

Reducing the incidence of net cage biting and the expression of escape-related behaviors in Atlantic cod (*Gadus morhua*) with feeding and cage enrichment

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ABSTRACT

The escape of fish from aquaculture is a persistent economic problem for farmers as well as an environmental problem that threatens wild fish population as a consequence of potential negative ecological and genetic interactions. Farmed Atlantic cod (*Gadus morhua*) cause significant damage by biting the net and creating holes through which they escape. We determined the role of food, cage enrichment, net damage, and individual temperament on net biting behavior. During four separate trials, net interactions by fish were observed in relation to combinations of the above treatments. Fish with no access to food and in plain (not enriched) cages interacted the most with the net wall, with 7.5 and 12.6 more interactions per h, respectively, than fish with food that were in enriched cages (food $P=0.01$; enrichment $P<0.01$). Of the stimulating objects used to enrich cages, 97% of interactions were with the tubes that provided refuge ($P<0.01$). Cod were attracted to damaged areas of net, interacting 0.12 more times per h than at undamaged areas ($P<0.01$). Individuals showed consistent behavior over time, but there was no relationship between temperament and net interactions ($P=0.17$). The results indicate that appropriate feeding levels and cage enrichment may lead to reduced net interactions and thus fewer holes, reducing the potential for fish to escape.

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1. Introduction

Aquaculture is the fastest growing food producing sector in the world (Food and Agriculture Organization, FAO, 2010). Fish escaping from net pens is a persistent problem in the aquaculture industry, with escapes reported for almost all cultured species worldwide (Jensen et al., 2010). Despite numerous improvements by industry to reduce the incidence and severity of fish escapes, the problem of

escapes is still unresolved. Fish can escape during large episodic events, such as extreme weather events, in addition to low-level leakage through holes in the net caused by mechanical abrasion, external predators, and by biting the net themselves (Dempster et al., 2007; Jensen et al., 2010).

Unlike traditional agriculture, aquaculture often grows cultured species in the habitat of their native conspecifics (e.g. Naylor et al., 2005). Through captivity, differences in morphology, physiology, and behavior arise from differences in rearing environments and selective breeding, which can be maladaptive with negative consequences if farmed individuals escape and interact with wild populations (Bekkevold et al., 2006; Diana, 2009; Einum and Fleming, 2001; Huntingford, 2004). Escapees can

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potentially interact with wild fish on spawning grounds, lowering the fitness of wild fish (Fleming et al., 2000; McGinnity et al., 2003; in cod see Uglem et al., 2008). Domesticated individuals often have less genetic variation than wild individuals, since stocks often come from small, non-native founder populations that lack local adaptations (Huntingford et al., 2012). Interbreeding could therefore result in population hybridization events and outbreeding depression, in which the offspring are often inferior and maladapted compared to the parents (reviewed in: Bekkevold et al., 2006; Hindar et al., 2006; Utter, 1998). Other potential negative interactions with wild conspecifics include pathogen transfer and resource competition (Fleming et al., 2000; McGinnity et al., 2003; reviewed in Naylor et al., 2005). Other species can also be impacted through competition or direct predation (Brooking et al., 2006; Naylor et al., 2005).

Though aquaculture in the North Atlantic is dominated by salmonids (Naylor et al., 2005), other marine species such as Atlantic cod (*Gadus morhua*), Arctic char (*Salvelinus alpinus*), Atlantic halibut (*Hippoglossus hippoglossus*), turbot (*Scophthalmus maximus*), and haddock (*Melanogrammus aeglefinus*) are now being commercially farmed (Paisley et al., 2010; Rosenlund and Halldórsson, 2007). These species can differ markedly from salmonids in their behavior and ecology. For example, cod are able to spawn inside cages and release genetic material into the environment (Jørstad et al., 2008). In addition, cod are 10–20 times more prone to escape than salmon due to their tendency to bite holes in nets and their willingness to escape (Esmark et al., 2005; Jensen et al., 2010; Moe et al., 2007). In Norway, the world's leader in cultured cod production, 1.05 million cod escaped from net cages between 2004 and 2009 (or 175,000 year⁻¹), representing 1.02% of cod held in sea cages (compared with 0.19% escaped salmon) (Jensen et al., 2010). Escapes of up to 160,000 cod from a single farm have been recorded (Moe et al., 2007).

Although the majority of escapes are caused by structural, external or operational factors (e.g. storms, abrasion, predators; Jensen et al., 2010), significant net damage can occur due to net biting (e.g. one bite per cod per day, creating one hole per net cage per month) (Hansen et al., 2009; Moe et al., 2009). Unlike schooling salmon, cod spend a lot of time exploring the net wall, increasing the chances of finding a hole and escaping (Hansen et al., 2009; Rillahan et al., 2011). Cod have also been observed to bite at loose threads associated with small holes or repairs, thereby potentially enlarging existing holes in addition to creating new ones (Moe et al., 2007, 2009). Suboptimal conditions, such as the level of feeding, biofouling, or crowding, may further encourage net interactions (Hansen et al., 2009; Moe et al., 2007).

The collapse and slow recovery of wild cod populations in the northwest Atlantic (Committee on the Status of Endangered Wildlife in Canada, COSEWIC, 2010; Myers et al., 1997; Rose et al., 2000) has increased the economic incentive to farm cod. However, the industry has faced many challenges (Brown et al., 2003; Øiestad, 2005), and the problem of escapes has yet to be addressed. To reduce the negative ecological and economic impacts of escapes, we examined factors that may mitigate the motivation of

Table 1

Initial mean weight (g) of experimental fish by temporal trial. There were no significant differences in fish weight between trials or treatments.

Temporal trial	Plain		Enriched	
	Fed	Deprived	Fed	Deprived
Trial 1 ^a 7–15 March	n/a	290 ± 50	n/a	290 ± 80
Trial 2 18–26 March	320 ± 60	300 ± 60	320 ± 70	320 ± 70
Trial 3 31 March–8 April	340 ± 80	350 ± 70	320 ± 70	310 ± 80
Trial 4 27 April–8 May ^b	350 ± 70	350 ± 100	320 ± 60	340 ± 60

^a Fish did not eat during the first trial, so only one food level (no food) was tested.

^b Data were not recorded 30 April–2 May due to condensation problems with the cameras. Thus, trial 4 ran for 12 days to provide 9 days of video data.

cod to bite net cage walls. We tested the hypothesis that interactions with the net increase with suboptimal conditions, specifically that: (1) net interactions increase with food deprivation and net damage; (2) stimulating cage environments reduce net interactions; and (3) cod exhibiting 'bold' temperaments interact more with the net than those with 'shy' temperaments. The results aim to provide direction for reducing potential ecological effects and industry costs of escapes from aquaculture.

2. Materials and methods

2.1. Experimental fish

Farmed cod (F_2 ; ~1.5 years of age; mean ± sd, 320 ± 70 g; 31 ± 2 cm) were obtained from a semi-commercial scale hatchery at the Joe Brown Aquaculture Research Building of Memorial University's Ocean Sciences Centre (OSC; St. John's, Canada), where they had been fed 1% of their body weight daily. After transfer to an experimental facility at the OSC in winter 2011, the cod were kept in a holding tank in ambient seawater (1.0 ± 0.6 °C; 105 ± 5% O₂; ~31 practical salinity units, psu) for 2–21 days prior to experimentation (variable among trials).

2.2. Experimental design

The experiment was conducted in a large indoor flume tank (11 m × 2.5 m) that housed 20 circular net compartments (1 m diameter, 0.5 m deep) made from white knotless nylon netting (3.8 cm stretch mesh size). This mesh is commonly used in the commercial Newfoundland cod industry. Throughout the experiment, the flume tank was supplied with heated (3.7 ± 2.1 °C) and oxygenated (129 ± 10% O₂) seawater and was on an ambient day–night cycle (daylight, 39 ± 13 lux, measured at three locations along the flume tank). Cod were transferred from the holding tank to the experimental tank, where they were held for 1 (trials 2–4) to 4 (trial 1) days prior to filming. Experiments were run from March through May of 2011 (Table 1).

Four temporal trials were conducted, with four treatments distributed randomly among the 20 cages within

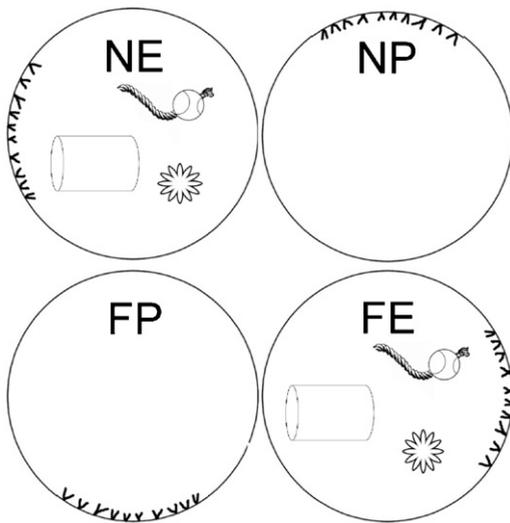


Fig. 1. Schematic representation of four circular net compartments (1 m diameter \times 0.5 m deep) per trial, depicting the four unique treatment combinations: food (F), no food (N), enrichment (E), plain (P). One randomly selected quarter of each net cage was tied with frayed string. Treatments were randomly distributed within the 20 cages per trial. Five cod were distributed randomly into each cage.

each trial (Table 1). The four treatments (Fig. 1) were replicated twice in the first trial (initially limited by the number of video cameras) and five times in each of the subsequent trials (17 replicates total) and were: (1) plain, un-enriched cage deprived of food, (2) plain cage supplied with food, (3) enriched cage deprived of food, and (4) enriched cage supplied with food. Cod in the “food” cages were offered \sim 1% of their body weight in chopped frozen herring daily after filming ended at 13:00 h. Net cages were enriched with pipes (one 30.5 cm \times 10.2 cm PVC pipe near the center of each cage lying horizontally on the bottom) for cod to swim through and as a potential refuge, and with stimulating objects (one tennis ball on a knotted rope because cod are attracted to fraying rope, and one knobby rubber ball toy (Pet Store, China, model 17-1700168 H4P 0A1) suspended near the cage bottom by fishing line). Within all net cages, a randomly chosen quarter of the net wall had frayed strings (extending 6 cm into the cage, same color as mesh) tied to it to simulate net “damage”/repair and to determine whether this would attract more biting activity than “undamaged” netting.

Each net cage contained five cod (\sim one-quarter of the typical commercial stocking density of 15 kg cod m^{-3}). Within each trial, cod were size matched with no initial difference in weight between trials (generalized linear mixed model, GLMM, with trial as fixed and random factor: $F_{3,318} = 1.88$, $P = 0.13$) or treatments (GLMM: $F_{3,318} = 0.92$, $P = 0.43$). Cod were tagged externally with t-bar tags for individual identification within each cage. During the first trial, cod were distributed sequentially through the cages (i.e. the first five cod from the holding tank were placed in the first net cage). For all following trials, cod were distributed randomly among the cages as they came from the holding tank.

2.3. Behavioral observations

All cages were filmed daily between 10:00 and 13:00 h for 9 days per trial using overhead cameras in real time at 25 frames s^{-1} at a resolution of 640 by 480 pixels (Axis 221 Day and Night Network Cameras, model no. 0221-01-04, Axis Communications, Lund, Sweden) placed 2.2 m above the water surface. We analyzed the behavior of individual fish for a minimum of 30 min each day (two randomly selected 15 min segments) for 9 days (4.5 h total). Recordings were analyzed at 4 \times native speed and were scored for frequency of interactions with the net wall (touching the net with the snout and biting at the net; Hansen et al., 2009).

In addition to examining the effects of cage enrichment, food deprivation, and net “damage” on net biting behavior, we also explored the role of individual temperament, measured as the willingness of cod to leave shelter; i.e. bold versus shy (exploration vs. avoidance according to Réale et al., 2007). To do this, each cod was placed in a closed box (50.8 cm \times 63.5 cm \times 33 cm) for a 2 min settling period following the net cage trial. A mesh door (40.6 cm \times 44.5 cm) was opened, and we measured the time for the cod to emerge fully from the box (see Brown et al., 2005; Brydges et al., 2008). Cod that had not emerged within 5 min were assigned a maximum time of 300 s. Cod were tested individually to decrease the possibility of social status or learning influencing behavior (Fenderson et al., 1968). Quickly emerging cod were assumed to be bolder (see Toms et al., 2010). Temperament traits may correlate across contexts, suggesting that this test of temperament may correlate with exploration of the netting (Huntingford, 1976; Mas-Muñoz et al., 2011; Réale et al., 2007).

2.4. Ethical note

This study was approved by the Memorial University Animal Care Committee (protocol 10-15-IF), in accordance with the regulations of the Canadian Council on Animal Care for the treatment and welfare of animals.

2.5. Data analysis

All data were analyzed using R 2.12.2 (R Development Core Team, 2011) and the R package *lme4* (Bates and Maechler, 2009). Null hypotheses were rejected when $P < 0.05$. Residuals of all models were checked for normality and homogeneity. Test statistics and p-values are only approximations because regular distributions do not apply to the random effects structure of linear mixed effects models (Bates, 2006; Winter, 2011). Fish that died during the experiment (14 of 340, spread across all treatments) were removed from all analyses.

Food, enrichment, fish size, and temperament: To determine if food level and cage enrichment affected net interactions, a generalized linear mixed model (GLMM) with Poisson error distribution was run with the response variable of total net interactions per fish per day (9 observational days per individual cod). Fixed effects included food level, enrichment and time to emerge, with initial weight and day included as covariates. Random effects included

trial ($n = 4$), cage nested within trial ($n = 68$), and individual fish ($n = 326$) allowing for a random variation in slope by day. Three-way and higher order interactions were considered biologically overly complex and not included in the initial model.

Specific enrichment: To further examine the influence of stimulating objects on net interactions, a subset of data including only enriched cages was used. The relationship between net interactions and interactions with stimulating objects was determined with a GLMM with Poisson error distribution and the response variable of total net interactions per fish summed over all days. The fixed effects were total interactions with stimulating objects and food level. The random effects were trial and cage nested within trial ($n = 34$). Furthermore, to determine if interactions with stimulating objects varied with object type, a subset of data with an average number of interactions per cage for each object type (i.e. maximum of three observations per cage) was used with a GLMM with Poisson error distribution. The response variable was total object interactions per cage, with fixed effect of object type and random effects of trial and cage nested within trial.

Net damage: Total interactions at undamaged net were divided by three to standardize the net area with the damaged area (one-quarter of the net cage). To determine if mean interactions depended on net damage, a GLMM was run with mean interactions per cage as the response variable, treatment and net status (damaged or not) as fixed effects, and trial as a random effect.

Individual temperament: Using only data from cod in enriched cages, a GLMM was run to determine if time to emerge (i.e. temperament test) varied between fish that interacted with the tube and those that did not interact with the tube. A subset of data from cod that swam into the tubes was used for a second GLMM to see if time to emerge varied significantly with the number of interactions with the tube. Random effects included trial and cage nested within trial.

3. Results

Two-way interaction terms associated with the GLMM model to examine effects of food, enrichment, fish size and temperament on net interactions were not significant ($P > 0.22$), and thus were removed from the final model. Both food level and enrichment had a significant effect on the rate at which cod interacted with the net wall in the final model (food $z = -2.46$, $P = 0.01$; enrichment $z = 6.47$, $P < 0.01$; Fig. 2). However, there was no significant relationship between time to emerge and net interactions ($z = -0.65$, $P = 0.17$, Fig. 3). For all treatments, the mean number of interactions increased over each 9 day trial by an average of 3.4 ± 4.1 interactions per fish per h ($z = 3.11$, $P < 0.01$).

3.1. Food deprivation and enrichment

Unfed (hungry) cod had on average 7.5 more interactions with the net wall per fish per h than fed cod (Fig. 2). Assuming similar interaction numbers per fish throughout a 12 h day (cod are more active during daytime; Rillahan

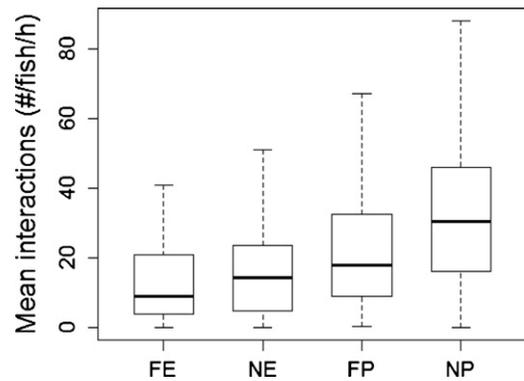


Fig. 2. Mean net interactions by treatment: food (F), no food (N), enriched (E), plain (P). Each box represents the 50% quartile, the dark line the median, and the whiskers 1.5 times the inner quartile range.

et al., 2011), this equates to 90 more interactions with the net wall per day per fish than fed cod. In comparison, cod in plain cages had on average 12.6 more interactions with the net wall per fish per h than cod in enriched cages (Fig. 2). Using the same assumptions, this equates to 151 more interactions with the net wall per day per fish than cod in enriched cages.

Cod interacted with stimulating objects in enriched cages as well as with the net wall. There was a significant negative correlation between interactions with the net and the objects: cod that interacted more with stimulating objects had fewer interactions with the net ($z = -25.18$, $P < 0.01$). Interactions did depend on object type ($z = 18.60$, $P < 0.01$): 97% of all interactions with stimulating objects were with the tube (Fig. 4).

3.2. Damage

Cod interacted at damaged areas 0.12 more times per fish per h than at undamaged areas ($F_{1,122} = 69.94$, $P < 0.01$). Extrapolated to a 12 h day, this equates to 1.4 more interactions at damaged areas per day per fish than at undamaged areas. However, there was no significant interaction between net status (damaged/undamaged) and treatment (four unique combinations of food level and enrichment; $F_{3,122} = 0.16$, $P = 0.93$).

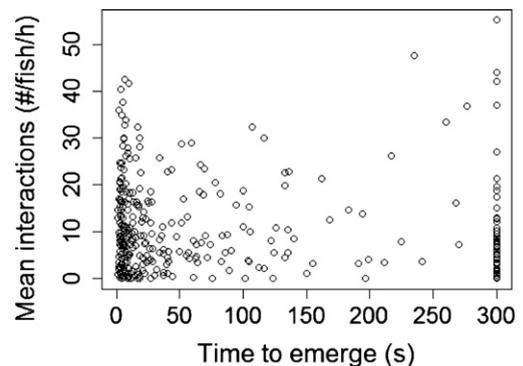


Fig. 3. Relationship between time to emerge and mean net interactions by individual fish.

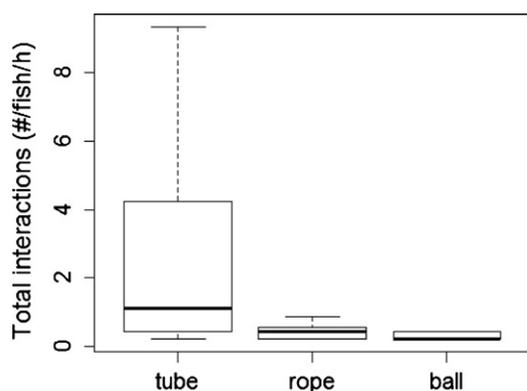


Fig. 4. Total number of interactions with stimulating objects. Each box represents the 50% quartile, the dark line the median, and the whiskers 1.5 times the inner quartile range.

3.3. Individual temperament

Time to emerge into a novel environment ranged from 0.85 to 300 s (the maximum time) (Fig. 3). Furthermore, there was no significant difference in time to emerge between cod that interacted with the tube and those that did not interact with the tube ($t = 0.29$, $P = 0.82$). There was also no significant relationship between time to emerge and number of interactions with the tube ($t = 1.59$, $P = 0.36$). Net biting behavior was consistent within individuals: the most active cod (i.e. having the most net interactions on average for each trial) within each cage interacted the most with the net on $60 \pm 21\%$ of the days over the 9 day trial.

4. Discussion

Fish that escape from aquaculture operations not only represent a direct economic loss for the farmer but are also of significant environmental concern. Although the potential impacts of these losses are widely documented for salmonids, Atlantic cod may escape at much higher rates and thus have the potential for both substantial problems and mitigation. Here we found that Atlantic cod escape-related behaviors can be reduced with cage enrichment, food availability, and net maintenance.

Cage enrichment resulted in the greatest reduction in net interactions. Cod housed in net cages enriched with stimulating objects interacted less with the net wall than cod housed in plain cages. This is an exciting result because cage enrichment would presumably be relatively easy and inexpensive to achieve on commercial farms. Numerous studies have investigated the use of housing enrichment on rodents and other species for medical research (e.g. Olsson and Dahlborn, 2002) and when rearing animals to be released for stock enhancement programs (in cod see Moberg et al., 2011; Salvanes and Braithwaite, 2006). Apart from studies on maintaining animals in zoos (Shyne, 2006) and organic animal husbandry (Spoolder, 2007), few studies have investigated the use of enrichment in a purely captive situation, such as for aquaculture, where the aim is

not for better survival in the wild but easier management of captive fish (but see Brydges and Braithwaite, 2009).

Our results suggest that the stimulating objects (and especially the tubes) distracted cod from investigating and interacting with the net wall. The enrichment may also provide a complex habitat such as those preferred by cod in the wild (Cote et al., 2002). The use of enrichment in aquaculture cages may therefore help reduce the amount of damage caused by net biting incidents and may also reduce the incidence of escapes through holes created by storm damage by reducing the net inspection behavior of cod. We tested a limited variety of stimulating objects in this study; by using other enrichment objects a bigger impact may also be observed. There was a clear preference for the tubes over the other enrichment objects, suggesting that the tubes may act as a preferred refuge for the cod.

Food availability also led to a reduction in the number of interactions with the net, with hungry cod interacting more with the net wall than cod with access to food. Hansen et al. (2009) found that cod starved for 9 days were more prone to escape, but they observed no correlation in net exploration and net biting. However, behavioral differences between stocks have been observed, especially between migratory and resident populations (Brown et al., 2003; Hansen et al., 2009). We conclude that well fed cod have less motivation to escape, resulting in fewer interactions with the cage wall. Furthermore, we suggest that hungry cod may investigate the net in search of additional food, as suggested by Moe et al. (2007). We observed 11.2 ± 14 interactions on average with the net per h, which is similar to the interaction rate of 13.8 interactions per h observed by Hansen et al. (2009). Our study used fish that were 219 g lighter and stocked at a density of 3.92 kg m^{-3} greater than that of Hansen et al. (2009). Moreover, the entire wall area of our cages consisted of mesh compared to only 34% in Hansen et al. (2009). Hungry cod interacted with the net 90 times more in a 12 h day than fed cod; when extrapolated to a commercial scale of 200,000–400,000 fish per cage (Jensen et al., 2010) this equates to 18–36 million more interactions per cage per day, representing a significant potential source of damage. This indicates that maintaining an appropriate feeding level in aquaculture cages is a key factor in reducing the number of escapes through holes cause by net biting. In addition, the effects of enrichment and food appear to be additive, resulting in the least amount of net interactions of all the treatments. This suggests that combining enrichment with appropriate feeding levels may further reduce net interactions.

Interactions with both the net and the stimulating objects increased across days during each experimental trial. This rate of increase did not vary significantly between treatments, indicating that the increase was not due to food availability or cage enrichment. As time elapsed, the novelty of the net cages and stimulating objects would have decreased, potentially encouraging the cod to try to escape from the cages. This may suggest an increase in exploratory behavior with habituation to the cage environment. Compared to the length of time cod would be housed in commercial net cages, the duration of our experiment (each trial = 9 days) was very short. Within the

constraints of the current experiment, we could not test the potential response of cod to objects over longer time scales that are more applicable to commercial operations, suggesting a direction for future studies.

Cod were more likely to interact with damaged net areas than undamaged areas. These results correspond with previous studies, which have observed increased attraction to damaged areas (Moe et al., 2007, 2009). However, these other studies used a pre-damaged net panel that was suspended in the aquaculture cages. Cod may have been attracted to these net panels as novel objects (similar to the stimulating objects used in this experiment), rather than due to the actual net damage. Furthermore, cod have been observed to be attracted to repairs made with string of contrasting color to the mesh (Moe et al., 2007). In our study, we used string of the same color as the mesh, potentially resulting in lower visibility of the strings and thus fewer interactions. These results suggest the importance of regular net maintenance to avoid frayed or damaged strings that may attract the attention of cod, resulting in investigatory biting which could develop into larger holes.

Individual behavior varied widely, as seen in other studies (i.e. see Sverdrup et al., 2011). There was no effect of fish size on behavior within the narrow size range we examined. We observed inter-individual variation but intra-individual consistency over time (within the tested context of net biting, there were consistent net-interactors over the course of the trials), suggesting that cod showed stable behavioral types (Conrad et al., 2011). Many studies have suggested that temperament traits correlate across contexts (i.e. domain-general), indicating the presence of behavioral syndromes (Sih et al., 2004b). For example, different genotypes may exhibit varying behavior along the “shyness–boldness” continuum, with bold fish more willing to take risks, explore the net cage environment, and escape for possible resource gains (Fraser et al., 2001; Hansen et al., 2009). This suggests that behavior in net cages may be strongly influenced by individual variation.

Our results, however, indicate that performance in our temperament test (emergence into a novel environment) is not a good predictor of interactions with the net. In contrast to domain-general temperament traits, other studies have found that behaviors are context specific (for review see Conrad et al., 2011). Depending on the circumstances (i.e. predator absence/presence), behavioral flexibility is important and it is optimal to have context-specific behavior (Conrad et al., 2011; Komers, 1997; Sih et al., 2004a; Toms et al., 2010; Wilson, 1998). Therefore, it is not necessarily surprising that inter-individual variation was not explained by cod size, or exploration behavior (as in Hansen et al., 2009). In addition, our experiment did not control for the role of social interactions experienced prior to the temperament test. Despotism interactions in the net cages may have caused subordinate fish to remain less mobile when tested for temperament (Øverli et al., 1998). It is generally accepted that animals have consistent behavioral types, as observed in our study, however the mechanisms controlling these types are not well understood and merit further study (see Conrad et al., 2011).

In summary, appropriate feeding levels, cage enrichment, and net maintenance may lead to reduced net interactions by farmed cod. Hansen et al. (2009) found that cod could rapidly discover new openings from several meters away, emphasizing the need to avoid net damage and maintain constant screening. In addition, we found consistent inter-individual variation in behavior, suggesting the presence of stable behavioral types (within but not across contexts). More studies are needed to further understand the mechanisms driving this variation and the linkages between behaviors. In comparison with commercial aquaculture, this study was of short duration (9 days) with a low stocking density (~one-quarter of typical stocking density), which may have affected the rate of net interactions observed. Further studies should be conducted to better relate these experimental findings to conditions typically encountered in commercial aquaculture environments. The results of this study can be used by aquaculture managers to avoid conditions which result in increased interactions between Atlantic cod and the net walls, decreasing damage to the net and reducing the number of escapes. These results may also be applied to other farmed pelagic marine fishes that bite at the net, such as sea bream (Dempster et al., 2007). Cage enrichment and appropriate feeding may also enhance the welfare of the captive fish, for example by reducing stereotypies such as repeated circular swimming, and even net biting, and encouraging natural behaviors in a complex habitat (Ashley, 2007; Cote et al., 2002).

5. Conclusion

This study indicates that cage enrichment and appropriate feeding, coupled with net maintenance may lead to reduced interactions with the net by cod. Proactively addressing the conditions that encourage net biting may prove to be a cost efficient and complementary means, along with that of improving net materials, to reduce escapes.

Conflict of interest

None.

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