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Capture Efficiency and Size Selectivity of a dry Clam Dredge Used In Fishing For Ocean Quahog (*Arctica islandica*)

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Veiðihæfni og stærðarval tannplógs við kúfskeljaveiðar var rannsökuð í september 2009 í Þistilfirði. Notaður var lítill tannplógur við veiðarnar og kafarar söfnuðu sýnum úr plógfari og úr ósnertum botni.

Veiðihæfni, sem hlutfall afla af kúfskeljum á svæðinu, var metin eftir beinni aðferð, óháð lengd. Annars vegar var stuðst við afla sem hlutfall af þyngd skelja úr ósnertum botni (16%) og hins vegar sem hlutfall af þyngd afla+ þyngd þess sem varð eftir í plógfari (27%). Veiðihæfnin jókst fyrir skeljar upp í 50 mm SL en minnkaði eftir það (estimated efficiency). Vegna fárra sýna, reyndist erfitt að meta stærðarval plógsins og voru notuð 3 mismunandi líkön til að túlka niðurstöður. 1) Mest veiddist af skel 40-60 mm SL (selectivity) 2) allir stærðarhópar veiddust jafn vel, (constant selectivity), 3) veiðgetan jókst upp í 40 mm SL en minnkaði eftir það (Spline). Tölfræðilegur samanburður á niðurstöðum líkana bendir til aukinnar veiðihæfni upp í 40 mm SL en minnkandi eftir það (Spline).

ABSTRACT

*Gudrún G. Thórarinsdóttir, 2013. Capture Efficiency and Size Selectivity of a dry Clam Dredge Used In Fishing For Ocean Quahog (*Arctica islandica*). Marine Research in Iceland 174.*

The capture efficiency and size selectivity a dry dredge used in the Icelandic ocean quahog fisheries were estimated by conducting fishing experiments during September 2009 in Thistilfjördur, northeast Iceland

The dredge efficiency, based on weight of shells caught, independent of shell length, was estimated by two direct methods. In the first one the efficiency was estimated as 16% when using abundance in catch divided by abundance of the unfished ocean quahog and 27% when using abundance in catch divided by abundance in catch + abundance of clams left in the track. The estimated efficiency for the entire fishery was highest for shells 50 mm SL (70%) but decreased after that. Three models were used to estimate the size selectivity of the dredge, which was imprecise for small and big size classes because of few samples collected; 1) In the logistic selectivity model (mixed-effect SELECT models, increasing or decreasing curves) the size selectivity increased up to 40 mm SL, was relatively constant until 60 mm SL was reached, declining after that. 2) In the constant selectivity model all size classes were caught with the same efficiency (flat) and 3) In the Spline model (flexible pattern) the selectivity increased up to 40 mm SL and declining after that. The analysis was problematic due to the sparse data, however depending on statistical tests, Spline selectivity is probably the best option.

1 INTRODUCTION

Ocean quahog (*Arctica islandica*) has been harvested off the Icelandic coast using a hydraulic clam dredge, that systemastically selects larger-sized ocean quahog (size selectivity) (Thorarinsdóttir & Einarsson 1996, Thorarinsdóttir et al. 2010). Off Iceland, ocean quahog densities have been assessed at depths of 5–50 m and found to be high but the fishery operates mainly at depths of 20–40 m (Eiríksson 1988, Thorarinsdóttir & Einarsson 1996).

In Icelandic waters fishing ocean quahog using a dry dredge (no hydraulic jet to loosen the sediments) is now in stage of development as the fishery is changing from bigger sized individuals to smaller ones which are exported alive to markets in Europe. Dry dredges are supposed to fish smaller individuals than the hydraulic dredges and with lower breakage rate. Size selectivity and capture efficiency for ocean quahog dredges are influenced by dredge design, operational factors (such as towing speed, the ratio of warp length versus water depth, duration of the tow etc.) and environmental factors (such as depth, current speed and bottom type). In addition, capture efficiency may be affected by the depth profile of ocean quahog within the sediment (Taylor 1976, Strahl et al. 2011).

Different methods have been used to estimate efficiency and selectivity of dredges. Direct estimates of capture efficiency of dredges used to harvest bivalves can be obtained by comparing dredge catches with unbiased samples from the population prior to dredging or to compare the catch to catch plus what was left in the track after dredging (Caddy 1968, Mason et al. 1979, Fifas 1991, Powell et al. 2007). When using mixed effect SELECT models for estimating efficiency and selectivity of clam dredges the probability of capture for clams in the path of a dredge is defined as the product of size selectivity and capture efficiency. Size selectivity is the relative probability (zero to one) of capture for clams of various sizes relative to the probability of capture for a large, fully selected individual. Size selectivity increases with shell length for ocean quahog in commercial hydraulic dredges (Thorarinsdóttir et al. 2010) because the dredges are designed to select large ocean quahog with highest meat weights and minimize the capture of small ocean quahog, along with other unwanted invertebrates, fish and trash (Murawski & Serchuk 1989). Thus, small ocean quahog tends to be underrepresented in the catch relative to the population and shell length distributions for the catch and the population differ (Thorarinsdóttir et al. 2010).

In addition to use for interpreting survey data, size selectivity estimates are key in many modelling approaches (Hilborn & Walters 1992, Quinn & Deriso 1999) that estimate maximum sustained yield (MSY) and per-recruit reference points (e.g. $F_{0.1}$ and F_{MAX}) that are used to manage, set catch quotas and define healthy or overfished stock conditions for ocean quahog (Thorarinsdóttir & Jacobson 2005, NEFSC 2007) and many other fisheries around the world.

The goal of this study was to estimate capture efficiency, size selectivity and associated variability for a dry dredge targeting ocean quahog off Iceland, as the fishery using a dry dredge is in a stage of development. Thorarinsdóttir et al. (2010) estimated capture efficiency and size selectivity for hydraulic dredge used in Icelandic waters by SELECT models but dry dredge efficiency has not been investigated.

2 MATERIAL AND METHODS

The experimental fishing trips were carried out in September 2009 in Thistilfjordur northeastern Iceland in an area of relatively high abundance of ocean quahog. The vessel used was Manni ÞH 88 (2328) an 11 m open boat with a 350 Hp inboard engine, the only fishing vessel currently targeting ocean quahog in Icelandic waters (Fig. 1). A different experimental site was occupied during each of the tows which were close to each other. The seabed at all sites was smooth tightly packed sand, which is typical ocean quahog habitat. Sampling depths ranged from 9 to 11 m.

In this study the outcomes from direct measurements and models used were compared for the same data. The capture efficiency was estimated by a direct method (Fifas 1991) and following Millar et al. (2004) a mixed effect SELECT models were used for size selectivity estimations (Fryer 1991, Millar 1992). As the model did not handle decreasing selectivity patterns because of small sample sizes a Spline model (Wahba 1990) which follows the data was used. To calculate confidence intervals for the capture efficiency a beta-binomial model (Miller et al. 2009) was used.

Figure 1. The fishing vessel, Manni ÞH 88 (2328).

Mynd 1. Hraðfiskibáturinn Manni ÞH 88 (2328) sem notaður var við rannsóknirnar.

2.1 Commercial dredge sampling

The dry dredge used in the study was 115 cm long, 50 cm high and 60 cm wide (Fig. 2). During all tows, tow speeds (approximately 1.5 km h^{-1}) and tow durations (approximately 10 minutes) were similar to those in commercial operations.

Three dredge tows were conducted and divers marked the start and end points of the intended dredge path for each tow with buoys. GPS coordinates of these locations were recorded aboard the boat. Dredge tows were parallel and close together. One set of diver samples was used to measure the underlying population length composition and density of ocean quahog in each tow.

After each tow, the total catch weight and tow path length (based on the boat's positions) were recorded. A random sample (about 15 kg) of ocean quahog (Fig 3.) was taken from each tow and individuals >10 mm in shell length were counted, weighted (whole wet weight) and measured with calipers to the nearest 0.1 mm.

2.2 Diver sampling

Two divers collected ocean quahog samples using 0.25 m^2 corers, pushed into the sediment down to 25 cm depth. The corers were placed randomly in undisturbed sediments, along each dredge track (4 control samples) and inside each track (4 samples). A total of 12 samples were taken as control and 8 samples from tracks as tow no. 2 was lost.

Sediment was extracted from corers with an underwater suction sampler and sieved through a 1 mm mesh net. All ocean quahog >10 mm shell length in the diver samples was measured with callipers to the nearest 0.1 mm and weighted (whole wet weight).

Figure 2. The dry dredge used in the investigation.

Mynd 2. Tannplógurinn sem notaður var við rannsóknirnar um borð í Manna.

Figure 3. Ocean quahog sample from the dry dredge.

Mynd 3. Kúfskel úr tannplógi.

3 DATA ANALYSIS AND RESULTS

Catch data were standardized to reflect harvest per unit area covered by the dredge. Linear distance travelled for each tow was calculated as the product of towing speed and tow duration. The total catch was weighted. The biomass (kg m-^{2}) taken by the dredge was estimated for each tow by dividing catch by swept area. The swept area was calculated by multiplying the dredge width with the tow length (each tow 165 m^2).

The dry dredge efficiency was calculated directly with the equations:

Efficiency = (Ca/Tr+Ca) x 100
Efficiency = (Ca/control) x 100

where Ca is the weight of ocean quahog caught by the dredge from each m^2, Tr the weight left in dredge track estimated from diver samples and control is the abundance in the undredged seabed.

Size compositions of clams collected by the diver (corers) were compared with those from the dredge catch to further investigate the selectivity of the dry dredge. Corer samples were used for estimating dredge efficiency followed by survey tows in the same area. Considering only ocean quahog available to the fishery, the ratio of densities measured by the dredge tows divided by corer densities is an estimate of survey dredge efficiency. A modified version of Millars´s (1992) SELECT model was used to estimate the capture efficiency and the size selectivity for the experimental dredge simultaneously. For description and parameter estimation see Thorarinsdóttir et al. (2010).

The number of ocean quahogs with damaged shells in the catch and in experimental plots was recorded. Shells that were fractured but otherwise remained intact were both measured and weighed. Shells with parts of one valve broken off were measured but not weighed while those with both valves broken were only counted. The number of clams too damaged to be measured, was very low (<1%) and these were excluded from the analysis. On the average, 4 % of shells were damaged during sampling.

3.1. Size frequency distributions

Based on the diver samples, ocean quahog of 50-60 mm shell length (SL) were most common in the population in Thistilfjördur (Fig. 4 and 5). The mean SL in the population was 55.2 mm, ranging from 51-57 mm in the experiments. The smallest clams present in the subsamples were 15-22 mm and the biggest 92-99 mm (Table 1).

A cumulative size frequency distributions and a Kolmogorov-Smirnov test were used to test the null hypothesis that the size frequency distributions from subsamples during the three tows (the catch) were the same (Zar 1999). The null hypothesis was accepted as the results indicated no difference in selectivity between the three tows, (p=0.76 (tow 1 and 2), p=0.96 (tow 1 and 3), p=0.96 (tow 2 and 3).

Shell length data from the dry dredge (catch) and diver samples (control) (Fig. 5, all experiments together) indicated that the dredge size selectivity was rather flat, as there was not a significant difference between the proportion of

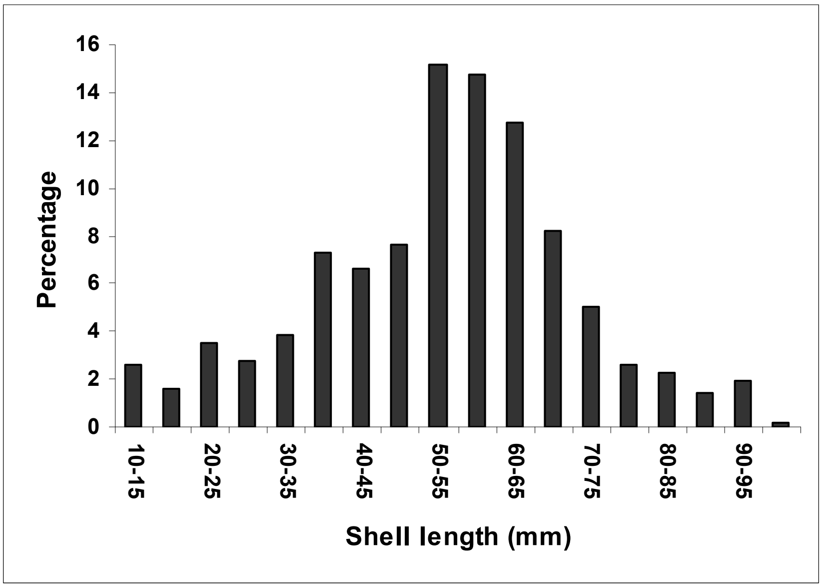

Figure 4. Size frequency distribution of ocean quahog from all subsamples (controls, tracks and catches, n= 575) taken during the survey

Mynd 4. Stærðardreifing allra mældra kúfskelja (ósnert svæði, plógfar og afli, n=575).

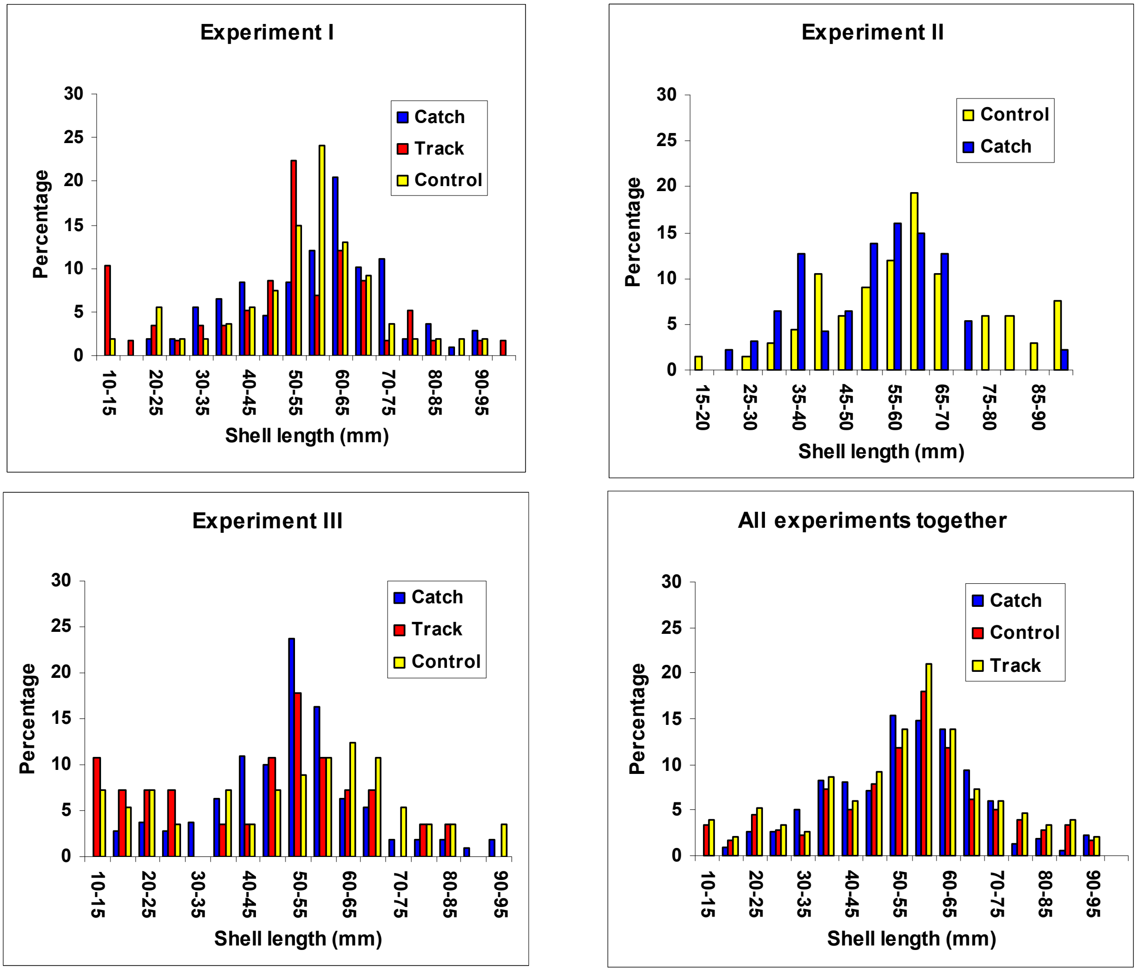

Figure 5. The size frequency distributions of the ocean quahog populations investigated in each comparative experiment are shown together with the proportion caught by the dry dredge and the clams left in the track.

Mynd 5. Stærðardreifing í kúfskeljastofninum á 3 rannsóknarsvæðum ásamt hlutfalli veiddra skelja og þeirra sem eftir voru í plógfari

all shell lengths in the population and in the catch (Kolmogorov-Smirnov test: p=0.853).

3.2 Proportion of damaged shells

The mean proportion of damaged shells in the dredge catch was 13.3% (range: 10-17% (Table 1). The proportion of ocean quahog with damaged shells in two of the tracks was 7.5 and 31 %, respectively (Table 1).

3.3. Capture efficiency and size selectivity of the dredge

3.3.1 Capture efficiency; The direct method

Based on the direct method the efficiency by weight was estimated on an average 16% (range 7-25%) when using abundance in catch/ abundance in control and 27% (range 14-40%)

Table 1. Mean shell length (± SD) of ocean quahog and size range in the catch, track left by the dredge and from undredged seabed. The proportion of damaged shells in catch and track are also given.

Tafla 1. Meðalskellengd (± SD) og lengdarsvið kúfskelja i afla, plógfari og ósnertum botni, ásamt hlutfalli brotinna skelja í afla og plógfari.

	Dredge catch				**Track**		**Undredged seabed**	
	Mean size (± SD) mm	Size range mm	Damage %	Mean size (± SD) mm	Size range mm	Damage %	Mean size (± SD) mm	Size range mm
Exp. 1	57.1 (± 15.4)	21-92	10	51.1 (± 20.0)	10-101	7	54.3 (±15.4)	14-90
Exp. 2	53.1 (± 14.7)	15-99	17				59.9 (± 17.2)	15-93
Exp. 3	51,3 (± 15.1)	16-93	13	44.4 (± 21)	11-84	31	50.5 (± 21.6)	10-94
Mean	53.8 (± 15.2)	15-99	13.3	48.9 (± 20.6)	10-101	18.7	55.2 (± 18.6)	10-94

Table 2. The mean efficiency of clam dredge for direct methods based on weight caught. Number of samples, plots and the mean biomass (kg/m^2) of ocean quahog in the track, undredged seabed (control) and in the catch is shown.

Tafla 2. Meðal veiðihæfni tannplógs eftir "direct" aðferð miðað við vigt veiddra skelja. Fjöldi sýna og meðal lífþyngd (kg/m^2) í plógfari,

	Nr.samples						Mean efficiency (E)	
	(plots/tows)			Mean biomass kg/m^2			(Catch/control) x 100	(Catch/catch+track) x 100
	Track	Control	Catch	Track	Control	Catch	By weight	By weight*
Exp.1	4	4	1	2.5	2.5	0.4	16	14
Exp.2	0	4	1		4,4	0.3	7	
Exp.3	4	4	1	0,9	2,4	0.6	25	40
Mean				1.7	3.1	0.4	16	27

using abundance in catch/abundance in catch+ track (Table 2). The dredge track nr. 2 was lost and not sampled by the divers.

3.3.2 Capture efficiency SELECT models

Capture efficiency curves for the dredge as a function of shell length were estimated for the three experiments combined using Millar (1992) maximum likelihood SELECT method (Fig. 6; the y-axis shows the ratio of density in the dry dredge/density in the dry dredge + density from the control). The relationship between shell length and meat weight $W=0.0567L^{3.08}$ (where W is meat weight in mg) was used (Thorarinsdóttir & Jóhannesson 1996).

The efficiency increased up to 50 mm shell length reaching 70% and decreased after that. Fifty percent probability of being caught was at 25 mm SL (L50=25 mm SL).

3.3.3 Selectivity: SELECT models: Logistic and constant selectivity curves

Selectivity curves for the fishery as a function of shell length were estimated for the three experiments combined using Millar (1992) maximum likelihood SELECT method (Fig. 7; the y-axis shows the ratio of counts in the dry dredge/count in the dry dredge + count from the suction sampling). Maximum selectivity was reached at 1. The selectivity may increase with size for ocean quahog < 40 mm and declining after 60 mm SL was reached. However, the evidence isn't strong because the sample sizes for quahog <25 mm and >70 mm SL are small. This model does not handle decreasing selectivity patterns.

A formal statistical analysis was carried out to see if the logistic selectivity curve is better than the constant (flat) selectivity curve. The

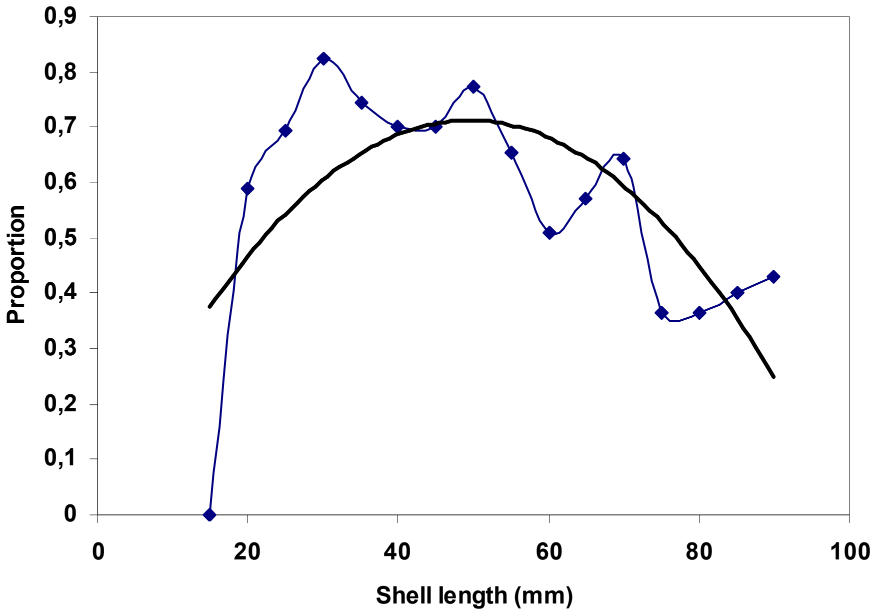

Figure. 6. The estimated efficiency for the dry dredge in catching ocean quahog (all three experiments) from the SELECT model (black line) and the data (dots).

Mynd 6. Veiðihæfni plógs samlvæmt SELECT líkani (heil lína) og niðurstöður (punktar)

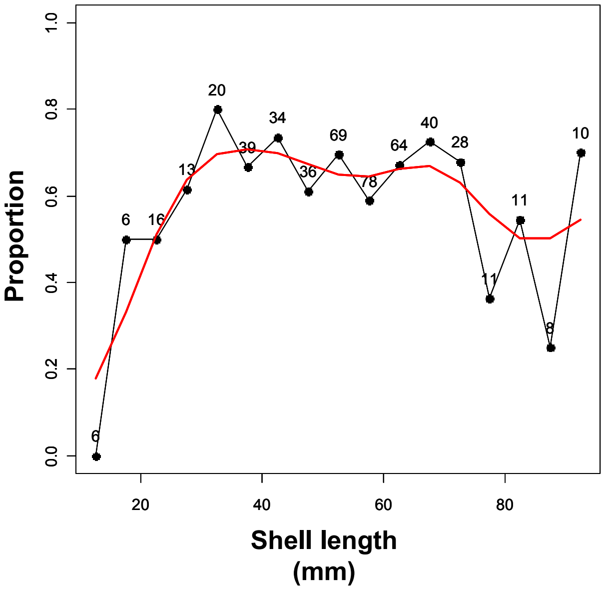

Figure. 7. The selectivity curve for the dry dredge in catching ocean quahog (all three experiments). The red line is a GAM version of SELECT model and the dots indicate the data. The sample size for each point is given.

Mynd 7. Stærðarval plógs samkvæmt SELECT líkani (rauð lína) og niðurstöður (punkta lína) . Tölurnar sýna fjölda skelja á bak við hvern punkt.

logistic selectivity curve was fitted as a generalized additive model. The statistical analysis indicated that the flat selectivity model was better statistically than the logistic selectivity model (t-test, p=0.846). This doesn't necessarily mean that selectivity is flat, only that there is not enough data to justify the logistic curve over the flat one.

However, the data seemed to suggest that selectivity declines with size for quahog >60 mm SL. The proportions in the dredge are low for the 77.5, 82.5 and 92.5 mm size groups but the sample sizes are also low. Selectivity could decline if the dry dredge does not catch large quahog as well as it catches medium size ones.

3.3.4 Mixed effects models

The capture efficiency of the dry dredge relative to diver samples collected from the control was estimated. To calculate confidence intervals a beta-binomial model was used to fit the data (Miller et al. 2009). The three dredge tows and their associated diver samples were treated as replicates. Calculations were carried out using 5 and 10 mm shell length intervals. The model analyzes each size interval independently and can be used to see if the data suggest an underlying size selectivity pattern. The results did not indicate a clear size selectivity pattern because the confidence intervals were wide and broadly overlapping (Fig. 8; the y-axis shows the ratio of catch in the dry dredge/control). Furthermore, the number of replicates (n=3) and ability of the model to precisely estimate relative capture efficiency were low.

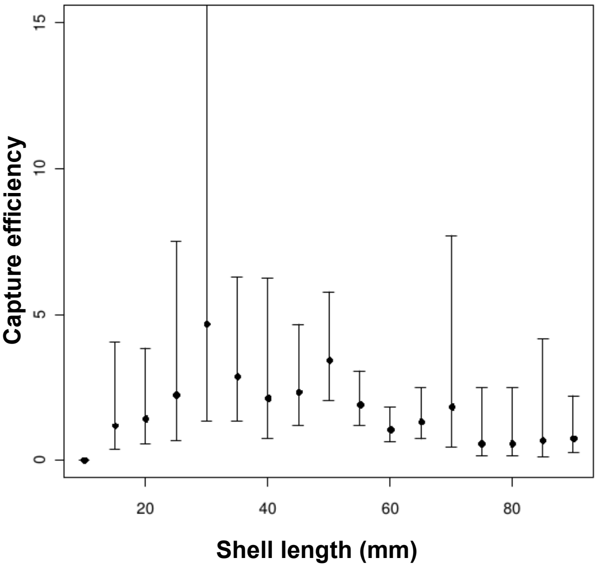

Figure 8. Relative capture efficiency of dry dredge in catching ocean quahog. Shown for each length class and confidence interval for all three experiments combined.

Mynd 8. Veiðihæfni plógs og öryggismörk, við mismunandi skellengdir. Gögn úr öllum þremur tilraunununum.

3.3.5 A Spline model

A Spline was fitted to the data as the logistic selectivity model used does not handle decreasing selectivity patterns. The Spline is a very flexible model that will basically just try to follow the data and has no predictive power. In contrast, the logistic model and flat models are rigid because they look at the data in just one way.

The Spline curve showed a dome shaped pattern with size based selectivity increasing up to about 40 mm SL and declining afterwards (Fig. 9). The confidence interval was wide for small and large sizes suggesting that the fit is imprecise for small and large quahog, making it uncertain how much the curve really changes (Fig. 9). However, the Spline dome shaped model is significantly better than the constant selectivity model (ANOVA, p=0.001).

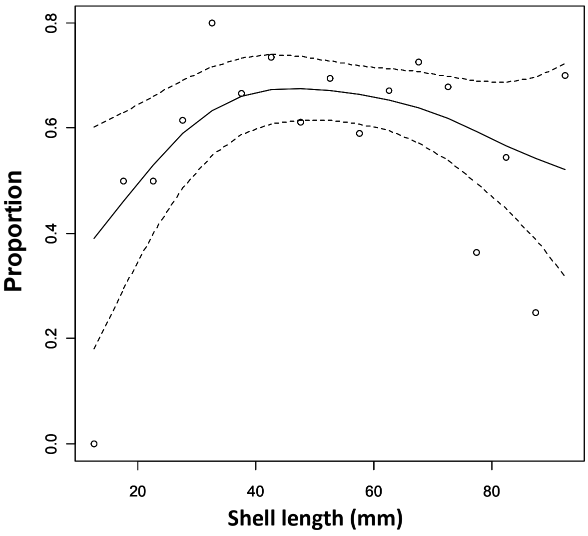

Figure 9. Size based selectivity of the dry dredge (all three experiments combined) and 95% confidence interval using Spline model.

Mynd 9. Stærðarval plógs (allar 3 tilraunir til samans) og 95% öryggismörk samkvæmt Spline líkani

3.3.6 Generalized additive models for each experiment

To determine if the results for individual experiments were consistent and suggested the same type of selectivity pattern, graphical analysis and generalized additive models were used. The proportion of the total catch in the dredge was plotted against shell length for each experiment.

Three generalized additive models were fitted to the data for each experiment assuming that the observed proportions were from binomial distributions with expected values given by the model and conditioned on the observed sample size. Model 1 assumed no relationship between the proportions and shell length (constant). Model 2 was a logistic pattern (increasing or decreasing). Model 3 was a flexible pattern determined by an estimated Spline.

The results indicate that the selectivity declined with size for two out of three experiments. Based on the AIC (Akaike information criterion) statistic, the best model for experiment 1 and 2 was a declining logistic pattern while the best model for experiment 3 was no relationship between selectivity and shell length (flat) (Fig.10).

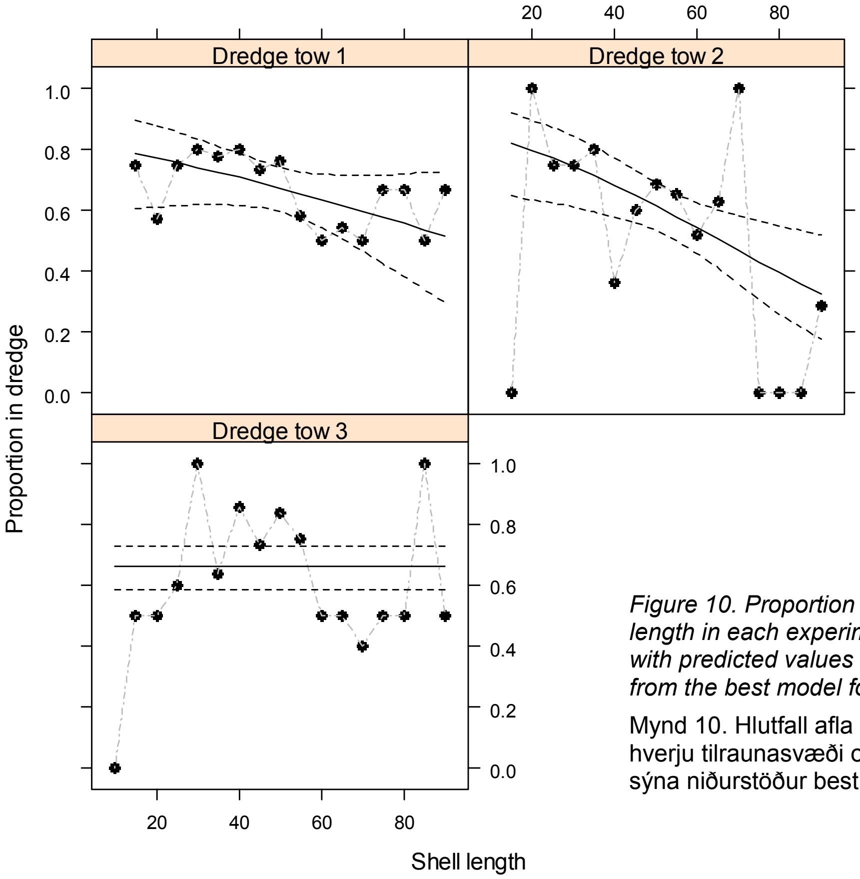

Figure 10. Proportion of total catch in dredge at shell length in each experiment (tow). The data are plotted with predicted values and 95% confidence intervals from the best model for each experiment.

Mynd 10. Hlutfall afla í plógi við ákveðna skellengd á hverju tilraunasvæði og 95% öryggismörk Myndirnar sýna niðurstöður bestu líkana fyrir hverja tilraun.

4 DISCUSSION

In the present study a direct method (based on weight) was used to estimate the efficiency of a dry ocean quahog dredge and mixed-effects SELECT models to estimate efficiency and selectivity. The direct method resulted in 16% and 27% overall efficiency, depending on using catch as a percentage of control or as a percentage of catch+what was left by the dredge in the track. This difference might be explained by the patchy distribution of ocean quahog and the fact that the divers surveyed only about 4% of the tracks. If by change the divers focused on low-density patches of clams, this could have elevated efficiency estimates. Diver surveys are generally thought to be close to 100% efficient for surveying bivalve populations (Mason et al. 1979, Coleman 1998) although very small individuals may be missed resulting in overestimates of the efficiency for these size classes. The model based relative capture efficiency was very low or from 1-5% depending on the size classes. The confidence intervals were wide and broadly overlapping making these results uncertain.

The efficiency of the dry dredge in the present study was headed against smaller individuals as L_{50}=25 mm SL. The efficiency increased up to 50 mm SL, decreasing after that. The efficiency of the hydraulic dredge used in the Icelandic fishery has been estimated by the SELECT model to be 92% for large clams, L_{50}=70 mm SL; in the same area as the present study was conducted (Thorarinsdóttir et al. 2010).

In the present study the ocean quahog size selectivity of the dry dredge was difficult to estimate precisely because of sparse data. Various methods were used. The selectivity curve for all three experiments combined, suggested that selectivity may increase with size for ocean quahog < 40 mm declining again with size > 60 mm SL, indicating that the dredge is mainly catching medium sized clams. However, the evidence isn't strong because the sample sizes for quahog < 25 mm and > 50 SL are small. Selectivity could decline if the dry dredge does not catch large quahog as effectively as it catches medium size, because they might lay deeper in the sediment (Taylor 1996, Strahl et al. 2011) and/or are too heavy to be picked up by the dredge. However, a constant selectivity curve (flat) was considered better than the logistic one. As the logistic selectivity curve did not handle the sparse data, a Spline model was used. This model follows the data and showed a dome shaped pattern with selectivity increasing up to about 40 mm and declining afterwards. Again, the confidence interval was wide for small and large sizes, suggesting that the fit is imprecise for these size classes making it uncertain how much the curve really changes. However, the Spline (dome shaped pattern) was statistically better than the constant selectivity.

When looking at each experiment separately the efficiency and selectivity of the dredge was the same when size distribution curves were compared by Kolmogorov-Smirnov test. However, models used on these data showed different results, as experiment 1 and 2 were best fitted as declining selectivity curves but experiment 3 as a flat curve. This difference indicates the weakness of the data which could reflect the patchiness of the clam population and sampling, as mentioned before.

Various methods are used to estimate dredge efficiency and selectivity and all have certain advantages and disadvantages. Estimates of capture efficiency for dredges used to harvest infaunal bivalves can be obtained by comparing unbiased samples of the population from undisturbed sediments (or catch and what is left in the track) to catches in the same area using the dredge (direct methods) (Caddy, 1968, Mason et al. 1979, Fifas 1991, Powell, et al. 2007). Capture efficiency for dry dredges has been estimated by this method for a number of bottom-dwelling commercial bivalves, primarily scallops with varying results (Mason et al. 1979, Fifas & Berthou 1999, Rudders et al. 2000, Beukers-Stewart et al. 2001). This method has also been used for a dry dredge catching ocean quahog depending on number caught, giving the efficiency < 1% on sand bottom (Medcof & Caddy 1971).

Model based estimates from depletion studies with dry dredges catching ocean quahog off the US coast have been used to assess the efficiency. These studies indicated an average capture efficiency for fully recruited ocean quahog 2-17% (MEDMR 2003) and 16% (NEFSC 2007) depending on the years investigated. Using a corer method followed by dredging, the efficiency was estimated to be 18% (NEFSC 2009). However, the dredges used in the US fisheries are bigger and heavier than the one used in the present study, different in design and working in deeper water, which might influence the efficiency.

A considerable proportion of clams both in the track (mean 18.7%) and catch (mean 13.3%) were found to be damaged by the dredge. While shells of some individuals were completely broken, others suffered only cracks in the shells. It is likely that a large proportion of the ocean quahog that suffer shell damage die soon afterwards. However, the damage caused by the dry dredge was less than caused by the hydraulic dredge that has been used for fishing ocean quahog in Icelandic waters (25 - 50% in catch and 16-18% in track, Thorarinsdóttir unpublished data). In an investigation on a sand bottom, Medcof & Caddy (1971) found the breakage rate of 50% in cathes and 80% in dredge tracks when investigating a dry dredge.

Ocean quahog remaining in sediments may be damaged or broken by direct contact with the gear (Rumohr & Krost 1991, Witbaard & Klein 1994) and subsequently become easily accessible to predators (Arntz & Weber 1972). In Thistilfjördur, considerable amount of cod is caught each year and fishermen claim that in a short time after dredging for ocean quahog cod accumulate in the dredge tracks and feeds on broken clams. The proportion of broken shells caused by dredging is different between size classes (Moschino et al. 2003) and larger-sized species as ocean quahog are vulnerable to shell damage by dredges (Tuck et al. 2000).

Ocean quahog is relatively slow growing and very long lived species, making them sensitive to overharvest. It is therefore very important to know the capture efficiency and size selectivity of the gear used in the fishery as well as the total mortality due to the fisheries. Results of the present study indicate that capture efficiency of the dry dredge is rather low, however depending on methods used. It was difficult to get reliable selectivity estimates because of too sparse data for the models. One might however, conclude, when all methods and factors are involved, that the selectivity follows a dome shape pattern with highest efficiency and selectivity for the middle sized classes (40-50 mm).

5 ACKNOWLEDGEMENTS

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