experimental data and model estimates, assuming the model is correct. Therefore, this p-value, which was calculated based on the model deviance and the degrees of freedom, should not be <0.05 for the combined model to describe the experimental data sufficiently well (Wileman et al., 1996). In case of poor-fit statistics (p-value < 0.05; deviance/DOF $\gg 1$), the deviations between the experimental points and the fitted curve were examined to determine if this was due to structural problems in describing the experimental data with the model or due to the overdispersion in the data.

Table 1. Catch summary table; N: average number of individuals caught per each creel longline; CL: carapace length; Lt: total length; Lt stuck: average length of individuals stuck in the creel meshes; SD: standard deviation.

Species		Soak time (days)	
		1	2
Norway lobster	N ± SD	4.27 ± 2.18	3.68 ± 2.21
	CL ± SD (mm)	47.86 ± 8.35	47.57 ± 7.81
	Min CL (mm)	31	34
	Max CL (mm)	68	65
Mantis shrimp	N ± SD	4.36 ± 2.24	5.03 ± 2.19
	CL ± SD (mm)	35.29 ± 3.55	35.50 ± 3.18
	Min CL (mm)	25	28
	Max CL (mm)	45	45
Blue-leg swimming crab	N ± SD	13.59 ± 4.38	15.52 ± 6.98
	CL ± SD (mm)	40.08 ± 4.36	40.62 ± 4.40
	Min CL (mm)	20	25
	Max CL (mm)	53	57
Poor cod	N ± SD	1.57 ± 0.84	1.78 ± 0.88
	CL ± SD (mm)	174.31 ± 18.09	173.44 ± 18.16
	Min Lt (mm)	145	145
	Max Lt (mm)	225	230
Blotched picarel	N ± SD	6.11 ± 6.52	2.58 ± 1.74
	Lt ± SD (mm)	166.40 ± 10.03	165.22 ± 10.07
	Min Lt (mm)	145	140
	Max Lt (mm)	195	185

The confidence limits for the combined model were estimated using the double bootstrap method for unpaired data described in Herrmann et al. (2017). This method accounted for between-deployment variation in the availability of crustaceans and fish, and creel catch performance, by selecting $q1$ longline deployments with replacement from the pool of 1-day deployments and $q2$ longline deployments with replacement from the pool of 2-day deployments, during each bootstrap iteration. The within-deployment uncertainty in the size structure of the catch was accounted for by randomly selecting crustaceans or fish with replacement from each of the selected longlines separately. The number of individuals selected from each deployment was the same as the number of crustaceans caught with that deployment of the longline. These data were then combined, and the catch comparison curve was estimated. For each species, 1000 bootstrap repetitions were performed and 95% Efron percentile confidence intervals were estimated (Efron, 1982). To identify the sizes of crustaceans or fish with significant difference in catch performance length classes in which the confidence limits for the combined catch comparison curve did not contain the $q2/(q1+q2)$ baseline value were checked.

2.3 Estimation of the catch ratio curve

The catch comparison rate $cc(l, \boldsymbol{v})$ cannot be used to quantify directly the ratio between the catch efficiency of longline deployed for one or two days for crustaceans with carapace length or width l or fish of total length l. Instead, the catch ratio $cr(l, \boldsymbol{v})$ was used. For the experimental data, the average catch ratio for length class l is:

$$cr_l = \frac{\frac{1}{q2}\sum_{j=1}^{q2} n2_{lj}}{\frac{1}{q1}\sum_{i=1}^{q1} n1_{li}}. \tag{4}$$

Simple mathematical manipulation based on (2) and (4) yields the following general relationship between the catch ratio and the average catch comparison rate cc_l:

$$cr_l = \frac{q1 \times cc_l}{q2 \times (1 - cc_l)}, \tag{5}$$

which also means that the same relationship exists for the functional forms:

$$cr(l, \boldsymbol{v}) = \frac{q1 \times cc(l, \boldsymbol{v})}{q2 \times (1 - cc(l, \boldsymbol{v}))}. \tag{6}$$

One advantage of using the catch ratio as defined by (6) is that it gives a direct relative value of the catch performance between longline deployments with one or two days soak time. Furthermore, it provides a value independent of the number of deployments. Thus, if the catch performance of 1-day and 2-day longlines is equal, $cr(l, \boldsymbol{v})$ should be 1. A $cr(l, \boldsymbol{v}) = 1.3$ would mean that 2-day longlines were catching on average 30% more individuals of length l than 1-day longlines.

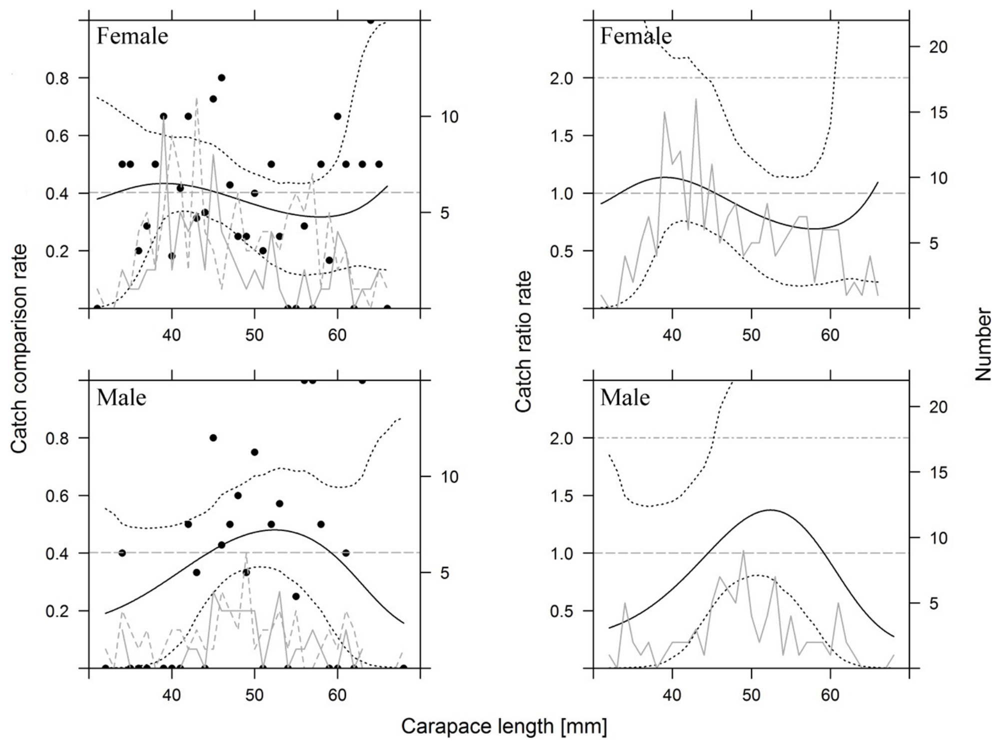

Fig. 3. Catch comparison rates (left column) and catch ratio rates (right column) for the longline deployments with one and two days soaking time (solid black curves) for females and males of Norway lobster. Dots represent the experimental rates. Thin black dotted curves represent the 95% CI for the catch comparison curves. Dark grey solid curves (left column) represent summed and raised catch populations for deployments with two day soaking time. Dark grey dashed curves (left column) represent summed and raised catch population for deployments with one day soaking time. Dark grey dashed curves (right column) represent total summed and raised catch population for one and two day soaking time. Horizontal dark grey dashed lines represent baselines for no effect of soaking time on the catch performance. Horizontal dark grey dot-dashed line represents line where longlines soaked for two days are catching twice as much as longlines soaked for one day. Female: Norway lobster females; male: Norway lobster males.

If doubling the soak time from one to two days led to a proportional increase in catch performance, $cr(l, \boldsymbol{v})$ should be 2. Therefore, the catch ratio was checked against the baseline 2.

Using equation (6) and incorporating the calculation of $cr(l, \boldsymbol{v})$ for each length class l into the double bootstrap procedure, the confidence intervals for the catch ratio were estimated.

2.4 Estimation of length-integrated catch ratio

A length-integrated average value for the catch ratio was calculated as follows (Herrmann et al., 2017):

$$\overline{cr} = \frac{\frac{1}{q2}\sum_l \sum_{j=1}^{q2} n2_{lj}}{\frac{1}{q1}\sum_l \sum_{i=1}^{q1} n1_{li}}, \quad (7)$$

where the outer summation is over the length classes in the catch.

By incorporating $\overline{cr}$ into each of the bootstrap iterations, it was possible to assess the corresponding 95% confidence limits. The value of $\overline{cr}$ was used to provide a length-averaged value for the effect of increasing soak time from one day to two days on creel catch performance.

In contrast to the length-dependent catch ratio, $\overline{cr}$ is specific for the population structure encountered during the experimental sea trials. Therefore, its value is specific for the size structure in the fishery at the time the trials were carried out, and can therefore not be extrapolated to other situations in which the size or sex structure of the catch composition may be different.

The analysis described above was conducted separately for each of the five species sampled. For Norway lobster the analysis was first performed separately for females and males. If the confidence intervals of the catch comparison and catch ratio curves overlapped, female and male data were pooled and additional analysis based on the pooled dataset was performed.

The relationships between the number of Norway lobsters and number of crabs and between the number of Norway lobster and the total number of bycatch specimens caught in each creel longline, were quantified using Spearman's rank correlation coefficient, separately for longlines soaked for one and two days.

3 Results

During 16 one-day fishing trips a total of 47 longlines were soaked for one day, and 33 for two days. There was no significant difference in water depth between treatments (72.12 ± 1.65 m for 1-day, 72.15 ± 2.55 m for 2-day; mean +

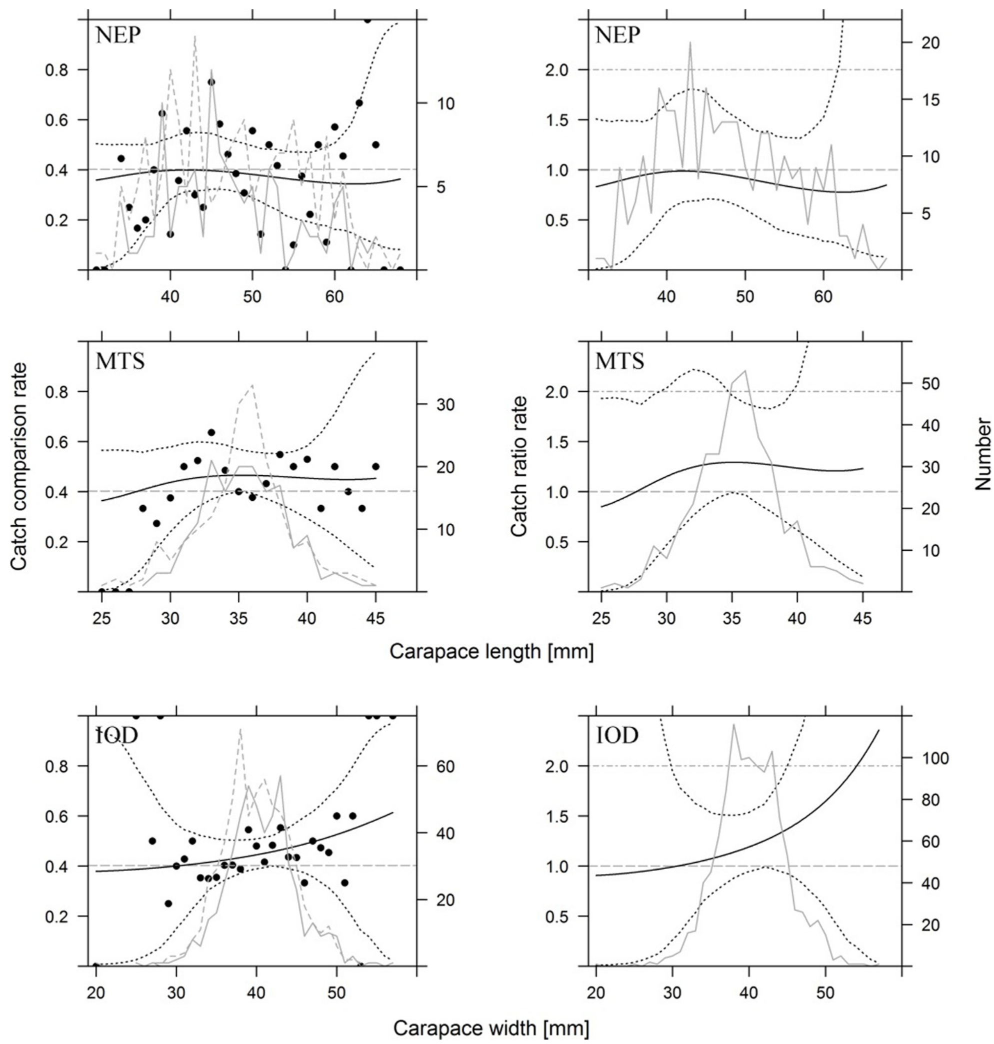

Fig. 4. Catch comparison rate (left column) and catch ratio rate (right column) for the longline deployments with one and two days soaking time (solid black curves) for crustacean species. Dots represent the experimental rates. Thin black dotted curves represent the 95% CI for the catch comparison curves. Dark grey solid curves (left column) represent summed and raised catch populations for deployments with two day soaking time. Dark grey dashed curves (left column) represent summed and raised catch population for deployments with one day soaking time. Dark grey dashed curves (right column) represent total summed and raised catch population for both deployments with one and two day soaking time. Horizontal dark grey dashed lines represent baselines for no effect of soaking time on the catch performance. Horizontal dark grey dot-dashed line represents line where longlines soaked for two days are catching twice as much as longlines soaked for one day. Performance is proportional to soaking time. NEP: Norway lobster; MTS: mantis shrimp; IOD: blue-leg swimming crab.

SD). Altogether, 302 Norway lobsters, 353 mantis shrimps, 1137 blue-leg swimming crabs, 68 poor cods and 214 blotched picarel were caught (Tab. 1).

The estimated length-dependant catch comparison rates for Norway lobster females and males showed that the curves in both cases reflect the main trend in the experimental data (Fig. 3). The p-value obtained for the model fit for Norway lobster females (Tab. 2) was <0.05, but after inspecting the residuals of the fit (see Fig. A1 in the Appendix A) this was considered to be due to the overdispersion in the data (Wileman et al., 1996). Since the effect of the soak time on the catches of Norway lobster females and males was not significant, the data were pooled and additional analysis based on the pooled data was performed.The estimated length-dependant catch comparison rates for crustacean and fish species, with the 1-day longlines as a baseline, reflected the trends in the experimental data well (Figs. 4 and 5). However, the p-values obtained for the model fits for Norway lobster and blotched picarel were below 0.05 (Tab. 2), potentially indicating that the chosen model was inappropriate for describing the experimental data. Given that no systematic patterns were observed after inspecting the residuals of the fits (see Fig. A1 in the Appendix A), the poor p-values obtained for these species were considered to be due to the over-dispersion in the data (Wileman et al., 1996). Therefore, we are confident in using the models to assess the difference in catch performance between longlines soaked for one and two days also for Norway lobster and blotched picarel.

The quantitative difference in catch performance between the1-day and 2-day longlines is evident from the catch ratio curves (right column of Figs. 4 and 5). The solid black lines in these figures represent the estimated catch ratio curves,

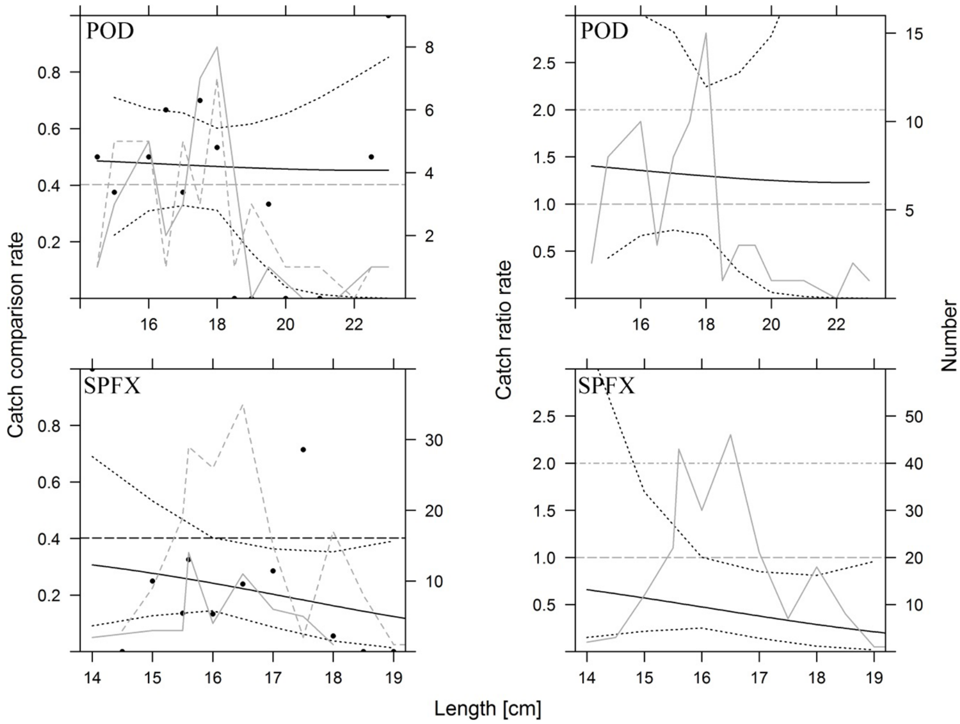

Fig. 5. Catch comparison rate (left column) and catch ratio rate (right column) for the longline deployments with one and two days soaking time (solid black curves) for fish species. Dots represent the experimental rates. Thin black dotted curves represent the 95% CI for the catch comparison curves. Dark grey solid curves (left column) represent summed and raised catch populations for deployments with two day soaking time. Dark grey dashed curves (left column) represent summed and raised catch population for deployments with one day soaking time. Dark grey dashed curves (right column) represent total summed and raised catch population for both deployments with one and two day soaking time. Horizontal dark grey dashed lines represent baselines for no effect of soaking time on the catch performance. Horizontal dark grey dot-dashed line represents line where longlines soaked for two days are catching twice as much as longlines soaked for one day. POD: Poor cod; SPFX: Blotched picarel.

Table 2. Fit statistics for the combined catch comparison curves. DOF: degrees of freedom.

Statistic	Norway lobster			Mantis shrimp	Blue-leg swimming crab	Poor cod	Blotched picarel
	Females	Males	Pooled	Pooled	Pooled	Pooled	Pooled
p-Value	<0.05	0.192	<0.05	0.448	0.452	0.17	<0.05
Deviance	45.36	32.02	55.45	16.07	27.21	12.84	27.3
DOF	29	26	31	16	27	9	8

while horizontal dashed lines represent the baselines of no effect.

To investigate if the catch performance was proportional to soak time, the fitted models were compared to the reference value $cr(l, \boldsymbol{v}) = 2$ which is expected if longlines soaked for two days were catching twice as much as longlines soaked for one day (dot-dashed lines in Figs. 4 and 5). Catch ratios were significantly below 2 for Norway lobster individuals up to ~61 mm CL, for mantis shrimp lengths from 25 to ~29 mm and ~35 to ~39 mm CL, for blue-leg swimming crab lengths from ~30 to 44 mm CL and for blotched picarel larger than 15 cm Lt. This demonstrated that doubling the soak time from one to two days did not double catches for those species in the above described size intervals. The results obtained for poor cod were inconclusive since both $cr(l, \boldsymbol{v}) = 1$ and $cr(l, \boldsymbol{v}) = 2$ baselines were inside the 95% confidence intervals of the estimated catch ratio curve. For Norway lobster doubling soak time did not even indicate any increase in the catch because the estimated catch ratio curve was slightly below 1, and this baseline was inside the confidence interval of the curve (Fig. 4). For other crustaceans, a slight but not significant increase was found. For the blotched picarel, catches were significantly lower with the longer soak time for individuals above 16 cm Lt (Fig. 5). For poor cod, results indicated a slight, although not significant, increase over the entire length range, possibly due to the wide confidence bands.

Finally, for all analysed species, the $\overline{cr}$ values showed the same pattern as described by the length-dependent results, showing that catches did not increase proportionally with soak time (Fig. 6).

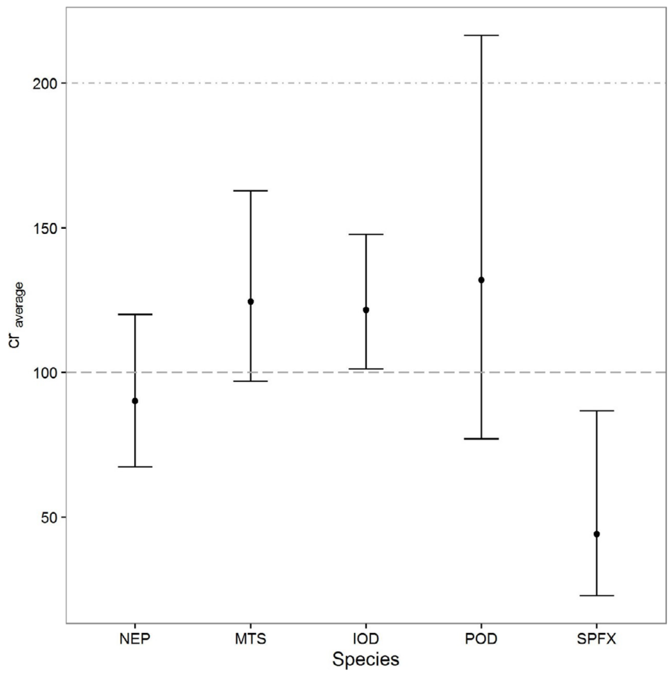

Fig. 6. Estimated values of average catch ratio for longlines soaked for one and two days, with one day soak time as a baseline. Horizontal dark grey dashed lines represent baselines for no effect of soaking time on the catch performance. Horizontal dark grey dot-dashed line represents line where longlines soaked for two days are catching twice as much as longlines soaked for one day. NEP: Norway lobster; MTS: mantis shrimp; IOD: blue-leg swimming crab; POD: poor cod; SPFX: blotched picarel.

There was no significant relationship between the number of Norway lobsters and the crab bycatch specimens caught in each creel longline soaked for one (rho = −0.10, $p = 0.48$) and two days (rho = 0.08, $p = 0.66$). Also, no significant relationship was detected between the number of Norway lobsters and the total bycatch specimens caught in each creel longline soaked for one (rho = −0.21, $p = 0.15$) and two days (rho = 0.08, $p = 0.67$).

4 Discussion

The aim of this study was to investigate the influence of soak time on catch performance of commercial creels targeting Norway lobster in the Adriatic Sea. We specifically wanted to investigate if creel catch performance was proportional to soak time by comparing catch performance of creels soaked for one and two days. It is advantageous for fishermen to know how catches, especially those of Norway lobster, are influenced by soak time, since this could enable them to adjust their fishing strategy accordingly and potentially reduce the costs of fishing. This could be achieved if longer soak times resulted in higher catches. Nevertheless, this would not necessarily imply a net advantage of increasing soak time, because if fisherman sets creels every second day, compared to every day, the costs of fishing would be cut in half, resulting in comparable net earnings over two days even with lower catches.

The results of our study demonstrated that doubling the soak time from one to two days did not result in doubled catches, and for Norway lobster there was even no indication of any catch increase. For other crustaceans, a small but non-significant increase was estimated. For the blotched picarel, significantly more individuals were caught in creels soaked for one day than in those soaked for two days. Since this was observed for individuals larger than ∼16 cm, it may indicate that blotched picarel was utilizing the creel entrances to escape.

Total catches increased to a lesser extent than expected with the increase of soak time, which indicates a decrease in creel catch per unit of effort. In this respect, our results are in line with the findings of Miller (1978), who showed that creel catch ability decreases with longer soak time due to gear saturation. However, there are other potential reasons for why longer soak time, in our study, did not increase Norway lobster catches accordingly. For example, Morello et al. (2009) speculated that the large number of blue-leg swimming crabs feeding on the bait inside the creel diminished the strength of the bait, thus reducing the attractive power of the creel over time. Since the blue-leg swimming crab was the most abundant species in our creel catches, the proposed mechanism of Morello et al. (2009) might explain the reduction in catch ability with increasing soak time found in our study. Furthermore, it can be speculated that the bait strength decreased with time due to the presence of small scavenger species feeding on bait, which are too small to be caught by the creels. This explanation is based on the results reported by Panfili et al. (2007) and Morello et al. (2009), who showed that in the Adriatic Sea (Pomo pit), small scavenger species (mainly *Natatolana borealis*) consume up to 50% of the bait within 6 h of the creel deployment and up to 100% within 24 h. Although there is no evidence that small scavenger species were present in the area during the fishing trials, this possibility should not be disregarded as, following the common fishing practice in the area, the bait was unprotected and accessible to the various organisms entering the creel. Therefore, it would be highly relevant to investigate if the catch ability of the creels would improve with increased soak time if the bait was protected.

The limited workspace on the fishing vessel prevented collection of data and analysis at the creel level. However, the analysis performed on the longline level did not show any significant correlation between the number of bycatch species and the number of Norway lobsters caught in the creels.

For practical reasons, the data in this study were not collected in pairs, which is why the unpaired catch comparison method was used for the analysis. The uncertainty in the estimates resulting both from the variation in the availability of target species in the study area, and the uncertainty in the size structure of the catch, was accounted for by using the double bootstrap method. This method has been previously used by Notti et al. (2016), to compare the catch efficiency of traditional boat seines with experimental surrounding nets without the purse line. Using the same approach Herrmann et al. (2017) investigated the effect of gear design changes on catch efficiency of the Spanish longline fishery, and Sistiaga et al. (2015, 2016) explored the effect of lifting the sweeps in Norwegian bottom trawls. The current study is the first to apply this method to a creel fishery and it demonstrates its utility for investigating factors potentially influencing creel catch performance. However, the results of this study are specific for the creel design and baiting system used in the area, so it

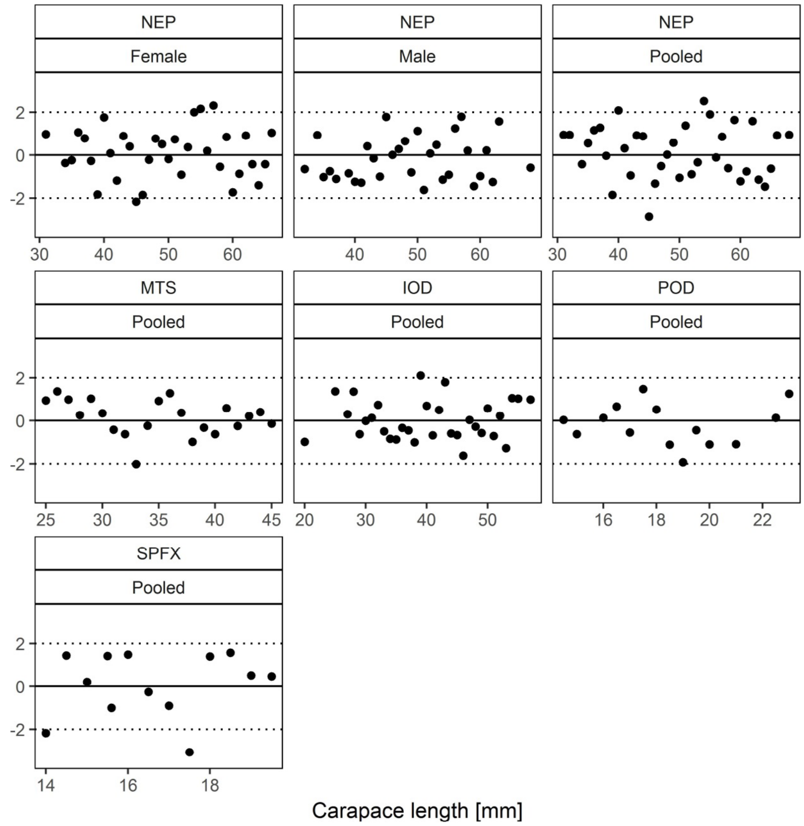

Fig. A1. Residuals of the model fits for all species. NEP: Norway lobster; MTS: mantis shrimp; IOD: blue-leg swimming crab; POD: Poor cod; SPFX: Blotched picarel. Pooled: based on the pooled female and male data.

requires precaution when extrapolating the results to other Norway lobster creel fisheries.

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Appendix A

See Figure A1.

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