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Size-dependent social attraction and repulsion explains the decision of Atlantic cod *Gadus morhua* to enter baited pots

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The present study tested whether the presence of already retained fishes inside baited fish pots acted as a social attraction and affected the entrance probability of Atlantic cod *Gadus morhua* in a fjord in northern Norway. Video analysis revealed that the probability of an entrance initially increased with the presence of low numbers of fishes inside the pot, but subsequently decreased at a critical number of caught fishes. The critical number was dependent on the size of the *G. morhua* attempting to enter. This demonstrates that social attraction and repulsion play a role in *G. morhua* pot fishing and has important implications for the capture efficiency of fisheries executed with pots.

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Key words: cod; fish pots; *Gadus morhua*; social attraction; social repulsion.

INTRODUCTION

Fisheries executed with fish pots can be environmentally friendly with minimal seabed disturbance (Thomsen *et al.*, 2010) and have high selectivity for species and size (Ovegård *et al.*, 2011). Such characteristics, along with their cost-effectiveness and low energy use, means fish pots can be considered as a low impact, fuel-efficient (LIFE) capture technique, the adoption of which can contribute towards more economical and sustainable fisheries (Suuronen *et al.*, 2012). If fisheries are to transition successfully towards using LIFE techniques, however, they must be able to compete in capture efficiency with more traditional, established gear types.

Fish pots are typically small, baited entrapment devices with one or more entrances, designed to facilitate entrance and thereafter prevent or hinder escape. Despite being an attractive fishing method, few gadoid fisheries worldwide are executed with pots as the capture efficiency is generally low (Rose *et al.*, 2005; Anders *et al.*, 2016) when compared with more established gear types such as trawls, seines and gillnets (Suuronen *et al.*, 2012).

In Norway, current capture methods for Atlantic cod *Gadus morhua* L. 1758 include trawl, gillnet, Danish seine, longline or handline, which have a range of potential negative effects including benthic disturbances (Kaiser *et al.*, 2006), significant amounts

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of by-catch, discarding (Davis *et al.*, 2009) and emission of greenhouse gases (Schau *et al.*, 2009). As such, the development of fish pots as an alternative capture method would help to promote responsible and sustainable fishing. Successful development of fishing gear is reliant upon a detailed understanding of the interaction between target species and gear (Fernö, 1993). Little is currently known, however, as to why fishes decide to enter pots. Owing to the importance of entrance rates to overall capture efficiency, understanding the factors influencing the probability of a pot entrance is crucial if fish pots are to be adopted as a viable alternative capture method for *G. morhua*.

Previous research shows that the basis of the capture process of baited pots is chemically mediated attraction to food (Furevik *et al.*, 2008; Anders *et al.*, 2016), although this factor alone is unlikely to fully determine the choice to enter pots. For example, it is known that fish are able to evaluate the benefit of feeding decisions based not only on their individual information, but also on social attraction and social information, *i.e.* social cues from other individuals (Laland, 2004). Thus, the willingness of a fish to enter a pot could be influenced by the presence, number and behaviour of other fish either responding to the gear or by those already caught, as the capture process results in fish being retained alive. Aggregation effects have been revealed to be an important aspect in approach and entry behaviour in Antillean reef-fish pot fisheries (High & Beardsley, 1970; Munro *et al.*, 1971; Luckhurst & Ward, 1987; Renchen *et al.*, 2012). In addition, previous research shows that *G. morhua* tend to approach other *G. morhua* which are feeding (Brawn, 1969) or caught (Løkkeborg *et al.*, 1989). The converse could also be true, however. The presence of potential predators (High & Beardsley, 1970) or competitive interactions between species and fish sizes inside the pot could serve to discourage entry by any observing fish. Avoidance behaviour when conspecifics were caught in the pot mesh has been observed in saithe *Pollachius virens* (L. 1758) (Bagdonas *et al.*, 2012). Further evidence that pot catches may be affected by the presence of other fishes is presented by Gobert (1998), who found that size selection in unbaited pots is determined not only by mesh size, but also by density dependent escapement rates.

The decision to enter a pot with captured fishes probably represents a trade-off between the benefits of social foraging and increased resource competition. To an approaching fish, captured fishes may represent a feeding shoal. Providing that a fish can locate the pot entrance and is motivated to enter, the decision then becomes whether to join this feeding shoal inside the pot or not. Feeding in a shoal can provide important advantages such as locating resources more rapidly (Pitcher *et al.*, 1982) or reducing the risk of predation (Pitcher & Parrish, 1993). For instance, when presented with two feeders with bait hidden inside, wild guppies *Poecilia reticulata* Peters 1859 preferentially enter feeders that contain captured conspecifics over feeders that do not (Reader *et al.*, 2003) and three-spined stickleback *Gasterosteus aculeatus* L. 1758 have been shown to prefer to shoal with a larger group (Thünken *et al.*, 2014; Mehlis *et al.*, 2015). Joining a large group can also have costs, however, such as increased competition (Rieucou *et al.*, 2015).

In this study, the hypothesis that entrance probability of *G. morhua* into pots is affected by the presence of other fishes already captured was tested. Previous studies showed that the actions of caught fishes can lead to both attraction (Løkkeborg *et al.*, 1989) and avoidance (Bagdonas *et al.*, 2012). It is reasonable to assume, therefore, that the strength of these opposite forces varies between not only species but also between the number of fish caught. Consequently, it was predicted that entrance

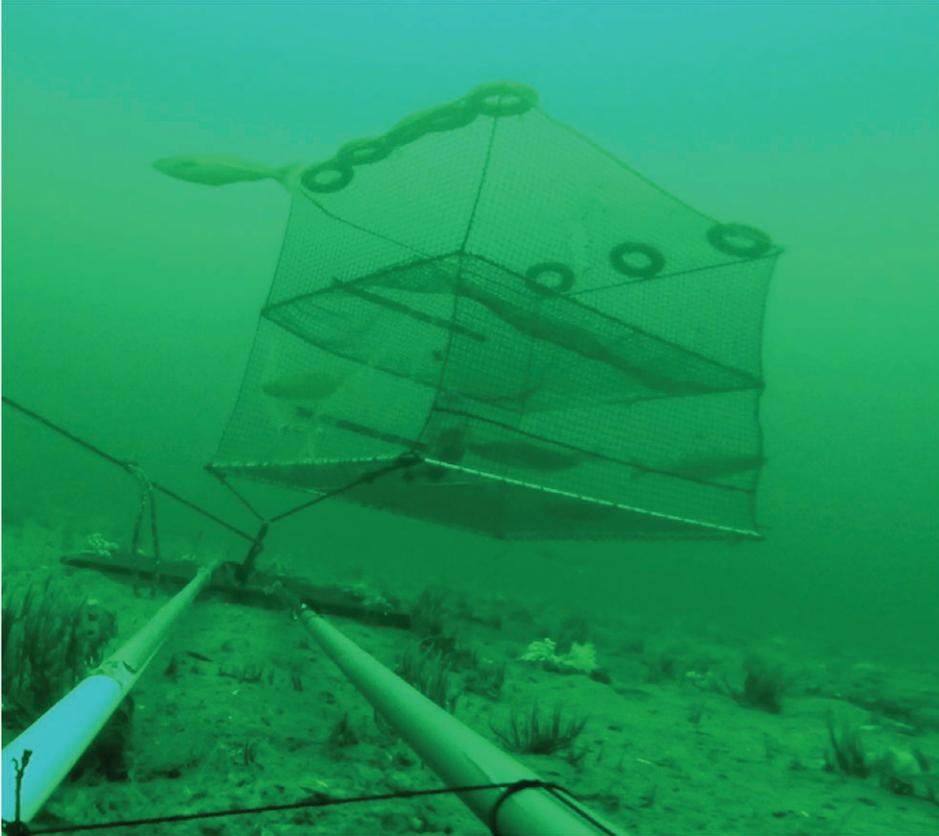


FIG. 1. *In situ* photograph of the 1.8 m³ (1.0 m × 1.2 m × 1.5 m) floating fish pot used to assess the rate at which *Gadus morhua* entered pots. The performance of bottom-set pots was also assessed.

probability would initially increase with increasing numbers of fishes retained in the pot and subsequently decrease when a critical number was caught.

MATERIALS AND METHODS

Observations of *G. morhua* entering pots were conducted on two pot designs; one design set on the seabed and one design set above the seabed (floated at either 35 or 95 cm). The bottom-set design had two monofilament funnel entrances. Floated versions had the same design, but with only one entrance (situated downstream) and the addition of floats to provide buoyancy. Consequently and in contrast to the bottom-set pot, floated designs were able to continually orient into the prevailing current. Floating designs have previously been shown to eliminate unwanted red king crab *Paralithodes camtschaticus* by-catch (Furevik *et al.*, 2008). It was possible for fishes to escape the pot *via* the entrances. All pots had a volume of 1.8 m³ (1.0 m × 1.2 m × 1.5 m), a mesh size of 28.5 mm and consisted of two chambers (Fig. 1). An additional inner funnel in the bottom chamber led to the upper chamber. A bait bag hung in the centre of the bottom chamber and was baited with three defrosted squid (*Illex* sp.) cut into five pieces, reflecting the typical bait used in baited gadoid fishing.

Filmed pots were deployed individually in daylight between 0900 and 1900 hours in Ramfjord in northern Norway in September 2013 and August–September 2014. Average setting depth was 40 m over sandy, flat bottom topography, with an approximate 2 h 45 min soak time. A pole mounted Go-Pro Hero 3+ (www.gopro.com) with underwater housing was attached to either the bottom of the pot (for pots set on the seabed) or to a weighted platform underneath the pot (for floated pots). Pole length was 1.5 m, giving a horizontal camera field of view of approximately 4 m. The field of view encompassed the pot and its surrounding area (Fig. 1) and was approximately the same for both floated and bottom set pots. In the case of the static bottom set pots, the camera was positioned directly in front of the pot entrances throughout the deployment. This was not the case for floated pots, in which the orientation between camera and entrance changed as the pot moved with the prevailing current.

Gadus morhua which came within approximately one body length distance to a pot (estimated visually) were classed as interacting fish and therefore had the possibility of entering. Other *G. morhua* in the field of view of the camera but not interacting were not recorded. For *G. morhua*, size [either large, total length (L_T) > c. 45 cm or small, L_T < c. 45 cm] was estimated in comparison with the known dimensions of the pot. Size was only estimated if the *G. morhua* position whilst outside the pot allowed for reasonably accurate estimation, otherwise recorded as unmeasured. Reasonably accurate estimation of size relied on the *G. morhua* swimming in close proximity and in parallel to the walls or entrances of the pot. *Gadus morhua* size classification was based on the minimum landing size for *G. morhua* (Jørgensen *et al.*, 2017). The number of other fish of any species retained within the pot at the time was also recorded for interacting fish upon their first appearance on camera. If a fish entered the pot at least once during its time on camera, its status was recorded as entered. The presence and size of other species interacting and entering the pot was also noted in the same way as for *G. morhua*. Number of fishes exiting the pot was not recorded.

Gadus morhua often left and re-entered the field of view of the camera. *Gadus morhua* which were absent for >20 s or could not be positively identified upon re-entering were considered to be new individuals. Identification of re-entering *G. morhua* was possible due to the low numbers of *G. morhua* interacting around the pot at any one time and was based on morphology, size and swimming direction. If several *G. morhua* of similar morphology and size left the field of view simultaneously, all subsequent re-entries were considered as new individuals. This approach to dealing with fishes re-entering the field of view of baited cameras has been successfully employed in previous studies (Løkkeborg *et al.*, 1989; Winger *et al.*, 2002).

STATISTICAL ANALYSIS

All statistical analysis was conducted using R 3.0.2 (www.r-project.org). A binomial generalized linear model (GLM) was used to model the probability of a pot entrance. A binomial-error structure was chosen as the response variable (probability of entrance) was binary (either entered or not). Sixteen candidate models were developed to describe the probability of entrance for an interacting *G. morhua* (Table I), containing all combinations of the variables: design (pot design, either seabed or floated), fish (number of other fishes retained within the pot), size (size of interacting *G. morhua*, either large, small or unmeasured) and soak (soak time of the pot, that being the duration of time the pot was in the water), as well as an intercept only null model. The most parsimonious model was selected using the Akaike information criterion corrected for small sample size (AICc). All candidate models were compared according to the AICc statistic and ranked based on their normalized Akaike weights (AICw), where the most adequate model had the largest AICw and the smallest AICc value. Tukey honestly significant difference (HSD) *post hoc* testing was used to compare levels of significant categorical predictor variables.

RESULTS

Twenty-three pot deployments were video recorded (Table II). Mean catch was 3.6 fish per pot, comprising *G. morhua* (71% by number), *P. virens* (20%) and haddock *Melanogrammus aeglefinus* (L. 1758) (9%) (Table II). The majority of interacting

TABLE I. Ranking of candidate *generalized linear models* (GLM) of *Gadus morhua* pot-entrance probability using AICc. Candidate covariate terms were design (pot design, either seabed or floated), fish (number of other fishes retained within the pot), size (size of approaching *G. morhua*, either large, small or unmeasured) and soak (soak time of pot). The best approximating model is highlighted in bold

Covariates	AICc	Δ AICc	Weight
Fish, size	791.0	0.00	0.598
Fish, size, soak	792.6	1.67	0.260
Fish, design, size	794.6	3.66	0.096
Fish, design, size, soak	796.3	5.32	0.042
Size	802.2	11.24	0.002
Size, soak	802.9	11.91	0.002
Design, size	804.6	13.66	0.001
Design, size, soak	805.1	14.10	0.001
Fish, soak	808.7	17.68	0.000
Fish	809.3	18.36	0.000
Fish, design, soak	812.3	21.29	0.000
Fish, design	813.1	22.10	0.000
Soak	819.8	28.81	0.000
(Null model)	820.6	29.60	0.000
Design, soak	822.6	31.58	0.000
Design	823.8	32.81	0.000

TABLE II. Catch rates and species composition at time of hauling to assess probability of *Gadus morhua* entering baited pots set on the seabed or floated above the seabed

Fishing position	Number of deployments	Mean (S.E.) number of fishes per pot	Mean (S.E.) percentage species composition by number
Seabed	11	3.8 (1.06)	<i>G. morhua</i> : 76 (11) <i>Pollachius virens</i> : 9 (6) <i>Melanogrammus aeglefinus</i> : 15 (11)
Floated	12	3.42 (0.88)	<i>G. morhua</i> : 68 (11) <i>P. virens</i> : 29 (11) <i>M. aeglefinus</i> : 3 (3)
All	23	3.6 (0.67)	<i>G. morhua</i> : 71 (8) <i>P. virens</i> : 20 (7) <i>M. aeglefinus</i> : 9 (5)

fishes on the videos were also *G. morhua* (67%), followed by *P. virens* (20%) and *M. aeglefinus* (13%) (Table III). The mean and maximum number of fishes observed inside a pot at any one time was 2.8 and 10, respectively. Behaviour of fishes prior to and after pot entrance reflected behaviour described by Anders *et al.* (2016), including attempts to feed on the bait and with the majority of fishes being retained in the bottom chamber, without ever entering the upper chamber.

The best adequate model contained number of other retained fishes (fish) and size of interacting *G. morhua* (size) as covariates (Table IV). The selected model had a

TABLE III. Numbers of interacting* and entering *Gadus morhua*, *Pollachius virens* and *Melanogrammus aeglefinus* for pots set on the seabed or floated above the seabed, used to assess probability of *Gadus morhua* entering baited pots

Fishing position		<i>G. morhua</i>			<i>P. virens</i>			<i>M. aeglefinus</i>		
		Large	Small	Unmeasured	Large	Small	Unmeasured	Large	Small	Unmeasured
Seabed	Interacting	152	328	149	12	113	94	14	58	29
	Entering	34	58	8	0	3	1	0	4	0
Floated	Interacting	90	131	71	10	73	8	4	57	28
	Entering	15	28	7	1	9	0	1	2	0

*Interacting fishes were those fishes which came within one body length's distance from the pot and were therefore considered to have the possibility of entering. Large, fish > c. 45 cm; small, fish < c. 45 cm.

TABLE IV. Best approximating GLM model for the probability that *Gadus morhua* will enter baited pots

Coefficient	Parameter estimate	S.E.	Z	P
Intercept	-0.992	0.19	-5.24	< 0.001
Size - Small	-0.077	0.20	-0.382	> 0.05
Size - Unmeasured	-1.222	0.31	-3.908	< 0.001
Fish	-0.143	0.04	-3.48	< 0.001

Size, the size of the approaching *G. morhua* (small, fish < c. 45 cm); Fish, the number of other fishes retained within the pot.

significantly better fit to the data than the null model (χ^2 difference test = 35.64, d.f. = 3, $P < 0.001$). Large *G. morhua* were not more likely to enter pots than small *G. morhua* (Tukey's HSD test, $P > 0.05$). The probability of entrance was, however, different between large and unmeasured *G. morhua* (Tukey's HSD test, $P < 0.001$) and between small and unmeasured *G. morhua* ($P < 0.001$). For large *G. morhua*, the highest probability of entrance (mean \pm S.E. 0.52 ± 0.09) occurred when one other fish was already retained within the pot; for small *G. morhua* it was with four other fishes in the pot (0.28 ± 0.07) (Fig. 2). Following these peaks, probability of entering tended to decrease with increasing numbers of fishes retained. For both large and small *G. morhua*, the probability of entrance when the maximum number of fishes was in the pot was similar to when there were no fish in the pot (large *G. morhua*: mean \pm S.E. 0.25 ± 0.15 v. 0.15 ± 0.05 ; small *G. morhua*: 0.13 ± 0.07 v. 0.22 ± 0.05).

DISCUSSION

The present study demonstrates that the likelihood that a *G. morhua* decides to enter a pot depends on the presence of fish already inside. Furthermore, it has been shown that although social interactions can encourage others to enter, such interactions can also serve to retard entry rates depending on the number of fishes inside the pot. To date, few studies have specifically addressed how the presence of caught fish influences capture in gadoid pot fishing. Valdemarsen *et al.* (1977) reported on an unbaited fish pot set with one live *G. morhua* which contained eight *G. morhua* 2 weeks later, implying that

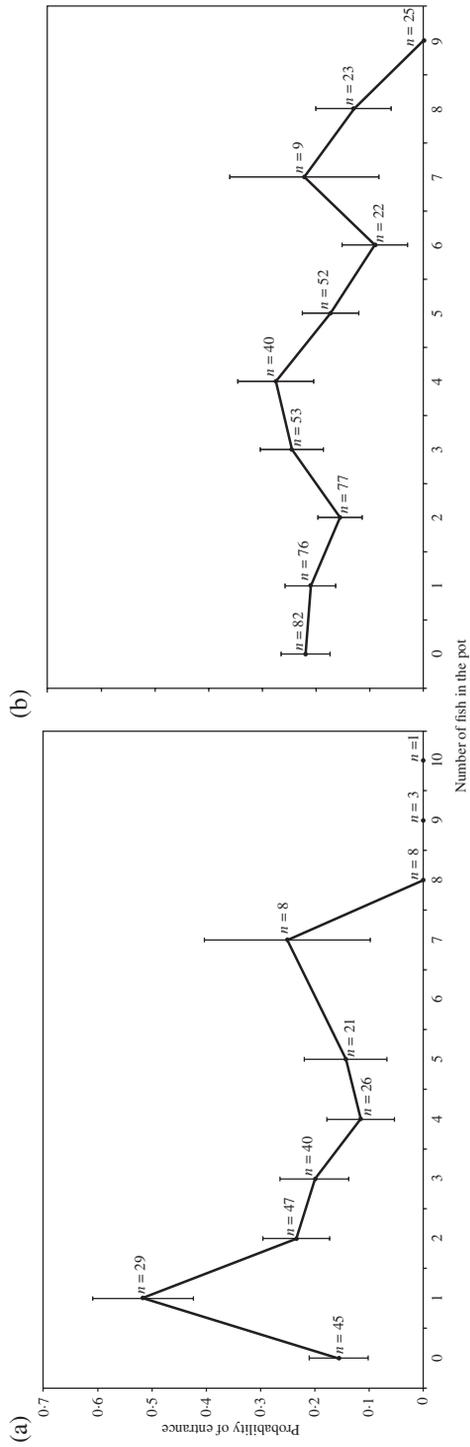


FIG. 2. (a) Large (> 45 cm) and (b) small (< 45 cm) *Gadus morhua* mean \pm S.E. probability of entrance into pots as a function of number of fishes already retained. No captures were recorded for large *G. morhua* when six fishes were retained in the pot, so this data point was removed from the plot.

social attraction can play a role in capture likelihood. This observation is supported by the Königson *et al.* (2015) study, showing pot catches peaked with a soak time of 6–7 days. As the rate of release of feeding attractants from bait declines rapidly over time (Løkkeborg, 1990), Königson *et al.* suggested that fishes were attracted into pots by social aggregation effects after the bait odour had been depleted. Hedgårde *et al.* (2016) demonstrated both the entrance and exit rate of *G. morhua* into pots was dependent on the number of *G. morhua* already retained. Outside of gadoid fishing, Munro (1974) developed a model to explain pot ingress but assumed entrance rate was independent of the number of fishes already retained. The present study provides further experimental evidence that social attraction influences entrance probability in gadoid pot fishing. Furthermore, the results demonstrate that this effect is multifaceted as the presence of other fishes can both attract and repulse other fishes.

It could be argued that the reduction in the probability of entering a pot with increasing numbers of fishes in the pot could be due to a saturation effect. The capture capacity of a fish pot is not infinite and previous entries occupy space within the pot (Beverton & Holt, 1957). If present, any saturation effect could have been exacerbated in the present study as retained fishes tended to remain in the lower chamber, not utilizing the available volume in the upper chamber. The generally small size and low number of fishes observed inside the pot at any one time (maximum 10) however, should mean that there was always sufficient space for other fishes to enter. Neither can bait odour depletion explain the results. The motivation of a fish to enter the pot could decline as the odour concentration from the bait declines due to washing out, but the short set durations (2.75 h) in this study means that the fishes were interacting with the pot whilst the bait still had high attraction potential (Løkkeborg, 1990). Modification of behaviour in caught fishes over time was noted by Furevik (1994), where fishes were seen to become less active and rest more over the time of a 14 h observation period, thereby reducing the visual cues available to approaching fishes. This may alter the strength of any attraction or repulsion effects at the later stages of the capture process.

Rather than effects of saturation or bait depletion, it is instead suggested that the probability of entrance may be explained in the context of social foraging behaviour. With no other fish in the pot, approaching fishes receive no social information about the bait and must therefore base the decision to enter solely on personally gathered chemical and visual cues. When other fishes are retained within the pot, however, their presence and feeding behaviours provide additional social cues *via* the processes of social attraction and social information regarding the location and quality of the bait (public information *sensus* Danchin *et al.*, 2004; Rieucau & Giraldeau, 2011). Consequently, the probability of pot entry should increase providing that the fish evaluate the social cues as favourable, based on how many fishes there are in the pot (social attraction) and at what rate they are feeding (public information). *Gadus morhua* have been observed feeding on bait whilst inside pots (Anders *et al.*, 2016). When these social cues are evaluated as unfavourable, as would be the case with increasing numbers of retained fishes with which to compete with for the resource, the probability of pot entry can be expected to decrease. The findings of an initial increase in pot entrance probability followed by a subsequent decrease (Fig. 2), supports this social foraging explanation.

Although overall entrance probability was not different between large and small *G. morhua*, differences in entrance probability were found between large and unmeasured

G. morhua and between small and unmeasured *G. morhua*. As unmeasured *G. morhua* are likely to contain examples of both large and small individuals and considering the significance of the size variable in the GLM, it is likely that the size of the approaching *G. morhua* does play an important role in entrance probability. It was not possible, however, to conclusively demonstrate this due to the high percentage (*c.* 25%) of the unmeasured *G. morhua* in the dataset. Technical limitations during observations contributed to this high percentage of unmeasured *G. morhua*, as *G. morhua* had to pass close to the known dimensions of the pot in order to estimate size. Future studies may avoid this by employing techniques that allow for more accurate size measurements, such as stereocamera systems.

Interestingly, the number of fishes in the pot which maximized the probability of entry was higher for small than for large *G. morhua*. This could be explained by difference in predation pressure between the two sizes of *G. morhua*. Smaller fishes have a higher predation pressure (Kristiansen *et al.*, 2000) and would therefore be more willing to trade-off competition for food for enhanced predator protection (Pitcher & Parrish, 1993). Previous research has shown that the choice of group size is influenced by state and context. For instance, *P. reticulata* had a strong preference for larger groups when threatened (Weetman *et al.*, 1999) and fathead minnows *Pimephales promelas* Rafinesque 1820 showed a strong tendency to avoid very small shoals in the presence of a predator (Hager & Helfman, 1991). The preference for larger groups was weaker in hungry golden shiners *Notemigonus crysoleucas* (Mitchill 1814) than well-fed ones (Reebs & Saulnier, 1997).

Alternatively, the *G. morhua* examined in this study tend to attain sexual maturation at approximately 35–40 cm L_T (O'Brien *et al.*, 1993) and as such, it is reasonable to assume the majority of small fish (defined here as $< c.$ 45 cm) were immature individuals, while the majority of large fish ($> c.$ 45 cm) were mature. Aksnes & Giske (1990) suggested that the value of food differs between mature and immature individuals, in that while an increase in food consumption for a mature fish may allow increases in clutch size, increases in consumption for immature fish may allow for earlier maturation. As earlier maturation represents a higher overall fitness value than increased clutch size, an immature (small) fish should be willing to take higher risks than a mature (large) fish to obtain food. This theory has been supported by both laboratory (Utne & Aksnes, 1994) and field (Giske & Aksnes, 1992) studies. Here, small (and presumably immature) *G. morhua* had a higher threshold of how much competition they were willing to undergo inside the pot in order to obtain food, compared with large mature *G. morhua*. Therefore, it is possible that ontogenetic differences between the two size groups may also explain these observations.

The maximum probability of entrance was two times higher for large *G. morhua* (0.51, with one fish in the pot) than for small *G. morhua* (0.28, with four fishes in the pot). This interesting difference could also be explained by differences in predation pressure, this time from predatory actions from other shoal members once inside the pot. The size of retained fishes should not affect the willingness for large *G. morhua* to enter the pot, as their larger size reduces their chance of predation from others within the pot. The opposite is true for small *G. morhua*, however, due to their smaller size and higher risk of predation. The willingness of small *G. morhua* to enter is therefore likely to be affected by the size of fishes retained in the pot. With both small and large fishes retained, the social attraction should be stronger for large than for small *G. morhua* and accordingly, the probability of entrance peaks at a higher level.

The effect of the gear may influence the number of fish at which repulsion becomes stronger than attraction when compared with a natural foraging situation. This social foraging explanation is based on fishes freely interacting around a food source, but in the present situation the encounter with the pot, the presence of retained fishes and the necessity to pass the funnel entrance in order to reach the food creates a more complex situation. First, a pot representing a novel object in the environment (Fernö *et al.*, 2011) can be expected to result in more cautious and defensive fish. Secondly, once significant numbers of fishes are in the pot, their movements and pushes against the pot mesh may deter other fishes from entering (Bagdonas *et al.*, 2012). Thirdly, the narrow funnel could make the fish more fearful and less willing to enter the pot. The number of fishes in the vicinity of the food source until repulsion is stronger than attraction could therefore be lower than in a natural situation.

Mixed species assemblages were observed both outside and inside the pots but the effects of interactions within and between species upon entrance probability could not be resolved. Such effects are known to influence crustacean pot catches (Fogarty & Addison, 1997). For instance, Addison (1995) noted that the presence of European lobster *Homarus gammarus* in a pot served to reduce the catch of edible crab *Cancer pagurus*. It is possible similar effects can occur during *G. morhua* pot fishing and that the strength of any attraction and repulsion effects is mediated by the species composition within the pot, especially considering the preference fishes show for shoaling with conspecifics (Brown *et al.*, 1993; Krause & Godin, 1994; Barber *et al.*, 1998; Ward *et al.*, 2002). In addition, the decision to enter may become more complex at times when the anti-predator benefits of shoaling with heterospecifics outweighs the costs of increased competition (Landeau & Terborgh, 1986). Entrance of *P. virens* or *M. aeglefinus* into the pots were rare events (Table III), preventing statistical exploration into the factors influencing the probability of entrance for these species. It would seem likely that the same factors that influence *G. morhua* entrance probability (number of fishes in the pot and size of interacting fish) also exert an influence on the probability of entrance for these other gadoid species. The particular life-history and behavioural strategies of individual species, however, are likely to determine in what way these factors determine entrance probability and further studies are required in order to resolve this.

In conclusion, the findings of the present study strengthen the idea that social attraction plays an important role in gadoid pot fishing and the strength of this effect is likely to be dependent on fish size. The observations can be explained by a combination of natural foraging behaviour, specific effects of the gear and differences in feeding motivation between the two sizes of *G. morhua*. It is noteworthy that the probability of entrance in a situation with many fishes retained was similar to when the pot was empty (see Fig. 2). Assuming that the probability of entrance continues to decrease with increasing number of fishes retained, it is suggested that the social repulsion effect is acting to limit the potential efficiency of the gear. Social repulsion may therefore go some way to explaining the currently low capture efficiency seen in many gadoid pot fisheries. For this reason and if fish pots are to be developed into a viable alternative capture method, efforts should be made in order to increase the attractiveness of the pots to the target species in order to counter this repulsion effect. Such efforts could consist of technical measures such as introducing green light to the pot (Bryhn *et al.*, 2014), or utilizing moving bait (as *G. morhua* prefer moving prey to stationary prey; Steingrund & Fernö, 1997). Based on the findings of the present study, the role of social

attraction and repulsion on the catch dynamics in pot fisheries around the world should be further investigated.

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