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Project Title: **WESTERN GULF OF MAINE WHITING FISHERY: DOCUMENTATION OF CATCH AND BYCATCH AND REDUCTION OF BYCATCH THROUGH GEAR DEVELOPMENT**

Period Covered: **03/01/96 – 12/31/99**

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Western Gulf of Maine Whiting Fishery. Documentation of Catch and Bycatch and Reduction of Bycatch through Gear Development.

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II. Abstract:

Characterization of the coastal Maine experimental whiting (silver hake) grate fishery through sea sampling between 1996 and 1999 has shown a bycatch level of ADF regulated species to be almost universally less than the 5% maximum established by the NEFMC. Sea sampling efforts were hindered by a decreasing and volatile fishery. Gear development efforts to reduce the bycatch of regulated species and then to increase the size at first capture through larger mesh resulted in the cooperative testing of several bar spacings in a whiting grate and several cod end meshes in combination with the grates. Raised footrope trawls were also tested with the best bar space/cod end mesh combinations and were found to reduce bycatch beyond what the best bar space/cod end combination net would do. Improvement in this gear is an ongoing process.

III. Executive Summary: A brief and succinct summary of Final Report.

Characterization of the coastal Maine experimental whiting (silver hake) grate fishery through sea sampling between 1996 and 1999 has shown a bycatch level of ADF regulated species to be almost universally less than the 5% maximum established by the NEFMC. The grate used has a 40 mm bar spacing and the nets have a 1-3/4 inch diamond mesh cod ends. Sea sampling efforts were hindered by a decreasing and volatile fishery and the results and problems are detailed. Gear development efforts to reduce the bycatch of regulated species and then to increase the size at first capture through larger mesh resulted in the cooperative testing with industry of several bar spacings in a whiting grate and several cod end meshes in combination with the grates. The bar spacings were 50 mm, 63 mm and 70 mm and the cod end meshes were 2-1/4 inch diamond, 2-1/2 inch diamond, 2.6 inch diamond and 2.2 inch square mesh. The best bar space and cod end mesh combinations were with the 50 mm bar space and the 2.6 in diamond and 2.2 inch square mesh cod ends. Raised footrope trawls with both 30 inch and 42 inch dropper chain lengths were tested with the best bar space/cod end mesh combinations and were found to reduce bycatch beyond what the best bar space/cod end combination net would do. Improvement in this gear is an ongoing process.

IV. Purpose

a. Detailed description of problem or impediment of fishing industry that was addressed.

The specific problem(s) that the proposed project dealt with are the incomplete characterization of the near-shore western Gulf of Maine whiting fishery and the inadvertent capture and subsequent mortality of groundfish and shrimp in the whiting fishery. Fishermen claim that the western Gulf of Maine whiting stock exhibits a slower growth rate than more southern components of the stock and thus the fishery here should be subject to different regulations in terms of mesh size, minimum legal size of fish, etc. They further claim that the fishery is a relatively clean one with minimal bycatch of regulated species, lobsters, etc. These two claims are the basis for an industry request to allow the fishery to continue in light of recent groundfish regulations requiring proof of less than 5% bycatch of regulated species. These are also the basis for industry claims that minimum mesh of 3" and/or minimum legal size of 10" are too restrictive and not applicable to the whiting fishery in the western Gulf of Maine. This project documents the catch, bycatch and discard in this fishery to provide evidence upon which to base decisions concerning this fishery. The project also cooperated with fisherman in size selectivity and bycatch reduction efforts to produce a low-bycatch, high quality product fishery.

The New England whiting fishery harvests fish from two stocks, one located in the Southern Georges Bank/Southern New England/Mid-Atlantic region, and the other in the Northern Georges Bank/Gulf of Maine region, although there is some question now about the independence of these stocks (Anthony, 1993; Helser and Mayo, 1994). The Northern Georges Bank/Gulf of Maine stock appears to be increasing in size, although this may be the result of migration from the southern stocks. The Gulf of Maine/Northern Georges Bank fishery peaked in 1964 at over 90,000 MT and subsequently fell to a low of less than 5,000 MT in 1979 (NMFS, 1993). The fishery has fluctuated between 5,000 and 8,000 MT ever since with the majority of the landings coming from Georges Bank (Figure 1). A coastal Gulf of Maine whiting fishery has existed off and on at low levels from the mid-70's until 1994, when whiting was again targeted by a few vessels and upwards of 600 MT were harvested in the summer and fall of 1994.

At the outset of this project, there were no regulations limiting the whiting fishery and it was controlled by availability and market price for the product compared to other species. The whiting fishery employs mesh sizes down to shrimp mesh (1-3/4") and thus may impact groundfish and shrimp resources based upon availability of those resources to the gear. When whiting are abundant in any particular area, they tend to exclude other species, thus at times the whiting fishery can be a very clean fishery, but this is not universally true.

Much work has been done in recent years to reduce the bycatch/discard in the Northwest Atlantic whiting fishery. DeAlteris and his lab at URI have looked at whiting survival after escaping through the mesh and whiting behavior in the net. They are currently looking at flatfish reaction to interruptions in ground gear and large mesh panels in the lower belly. Bob Bruce, of the Massachusetts Div. Mar. Fisheries has

designed and tested a net that fishes clean by using long dropper chains to raise the fishing wire off the bottom. Arnold Carr of MA DMF has worked in conjunction with DeAlteris and is currently working with Captain Amaru on a whiting grate. Captain McPhelim and Schick conducted preliminary trials on a whiting grate in 1995. Cooper (1992) has conducted gear trials on a whiting grate off Nova Scotia and the grate is now mandatory there. An NEFMC whiting plan is nearing completion that may call for 3" minimum mesh size to protect whiting smaller than 10", the minimum length for a sexually mature female whiting in the Gulf of Maine-Northern Georges Bank stock. Several net modifications are recognized as being cleaner, such as shorter, bare wire ground wires between the net and doors, long dropper chains between the fishing wire and the roller frame, square mesh in the cod end, etc. At present, there are no net restrictions in place to mandate these modifications.

b. Objectives of the project.

The project was designed to document the catch of whiting (silver hake, Merluccius bilinearis) in the nearshore western Gulf of Maine summer fishery, document the bycatch of juvenile whiting and regulated species, and research means of reducing this bycatch through gear modification trials with industry participation.

V. Approach

a. Detailed description of the work that was performed.

This project spans a period of almost four years, from March 1, 1996 through December 31, 1999. The work performed involves two major elements, sea sampling the commercial fishery and gear trials for improved size selectivity of silver hake and reduction of bycatch. Each of these elements will be reported as a cohesive unit over time.

Sea sampling was to follow NMFS sea sampling protocol, so sea sampled trips could be entered into the same data base.

Sea sampling of the commercial catch started in May, 1996 and continued as possible, given the sporadic nature of the fishery, through September, 1999. Initially, sea samplers were to be fishermen retrained for sea sampling in the northeast fisheries. Three fishermen were recruited and trained through the Manomet Observatory/NMFS training program, but it didn't work out very well. Consequently, Manomet Observatory was contracted, through competitive bidding, to do the sea sampling for the 1996, 1997 and 1998 seasons and Northeast Ecological Associates was similarly contracted to do the sea sampling in 1999.

In 1996, the agreement was to conduct 66 sea sample trips and to concentrate on the whiting for food fishery. The target sampling design was: June - 8 trips, July - 10 trips, August - 13 trips, September - 13 trips, October - 13 trips, November - 9 trips. In 1997, the contract was for 18 sea sample trips again concentrating on the whiting for food fishery. Sampling trips were assigned according to the results from 1996 sampling. These were: August, 4 trips, September, 4 trips, October, 5 trips and November, 5 trips.. In 1998, the contract was for 30 sea sample trips and the trips were to be spread over the for food fishery, the tuna bait fishery and the lobster bait fishery. Similarly, in 1999, the

contract was for 43 sea sample trips spread over these three fisheries with the trips apportioned between months and fishing permit types according to the schedule: July, 6; August, 13; September, 12; October, 8; November, 4 with weighting of trips towards the food and landed bait permits.

Gear Development: Initial rfp in 1996 was for industry-initiated research proposals. An industry-based review board was appointed and the proposals were judged and grants were awarded to 5 projects. A second rfp was submitted in 1996 and two more proposals were accepted for funding. Timing became short in 1996 and all but two of the grants were delayed until summer, 1997. As no fishery developed in 1997, the fishers were reluctant to do the work as they would not make any money at it. In 1998, the fishers with the remaining gear grants decided not to remain involved as there was again no sign of any concentration of whiting and the market was very volatile.

Preparation for the 1998 gear research included a shift from fishermen-initiated gear research to developing a research agenda based on recent history of small mesh gear research in northeast and putting out an RFP for vessel services for getting that work done. An RFP was submitted, vessel owners responded and the vessels were selected in early fall, but the gear didn't arrive until too late, so research put off until summer, 1999. The work was completed in the early fall of 1999.

The work was a combination of work funded by FIG and work funded by the Maine Fishing Industry Development Corporation (MFIDC). Several cod end meshes and bar space combinations were tested and then two of them were used with a raised footrope net with dropper chain lengths of 30 inches and 42 inches. Specifically, the testing evaluated seven different combinations of codend mesh size, bar spacing and raised footrope modifications: Grate bar spacings of 50mm (2") = G1 & 63.5mm (2 ½") = G2; cod end mesh sizes of 56mm (2 ¼") diamond = CE1, 63.5mm (2 ½") diamond = CE2, 44.5mm (1 ¾") diamond = CE3 and 55 mm (2 ¼") square = CE4; raised footrope w/chain and 42" dropper chains (F1); raised footrope w/roller frame and 42" dropper chains (F2) and raised footrope w/roller frame and 30" dropper chains (F3). These treatments were compared against the traditional 44.5mm (1 ¾") shrimp trawl with no grate (C1) and against the current whiting gear, 1 ¾" codend mesh with a 40 mm bar space grate (C2). See Table 1 for the tow schedule.

b. Project management: List individuals and/or organizations actually performing the work and how it was done.

Dan Schick and Mike Brown were the two DMR scientists involved in the research. Dennis Frappier of the Portland Fish Exchange was a collaborator as the Exchange was interested in promoting the alternative fishery. Wendi White took over for Dennis as Executive Director of the PFE in 1998 and assisted with the project. Manomet Observatory and Northeast Ecological Associates were contractors for doing the sea sampling of the commercial fishery and doing sea sampling support of the gear research efforts. Fishermen that responded to the RFP's for conducting their own research with our help and that were selected for funding were Proctor Wells(2), Kevin McPhelim(2), Tim Larochelle(1), Richard Webber(2). The one fisherman that completed his research was Proctor Wells. Fishermen that answered the RFP for supporting the DMR-designed gear work and were selected were Marshall Alexander and Jerry Balzano.

In 1996, samples of whiting from the sea sampling trips were measured for length, weight and sexual maturity stage and the otoliths removed for age determination. In January, 1997, the otoliths were mounted and cut in preparation for age determination using several techniques, including electron microscopy. The sea sampling data will be plotted by location caught by season using GIS techniques. Sections from the whiting otoliths from the 1996 sea sampling trips have been etched and photographed. Over 190 otoliths from the 1996 sea sampling have been sectioned and aged. This data has been compared with similar data from NMFS cruises. The age data has been classified and organized by sex, maturity stage, length and age.

VI. Findings

a. Actual accomplishments and findings.

Sea Sampling findings: The majority of the Maine whiting fishery takes place in Area 513. The landings in that area from VTR records, show a greatly diminished fishery after 1996 (Table 2). The sea sampling efforts between 1996 and 1999 reflect that decline in the fishery. In 1996, there were 32 trips made. The results in catch, bycatch of regulated species and percent bycatch of regulated species showed that all five sampled months had rates under 5% (Table 3, Figure 1). The catch by species by month showed shifts in catch as the areas fished changed with season (Table 4, Figure 2). In 1998, there were 11 trips made and the percent bycatch of regulated species data are shown by tow (Table 5). While one tow showed a % bycatch rate over 5%, that was due to a very low total catch weight, not an excessive catch of regulated species. All the other tows were under 5%. In 1999, there were 11 trips made and all tows showed a less than 5% catch of regulated species (Table 6).

Gear Development: In 1996, an RFP was published requesting fishermen to send in their ideas for gear research in the coastal Maine whiting fishery. The gear would be built, the testing would be done by scientific design and sea samplers would be on board to aid in the sampling. Of the respondees, 5 projects were selected by a board of referees selected from the industry. Of these, two were completed and one was started. A second RFP produced another pair of experiments, but this was started too late in the season to complete. The fishery fell apart in 1997 and 1998 and the fisherman finally declined to continue trying to do the work.

The first experiment was a test of a 50 mm bar space grate with a 2-1/2 inch cod end against a 40 mm bar space grate with a 1-3/4 inch cod end. The results showed a slightly lower catch of whiting and total catch and a slightly elevated catch of regulated species (Figure 3). The catch by species showed elevate catches of American plaice and white hake for the larger bar spacing/cod end mesh combination (Figure 4).

The second experiment was a test of a modified chain sweep against a control. The only difference between the nets was that the chain sweep was looped onto the footrope in the control and the loops were cut free at one end and allowed to dangle in the modified version. The results showed slight elevations in regulated species and in whiting, but a slight decline in overall catch, but probably no real difference between the two pieces of gear (Figure 3). The catch by species showed a slight increase in catch of white hake with the modified sweep (Figure 5).

The third experiment was a test of a 70 mm bar space grate with a 1-3/4 inch cod end using a net with a 40 mm grate and a 1-3/4 inch cod end as a control. The overall results for the few paired tows made showed a decrease in bycatch of regulated species, a decrease in whiting catch and an increase in catch of unregulated species in the 70 mm bar space net (Figure 3). The catch by species showed declines in catch of American plaice and white hake (Figure 6). The length frequency of whiting showed a decrease in the catch of small whiting with the experimental grate and an increase in larger whiting (Figure 7).

In 1998, after futile efforts to finish the initial projects, the focus shifted to organizing a series of experiments that were deemed useful in furthering the knowledge of whether a larger bar space/cod end mesh combination would be useful and whether a raised footrope in addition to the bar space/cod end mesh combination would help reduce bycatch of regulated species. Part of the driving forces for this shift was the implementation of a whiting management plan that discouraged the harvesting of small fish by establishing severe landings limits on vessels using small mesh in the cod end. Another driver was the loss of the Spanish market for small fish such that the landed price for whiting became very volatile and unpredictable. The gear tested reflects the need to target a larger whiting and to try to reduce bycatch even further as decreased catch weights of whiting due to the release of the prevalent smaller fish tends to increase the percent catch of regulated species.

The results of the trials of the 2.6 inch diamond mesh cod end, 2.25 diamond mesh cod end, 2.2 inch square mesh cod end, the 2.5 inch bar space grate, the 2 inch bar space grate and the 30 inch and 42 inch dropper lengths in the raised footrope trials are presented in the final report to the MFIDC as the various parts of the study were inextricably intertwined and the results could not be reported separately. The MFIDC final report is appended to this report and should be considered as an integral part of this final report to FIG (Appendix A).

b. If significant problems developed which resulted in less than satisfactory or negative results, they should be discussed.

The single salient factor that acted as a major impediment to the timely completion of this project was the lack of any appreciable body of fish to catch. The Spanish market for 8 to 10 inch whiting started to provide a steadier market price for a size whiting readily available along the south-central Maine coast in 1994 – 1995. A whiting grate fishery was proposed and funding was obtained through the NMFS FIG program to develop a grate net appropriate for retaining the small whiting and releasing regulated species bycatch. In 1996 a reasonable fishery occurred that was much smaller than the two previous years and sea sampling and gear testing were done, but not completed. The fish, the market price and thus the fishery hit rock bottom in 1997 and again in 1998, making it very difficult to find vessels to sea sample, or to participate in the gear work. During this time, the fishery that did endure was the bait fishery, supplying fish for the bluefin tuna and lobster fisheries during the summer and early fall. With the recognized need for the continuation of this fishery, albeit a different fishery from the originally intended fishery, the sea sampling and gear work shifted to address this fishery's needs. The sea sampling and gear development work proceeded during the

summer and eary fall of 1999, completing the requirements of this project, but leaving some only partially answered questions.

c. Description of need, if any, for additional work.

The Department of Marine Resources will continue to conduct gear/selectivity studies in the whiting trawl fishery to complete the development of a whiting net that can be fished in the Gulf of Maine successfully meeting the conservation needs of the whiting resource and maintaining acceptably low bycatch levels. The objectives towards this goal are: i. To test 2-1/2" diamond mesh and 2-1/4" square mesh cod ends with a 50 mm bar space grate for whiting selectivity and bycatch reduction. ii. To test a raised footrope with 42" dropper chains between the footrope and roller frame in combination with the cod end/bar spacing above. iii. To obtain good video footage of the interaction between the gear and fish and the gear and the bottom. iv. To sea trial the best combination with several fishers to generate feedback as to the gear's behavior under commercial conditions. v. To gain acquaintance with and acceptance of the gear within the whiting fishing community.

This research will build on preliminary work conducted by DMR, the Massachusetts Division of Marine Fisheries and the Manomet Marine Program. This work is of particular interest as the whiting fishery is caught between the need to conserve small whiting to meet the objectives of a whiting management plan and the need to keep the bycatch of groundfish under 5% by weight. To date, the catch of small whiting has been reduced faster than the bycatch of groundfish, creating a higher percent bycatch of groundfish.

VII. Evaluation: Describe the extent to which the project goals and objectives were attained.

The initial goals and objectives of the project had to be reassessed over the four year duration of the project as the structure of the fishery and the demands for the focus of the research changed. The initial focus was to develop a fishery that was clean with respect to bycatch and targeted small to medium sized whiting. As the market for that size fish disappeared and new regulations came into place encouraging the harvest of larger fish, the gear designs initially considered for testing were modified to retarget the gear onto larger fish. Opening the gear up so that it could capture larger fish and release the smaller fish meant that the bulk of fish available to the trawl would escape the net, leaving a much smaller overall catch. While this is good, the ability of the gear to release regulated species became more important as the gear is judged on the percentage of bycatch relative to the total catch. Thus the bycatch must decrease as the total catch decreases in order to maintain the same percent bycatch. This is not easy. Where the initial gear, 40 mm bar space grate and 1-3/4 inch cod end consistently caught less than 5% bycatch, the newer gear, while catching less bycatch, is catching a higher percent bycatch as the small fish are allowed to escape the net. Thus establishing a whiting fishery that meets the whiting size requirements and also meets the percent bycatch of regulated species requirements is a work in progress. We are fishing with much cleaner gear, but have not achieved less than 5% bycatch of regulated species.

Table 1: Tow Schedule for Whiting Size Selectivity/Raised Footrope Research.

Vessel 1	Vessel 2
Expt. 1. 50mm Grate w/56mm Cod End vs 2 controls	
G1CE1	C2
G1CE1	C1
G1CE1	C1
G1CE1	C2
G1CE1	C2
C1	G1CE1
C1	G1CE1
C2	G1CE1
C2	G1CE1
C1	G1CE1
Expt. 2. 63.5mm Grate w/63.5 mm Cod End vs 2 controls	
G2CE2	C2
G2CE2	C1
G2CE2	C1
G2CE2	C2
G2CE2	C2
C1	G2CE2
C1	G2CE2
C2	G2CE2
C2	G2CE2
C1	G2CE2
Expt. 3. 50mm and 63.5mm Grates w/44.5mm Cod End vs control w/no grate	
G2CE3	C1
G1CE3	C1
G1CE3	C1
G2CE3	C1
G2CE3	C1
C1	G1CE3
C1	G1CE3
C1	G2CE3
C1	G2CE3
C1	G1CE3

Table 1: Tow Schedule for Whiting Size Selectivity/Raised Footrope Research, cont.

Vessel 1	Vessel 2
Expt. 4. 63.5 mm Grate w/55 mm square mesh Cod End vs 2 controls	
G2CE4	C2
G2CE4	C1
G2CE4	C1
G2CE4	C2
G2CE4	C2
C1	G2CE4
C1	G2CE4
C2	G2CE4
C2	G2CE4
C1	G2CE4
Expt. 5. Raised footrope w/roller sweep and 42" dropper chains & best grate/cod end and raised footrope w/rollersweep and 42" dropper chains & no grate/44.5mm Cod End vs control w/no grate.	
G?CE?F2	C1
CE3F2	C1
CE3F2	C1
G?CE?F2	C1
G?CE?F2	C1
C1	CE3F2
C1	CE3F2
C1	G?CE?F2
C1	G?CE?F2
C1	CE3F2
Expt. 6. Raised footrope w/roller sweep and 30" dropper chains & best grate/cod end and raised footrope w/ roller sweep and 30" dropper chains & no grate/44.5mm Cod End vs control w/no grate.	
G?CE?F3	C1
CE3F3	C1
CE3F3	C1
G?CE?F3	C1
G?CE?F3	C1
C1	CE3F3
C1	CE3F3
C1	G?CE?F3
C1	G?CE?F3
C1	CE3F3

Table 1: Tow Schedule for Whiting Size Selectivity/Raised Footrope Research, cont.

Gear to be tested:

Grate bar spacings:

G1 = 50mm (2"),

G2 = 63.5mm (2-1/2").

Cod end mesh sizes:

CE1 = 56mm (2-1/4") diamond,

CE2 = 63.5mm (2-1/2") diamond,

CE3 = 44.5mm (1-3/4") diamond,

CE4 = 55 mm (2-1/4") square.

Raised footrope w/chain sweep and 42" dropper chains (**F1**).

Raised footrope w/roller frame and 42" dropper chains (**F2**).

Raised footrope w/roller frame and 30" dropper chains (**F3**).

Control nets:

Shrimp mesh w/no grate (**C1**),

Shrimp mesh w/40mm grate (**C2**).

Table 2.

Whiting Landings in Maine from Area 513
From Vessel Trip Reports

	Landed	Discard	Total
1995	1703747	32262	1736009
1996	2320976	38335	2359311
1997	537703	55731	593434
1998	168833	26263	195096
1999	53465	32407	85872

Table 3. Gulf of Maine Experimental Whiting Fishery. Catch and Bycatch in 1995 & 1996 from Sea Sampled Trips.

1995

	June	July	Aug.	Sept	Oct	Nov.	Totals
No. of Trips	0	1	1	1	1	1	5
Ave. Reg. Species		1.88	2.03	1.04	4.23	2.66	2.36
Ave Unreg. Species		27.53	15.41	13.21	15.12	17.75	17.8
Whiting		70.57	82.55	85.74	80.64	79.58	79.81
No. of Trips > 5%	0	0	0	0	0	0	0

1996

	June	July	Aug.	Sept.	Oct	Nov.	Totals
No. of Trips	0	6	7	7	7	5	32
Ave. Reg. Species		4.34	1.13	1.44	3.28	4.32	2.77
Ave Unreg. Species		39.96	22.73	10.67	12.90	27.92	22.84
Whiting		56.29	76.08	88.45	83.08	67.73	74.32
No. of Trips > 5%	0	3	0	0	2	1	6

Table 4. Maine Whiting Grate Fishery Catch by Species by Mont
From Sea Sampling Trips, 1996

	May	July	Aug	Sept
AMERICAN PLA	86.3	839.2	400.5	123.7
COD	161	2.6	1.3	0
GRAY SOLE	71	41.6	67.2	30.1
HADDOCK	8.4	1.8	0.3	
POLLOCK	343	2.2	3.5	0.3
REDFISH	694	39.4	4.6	32.7
WHITE HAKE	26.6	3.2	116.5	50
WINTER FLOUN	14	1.6	3.8	2.2
YELLOWTAIL	1	3.1	5.6	3
TOTAL REG SP.	1405.3	934.7	603.3	242
SILVER HAKE	1618	14202.7	34044	24883
ALEWIFE	2.5	86	30.5	97
ATLANTIC HER	11.9	5266	3240	469
ATLANTIC MAC				0.1
CUSK	2			0.5
DOGFISH		17.8	8.8	7
FOURSPOT FLO	0.1			2
MENHADEN			0.1	4.5
MONKFISH	23.8	12.1	21.4	17.3
OCEAN POUT	124.5	57.1	51.6	8
RED HAKE	908	3919.1	6402	1931
WOLF FISH		8		
BUTTERFISH		0.4	15	0.5
CUNNER			4.8	
FOURBEARD RO	0.3	40.2	4.8	8.1
LONGHORN SCU	8	17.7	11.3	3
SEA RAVEN	22		5.5	0.1
SEA ROBIN		1	27.5	24.7
WRYMOUTH	0.3	38	24	48
AMERICAN LOB		22.6	18.8	69
CRAB				2
JONAH CRAB	4		1.5	
RED CRAB	2			
ROCK CRAB				4.2
SHRIMP	355	789.9	15	30.3
ILLEX SQUID		24.6	82.1	74.1
LOLLIGO SQUI		3.6		
OCTOPUS	0.2		0.9	
QUOHOG				0.1
SEA SCALLOP	1.5	3.5	6.1	19.2
SKATE			2	102.5
THORNY SKATE	4	2	2.7	
TOTAL CATCH	4493.4	25447	44623.7	28047.2

Table 5. Weight of Regulated Species, Total Weight and Percent Regulated Species by Tow for Transfer at Sea and Landings Permitted Vessels for 1998.

Transfer at Sea Permitted Vessels

	reg sp wt	tot wt	% reg sp
7/26/98	14.4	114.7	11.15
7/30/98	25	1480.2	1.66
7/31/98	7.3	2193.5	0.33
7/31/98	4.3	1997.2	0.21
7/31/98	0	3997.1	0.00
7/31/98	0.5	1507.5	0.03
tot	51.5	11290.2	
mean	8.6	1881.7	0.46
8/2/98	17.3	523	3.20
8/3/98	35.2	835	4.05
8/3/98	48.3	948	4.85
8/3/98	23.1	723	3.10
8/4/98	21.5	599	3.46
8/5/98	1.1	36.4	2.93
8/6/98	16.8	397	4.06
tot	171.9	5943.1	
mean	24.6	849.0	2.89
9/11/98	0	45.5	0
9/11/98	5.3	600	0.88
9/11/98	11	790	1.37
9/12/98	15.7	404.8	3.73
tot	32.0	1840.3	
mean	8.0	460.1	1.74

Landings Permitted Vessels

	reg sp wt	tot wt	% reg sp
8/17/98	9.9	1613.2	0.61
8/17/98	15.3	2246	0.68
8/17/98	14.8	1514.5	0.98
tot	40	5373.7	
mean	13.3	1791.2	0.74

Table 6. Maine Whiting Fishery % Bycatch of Regulated Species from Sea Sampling Trips, 1999.

Bait Commercial Samples '99 season

Date	Tow	Type	Tow Time	State	%bycatch
7/28/99	1	Bait	1.12	ME	0.91518
7/28/99	2	Bait	1.63	ME	0.42715
7/28/99	3	Bait	0.8	ME	0.80139
7/28/99	4	Bait	1.1	ME	0.60146
7/28/99	5	Bait	0.63	ME	0.45249
7/28/99	6	Bait	0.87	ME	0.73166
8/20/99	1	Bait	1	ME	2.41747
8/20/99	2	Bait	0.92	ME	0.5588
8/20/99	3	Bait	1	ME	1.44007
8/27/99	1	Bait	0.82	ME	2.08852
9/3/99	1	Bait	0.83	ME	1.18677
9/3/99	2	Bait	0.92	ME	1.86408
8/24/99	1	Bait	1.62	NH	1.92595
8/24/99	2	Bait	1.7	NH	2.16526
9/2/99	1	Bait	2.62	NH	7.38471
9/3/99	1	Bait	1.23	NH	6.78955
9/4/99	1	Bait	1.62	NH	6.45868
8/25/99	1	Bait?	1.62	NH	1.91349
			Food Commercial Samples '99 Season		
7/26/99	1	Food	1.93	ME	0.37275
7/26/99	2	Food	2.23	ME	2.09675
7/26/99	3	Food	2.23	ME	0.25857
7/29/99	1	Food	2.02	ME	1.59471
7/29/99	2	Food	2.13	ME	0.63091

Figure 1. 1996 Maine Commercial Whiting Fishery.

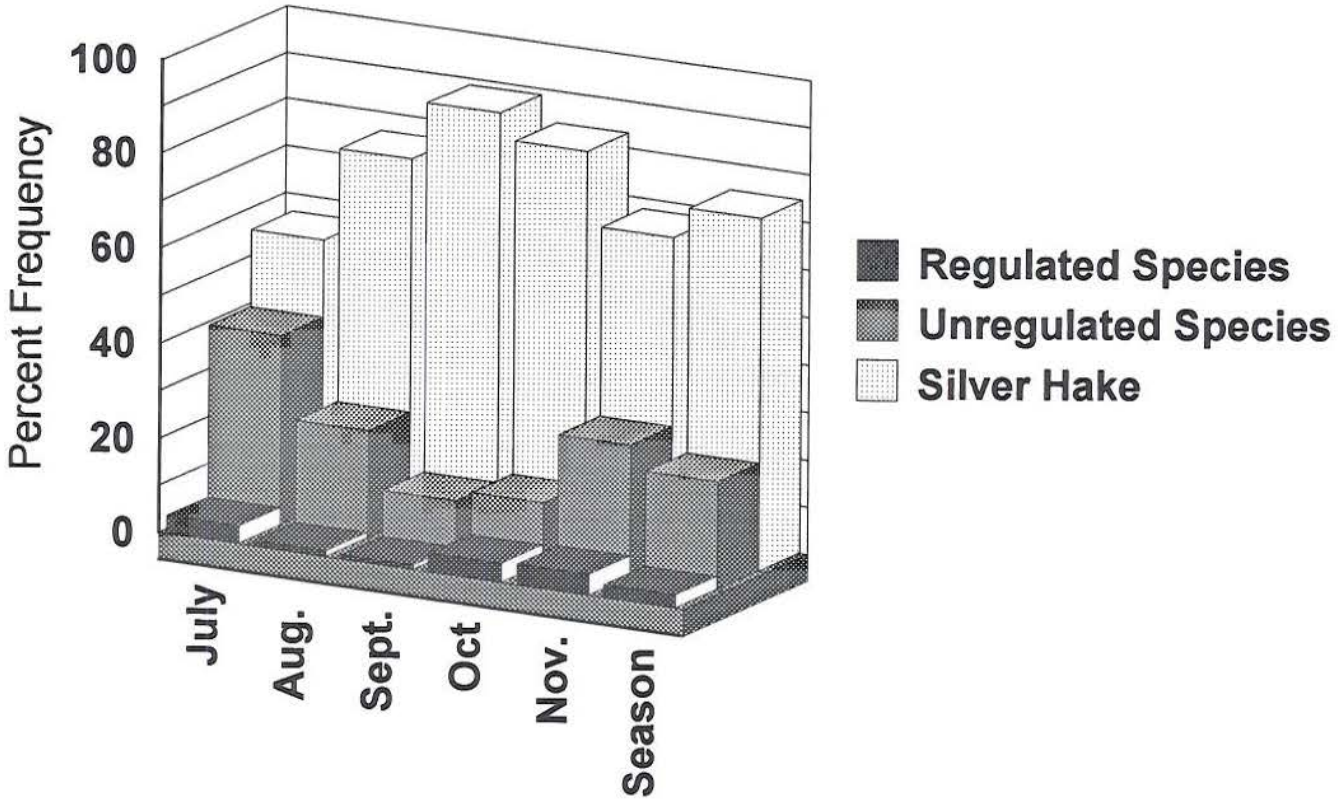
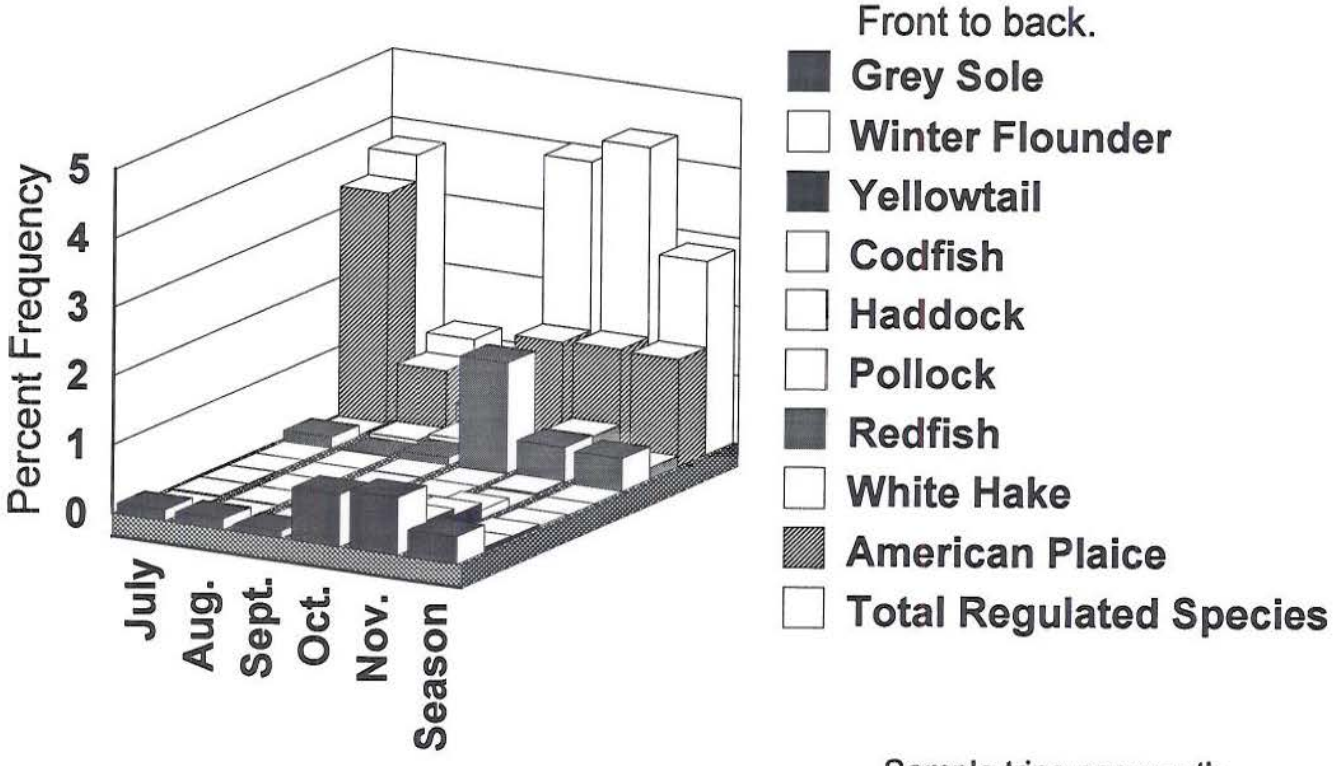


Figure 2. 1996 Maine Whiting Fishery.



Sample trips per month.

Jul. 6, Aug. 7, Sept. 9, Oct.9, Nov. 6.

Figure 3.
Mini-Grant Gear Trials.

Percent Composition of Gear Trial Catches.

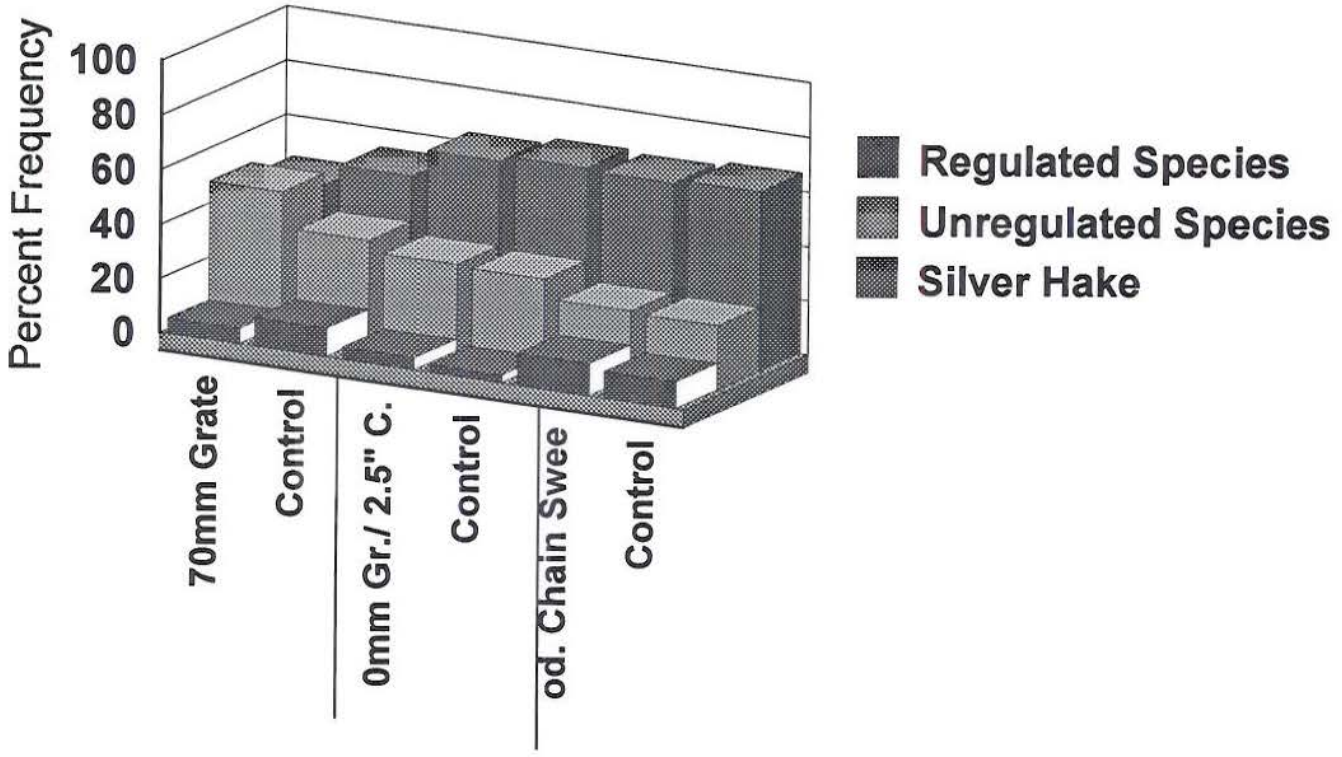
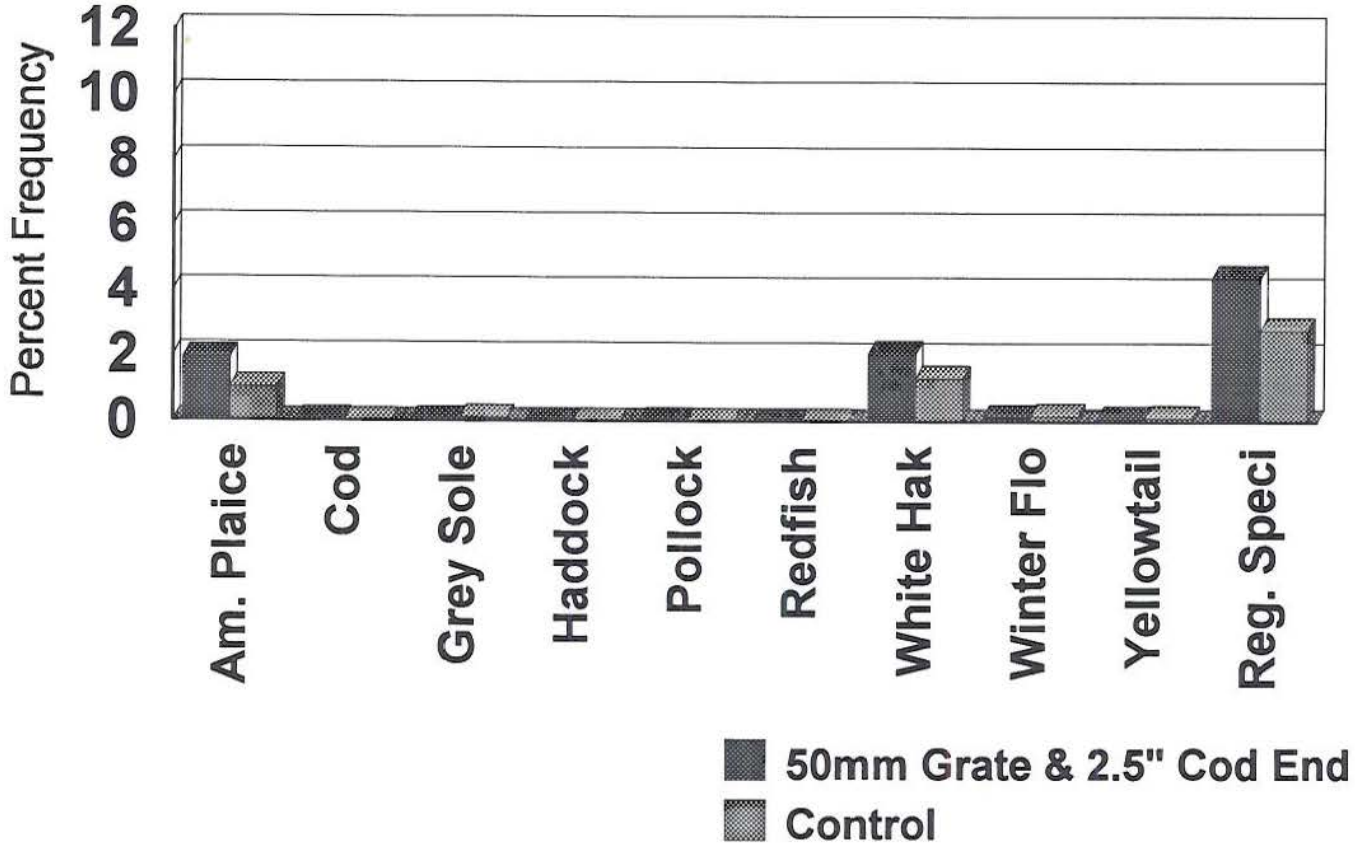


Figure 4.

Mini-Grant Gear Trials.

50mm Grate w/ 2.5" Cod End vs. Control.



Control Net: 40mm Grate & 2" Cod End.

Figure 5.

Mini-Grant Gear Trials.

Modified vs. Standard Chain Sweep.

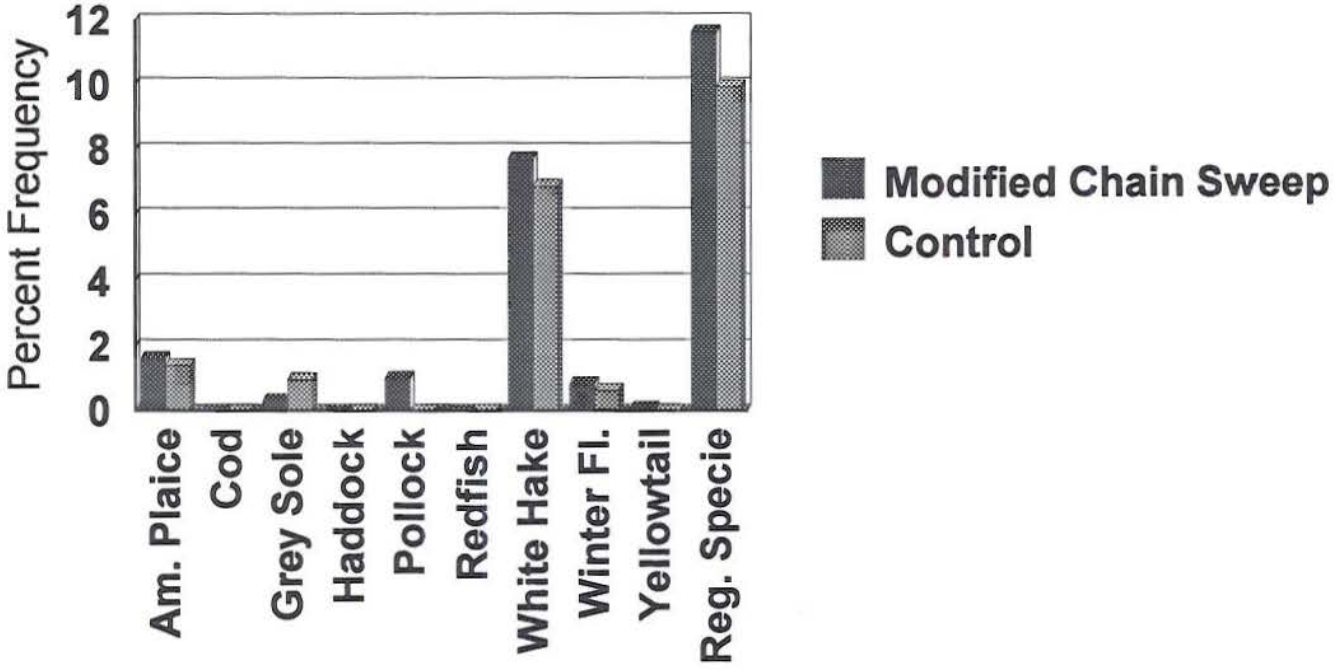
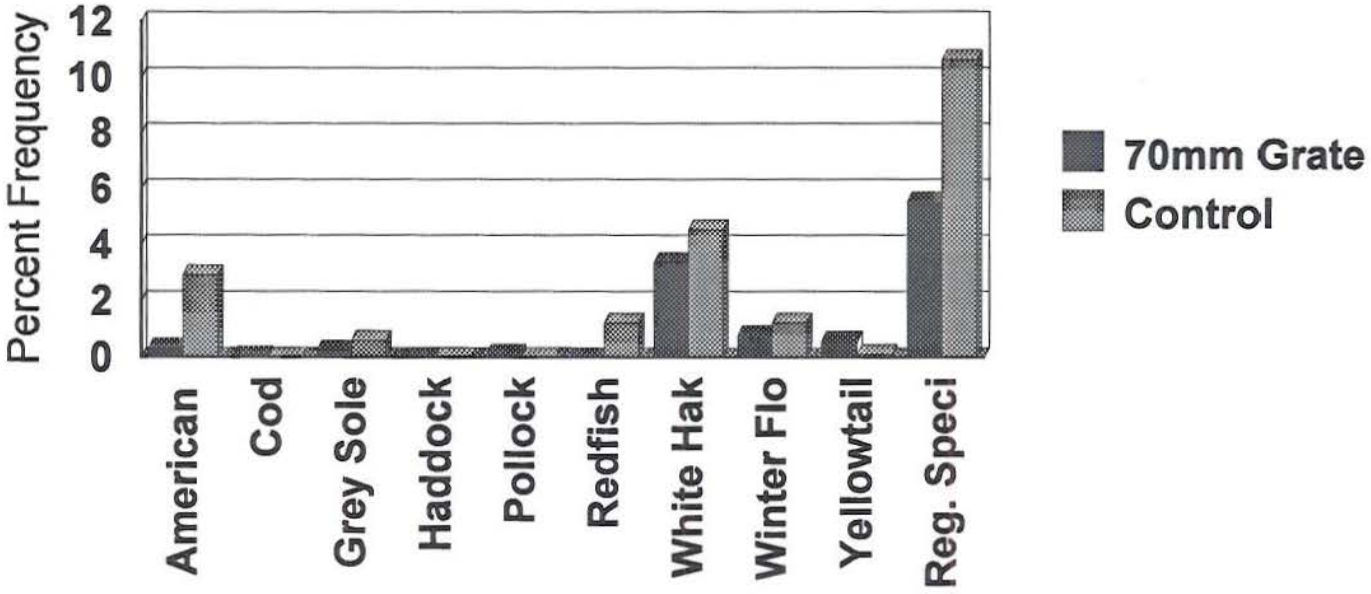


Figure 6.

Mini-Grant Gear Trials.

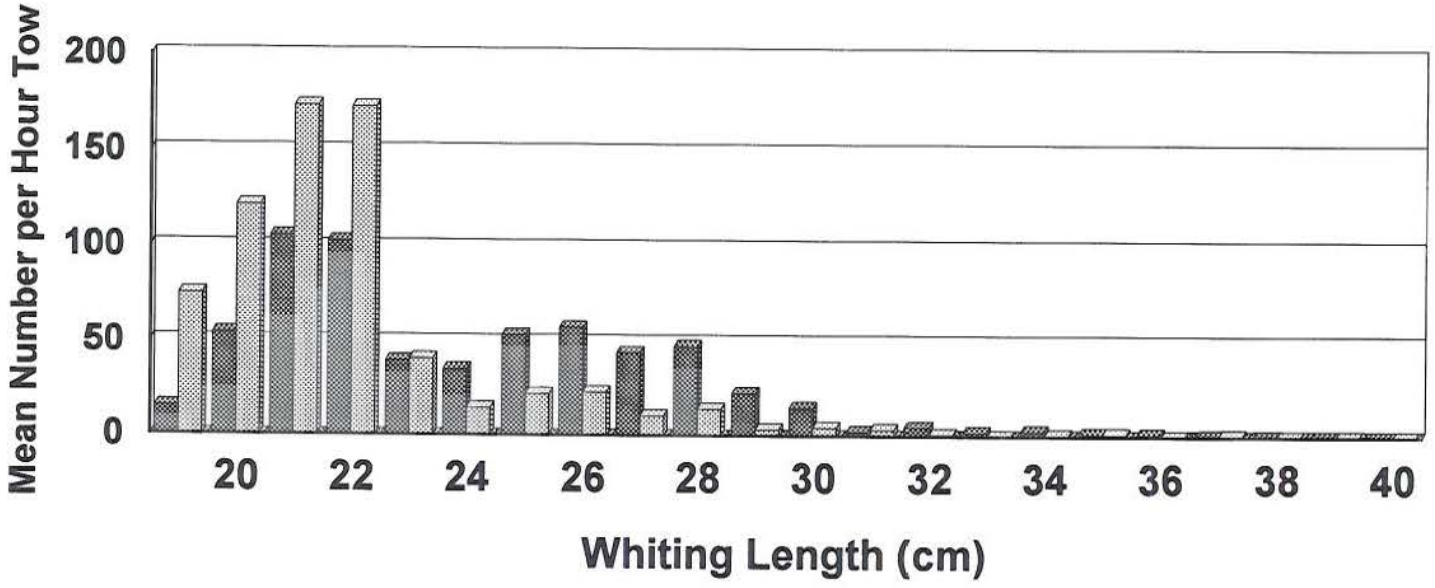
70mm Grate vs. Control.



Number of Tows:
3 Experimental
4 Control

Figure 7.

Whiting Length Frequency Comparison. 70 mm Grate w/ 2 Inch Codend vs 40mm Grate w/ 2 Inch Codend.



Tim Larochelle. 1996. FIG Funding.
20 cm = 8 in., 30 cm = 12 in. +/-.

70mm Grate w/ 2" Cod End
40mm Grate w/ 2" Cod End

Appendix A.

Final Technical Report: MFIDC Whiting Project # 98-B-03.
Date: November 26, 1999

"Improving Maine's Whiting Fishery: Sampling the Current Fishery and Reducing Bycatch Through the Use of a Raised Footrope."

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and
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Project Start Date: January 25, 1999
End Date: October 31, 1999

Funding: MFIDC: $60,151
MEDMR: $20,050
$80,201

Approved: _____
George Lapointe, Commissioner, MEDMR

Approved: _____
William J. Brennan, Exec. Dir., MFIDC

A. Definition of the problem.

In Maine, the coastal whiting fishery averaged almost 9000 t during the 1960's and early 70's, but declined rapidly in the late 70's to just 65 t. The fishery rebounded a little during the 80's, averaging 1800 t, but again declined during the early 90's to 28 t in 1993. In 1994, an innovation that helped reduce finfish bycatch in the shrimp fishery, the Nordmore grate, was modified to allow a slightly larger size whiting through the grate, yet keep the bycatch of regulated species down below 5%. The grate bar spacing was widened to 40 mm from 25 mm and testing at sea showed good success at catching whiting and keeping bycatch low. There was no whiting management plan in place at that time and the 8" to 10" fish targeted by this gear, a 1 ¾" mesh net and 40 mm bar space grate, was salable in the Spanish whiting market if properly handled on deck to preserve quality. This fishery has been permitted as an experimental fishery by the NMFS to allow it to prove that its bycatch of regulated species is less than 5%. To date, data between sea sampling and logbooks differ as to bycatch percentage and the fishery was given one more year, 1999, to document its bycatch.

On top of the onus of proving low bycatch, the Maine whiting fishery is facing a new NEFMC fishery management plan that calls for sharp reductions in catch to meet the target F of 0.36. Current estimates of F are in the region of 1.5. For the Northern Management Zone, the draft plan calls for increasing mesh size to 3" and trip limits to effect these reductions. The 3" mesh size will eliminate the Maine grate whiting fishery as it existed in the mid-90's, as there are few fish large enough to be retained in a 3" mesh found along the coast. Market events have made this point moot, as the Canadian whiting fishery has flooded the Spanish market with the size fish it desires at a price well below what Maine fishermen can afford to harvest their fish for. Thus the Maine whiting for food fishery is relegated to a market for larger fish that is notoriously peripatetic with wide, sudden fluctuations in demand and therefore price to the fisherman. Most of what has continued of the Maine whiting grate fishery for the last three years has been bait fishing for either tuna bait or lobster bait.

The sea sampling conducted over two of the last three years has shown that the highest numbers of regulated fish taken as bycatch in the Maine whiting fishery are flatfish. If the cod end mesh and grate bar spacing are changed to help the fishery conform to the new whiting management plan, the raised footrope could make the difference between keeping the fishery under 5% or not. The wider the bar spacing, the more gadoid fish, cod, haddock, hakes are likely to be caught. The larger codend mesh size may release some of these fish, but not many. Greatly reducing the flatfish that enter the net will be a large savings to the resource and probably allow the whiting fishery in Maine to continue.

In research conducted concurrently with this work, a mesh and bar space combination of either 2.2 inches square mesh or 2.6 inches diamond mesh cod end with a 2 inch bar space proved to provide a catch length frequency that will probably be acceptable to the new whiting management plan. The current work asked two questions.

First, what is the bycatch of regulated species in the three components of the Maine whiting fishery? Second, what is the effect of using a modified raised footrope on bycatch reduction?

B. Methodology.

Sea Sampling of the experimental whiting grate fishery: An RFP was used as a means of soliciting bids for conducting the sea sampling. The successful bidder was Northern Ecological Associates, Inc. The contract was for 49 sea sample days, with 4 days devoted to the raised footrope and 45 days devoted to the commercial experimental fishery. The sample days were to be spread between the three permitted fisheries, transfer at sea, landed bait and whiting for food and over time to give the best coverage of each fishery. Sea sampling effort on deck followed NMFS standard form using their log sheets. For each tow, the catch was sorted by species and either estimated weights or actual weights taken for each species. The whiting and regulated species were measured for length frequency as well. Thus the data necessary for determining percent bycatch of regulated species was collected for each tow.

Raised footrope trawl testing: The Massachusetts raised footrope trawl was modified by replacing the chain sweep with a roller frame typically used in Maine. Two different lengths of dropper chains, 30 inches and 42 inches, were tested against a control net with no droppers to determine the best configuration for releasing flatfish and retaining whiting. To insure that this gear is rigged correctly, we brought the Massachusetts fisherman most involved with the development of the raised footrope, Henry Sousa, and one of the Massachusetts gear technology personnel up here to work on the gear with us. They provided the expertise and the testing equipment including a pan and tilt underwater camera system and a net mensuration system. Rigging the net with variable length dropper chains took a couple of days of work on land and a day at sea to make sure the net was fishing correctly. During the day at sea testing, an underwater camera was attached to the net in several locations to document the conformation of the net in terms of the relationship between the roller frame, the dropper chains, the fishing wire and the general tension in the net.

The testing of the net against the control net took two days. Trawl testing the gear involved towing each test net as a paired tow against a control net using two vessels. The control net was a 1 ¾" mesh shrimp net with no grate and with the fishing wire down on the roller frame. Each dropper chain length, 30 inches and 42 inches, was towed for five paired tows using a 50 mm grate and a 2.2 inch square mesh cod end, and for five paired tows using a 50 mm grate and a 2.6 inch diamond mesh cod end. These were the best codend mesh size and bar space combinations developed in the concurrent research funded by an NMFS Fishing Industry Grant.

During all testing, the catch for each tow was sorted by species and each species was counted and weighted and measured for length frequency. For tows with too large a catch to process each fish, subsampling was done and priority for length frequency analysis was given to whiting and regulated species. The difference in catch weight,

number and length frequency between the control nets and the test nets is being used to determine the increased efficacy of the gear in reducing bycatch of regulated species and shifting the catch of whiting away from the small fish.

C. **The match received:**

The matching funds for this research came from two sources. First, ten weeks of the senior investigator's time to conduct this work was paid by the State of Maine for a match, including overhead, of $12,364. Also, an additional five weeks of Mr. Brown's time was needed to conduct this work and that was paid for by the State of Maine for a match, including overhead, of $5376. Second, a proposed match from the fishing vessels for half their daily operating expenses of $2k/day, not including Captain and crew costs. The pair of vessels fished for two days for the raised footrope work and one of the vessels put in another day for the camera work. The low bid from the RFP was for $1500/day for the vessel, plus $300/day for the Captain and $400/day for two crew members at $200 each. The total cost came to $2200/day, which was more than we had budgeted for. The low bid cost of $1500/day for the vessel was ¾ of the projected cost of running the vessel of $2000/day, so the vessel provided a match of $500X5, or $2500 ($3262.5 with overhead). The total match, including the increased personal services, was $21,002. The increased time put in by the senior investigator, ten weeks instead of the proposed nine weeks and by Mr. Brown, 10 weeks instead of the proposed five, more than made up for the decreased match provided for by the contracting vessels. The total match is now $740 over the proposed match.

D. Other resources leveraged in support: None

E. **New products, processes or services developed:**

The results of the sea sampling coverage of the 1999 experimental whiting fishery and the raised footrope trials are presented here.

Sea Sampling:

The sea sampling efforts produced eleven trips between July 26 and September 4, 1999. Two trips were with a for-food permit, one trip was with a landed for bait permit and six trips were with an at-sea transfer for bait permit (Table 1). Two trips were made with a vessel using a raised footrope net with no grate out of New Hampshire. At one time or another during the season, five vessels signed up for a for-food permit, two vessels signed up for a landed bait permit and 24 vessels signed up for a transfer at sea bait permit. This list of vessels, with contact information, was supplied to the sea sampling contractor. The data for each of the sampled trips has been entered into a computer and is currently being analyzed for catch and bycatch by species. Preliminary analysis shows a rate of bycatch of regulated species of 0.8% for July, 1.8% for August and 4.7% for September for an overall bycatch rate of 2.0% (Table 1). There were much fewer sea sampling trips made than planned for, but that was due more to the nature of

the fishery than a lack of effort in getting out on vessels. There simply was not much activity going on in the experimental whiting fishery this year.

Raised Footrope Experiments:

The raised footrope experiments were conducted between September 6 and 10, 1999 out of Portland, Maine. All trawling was done within 10 miles of Portland. The raised footrope trawl was rigged on September 6 and 7 and the sea trial for camera work was done on the 8th. The comparison trials with the control net were conducted on September 9 and 10. The trials compared two footrope heights, 42 inches and 30 inches, two cod end meshes, 2.6 inch diamond and 2.2 square mesh coupled with one grate with 2.0 inches bar space all compared to a control net with no grate and 1.75 inch cod end mesh. With so many components in the comparisons, it is necessary to break out separate effects of the cod end mesh/bar space with the control net and the differences due to the raised footrope. To do this, we look at the differences in weight of the total catch, differences in weight of bycatch of regulated species and differences in length frequency of selected species. While the nets were switched between vessels, the tows where the experimental net is towed by the Dee Dee Mae II will be considered here as that vessel towed the experimental gear in the raised footrope trials.

The effect of the 2.5 inch bar space grate and the 2.6 inch diamond mesh cod end on the catch relative to the control net with no grate is to decrease the catch by an average of 279 kg, or 47%. There is a similar decrease in the catch, 237 kg, or 45%, relative to the control net with the 1.6 inch grate and 1.75 inch cod end. The results with the 2.2 inch square mesh cod end are similar, with decreases of 30% and 26% respectively (Table 2). The effect of the 2.5 inch bar space grate and the 2.6 inch diamond mesh cod end on the bycatch of regulated species relative to the control net with no grate is a 38% decrease in the bycatch weight, but a 52% increase in percent bycatch from 5.3% to 5.9%. The gear shows an overall increase of 95% in weight of bycatch relative to the control net with the 1.6 inch grate, changing from 7 kg to 13.6 kg per tow. The percent bycatch increased from 1.3% to 4.7%. The effect of the 2.5 inch bar space grate and the 2.2 inch square mesh cod end relative to the control net with no grate is a decrease in the bycatch weight of 79% from 38.9 kg to 8.2 kg and compared to the control net with 1.6 inch grate, a increase of 39% from 4.6 kg to 6.3 kg. The percent bycatch decreases from 4.8% to 2.2% compared to the control net with no grate and increases from 7.1% to 17.1% compared to the control net with the 1.6 inch grate (Table 2).

The total catch weights, regulated species bycatch weights and bycatch percents for the two raised footrope trials show differences from the control tows over and above those accounted for by the grates and cod ends alone. For the 42 inch dropper chain length, the catch with the 2.6 inch cod end showed less of a decrease from the control than did the grate/cod end trial and showed a greater decrease in bycatch weight (Table 3). The percent bycatch went from 7.6% down to 2.0%. The catch weight for the 42 inch dropper chains with the 2.2 inch square mesh cod end showed a gain in weight over the catch of the control net while the grate/cod end trials showed a decrease in catch weight. The bycatch weight for the 42 inch dropper/2.2 inch cod end net showed almost as much

decrease in weight, 4.8 kg down to 1.3 kg, as did the grate/cod end trial. The result is a greater decrease in percent bycatch, 78%, compared to 54% for the grate/cod end trial.

The catch weight for the 30 inch dropper chain tows decreased by 63% for both the 2.6 inch diamond and the 2.2 inch square mesh cod ends (Table 3). This was greater in both cases from the grate/cod end trials. The bycatch weight also decreased substantially from the control tows with the 2.6 inch decrease being greater than the grate/cod end trials and the 2.2 inch decrease being less. The percent bycatch increased slightly for the 2.6 inch cod end compared to the control and showed about the same increase as the grate/cod end trials. The percent bycatch increased from 8.4% to 11.9%, an increase of 41%, for the 2.2 inch cod end, which is a distinct reverse from the grate/cod end trial results, where the percent bycatch decreased by 54%. Thus the results for the 30 inch dropper chains are somewhat more sporadic than those from the 42 inch dropper chain trials.

The effects of the addition of the dropper chains on specific species show definite differences from the control. The results for the flatfish as a group, plaice, red hake and silver hake were evaluated. These species were chosen for their relative importance in the catch/bycatch of the fishery and for their interaction with the net. The flatfish as a group showed consistent decreases in bycatch weight in the range of 70 – 75% from the no grate control net (Table 4). Plaice made up a large proportion of the flatfish catch and their weight decreased by 23% with the 2.5 in grate and 2.6 inch diamond cod end and declined 49% with the 2.5 inch grate and 2.2 inch square mesh cod end (Table 5). The addition of the 42 inch raised footrope showed a 59% greater decline in weight of plaice for the 2.6 inch cod end and 24% greater decline for the 2.2 inch square mesh cod end (Table 6). The 30 inch raised footrope showed greater declines by 38% and 28% respectively for the 2.6 inch diamond and 2.2 inch square mesh cod ends relative to the non-raised footrope trials (Table 6). Thus both raised footrope lengths produced increased release of plaice. The red hake weight increased for the 2.6 inch diamond and the 2.2 inch square mesh cod ends by 5% and 29%, respectively (Table 7). The addition of the 42 inch raised footrope showed similar slight increases in catch. The 30 inch raised footrope showed a slight increase in weight of red hake with the 2.6 inch diamond cod end and a slight decrease in catch with the 2.2 inch square mesh cod end (Table 8). Thus there were no major changes produced by the addition of the raised footrope for red hake bycatch. Whiting catch declined by 8% with the 2.6 inch diamond mesh cod end and by 51% with the 2.2 inch square mesh cod end (Table 9). The addition of the 42 inch raised footrope showed no difference for the 2.6 inch diamond cod end and 17% less of a decline with the 2.2 inch square mesh cod end. The 30 inch raised footrope showed a similar comparative pattern (Table 10). Thus the addition of the raised footrope did not significantly affect the weight of whiting caught relative to the total weight of the catch.

The length frequency for whiting caught with the dropper chains in place showed a shift away from the smaller fish and a greater catch of larger fish relative to the control tows and to the grate/cod end trials for both the 2.6 inch diamond and 2.2 inch square mesh cod ends (Figure 1). The percent length frequency for whiting show this shift more clearly and also shows a definite selection for larger whiting with the 2.2 in square mesh

cod end compared to the 2.6 inch diamond mesh cod end (Figure 2). The difference in length frequency between the 42 and 30 inch dropper trials and their controls for both the 2.6 inch diamond and 2.2 inch square mesh cod ends were compared to the difference between the 2.5 inch grate/2.6 inch cod end and 2.5 inch grate/2.2 inch square mesh cod end and their controls in the grate/cod end trials. The pattern shift shows a definite increase in release of smaller fish with the dropper chains in place for both the 2.2 inch square mesh cod end (Figure 3) and the 2.6 inch diamond mesh (Figure 4). This shift away from retaining the smaller fish with the use of a raised footrope is also evident for the plaice length frequency (Figure 5), percent length frequency (Figure 6) and comparative difference (Figures 7 & 8) and for the red hake length frequency (Figure 9), percent length frequency (Figure 10) and comparative difference (Figures 11 & 12).

F. Benefits to Maine's fishing industry and fishing dependent communities.

The results of the research in raised footrope technology show that the raised footrope significantly reduces the bycatch of flatfish compared to no raised footrope with no grate. The comparative results between the same grate/cod end combinations with and without the raised footrope show an increased release of small flatfish, whiting and red hake with the raised footrope. While the individual effects of the increased grate bar spacing and the increased cod end mesh size show considerable savings in small fish, the raised footrope net performs even more admirably and should be considered for small mesh fisheries where bycatch of demersal finfish is prevalent. The results of this series of experiments show that the raised footrope technology can be transferred to nets with roller frames and that reductions in bycatch of regulated species can be realized. The 42 inch length dropper chain gave more consistent reductions in bycatch than did the 30 inch dropper. More work should be done to determine the optimum dropper length and ground gear configuration.

G. Degree to which original proposal goals were met.

The original proposal included an underwater camera documentation of the raised footrope while under tow. The camera gear was utilized for this purpose and the trip entailed two days of work, one at sea doing the active camera work and one day on shore preparing the vessel and net for the camera gear. The day of the at-sea work proved to be unsuccessful in that the visibility underwater was too poor to observe much of the net from any one of several vantage points even with underwater lights. This produced a great deal of frustration after a lot of work preparing for the trials. Other than that, the goals outlined in the proposal were met.

Tables and Figures for Final Technical Report: MFIDC Project #98-B-03

TABLE 1.

BYCATCH OF REGULATED GROUNDFISH SPECIES IN THE 1999 SILVER HAKE EXPERIMENTAL GR FISHERY IN THE GULF OF MAINE FROM SEA SAMPLING DATA: JULY 26 - SEPTEMBER 4, 1999.

	#TRIPS(#TOWS) BY PERMIT CATEGORY				%BYCATCH BY PERMIT CATEGORY			
MONTH	TOTAL	FOOD	AIT(LAN	AIT(SEA)	TOTAL	FOOD	AIT(LAN	AIT(SEA
JULY	3(11)	2(5)	1(6)	0	0.808	0.99	0.655	NA
AUGUST	4(7)	0	0	4(7)	1.787	NA	NA	1.787
SEPTEMBER	4(5)	0	0	4(5)	4.737	NA	NA	4.737

Table 2.
Mean Total Catch per Tow, Regulated Species Bycatch and Percent Bycatch for Tow Pairs from Comparisons of 2.5" Grate and 2.6" Diamond Cod End and 2.5" Grate and 2.2" Square Mesh Cod End with a Control Net with No Grate and 1.75" Diamond Cod End and a Control Net with 1.6" Grate and 1.75" Diamond Cod End.

Con : Expt (# paired tows)	No Grate 1.75" Cod End	1.6 Grate 1.75" Cod End	2.5" Grate 2.6"Cod End	2.5" Grate 2.2"SqCod End	% Reduction
		Mean Weight (kg) of Catch			
J&J : DDM (2)	597		318		46.7
DDM : J&J (2)	318		162		48.9
Mean	457		240		47.5
J&J : DDM (2)		525	289		45.1
DDM : J&J (3)		325	126		61.2
Mean		405	191		52.8
J&J : DDM (2)		67		50	25.7
DDM : J&J (1)		1841		516*	72.0
Mean		658		205	68.9
J&J : DDM (3)	808			564	30.2
DDM : J&J (2)	2803			164*	94.2
Mean	1606			404	74.9
		Mean Weight (kg) of Bycatch of Reg. Sp.			
J&J : DDM (2)	30.0		18.8		37.5
DDM : J&J (2)	7.9		10.3		-29.7
Mean	19.0		14.5		23.5
J&J : DDM (2)		7.0	13.6		-95.2
DDM : J&J (3)		7.0	10.4		-48.6
Mean		7.0	11.6		-67.2
J&J : DDM (2)		4.6		6.3	-38.5
DDM : J&J (1)		21.8		7.6*	65.4
Mean		10.3		7.0	32.1
J&J : DDM (3)	38.9			8.2	78.9
DDM : J&J (2)	10.8			12.8*	-18.6
Mean	27.6			10.0	63.8
		Mean Percent Weight of Bycatch of Reg. Sp.			
J&J : DDM (2)	5.0		5.9		-10.7
DDM : J&J (2)	2.5		6.3		-134.3
Mean	3.8		6.1		-62.5
J&J : DDM (2)		1.3	4.7		-252.5
DDM : J&J (3)		2.1	8.2		-260.5
Mean		1.8	6.8		-274.8
J&J : DDM (2)		7.1		17.1	-140.3
DDM : J&J (1)		1.2		1.5*	-23.3
Mean		5.1		12.0	-133.5
J&J : DDM (3)	4.8			2.2	54.1
DDM : J&J (2)	0.4			8.7*	-2080.4
Mean	3.0			5.0	-65.6

* J&J tows used 2.0" grate instead of 2.5".

Table 3.
Mean Total Catch per Tow, Regulated Species Bycatch and Percent Bycatch for Tow Pairs from Comparisons of Two Raised Footrope Heights with 2.0" Grate and 2.6" Diamond, or 2.2" Square Mesh Cod Ends Towed Against a Control Net with No Grate and 1.75" Diamond Mesh Cod End.

Raised Footrope Ht (# Tow Pairs)	No Grate 1.75" Cod End	2.0" Grate 2.6"Cod End	2.0" Grate 2.2"SqCod End	% Reduction	% Reduction from Grate/Cod End Trials
		Mean Weight (kg) of Catch			
42" (5)	64.0	55.3		13.5	-33.2
42" (5)	53.3		67.6	-26.7	-56.9
30" (5)	227.8	83.5		63.3	16.6
30" (5)	225.9		83.3	63.1	32.9
		Mean Weight (kg) of Bycatch of Reg. Sp.			
42" (5)	4.5	1.0		76.8	39.4
42" (5)	4.8		1.3	73.0	-5.9
30" (5)	9.8	4.0		59.5	22.0
30" (5)	16.7		5.3	68.2	-10.7
		Mean Percent Weight of Bycatch of Reg. Sp.			
42" (5)	7.0	1.9		73.2	83.9
42" (5)	9.0		1.9	78.7	24.6
30" (5)	4.3	4.8		-10.4	0.3
30" (5)	7.4		6.4	13.9	-40.2

Table 4.
Flatfish Catch Weight Comparison Between Raised Footrope Nets and Control Net with No Grate

Date	Footrope	Grate	Cod End	Species	Ave wt./to	Sum	Decrease
9/999	42	2	2.6	Gray Sole	0.4		
9/999	42	2	2.6	Plaice	0.42	0.82	
9/999	0	0	1.75	Gray Sole	0.74		
9/999	0	0	1.75	Plaice	2.37		
9/999	0	0	1.75	Yellowtail	0.12	3.23	0.74613
9/999	42	2	2.2	Gray Sole	0.02		
9/999	42	2	2.2	Plaice	0.82		
9/999	42	2	2.2	Yellowtail	0.06	0.9	
9/999	0	0	1.75	Gray Sole	0.14		
9/999	0	0	1.75	Plaice	2.99		
9/999	0	0	1.75	nter Flounder	0.02		
9/999	0	0	1.75	Yellowtail	0.1	3.25	0.723077
9/10/99	30	2	2.2	Gray Sole	0.43		
9/10/99	30	2	2.2	Plaice	1.62		
9/10/99	30	2	2.2	nter Flounder	0.04		
9/10/99	30	2	2.2	Yellowtail	0.04	2.13	
9/10/99	0	0	1.75	Gray Sole	0.65		
9/10/99	0	0	1.75	Plaice	6.87		
9/10/99	0	0	1.75	nter Flounder	0.27		
9/10/99	0	0	1.75	Yellowtail	0.05	7.84	0.728316
9/10/99	30	2	2.6	Gray Sole	0.26		
9/10/99	30	2	2.6	Plaice	1.96	2.22	
9/10/99	0	0	1.75	Gray Sole	0.88		
9/10/99	0	0	1.75	Plaice	5.08		
9/10/99	0	0	1.75	nter Flounder	0.2		
9/10/99	0	0	1.75	Yellowtail	0.05	6.21	0.642512

Table 5

Mean Total Catch per Tow, Plaice Bycatch and Percent Bycatch for Tow Pairs from Comparisons of 2.5" Grate and 2.6" Diamond Cod End and 2.5" Grate and 2.2" Square Mesh Cod End with a Control Net with No Grate and 1.75" Diamond Cod End and a Control Net with 1.6" Grate and 1.75" Diamond Cod End.

Con : Expt (# paired tows)	No Grate 1.75" Cod End	1.6 Grate 1.75" Cod End	2.5" Grate 2.6"Cod End	2.5" Grate 2.2"SqCod End	% Reduction
		Mean Weight (kg) of Catch			
J&J : DDM (2)	597		318		46.7
DDM : J&J (2)	318		162		48.9
Mean	457		240		47.5
J&J : DDM (2)		525	289		45.1
DDM : J&J (3)		325	126		61.2
Mean		405	191		52.8
J&J : DDM (2)		67		50	25.7
DDM : J&J (1)		1841		516*	72.0
Mean		658		205	68.9
J&J : DDM (3)	808			564	30.2
DDM : J&J (2)	2803			164*	94.2
Mean	1606			404	74.9
		Mean Weight (kg) of Plaice			
J&J : DDM (2)	20.0		15.4		23.3
DDM : J&J (2)	3.8		4.4		-15.3
Mean	11.9		9.9		17.1
J&J : DDM (2)		4.9	13.0		-168.0
DDM : J&J (3)		4.3	5.4		-24.0
Mean		4.5	8.4		-85.6
J&J : DDM (2)		1.3		2.9	-123.1
DDM : J&J (1)		19.6		4.2*	78.6
Mean		7.4		3.3	55.4
J&J : DDM (3)	11.3			5.8	48.7
DDM : J&J (2)	4.9			7.8*	-59.2
Mean	8.7			6.6	24.5
		Mean Percent Weight of Plaice			
J&J : DDM (2)	3.4		4.8		-44.0
DDM : J&J (2)	1.2		2.7		-125.6
Mean	2.3		3.8		-65.5
J&J : DDM (2)		0.9	4.5		-252.5
DDM : J&J (3)		1.3	4.3		-260.5
Mean		1.2	4.4		-272.8
J&J : DDM (2)		1.9		5.8	-140.3
DDM : J&J (1)		1.1		0.8*	-23.3
Mean		1.6		4.1	-148.9
J&J : DDM (3)	1.4			1.0	54.1
DDM : J&J (2)	0.2			4.7*	-2080.4
Mean	0.9			2.5	-175.2

* J&J tows used 2.0" grate instead of 2.5".

Table 6.
Mean Total Catch per Tow, Plaice Bycatch and Percent Bycatch for Tow Pairs from Comparisons of Two Raised Footrope Heights with 2.0" Grate and 2.6" Diamond, or 2.2" Square Mesh Cod Ends Towed Against a Control Net with No Grate and 1.75" Diamond Mesh Cod End.

Raised Footrope Ht (# Tow Pairs)	No Grate 1.75" Cod End	2.0" Grate 2.6"Cod End	2.0" Grate 2.2"SqCod End	% Reduction	Difference in % Reduction from Grate/Cod End Trials
		Mean Weight (kg) of Catch			
42" (5)	64.0	55.3		13.5	-33.2
42" (5)	53.3		67.6	-26.7	-56.9
30" (5)	227.8	83.5		63.3	16.6
30" (5)	225.9		83.3	63.1	32.9
		Mean Weight (kg) of Plaice			
42" (5)	2.37	0.42		82.3	59.0
42" (5)	2.99		0.82	72.6	23.9
30" (5)	5.08	1.96		61.4	38.2
30" (5)	6.87		1.62	76.4	27.7
		Mean Percent Weight of Plaice			
42" (5)	3.7	0.8		79.5	123.5
42" (5)	5.6		1.2	78.4	24.3
30" (5)	2.2	2.3		-5.2	38.8
30" (5)	3.0		1.9	36.1	-18.1

Table 7.
Mean Total Catch per Tow, Red Hake Bycatch and Percent Bycatch for Tow Pairs from Comparisons of 2.5" Grate and 2.6" Diamond Cod End and 2.5" Grate and 2.2" Square Mesh Cod End with a Control Net with No Grate and 1.75" Diamond Cod End and a Control Net with 1.6" Grate and 1.75" Diamond Cod End.

Con : Expti (# paired tows)	No Grate 1.75" Cod End	1.6 Grate 1.75" Cod End	2.5" Grate 2.6"Cod End	2.5" Grate 2.2"SqCod End	% Reduction
		Mean Weight (kg) of Catch			
J&J : DDM (2)	597		318		46.7
DDM : J&J (2)	318		162		48.9
Mean	457		240		47.5
J&J : DDM (2)		525	289		45.1
DDM : J&J (3)		325	126		61.2
Mean		405	191		52.8
J&J : DDM (2)		67		50	25.7
DDM : J&J (1)		1841		516*	72.0
Mean		658		205	68.9
J&J : DDM (3)	808			564	30.2
DDM : J&J (2)	2803			164*	94.2
Mean	1606			404	74.9
		Mean Weight (kg) of Red Hake.			
J&J : DDM (2)	61.5		64.3		-4.6
DDM : J&J (2)	16.5		19.5		-18.2
Mean	39.0		41.9		-7.4
J&J : DDM (2)		13.0	40.0		-207.7
DDM : J&J (3)		19.1	15.2		20.4
Mean		16.7	25.1		-50.8
J&J : DDM (2)		11.0		16.0	-45.5
DDM : J&J (1)		55.6		20.5*	63.1
Mean		25.9		17.5	32.3
J&J : DDM (3)	35.3			45.6	-29.2
DDM : J&J (2)	4.3			15.0*	-248.8
Mean	22.9			33.4	-45.9
		Mean Percent Weight of Red Hake.			
J&J : DDM (2)	10.3		20.2		-96.2
DDM : J&J (2)	5.2		12.0		-131.3
Mean	7.7		16.1		-108.0
J&J : DDM (2)		2.5	13.9		-460.1
DDM : J&J (3)		5.9	12.0		-105.0
Mean		4.5	12.8		-182.9
J&J : DDM (2)		16.4		32.1	-95.8
DDM : J&J (1)		3.0		4.0*	-31.5
Mean		11.9		22.7	-90.1
J&J : DDM (3)	4.4			8.1	-85.1
DDM : J&J (2)	0.2			9.1*	-5832.9
Mean	2.7			8.5	-217.0

* J&J tows used 2.0" grate instead of 2.5".

Table 8.
Mean Total Catch per Tow, Red Hake Bycatch and Percent Bycatch for Tow Pairs from Comparisons of Two Raised Footrope Heights with 2.0" Grate and 2.6" Diamond, or 2.2" Square Mesh Cod Ends Towed Against a Control Net with No Grate and 1.75" Diamond Mesh Cod End.

Raised Footrope Ht (# Tow Pairs)	No Grate 1.75" Cod End	2.0" Grate 2.6"Cod End	2.0" Grate 2.2"SqCod End	% Reduction	Difference in % Reduction from Grate/Cod End Trials
		Mean Weight (kg) of Catch			
42" (5)	64.0	55.3		13.5	-33.2
42" (5)	53.3		67.6	-26.7	-56.9
30" (5)	227.8	83.5		63.3	16.6
30" (5)	225.9		83.3	63.1	32.9
		Mean Weight (kg) of Red Hake			
42" (5)	7.6	8.7		-15.0	-10.4
42" (5)	3.2		3.7	-18.1	11.1
30" (5)	7.9	9.2		-15.9	-11.4
30" (5)	15.0		12.0	20.0	49.2
		Mean Percent Weight of Red Hake			
42" (5)	11.8	15.7		-32.9	63.3
42" (5)	5.9		5.5	6.8	91.9
30" (5)	3.5	11.0		-216.2	-120.0
30" (5)	6.6		14.4	-117.0	-31.9

Table 9.
Mean Total Catch per Tow, Silver Hake Bycatch and Percent Bycatch for Tow Pairs from Comparisons of 2.5" Grate and 2.6" Diamond Cod End and 2.5" Grate and 2.2" Square Mesh Cod End with a Control Net with No Grate and 1.75" Diamond Cod End and a Control Net with 1.6" Grate and 1.75" Diamond Cod End.

Con : Expt (# paired tows)	No Grate 1.75" Cod End	1.6 Grate 1.75" Cod End	2.5" Grate 2.6"Cod End	2.5" Grate 2.2"SqCod End	% Reduction
		Mean Weight (kg) of Catch			
J&J : DDM (2)	597		318		46.7
DDM : J&J (2)	318		162		48.9
Mean	457		240		47.5
J&J : DDM (2)		525	289		45.1
DDM : J&J (3)		325	126		61.2
Mean		405	191		52.8
J&J : DDM (2)		67		50	25.7
DDM : J&J (1)		1841		516*	72.0
Mean		658		205	68.9
J&J : DDM (3)	808			564	30.2
DDM : J&J (2)	2803			164*	94.2
Mean	1606			404	74.9
		Mean Weight (kg) of Silver Hake.			
J&J : DDM (2)	228.1		210.0		7.9
DDM : J&J (2)	179.4		109.8		38.8
Mean	203.8		159.9		21.5
J&J : DDM (2)		4.6	105.0		-2182.6
DDM : J&J (3)		271.7	89.0		67.2
Mean		164.9	95.4		42.1
J&J : DDM (2)		37.9		20.0	47.2
DDM : J&J (1)		169.3		89.0*	47.4
Mean		81.7		43.0	47.4
J&J : DDM (3)	184.4			89.8	51.3
DDM : J&J (2)	72.9			46.5*	36.2
Mean	139.8			72.5	48.1
		Mean Percent Weight of Silver Hake.			
J&J : DDM (2)	38.2		66.1		-72.8
DDM : J&J (2)	56.4		67.6		-19.8
Mean	47.3		66.8		-41.2
J&J : DDM (2)		0.9	36.4		-4054.9
DDM : J&J (3)		83.5	70.5		15.6
Mean		50.5	56.9		-12.7
J&J : DDM (2)		56.5		40.2	29.0
DDM : J&J (1)		9.2		17.2*	-87.5
Mean		40.7		32.5	20.2
J&J : DDM (3)	22.8			15.9	30.2
DDM : J&J (2)	2.6			28.4*	-992.2
Mean	14.7			20.9	-41.9

* J&J tows used 2.0" grate instead of 2.5".

Table 10.
Mean Total Catch per Tow, Silver Hake Bycatch and Percent Bycatch for Tow Pairs from Comparisons of Two Raised Footrope Heights with 2.0" Grate and 2.6" Diamond, or 2.2" Square Mesh Cod Ends Towed Against a Control Net with No Grate and 1.75" Diamond Mesh Cod End.

Raised Footrope Ht (# Tow Pairs)	No Grate 1.75" Cod End	2.0" Grate 2.6"Cod End	2.0" Grate 2.2"SqCod End	% Reduction	Difference in % Reduction from Grate/Cod End Trials
		Mean Weight (kg) of Catch			
42" (5)	64.0	55.3		13.5	-33.2
42" (5)	53.3		67.6	-26.7	-56.9
30" (5)	227.8	83.5		63.3	16.6
30" (5)	225.9		83.3	63.1	32.9
		Mean Weight (kg) of Silver Hake			
42" (5)	43.7	40.0		8.5	0.5
42" (5)	24.8		16.4	33.9	-17.4
30" (5)	32.0	26.6		16.7	8.8
30" (5)	44.3		32.8	26.0	-25.3
		Mean Percent Weight of Silver Hake			
42" (5)	68.3	72.3		-5.8	67.0
42" (5)	46.5		24.3	47.8	17.6
30" (5)	14.0	31.8		-127.0	-54.3
30" (5)	19.6		39.4	-100.8	-131.0

Figure 1. Silver Hake: Catch Length Frequency from DDM 2.5 in. Grate, 2.6 in. Diamond and 2.2 in. Square Mesh Cod Ends vs J&J Controls

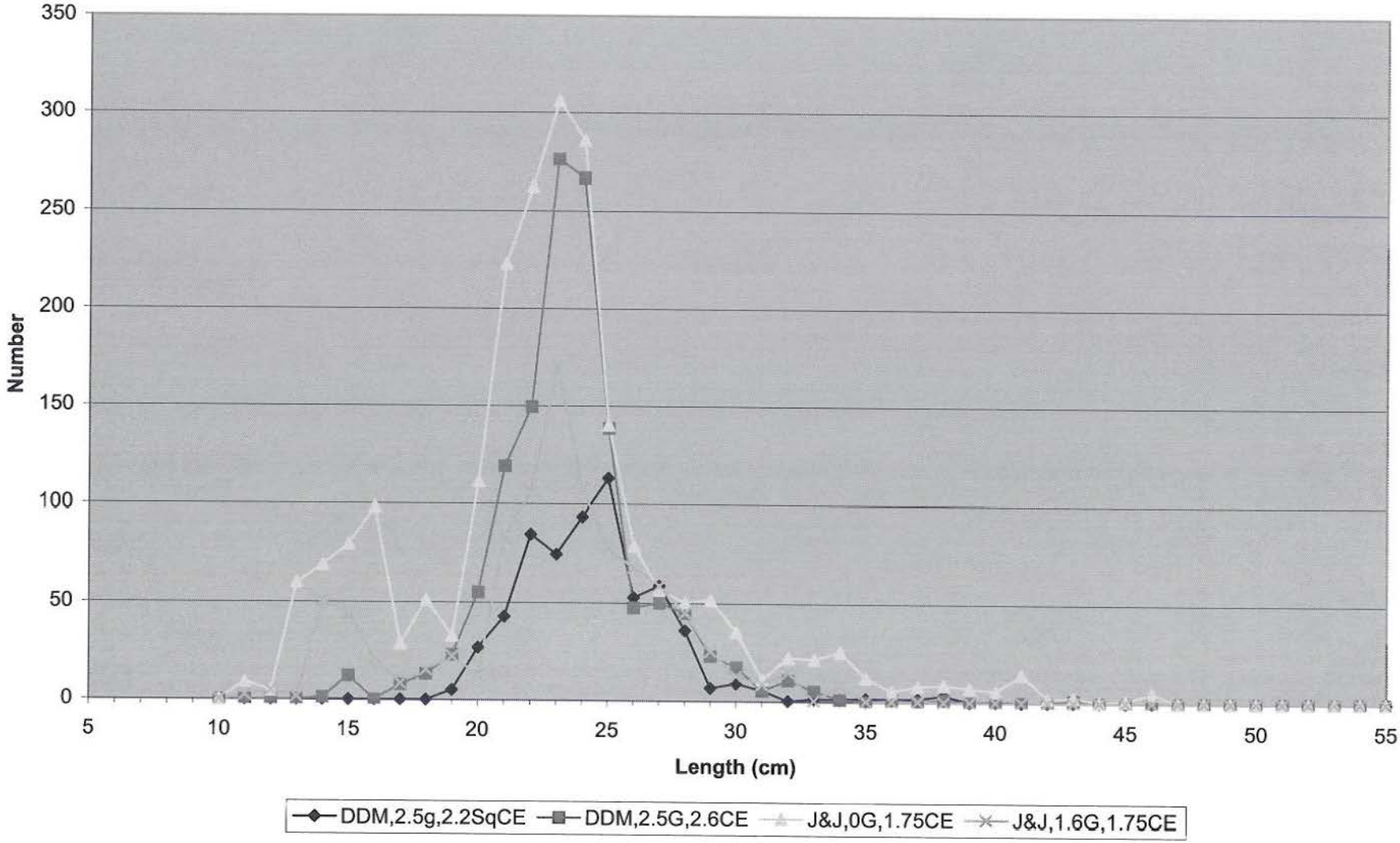

Figure 2. Silver Hake: Percent Length Frequency from DDM 2.5 in. Grate, 2.2 in. Square Mesh and 2.6 in. Diamond Cod Ends vs J&J Controls

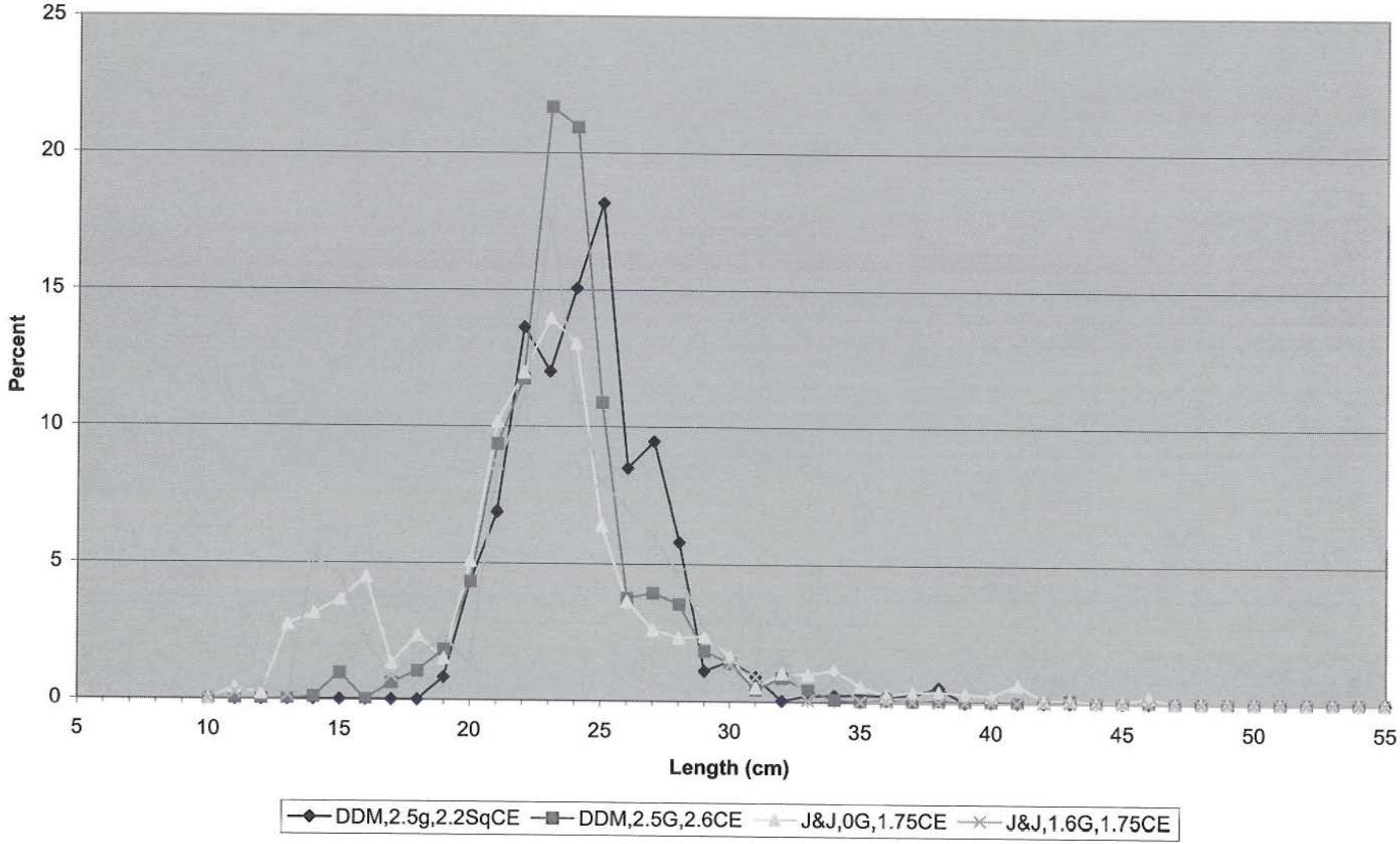

Figure 3. Whiting: Length Frequency with 42 in and 30 in Raised Footrope and 2.0 in Grate, 2.2 in Sq. Mesh Cod End(CE) vs No Grate,1.75 in CE and 2.5 in Grate, 2.2 in Sq. Mesh CE vs No Grate,1.75 in CE and 1.6 in Grate, 1.75 in CE

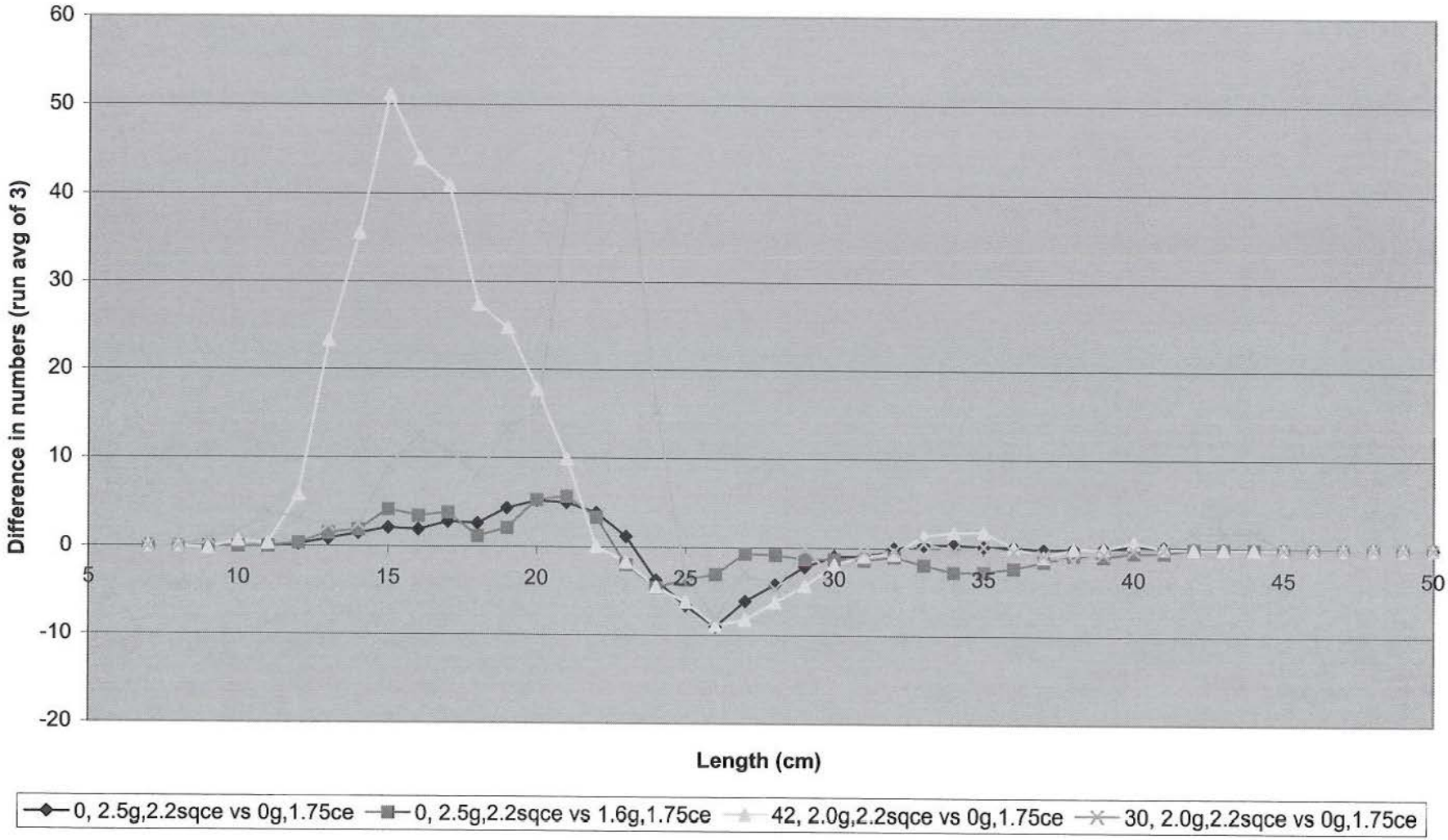

Figure 4. Whiting: Length Frequency with 42 in and 30 in Raised Footrope with 2.0 in Grate and 2.6 in Cod End(CE) vs No Grate, 1.75 in CE and 2.5 in Grate and 2.6 in CE vs No Grate, 1.75 in CE and 1.6 in Grate, 1.75 in CE.

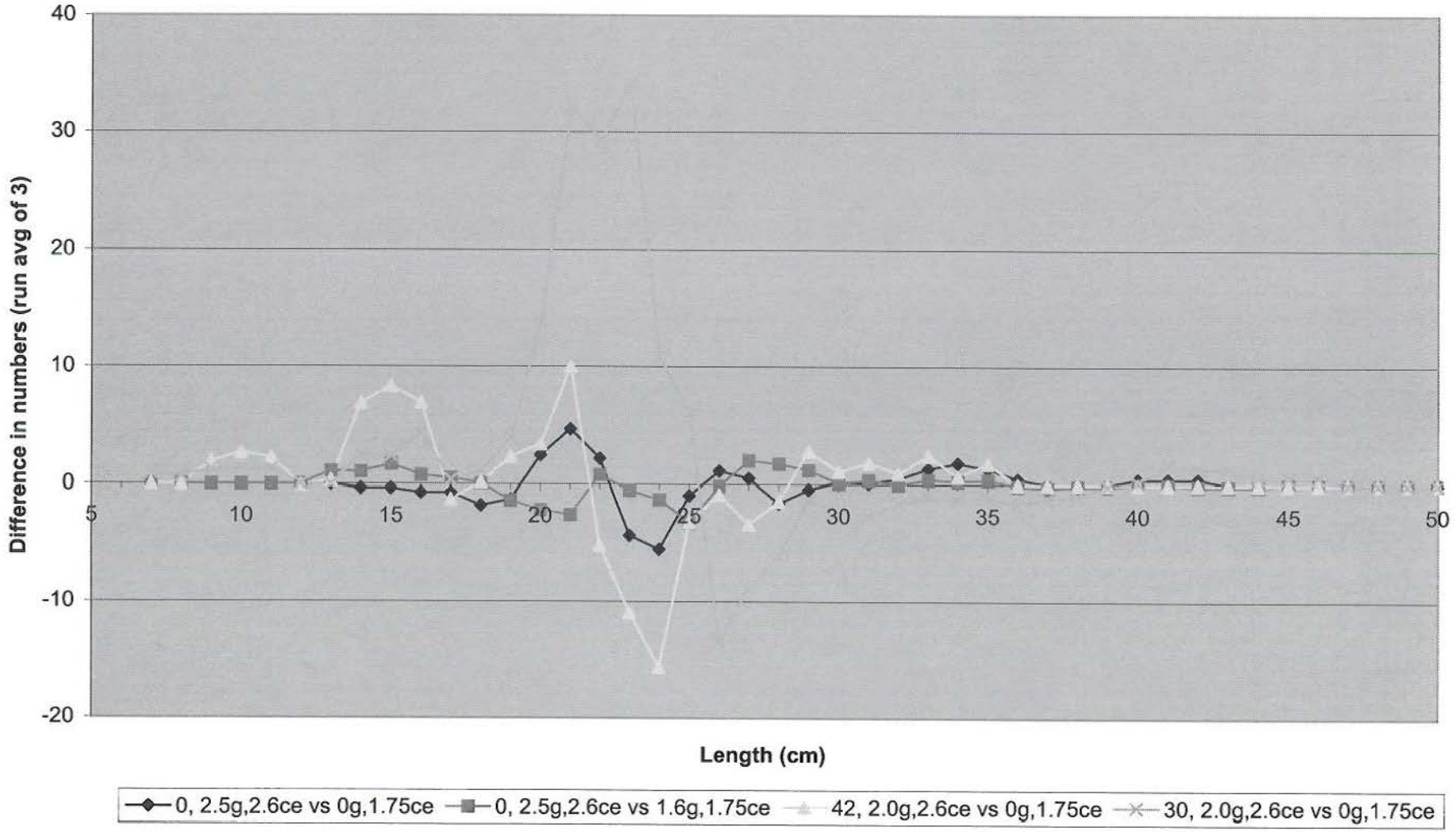

Figure 5. Plaice: Catch Length Frequency from DDM 2.5 in. Grate, 2.6 in Diamond and 2.2 in. Square Mesh Cod Ends vs J&J Controls

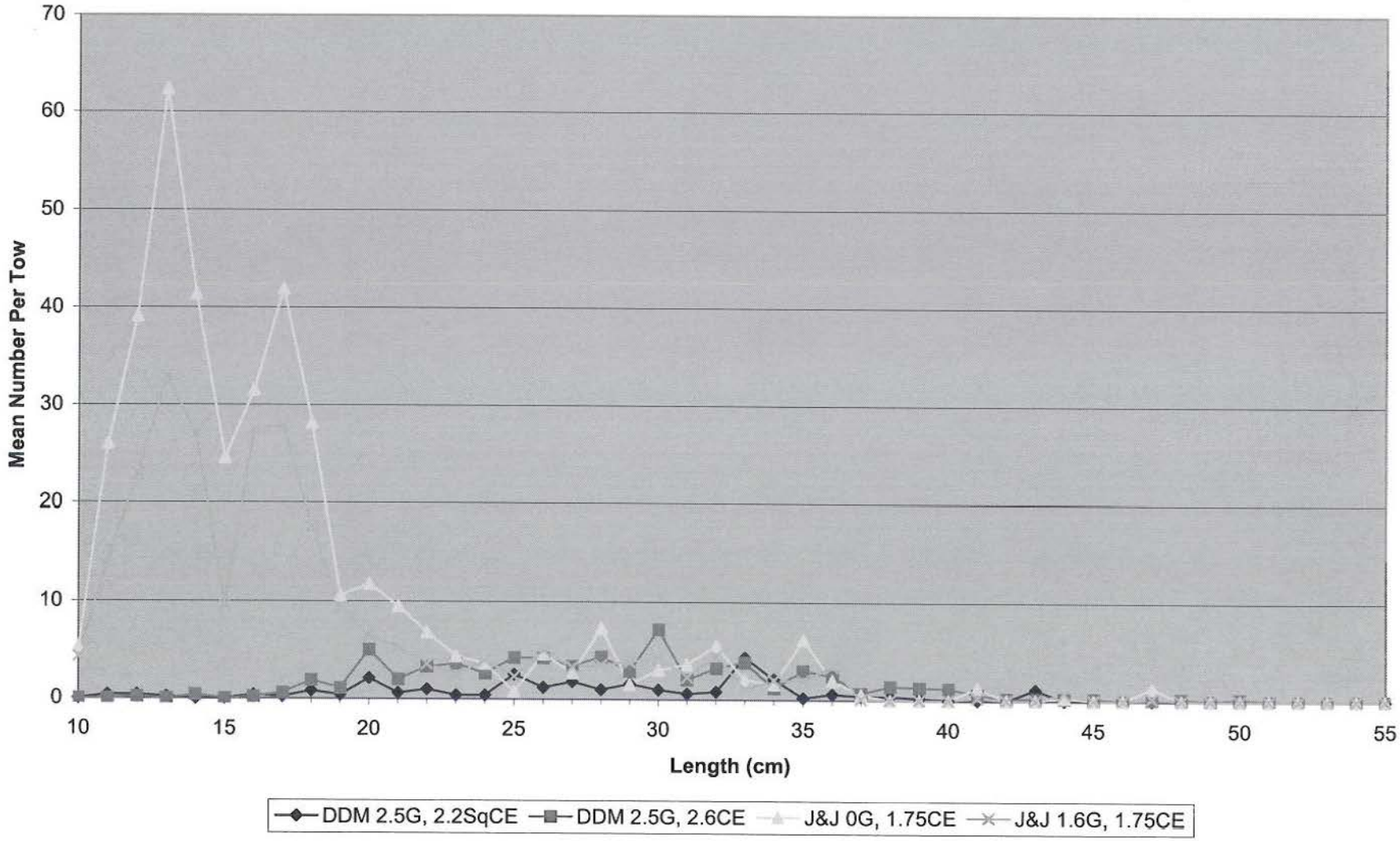

Figure 6. Plaice Percent Length Frequency from DDM 2.5 in. Grate, 2.2 in. Square and 2.6 in. Diamond Cod Ends vs J&J Controls

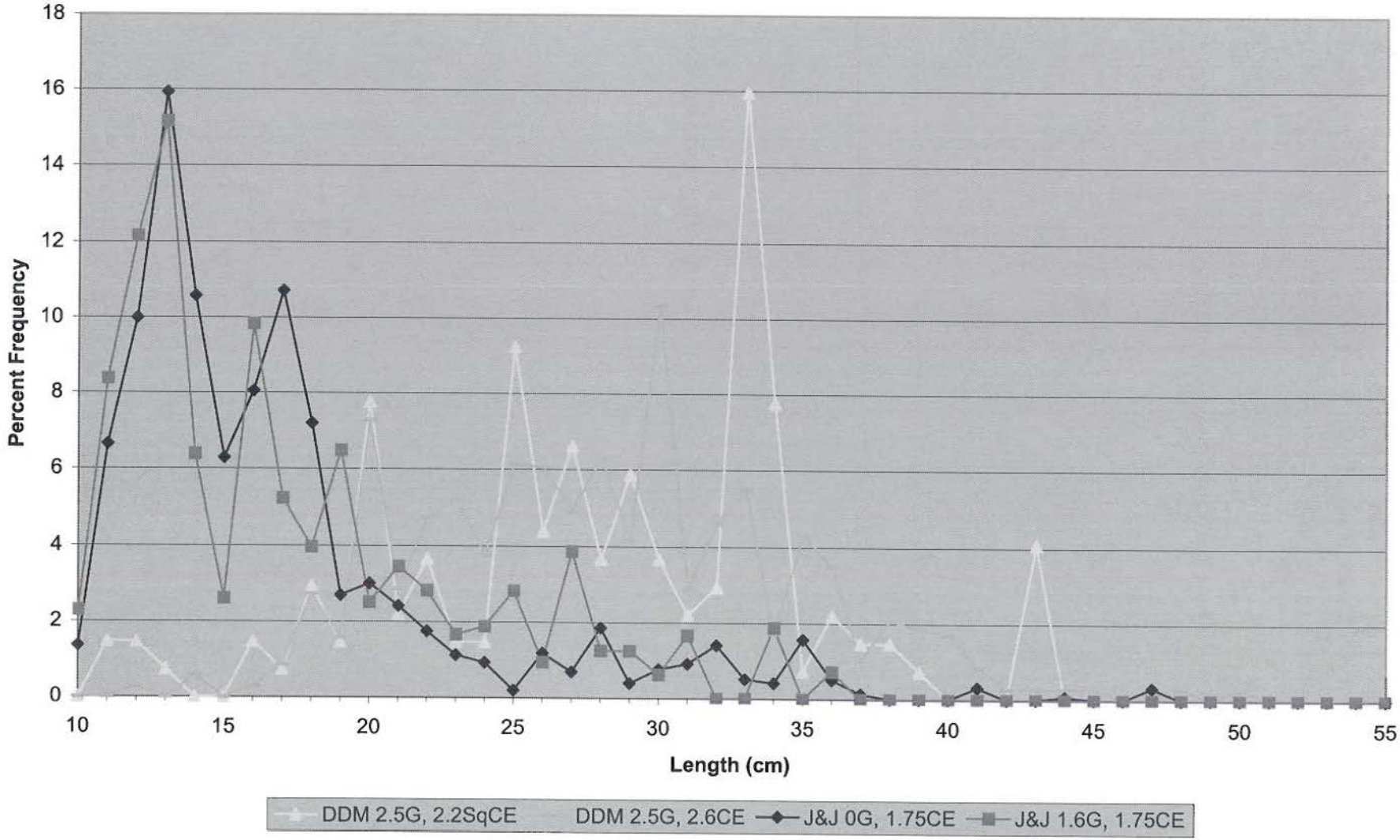

Figure 7. Plaice: Length Frequency with 42 in, or 30 in Raised Footrope with 2.0 in Grate and 2.2 in Sq. Cod End vs No Grate, 1.75 in Cod End and 2.5 in Grate, 2.2 in Sq. Cod End vs No Grate, 1.75 in Cod End or 1.6 in Grate, 1.75 in Cod End.

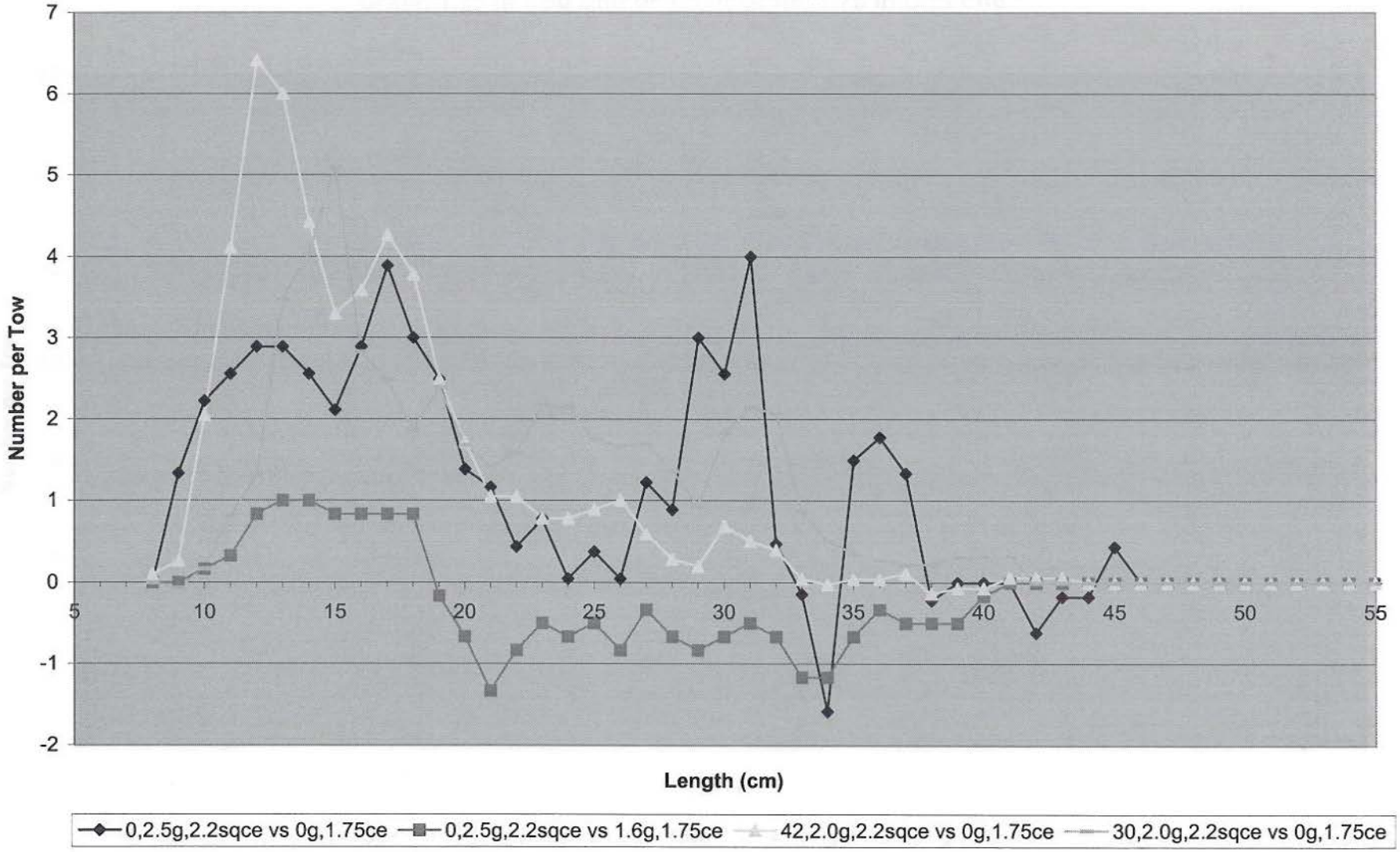

Figure 9. Red Hake Catch Length Frequency from DDM 2.5 in. Grate, 2.6 Diamond and 2.2 Square Cod Ends vs J&J Controls

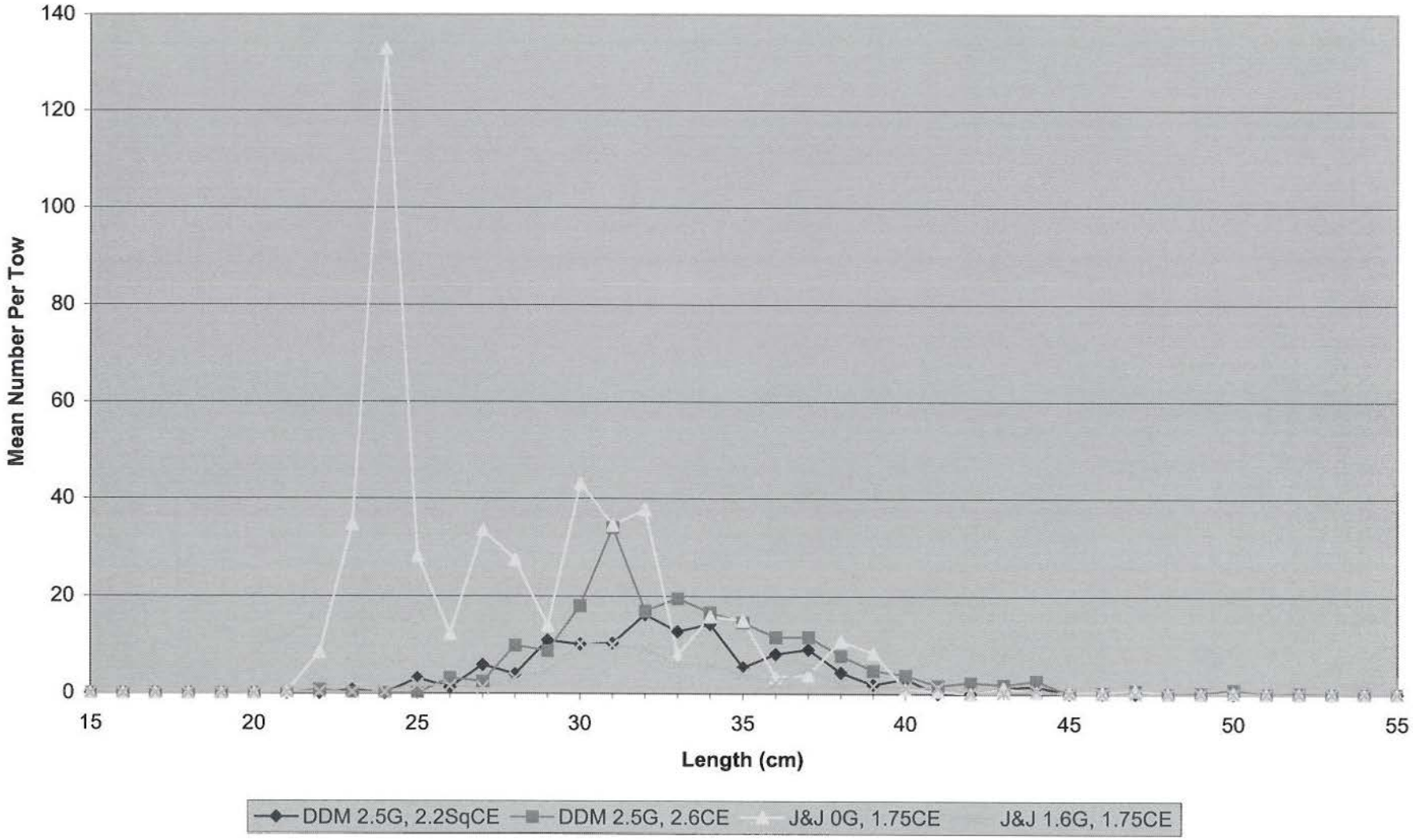

Figure 10. Red Hake Percent Length Frequency from DDM 2.5 in. Grate, 2.6 in. Diamond and 2.2 in. Square Cod Ends vs J&J Controls

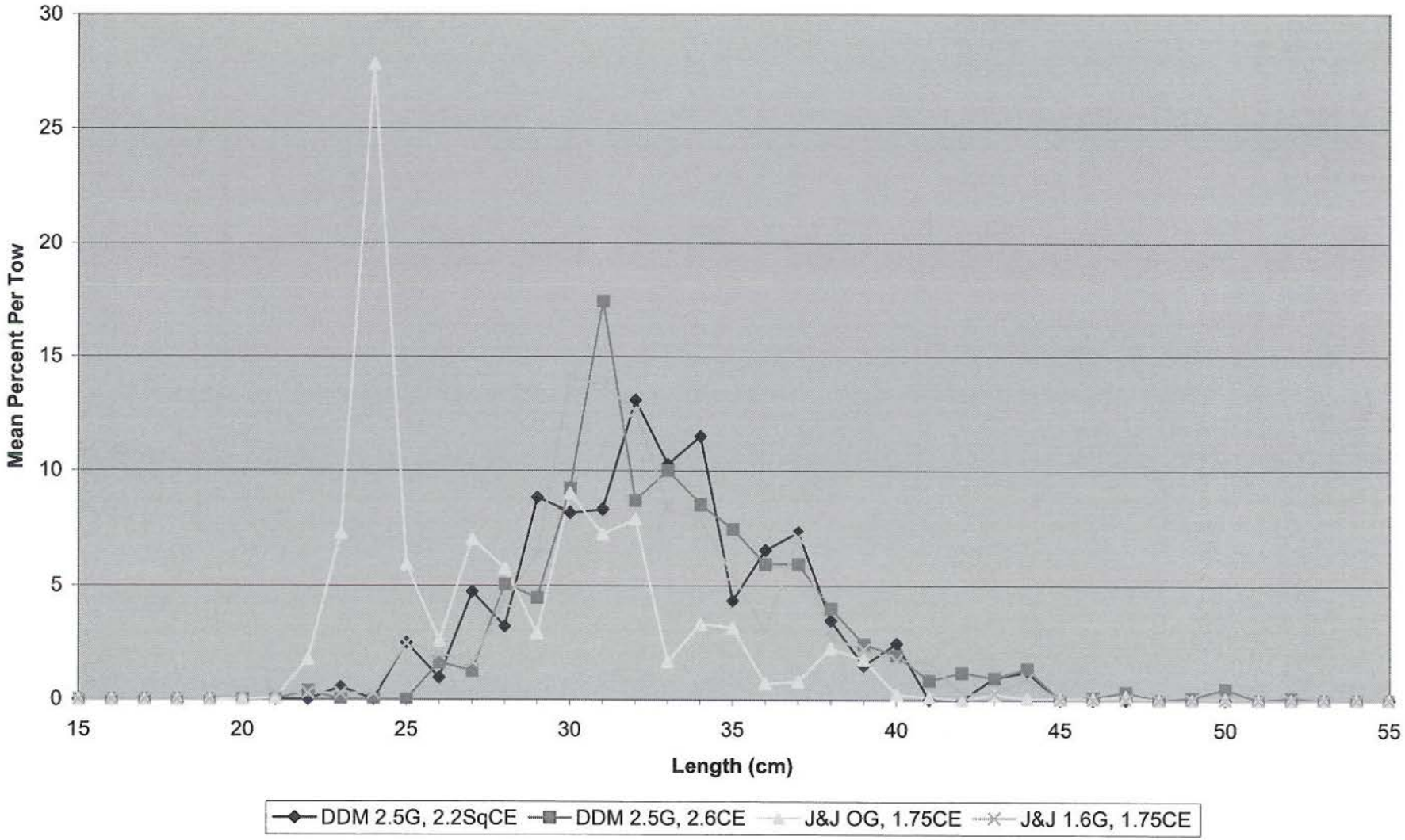

Figure 11. Red Hake: Length Frequency with 42 in, or 30 in Raised Footrope with 2.0 in Grate and 2.2 in Sq. Mesh Cod End vs 0 Grate, 1.75 in Cod End and 2.5 in Grate, 2.2 in Sq. Cod End vs 0 Grate, 1.75 in Cod End or 1.6 in Grate, 1.75 in Cod End

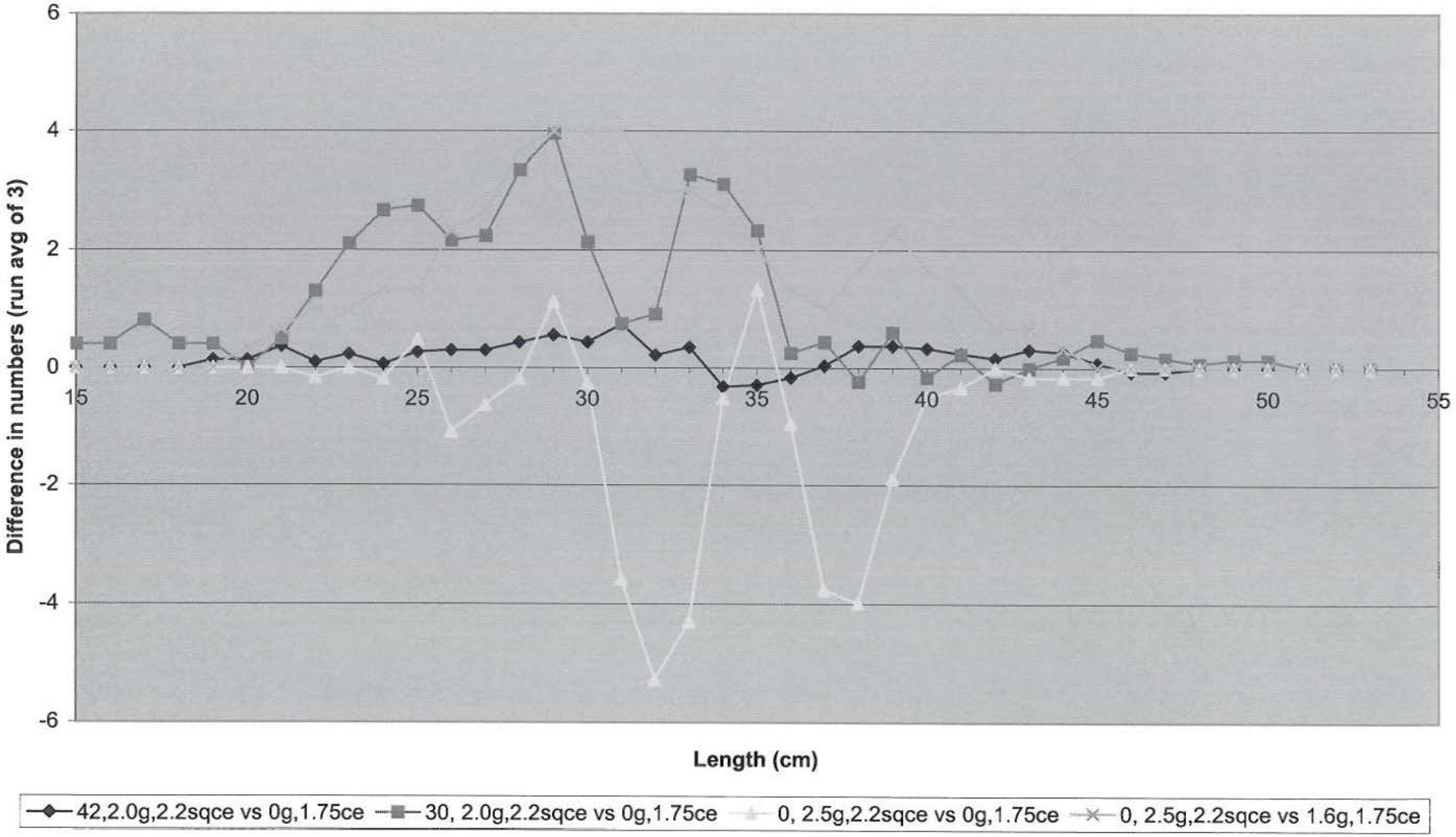

Figure 12. Red Hake: Length Frequency with 42 in, or 30 in Raised Footrope with 2.0 in Grate, 2.6 in Cod End vs 0 Grate, 1.75 in Cod End and 2.5 in Grate, 2.6 in Cod End vs 0 Grate, 1.75 in Cod End or 1.6 in Grate, 1.75 in Cod End