New Generation Trawl for Efficiency and Conservation

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Abstract:

The objectives of this project were to build the New Generation Trawl (NGT) and demonstrate a reduction in the catch of undersized market species as well as non-market species, compared with standard gear. The second objective was to show how the Sort V fish grate can reduce bycatch of undersized market species as well as non-market species. The final objective was to look at fuel consumption differences (indicated by RPM) comparing the NGT vs. a traditional groundfish trawl.

The NGT in its standard form did not appear to be a viable alternative to the standard groundfish trawl, but when paired with the Sort V grate there were glimpses of potential. The NGT made significantly larger catches of significantly smaller fish compared with the standard groundfish trawl. The results for the NGT with the Sort V grate were mixed, showing four out of nine species having significantly higher catch weights and only one of nine with a significantly lower catch weight for the NGT w/Sort V grate. Four of the nine species showed a significantly smaller fish being caught, while two of the nine showed a significantly larger fish was being caught in the NGT w/Sort V grate. The NGT also was shown to fish with a significantly higher RPM. The NGT w/Sort V grate should be tested with different size bar spacing in the grate or different mesh size in the net. The fuel consumption could be better if smaller doors were used.

Introduction:

As the managers of groundfish stocks in the Gulf of Maine impose severe reductions in fishing effort in order to restore groundfish populations, groundfishing has become more difficult, with decreases in the number of fishing days and areas where fishing can occur, increases in the price of gear, ice, dock fees, fuel, insurance, shipping costs, increased competition from overseas imports, and greatly increased scrutiny concerning levels of bycatch and the effect of fishing activity on the marine environment. As a result, fishing vessel operators have experimented with the development of new, highly targeted, habitat-sensitive gear that is more cost-effective than the standard gear used today. One of the results of this work is the New Generation Trawl.

This trawl has been tested in Iceland with good results (Jonsson, pers.comm.). The trawl combines three features developed separately by fishermen and gear research scientists in Norway and Iceland: the Sort V grid, flat rubber plate ground gear, and compressed twine. We tested the trawl in the Gulf of Maine to see if we could reproduce those results in our waters.

The trawl has reduced undersized target species capture and reduced bycatch of untargeted species by using a Sort V fish grid in Icelandic waters (Jonsson, pers.comm.). The Sort V grid is the end product of years of research on hard panel, parallel bar devices mounted generally in the extension of the net. The ICES Fishing Technology and Fish Behavior Working Group has produced an excellent review of the development of fishing technology to conserve fish, including sorting grids and the Sort V grid in particular (Walsh, et al, 2000). The rigid grids were first used in the shrimp fishery to reduce fish bycatch (Isaksen, Valdemarsen and Larsen, 1990). Larsen and Isaksen (1993) have reviewed the early subsequent work on the use of sorting grids for finfish fisheries. Several lines of research to improve sorting grids, and test their utilization in combination

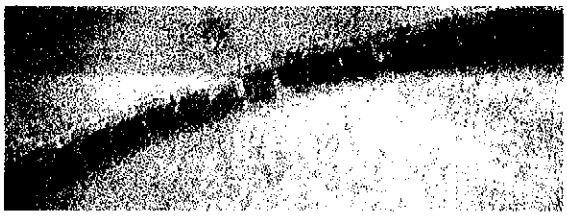
with other devices in trawls, have continued to the present (Ingolfsson et al, 2002; Galbraith et al, 2002).

Another attribute of the New Generation Trawl is that it uses flat, vertical rubber plates as the ground gear instead of the standard roller frame, or rock hoppers. This flat plate technology was developed by the Institute of Marine Research in Norway (Valdemarsen, 2004). In subsequent research, these plates have been shown to do the job of herding fish into the trawl while having less contact and impact on the bottom in Icelandic waters (Jonsson, pers.comm.). In addition to the ground gear having less impact on the bottom, the flat plates help the net spread and provide more width and more height than standard groundfish trawls while using smaller nets. Also the flat plates that are used as ground gear are roughly 25% to 30% lighter than their equivalent rock hoppers. This reduction in the weight of both the plates and the net leads to being able to use smaller doors. The reduction in weight and use of smaller doors results in even less impact to the bottom, and lower fuel costs.

In Iceland the New Generation Trawl was shown to be more fuel efficient than the standard groundfish gear (Jonsson, pers.comm.). This is due in part to the use of compact twine, which is stronger and thinner than polyethylene twine, resulting in a smaller net mass with less drag. The compact twine is the third element of the New Generation Trawl that should reduce its ecological impact and increase its fuel efficiency. This would be an enormous benefit to vessel owners because of the continuous increase in the cost of diesel fuel.

The New Generation Trawl has also been shown to sustain less damage while under tow than standard groundfish gear used in the same areas in Iceland. This is due in part to the use of compact twine instead of polyethylene twine and in part to the design of the trawl. The more minimal the damage to the trawl the less time and supplies are needed to fix it, resulting in more actual fishing time and fewer expenses. Combining this with a better fuel efficiency should result in reducing the cost of fishing.

The use of the Sort V fish grid should reduce bycatch mortality, and the sorting time on deck so that a better quality product can be obtained. All of this equates to a greater ability to compete with the flood of imported fish from foreign countries, and improved stock conservation.



These pictures show the New Generation Trawl's flat, vertical rubber plates that are used as ground gear instead of the standard roller frame, or rock hoppers.

Objectives:

The objectives of this project were to build the New Generation Trawl and demonstrate a reduction in the catch of undersized market species as well as non-market species, when compared with a standard trawl. The second objective was to show how the Sort V fish grate can reduce bycatch of undersized market species as well as non-market species. The final objective was to compare the fuel consumption (indicated by RPM) of the New Generation Trawl vs. a traditional groundfish trawl.

Participants:

The participants for this research included project leader Allyson Jordan, owner of the vessels involved in the research. The primary scientist was Dan Schick of the Maine Department of Marine Resources (DMR) until his retirement, at which time Lessie White took over the research. Hordur Honsson was an industry collaborator on the project and built the New Generation Trawls used in the research. Bill Train captained the F/V Theresa & Allyson and Timothy Cook captained the F/V Jamie & Ashley. Margaret Hunter, Matt Cieri, Sally Sherman, Kohl Kanwit, and David Libby (DMR) guided the data analysis. Without the hard work of all of these individuals working as a team, completion of this project would not have been possible.

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Methods:

A New Generation Trawl was assembled according to cutting diagrams and a materials list obtained from Hordur Jonsson, VT Fishing Supplies, Iceland. The trawl was assembled during the spring of 2006 and ready for test tows by May. The New Generation Trawl was a panel net with a headrope length of 99' and a footrope length of 105'. The ground cables were 50' and the fishing circle was 375 meshes. The meshes were 6" IK mesh and the twine was 4 mm dynema twine. Top and bottom legs measured 30' and the flat vertical rubber plates measured 16". There were 99 floats used on this net. The standard groundfish gear used was a four-seam Ivan Christiansion net with a headrope length of 80'7" and a footrope length of 98'. The ground cables were 50' and the fishing circle was 388 meshes. The meshes were 6" IK mesh and the twine was 4 mm twine. Top and bottom legs measured 20' and the rollers were 16". There were 80 floats used on this net. The doors that were used on the Jamie & Ashley were 3.0 NET doors that weighed 527 kg. The doors used on the Theresa & Allyson were Bison #10 doors that weighed 550 kg.

To test the effectiveness of the New Generation Trawl we used a side by side comparison with two vessels that were well matched in size and horsepower, the Theresa & Allyson and the Jamie & Ashley. The Theresa and Allyson has a length of 70.7', a breadth of 20.0', a depth of 10.5', a gross tonnage of 99 and a net tonnage of 79. The main propulsion is provided by a single twelve cylinder Caterpillar diesel, 3412, which delivers approximately 540 horsepower at 1800 RPM's at continuous duty. The Jamie and Ashley has a length of 65.0', a breadth of 19.0', a depth of 9.0', a gross tonnage of 75 and a net tonnage of 59. The main propulsion is provided by a single eight cylinder Caterpillar diesel, 3408, which delivers approximately 402 horsepower at 1800 RPM's at continuous duty.

The Jamie & Ashley towed a standard groundfish trawl and the Theresa & Allyson towed the New Generation Trawl for three days. The vessels then switched trawls so that the Jamie & Ashley was towing the New Generation Trawl and the Theresa & Allyson was towing the standard groundfish trawl for another three days in order to minimize vessel variation. Tows were three hours long and took place twenty-four hours a day for the six days. Three hour tows running twenty-four hours a day is a normal fishing practice during the summer months. These experiments were conducted between the dates of May 24, 2006 and June 2, 2006, the latitudes of 42.81 and 43.84, the longitudes of 67.76 and 69.81 and in the depth range of 89-134 fathoms (163-245 m) (Map 1).

An additional three days of towing was used to test the New Generation Trawl against the New Generation Trawl with the Sort V grate. The vessels again switched trawls, this time after a day and a half of towing so that each piece of gear was towed equally between vessels to minimize vessel variation. Again the tows were three hours long and towing took place twenty-four hours a day. These experiments were conducted between the dates of October 16, 2006 and October 25, 2006, 42.50 and 43.23 N Lat, 69.48 and 69.88 W Long, and in the depth range of 73-146 fm (134-267 m) (Map 2).

The tow time started at the locking of the brakes and the tow time ended when the brakes were unlocked and retrieval started. Recorded for each tow were the date, starting time, ending time, starting latitude, ending latitude, starting longitude, ending longitude, starting depth, ending depth, tow speed, wire out, gear type and RPM. Once the catch came on board the boat, the fish were separated by species and a total weight by species was recorded. Individual lengths of each fish were usually taken. In the cases where there were quite a few fish a weighed sub-sample was taken. Tows that were not exactly three hours were standardized to three hours. Data were entered into a database and appropriate statistical analyses including parametric, ie ANOVA and paired and unpaired 't' tests were done to test the null hypotheses. The null hypotheses that were tested were that there is no difference in catch weights or mean fish length, between the New Generation Trawl and the standard groundfish trawl, and no difference between the New Generation Trawl with the Sort V fish grid and the New Generation Trawl without the grid. The null hypothesis for testing the fuel efficiency was that there was no difference in RPM between the New Generation Trawl and the standard groundfish trawl.

Test results are reported as "significantly different" if the probability (p) of obtaining a test statistic that high by chance (α) is less than 0.05 (5%). However, in the tables, test results with p values less than 0.10 (10%) are also highlighted, and sometimes mentioned in the text.

Data Analysis and Results:

There were 29 paired tows done to compare the standard groundfish trawl to the New Generation Trawl (without the Sort V grid). Only 28 of these tows were used in analysis due to the codend being open during tow number 5 for the F/V Theresa & Allyson (Table 1). There were 14 tows done with the New Generation Trawl (without the Sort V grid) and 17 tows done with the New Generation Trawl with the Sort V grid for the experiments looking at the effect of a Sort V grid (Table 2).

Standard Groundfish Trawl vs. New Generation Trawl (without the SortV grid) Total Catch Weights, and Catch Weights by Species

A t-test (paired two sample for means) was performed on the mean total catch weight of all species, with data combined from both boats for the standard groundfish trawl compared with the New Generation Trawl (NGT). The standard trawl had a mean catch weight of 313.1 kg, while the NGT had a mean catch weight of 601.4 kg. These were highly significantly different ($p = 0.000095$) (Table 3).

A t-test (two-sample assuming unequal variances) to compare the mean total catch weights from the two trawls was performed on each boat separately. For the Theresa & Allyson, the standard trawl had a mean catch weight of 300.0 kg, while the

NGT had a mean catch weight of 454.2 kg. These were not quite significantly different ($p = 0.0952$). The Jamie & Ashley had a mean catch weight of 328.2 kg for the standard groundfish trawl and the NGT had a mean catch weight of 729.0 kg. These were highly significantly different ($p = 0.00303$) (Table 3).

There were nine species of fish evaluated in more detail (Table 3): white hake (*Urophycis tenuis*), Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), pollock (*Pollachius virens*), dab (*Hippoglossoides platessoides*), gray sole (*Glyptocephalus cynoglossus*), redfish (*Sebastes fasciatus*), monkfish (*Lophius americanus*) and spiny dogfish (*Squalus acanthias*). A t-test (paired two sample for means) was performed on the catch weight for each of the species above on the data combined from both boats for the standard groundfish trawl and the NGT. A t-test (two-sample assuming unequal variances) was also performed on each boat separately for the catch weight of each of the species above (Table 3).

White hake, redfish and dogfish showed a significant difference in mean catch weight. These three species showed higher catch weights for the NGT. Pollock and gray sole also showed a difference in weight with 90% confidence, with the higher weights being for the NGT. Cod, haddock, dab and monkfish did not show a statistically significant difference in weight between the NGT and the standard groundfish trawl. All nine species had higher catch weights in the NGT for both boats combined.

The Theresa & Allyson showed a significant difference in mean catch weights for white hake and gray sole, with the NGT being higher for both. There was no significant difference in catch weights for cod, haddock, pollock, dab, redfish, monkfish and dogfish for the Theresa & Allyson. Only cod, pollock and monkfish, showed higher catch weights for the standard groundfish trawl.

The Jamie& Ashley showed a significant difference in the mean catch weight for pollock with more being caught by the NGT. The New Generation Trawl also caught more white hake, cod, redfish and dogfish at a 90% confidence limit than the standard trawl. Haddock, dab, gray sole and monkfish did not show a significant difference in catch between the two trawls for the Jamie & Ashley. Only dab and gray sole had higher catch weights for the standard groundfish trawl.

Standard Groundfish Trawl vs. New Generation Trawl (without the SortV grid) Catch Lengths

An analysis of variance: estimate model was run on the mean lengths, with boat and gear type being factors, for each of the above nine species (Table 4). For both boats combined, cod, gray sole and monkfish did show a lower mean length for the NGT than for the standard trawl, though not significantly so. The other six species showed a significant boat or boat*gear interaction and had to be evaluated by the individual boats separately.

For the Theresa & Allyson, white hake, haddock and dogfish were significantly smaller in the NGT than in the standard groundfish trawl. The last three species for the Theresa & Allyson did not show a significant difference in length, with pollock and dab having a slightly larger mean length in the NGT than the standard trawl and redfish having a slightly smaller mean length in the NGT than the standard trawl.

For the Jamie & Ashley, there was a significant difference in length for four of the six remaining species. White hake, pollock and redfish showed significantly smaller

mean lengths in the NGT than in the standard trawl. Dab was the only one to show a significantly larger mean length in the NGT than in the standard trawl. Haddock and dogfish did not show a significant difference in length but had slightly smaller mean lengths in the NGT than in the standard trawl.

The data were also analyzed to determine what percent of the total catch was legal vs. sub-legal for the standard trawl vs. NGT and how many legal and sub-legal fish were caught per tow for seven of the species that have legal minimum size restrictions (cod, haddock, pollock, dab, gray sole, redfish and monkfish) (Tables 5 and 6). The NGT caught a higher percentage of sub-legal sized fish for all but dab and redfish (Figures 1, 3, 5, 7, 9, 11, 13, 15, 17).

New Generation Trawl vs. New Generation Trawl with Sort V grate
Total Catch Weights, and Catch Weights by Species

A t-test (two-sample assuming unequal variances) was performed on the total catch weight data combined from both boats for the New Generation Trawl (NGT) and the New Generation Trawl with a Sort V grate (NGT w/Grate). Mean catch weights were not significantly different ($p = 0.5674$) between the NGT (555.1 kg) and the NGT w/Grate (474.9 kg).

A t-test (two-sample assuming unequal variances) was performed on each boat separately. The mean catch weights for the NGT (396.3 kg) and the NGT w/Grate (342.2 kg) on the Theresa & Allyson were not significantly different ($p = 0.5924$). The Jamie & Ashley mean catch weights for the NGT (841.0 kg) and the NGT w/Grate (624.3) also were not significantly different ($p = 0.4260$).

The same nine species of fish (white hake, codfish, haddock, pollock, dab, gray sole, redfish, monkfish and dogfish) that were analyzed in the standard trawl vs. NGT were analyzed in the NGT vs. NGT w/Grate. A t-test (two-sample assuming unequal variances) was performed on the catch weight for each of the species combined from both boats for the NGT and the NGT w/Grate. A t-test was also performed on each boat separately for total catch weight of each of the nine species above (Table 7).

Five of the nine species had higher catch weights in the NGT w/ Grate for both boats combined. Only white hake, dab and dogfish showed a significant difference in weight, with higher catch weights for the NGT w/ Grate. Haddock also showed a difference in weight at a 90% confidence limit with the higher weights being for the NGT w/ Grate.

The Theresa & Allyson showing a significantly higher catch weight for white hake, dab and dogfish and a significantly lower catch weight for pollock with the NGT w/ Grate. There was also a higher catch weight at a 90% confidence limit for haddock with the NGT w/ Grate. Cod, gray sole, redfish and monkfish for the Theresa & Allyson did not show a significant difference in catch weight. Pollock, gray sole and monkfish, showed lower catch weights for the New Generation Trawl w/ Grate.

The Jamie& Ashley did not show any significant difference between the NGT and the NGT w/ Grate at a 95% confidence limit for catch weight of all nine species. Cod, pollock, gray sole and monkfish showed lower catch weights for the NGT w/ Grate.

New Generation Trawl vs. New Generation Trawl with Sort V grate
Catch Lengths

An analysis of variance: estimate model was run on the mean lengths, with boat and gear type being factors for each of the above nine species (Table 8). For both boats combined, haddock, dab and monkfish did not show a significant difference in length. All three of these species did show a higher mean length for the NGT w/ Grate than for the NGT. White hake and gray sole had a smaller mean length for the NGT w/ Grate than the NGT. The other four species showed a significant boat or boat*gear interaction and were evaluated for the individual boats separately.

For the Theresa & Allyson, pollock and redfish were significantly larger, while dogfish were significantly smaller in the NGT w/ Grate than in the NGT. Cod for the Theresa & Allyson did not show a significant difference in length but had a larger mean length in the NGT w/ Grate than in the NGT. For the Jamie & Ashley, cod had a significantly smaller mean length, while pollock had a significantly larger mean length in the NGT w/ Grate than in the NGT. Redfish and dogfish did not show a significant difference in length but redfish had slightly smaller mean length and dogfish had a slightly larger mean length in the NGT w/ Grate than in the NGT. Overall four of the six species that showed significant differences in length had smaller mean lengths for the NGT w/ Grate than for the NGT. In looking at all nine species, five species showed larger mean lengths for the NGT w/ Grate than for the NGT.

The data were also analyzed to determine what percent of the total catch was legal vs. sub-legal for the NGT vs. NGT w/Grate and how many legal and sub-legal cod, haddock, pollock, dab, gray sole, redfish and monkfish were caught per tow (Table 9 and 10). The NGT caught a higher percentage of legal-sized cod, haddock, gray sole, and redfish (Figures 2, 4, 6, 8, 10, 12). The NGT w/Grate caught a higher percentage of legal-sized fish for dabs and monkfish (Figures 16, 18).

Fuel Efficiency

A t-test (paired two sample for means) was performed on the RPM data combined from both boats for the standard groundfish trawl and the New Generation Trawl (NGT). The standard trawl had a mean RPM of 1,629.7, while the NGT had a mean RPM of 1,668.6. These were not significantly different ($p = 0.09532$)

A t-test (two-sample assuming unequal variances) was performed on each boat separately. The Theresa & Allyson with the standard trawl had a mean RPM of 1,666.9, while the NGT had a mean RPM of 1,688.8. These were not significantly different ($p = 0.4307$). The Jamie & Ashley had a mean RPM of 1,589.9 for the standard groundfish trawl and the NGT had a mean RPM of 1,649.7. These were not significantly different ($p = 0.07712$).

Results and Discussion:

Standard Groundfish Trawl vs. New Generation Trawl

Analysis of catch weight data indicates that the NGT catches more than the standard groundfish gear. However when size composition data are considered, five of the six species showed a significantly smaller mean length of fish being caught in the NGT. The only species that showed a significantly larger mean length for the NGT was redfish and the catch weight for redfish showed no statistical difference between the NGT and the standard trawl.

Considering the length data with the weight data, it looks as if the New Generation Trawl is catching more fish that are of a smaller size than the standard groundfish gear, but are they smaller legal fish or sub-legal fish? If the smaller fish are of legal size then the NGT could still be a good alternative to the standard groundfish gear.

The seven species that had legal size requirements were looked at by percent of the total catch that were sub-legal and percent of the total catch that were legal for both gear types. The NGT showed an increase in the percent of sub-legal fish for five species, cod, haddock, pollock, gray sole and monkfish. The only two species that showed a decrease in sub-legal fish for the NGT was dab and redfish. In viewing these results the New Generation Trawl does not look like an equal or better option than the standard groundfish trawl.

New Generation Trawl vs. New Generation Trawl with Sort V grate

The New Generation Trawl w/ Grate had a slightly lower but not significantly lower total catch than the New Generation Trawl for both boats combined and for each boat individually.

Four of the nine species (white hake, haddock, dab and dogfish) had significantly higher catch weights for the NGT w/ Grate than the NGT. The length data showed six of the nine species with significant statistical differences for at least one boat. Four of the six showed a significantly smaller mean length for the NGT w/ Grate than for the NGT. The only two species that showed a significantly larger mean length for the NGT w/ Grate over the NGT were pollock and redfish and these were two species that did not show a significant difference in catch weights. Looking at the length and weight data together, there were two species, white hake and dogfish, which had a significant increase in catch weight and a significant decrease in mean length. There were also two species, cod and gray sole, that showed a significant decrease in catch length but no significant difference in catch weights. Pollock and redfish showed a significant increase in catch lengths and no significant difference in catch weights. Apparently the New Generation Trawl with Grate is catching significantly more fish that are of a significantly smaller size than the New Generation Trawl, but again are they smaller legal fish or sub-legal fish? If the smaller fish are of legal size then the grate could still be a good addition to the standard groundfish gear.

The seven species that had legal size requirements were looked at by percent of the total catch that were sub-legal and percent of the total catch that were legal for both gear types. The NGT w/ Grate showed an increase in the percent of sub-legal fish for four species, cod, haddock, gray sole and redfish. The only two species that showed a decrease in sub-legal fish for the NGT w/ Grate was dab and monkfish. Pollock showed the same amount of sub-legal fish for both gear types. In viewing these results the Sort V grate in its present state appears to be equivalent to but probably not a better option than the New Generation Trawl.

Fuel Efficiency

The analysis for both boats combined showed a difference at a 90% confidence limit for RPM, with the NGT having a higher RPM than the standard groundfish trawl. Each boat was then looked at individually with the Jamie & Ashley showing a statistically significant difference at a 90% confidence limit again with the NGT having a

higher RPM than the standard groundfish trawl. The Theresa & Allyson showed no difference in RPM at a 90% confidence limit. Overall the RPM for the New Generation Trawl was higher than the RPM for the standard groundfish trawl for both boats combined and for each boat individually.

This in turn leads to worse fuel efficiency for the NGT than for the standard groundfish trawl. The fuel efficiency numbers would have been better for the NGT but the same doors that were used for the standard groundfish trawl were used for the NGT. One of the advantages of the NGT was that its construction would allow it to be towed with smaller doors and still fish the same as a standard groundfish net. Since one of the main reasons for fuel efficiency was not used (smaller doors) it still may be more fuel efficient than our standard groundfish net.

Overall

The New Generation Trawl by itself it is not in its present form a viable alternative to the standard groundfish trawl. When it was paired with the Sort V grate there were glimpses of potential. The New Generation Trawl with the Sort V grate did not perform as expected but improved results might be achieved with slight changes in grate bar spacing and some possible changes in mesh size. A change in door size to the smaller doors could also result in better fuel efficiency than the present groundfish gear. Overall the results for the New Generation Trawl with Sort V grate were mixed at best.

Partnerships:

Allyson Jordan is very enthusiastic about trying new types of gear that catch only what can be sold and are cost efficient. This pursuit is what brought the New Generation Trawl with the Sort V grate to the Gulf of Maine. With Allyson's gear and fishing expertise and Dan Schick putting together the experimental design and analysis to show the appropriate results, communication was key. When Dan retired Lessie White stepped in and took over the data gathering, data entry, data checking, analysis and writing of the report.

Impacts and Applications:

Results of this study indicate that the New Generation Trawl in its present form is not going to reduce the catches of undersized market species or non-market species. The addition of the Sort V grate does show some potential but still needs work before being considered better than the gear that the fishery is presently using. In order for the NGT to have better fuel efficiency than the standard groundfish trawl, fishermen would have to install smaller doors. Until tests are done with smaller doors it is not known how much of a savings, if any, this would provide. Overall this research should not have any impact on the fishermen at this time. The science and fishing communities may want to look into doing some more research on this gear before giving up on it completely. There may be pieces of it that will work if the gear as a whole does not. At this early stage in researching this gear for the Gulf of Maine there should be no impact on management at this time.

Related Projects:

None.

Presentations:

None to date.

Student Participation:

None.

Published Reports and Papers:

None to date.

Images:

None:

Future Research:

The New Generation Trawl with the Sort V grate did not perform as expected but with slight changes in bar spacing of the Sort V grate and some possible changes in mesh size the desired result may be achieved. Testing the New Generation Trawl with the smaller doors could also result in better fuel efficiency than the present groundfish gear. None of this testing is planned to be done at this time.

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Table 1. This table shows the tow starting date, fishing vessel, tow number, trawl type, tow starting time, tow ending time, tow starting depth in fathoms, tow ending depth in fathoms, tow speed in knots and RPM for the 29 paired tows done testing the standard groundfish trawl against the New Generation Trawl.

TOW STARTING DATE	VESSEL NAME	TOW NUMBER	TRAWL TYPE	TOW STARTING TIME	TOW ENDING TIME	TOW STARTING DEPTH	TOW ENDING DEPTH	TOW SPEED	RPM
5/24/2006	JAMIE & ASHLEY	1	Standard	11:17	13:22	99	115	2.9	1480
5/24/2006	THERESA & ALLYSON	1	New Generation	11:23	13:28	99.2	98	3	1590
5/24/2006	JAMIE & ASHLEY	2	Standard	18:20	21:20	122	102	2.9	1680
5/24/2006	THERESA & ALLYSON	2	New Generation	18:39	21:42	122	107	3	1782
5/24/2006	JAMIE & ASHLEY	3	Standard	22:10	01:10	100	127	3	1600
5/24/2006	THERESA & ALLYSON	3	New Generation	22:35	01:47	108	131	3.1	1766
5/25/2006	JAMIE & ASHLEY	4	Standard	02:20	05:23	120	120	3	1600
5/25/2006	THERESA & ALLYSON	4	New Generation	02:30	05:57	128	122	3.1	1705
5/25/2006	JAMIE & ASHLEY	5	Standard	06:28	09:28	121	133	3.2	1600
5/25/2006	THERESA & ALLYSON	5	New Generation	06:35	09:36	124	134	3	1680
5/25/2006	JAMIE & ASHLEY	6	Standard	10:33	13:35	131	109	3.1	1550
5/25/2006	THERESA & ALLYSON	6	New Generation	10:35	13:40	131	107	3	1755
5/25/2006	JAMIE & ASHLEY	7	Standard	14:10	17:15	107	99	3	1600
5/25/2006	THERESA & ALLYSON	7	New Generation	14:35	17:40	105	111	3.1	1745
5/25/2006	JAMIE & ASHLEY	8	Standard	18:22	21:21	105	98	3.1	1500
5/25/2006	THERESA & ALLYSON	8	New Generation	19:25	22:25	105	100	3.1	1650
5/26/2006	JAMIE & ASHLEY	9	Standard	01:03	04:04	105	115	3	1500
5/26/2006	THERESA & ALLYSON	9	New Generation	01:05	04:18	106	108	3.1	1735
5/26/2006	JAMIE & ASHLEY	10	Standard	05:20	08:31	118	134	2.9	1512
5/26/2006	THERESA & ALLYSON	10	New Generation	05:35	08:36	117	133	3.1	1640
5/26/2006	JAMIE & ASHLEY	11	Standard	11:20	14:20	120		3	1700
5/26/2006	THERESA & ALLYSON	11	New Generation	11:19	14:19	121	111	3	1640
5/26/2006	JAMIE & ASHLEY	12	Standard	15:03	16:55	113	106	3.1	1600
5/26/2006	THERESA & ALLYSON	12	New Generation	15:00	16:50	111	106	3.1	1630
5/26/2006	JAMIE & ASHLEY	13	Standard	17:30	20:30	101	101	2.8	1675
5/26/2006	THERESA & ALLYSON	13	New Generation	17:35	20:34	115	97.7	3.1	1825
5/26/2006	JAMIE & ASHLEY	14	Standard	21:16	00:24	101	99	3.1	1685
5/26/2006	THERESA & ALLYSON	14	New Generation	21:14	00:25	99	97	3.1	1800
5/30/2006	JAMIE & ASHLEY	15	New Generation	05:25	08:29	100	100	2.9	1700
5/30/2006	THERESA & ALLYSON	15	Standard	05:24	08:24	102	98.5	3	1723
5/30/2006	JAMIE & ASHLEY	16	New Generation	09:21	12:17	96.6	100	3.1	1575
5/30/2006	THERESA & ALLYSON	16	Standard	09:20	12:20	99	101	3	1676
5/30/2006	JAMIE & ASHLEY	17	New Generation	13:06	16:11	110	117	2.9	1650
5/30/2006	THERESA & ALLYSON	17	Standard	13:21	16:19	108	117	3	1682
5/30/2006	JAMIE & ASHLEY	18	New Generation	17:09	20:07	123	118	3.2	1682
5/30/2006	THERESA & ALLYSON	18	Standard	17:00	20:00	121		3	1617
5/30/2006	JAMIE & ASHLEY	19	New Generation	21:15	00:11	119	108	2.9	1675
5/30/2006	THERESA & ALLYSON	19	Standard	21:07	00:07	115	107	3	1745
5/31/2006	JAMIE & ASHLEY	20	New Generation	00:54	03:57	111	132	2.9	1675
5/31/2006	THERESA & ALLYSON	20	Standard	00:50	03:50	110		3	1740
5/31/2006	JAMIE & ASHLEY	21	New Generation	04:52	07:55	132	118	3.1	1650
5/31/2006	THERESA & ALLYSON	21	Standard	04:56	08:55	130	119	3	1620
5/31/2006	JAMIE & ASHLEY	22	New Generation	09:36	12:42	114	108	3.1	1620
5/31/2006	THERESA & ALLYSON	22	Standard	09:46	12:46	114	109	3	1600
5/31/2006	JAMIE & ASHLEY	23	New Generation	13:30	16:29	104	96	2.9	1566
5/31/2006	THERESA & ALLYSON	23	Standard	13:22	16:20	111	100	3	1660
5/31/2006	JAMIE & ASHLEY	24	New Generation	17:20	20:16	95	103	3	1650
5/31/2006	THERESA & ALLYSON	24	Standard	17:47	20:46	97.7	103	3	1670
6/1/2006	JAMIE & ASHLEY	25	New Generation	01:14	04:14	110	111	3	1650
6/1/2006	THERESA & ALLYSON	25	Standard	02:12	05:12	119	115	3	1550
6/1/2006	JAMIE & ASHLEY	26	New Generation	07:12	10:26	114		3	1650
6/1/2006	THERESA & ALLYSON	26	Standard	05:46	08:48	115	113	3	1690
6/1/2006	JAMIE & ASHLEY	27	New Generation	11:10	14:12	103	100	3	1702
6/1/2006	THERESA & ALLYSON	27	Standard	11:19	14:19	102	102	3	1780
6/1/2006	JAMIE & ASHLEY	28	New Generation	15:13	18:08	95	100	3.2	1660
6/1/2006	THERESA & ALLYSON	28	Standard	15:28	18:28	96.4	99.7	3	1600
6/1/2006	JAMIE & ASHLEY	29	New Generation	22:36	01:38	89	95	3	1700
6/1/2006	THERESA & ALLYSON	29	Standard	22:44	01:44	90.7	93.6	3	1650

Table 2. This table shows the tow starting date, fishing vessel, tow number, trawl type, tow starting time, tow ending time, tow starting depth in fathoms, tow ending depth in fathoms, tow speed in knots and RPM for the tows done testing the New Generation Trawl against the New Generation Trawl with the Sort V Grate.

TOW STARTING DATE	VESSEL NAME	TOW NUMBER	TRAWL TYPE	TOW STARTING TIME	TOW ENDING TIME	TOW STARTING DEPTH	TOW ENDING DEPTH	TOW SPEED	RPM
10/16/2006	THERESA & ALLYSON	1	New Generation w/ Grate	17:08	20:02	95.3	105	3	1828
10/16/2006	THERESA & ALLYSON	2	New Generation w/ Grate	20:55	23:52	116	127	2.9	1900
10/17/2006	THERESA & ALLYSON	3	New Generation w/ Grate	00:35	03:41	123	128	2.9	1575
10/17/2006	THERESA & ALLYSON	4	New Generation w/ Grate	04:45	07:47	138	135	3	1800
10/17/2006	THERESA & ALLYSON	5	New Generation w/ Grate	08:30	11:20	137	146	2.9	1775
10/17/2006	THERESA & ALLYSON	6	New Generation w/ Grate	12:05	15:05	146	133	3	1715
10/17/2006	THERESA & ALLYSON	7	New Generation w/ Grate	15:50	18:51	134	139	3	1750
10/17/2006	THERESA & ALLYSON	8	New Generation w/ Grate	19:50	22:53	140	135	3	1730
10/17/2006	THERESA & ALLYSON	9	New Generation w/ Grate	23:50	03:00	127	92.9	3	1850
10/18/2006	JAMIE & ASHLEY	1	New Generation w/ Grate	16:08	19:08	93	94	2.9	1844
10/18/2006	JAMIE & ASHLEY	2	New Generation w/ Grate	20:00	22:58	97	119	3.1	1855
10/18/2006	JAMIE & ASHLEY	3	New Generation w/ Grate	23:45	02:43	118		3	1644
10/19/2006	JAMIE & ASHLEY	4	New Generation w/ Grate	04:31	07:54	125	122	3	1650
10/19/2006	JAMIE & ASHLEY	5	New Generation w/ Grate	08:30	11:20	110	76	3	1850
10/19/2006	JAMIE & ASHLEY	6	New Generation w/ Grate	12:01	14:53	82	85	3	1590
10/19/2006	JAMIE & ASHLEY	7	New Generation w/ Grate	16:30	18:34	84	94	2.9	1680
10/19/2006	JAMIE & ASHLEY	8	New Generation w/ Grate	19:06	21:21	95	120	3.3	1664
10/19/2006	JAMIE & ASHLEY	1	New Generation	23:07	02:17	103	80	3.2	1650
10/20/2006	JAMIE & ASHLEY	2	New Generation	02:55	05:55	90	92	2.9	1642
10/20/2006	JAMIE & ASHLEY	3	New Generation	06:38	09:20	90	86	3.2	1700
10/20/2006	JAMIE & ASHLEY	4	New Generation	10:40	13:38	73	93	3.2	1653
10/20/2006	JAMIE & ASHLEY	5	New Generation	14:20	17:16	94	90	2.8	1694
10/23/2006	THERESA & ALLYSON	1	New Generation	20:13	23:08	111	127	3	1600
10/23/2006	THERESA & ALLYSON	2	New Generation	23:53	03:00	120	92	2.9	1600
10/24/2006	THERESA & ALLYSON	3	New Generation	03:51	06:48	94	88	2.6	1645
10/24/2006	THERESA & ALLYSON	4	New Generation	07:33	10:23	90	95	2.6	1635
10/24/2006	THERESA & ALLYSON	5	New Generation	11:06	13:33	86	90	2.9	1750
10/24/2006	THERESA & ALLYSON	6	New Generation	14:38	17:44	92	94	2.9	1844
10/24/2006	THERESA & ALLYSON	7	New Generation	18:42	21:46	82	86	3.2	1803
10/24/2006	THERESA & ALLYSON	8	New Generation	22:36	01:35	85	95	2.8	1715
10/25/2006	THERESA & ALLYSON	9	New Generation	02:07	05:02	101	90	2.9	1720

Table 3. Student's 't' results for paired sample means and for two-samples assuming unequal variances. Tests for difference in mean catch weight/tow (kg/tow) for nine species of fish, for both boats combined and for each boat individually, for the standard groundfish trawl versus the New Generation Trawl. Values in blue with "" represent statistical difference with 95% confidence (p-value less than 0.05), values in red with "*" represent statistical difference with 90% confidence (p-value less than 0.10), and black with no "*" represents no statistical difference.**

		t-Test: Two-Sample Assuming Unequal Variances		t-Test: Paired Two Sample for Means			
Species	**Gear Type**	**Boat Theresa & Allyson p-values**	**Boat Jamie & Ashley p-values**	**Both Boats Combined p-values**	**Boat Theresa & Allyson Mean Weight in KG**	**Boat Jamie & Ashley Mean Weight in KG**	**Both Boats Combined Mean Weight in KG**
White Hake	Standard Trawl	**0.0400993321741015	*0.0506071415214296	**0.00432517448483263	57.4	63.1	60
White Hake	New Generation Trawl	**0.0400993321741015	*0.0506071415214296	**0.00432517448483263	97.1	102.9	100.2
Cod	Standard Trawl	0.200921048	*0.0797152131902881	0.961019137	9.5	1.9	6
Cod	New Generation Trawl	0.200921048	*0.0797152131902881	0.961019137	2.8	9	6.1
Haddock	Standard Trawl	0.190570862	0.996025783	0.387760202	9.6	16	12.6
Haddock	New Generation Trawl	0.190570862	0.996025783	0.387760202	19.7	16	17.7
Pollock	Standard Trawl	0.21051403	**0.0200557856425424	*0.0606667143549567	39	41.5	40.2
Pollock	New Generation Trawl	0.21051403	**0.0200557856425424	*0.0606667143549567	25.7	133.8	83.6
Dabs	Standard Trawl	0.113357682	0.659872289	0.578380264	7.5	14.6	10.8
Dabs	New Generation Trawl	0.113357682	0.659872289	0.578380264	12.8	12.3	12.5
Gray Sole	Standard Trawl	**0.00227944792038054	0.894102264	*0.0667581470873295	7	11.3	9
Gray Sole	New Generation Trawl	**0.00227944792038054	0.894102264	*0.0667581470873295	16	10.9	13.3
Redfish	Standard Trawl	0.272799938	*0.0554311158698525	**0.0241034417123901	7.7	12.6	9.9
Redfish	New Generation Trawl	0.272799938	*0.0554311158698525	**0.0241034417123901	49.4	122.7	88.7
Monkfish	Standard Trawl	0.840248531	0.416659887	0.845442944	83.1	61.6	73.1
Monkfish	New Generation Trawl	0.840248531	0.416659887	0.845442944	79	72.8	75.7
Dogfish	Standard Trawl	0.246594026	*0.095700696727589	**0.0368668590892884	41.1	73.6	56.2
Dogfish	New Generation Trawl	0.246594026	*0.095700696727589	**0.0368668590892884	94.6	198.9	150.5

Table 4. ANOVA. Tests for difference in mean length in centimeters for nine species of fish, for the standard groundfish trawl versus the New Generation Trawl. Boat difference, gear type difference and boat*gear type interaction difference were evaluated for both boats. If a significant difference in boat or boat*gear type interaction was detected, then the gear type difference was looked at for each boat individually. Significant differences (p-value less than 0.05) are shown in blue print with "*"and non significant differences are in black print with no "*".

Species		Both Boats Combined	Boat Theresa & Allyson	Boat Jamie & Ashley
White Hake	Boat (p-value)	0.326		
White Hake	Gear Type (p-value)	*0	*0	*0
White Hake	Boat * Gear Type (p-value)	*0.008		
White Hake	Standard Trawl Mean Length in cm	*69.9	*69.3	*70.6
White Hake	New Generation Trawl Mean Length in cm	*62.2	*63.9	*61.2
Cod	Boat (p-value)	0.521		
Cod	Gear Type (p-value)	0.294		
Cod	Boat * Gear Type (p-value)	0.611		
Cod	Standard Trawl Mean Length in cm	72.2		
Cod	New Generation Trawl Mean Length in cm	68.5		
Haddock	Boat (p-value)	*0.012		
Haddock	Gear Type (p-value)	*0.002	*0	0.534
Haddock	Boat * Gear Type (p-value)	*0.031		
Haddock	Standard Trawl Mean Length in cm	*53.7	*53.6	53.8
Haddock	New Generation Trawl Mean Length in cm	*51.9	*50.6	53.3
Pollock	Boat (p-value)	*0		
Pollock	Gear Type (p-value)	*0	0.368	*0
Pollock	Boat * Gear Type (p-value)	*0		
Pollock	Standard Trawl Mean Length in cm	*73.1	72.5	*73.9
Pollock	New Generation Trawl Mean Length in cm	*64.7	73.6	*63.7
Dabs	Boat (p-value)	*0		
Dabs	Gear Type (p-value)	0.150	0.848	*0.033
Dabs	Boat * Gear Type (p-value)	0.259		
Dabs	Standard Trawl Mean Length in cm	35.2	36.4	*34.6
Dabs	New Generation Trawl Mean Length in cm	36.0	36.6	*35.6
Gray Sole	Boat (p-value)	0.309		
Gray Sole	Gear Type (p-value)	0.148		
Gray Sole	Boat * Gear Type (p-value)	0.200		
Gray Sole	Standard Trawl Mean Length in cm	39.3		
Gray Sole	New Generation Trawl Mean Length in cm	38.9		
Redfish	Boat (p-value)	0.875		
Redfish	Gear Type (p-value)	*0	0.056	*0
Redfish	Boat * Gear Type (p-value)	*0.001		
Redfish	Standard Trawl Mean Length in cm	*30.1	29.7	*30.3
Redfish	New Generation Trawl Mean Length in cm	*28.6	29.1	*28.4
Monkfish	Boat (p-value)	0.290		
Monkfish	Gear Type (p-value)	0.163		
Monkfish	Boat * Gear Type (p-value)	0.192		
Monkfish	Standard Trawl Mean Length in cm	46.7		
Monkfish	New Generation Trawl Mean Length in cm	45.9		
Dogfish	Boat (p-value)	0.307		
Dogfish	Gear Type (p-value)	*0	*0	0.221
Dogfish	Boat * Gear Type (p-value)	*0.029		
Dogfish	Standard Trawl Mean Length in cm	*76.4	*76.7	74.7
Dogfish	New Generation Trawl Mean Length in cm	*72.8	*72.5	73.2

Table 5. Percent sub-legal fish and percent legal fish for the standard groundfish trawl catches versus the New Generation Trawl for seven species of fish. The total number of sub-legal fish measured, total number of legal fish measured and the total number of fish measured for the standard groundfish trawl and the New Generation Trawl are also reported.

Species	Gear Type	Total Catch % Sub-legal	Total Catch % Legal	Number of Fish Measured Sub-legal	Number of Fish Measured Legal	Number of Fish Measured Total
Cod	Standard Trawl	18.4	81.6	7	31	38
Cod	New Generation Trawl	25	75	12	36	48
Haddock	Standard Trawl	14.1	85.9	29	177	206
Haddock	New Generation Trawl	31	69	99	220	319
Pollock	Standard Trawl	0.4	99.6	1	249	250
Pollock	New Generation Trawl	11.2	88.8	86	681	767
Dabs	Standard Trawl	50.9	49.1	338	689	1027
Dabs	New Generation Trawl	47.7	52.3	390	746	1136
Gray Sole	Standard Trawl	18.9	81.1	116	497	613
Gray Sole	New Generation Trawl	21.1	78.9	197	735	932
Redfish	Standard Trawl	5.3	94.7	27	484	511
Redfish	New Generation Trawl	4.7	95.3	275	5575	5850
Monkfish	Standard Trawl	51	49	505	485	990
Monkfish	New Generation Trawl	53.1	46.9	556	491	1047

Table 6. Number of sub-legal fish, number of legal fish and total number of fish per tow for the standard groundfish trawl catches versus the New Generation Trawl for seven species of fish.

Species	Gear Type	Number of Sub-legal Per Tow	Number of Legal Per Tow	Total Number Per Tow
Cod	Standard Trawl	0.4375	1.9375	2.3750
Cod	New Generation Trawl	0.4857	1.4571	1.9428
Haddock	Standard Trawl	1.5190	9.2714	10.7904
Haddock	New Generation Trawl	5.1071	11.3492	16.4563
Pollock	Standard Trawl	0.0419	10.4394	10.4813
Pollock	New Generation Trawl	3.0714	24.3214	27.3928
Dabs	Standard Trawl	12.5357	12.0714	24.6071
Dabs	New Generation Trawl	13.7314	15.0429	28.7743
Gray Sole	Standard Trawl	4.1429	17.7500	21.8929
Gray Sole	New Generation Trawl	7.0357	26.2500	33.2857
Redfish	Standard Trawl	1.1739	21.0435	22.2174
Redfish	New Generation Trawl	10.1852	206.4815	216.6667
Monkfish	Standard Trawl	18.0357	17.3214	35.3571
Monkfish	New Generation Trawl	19.8214	17.5357	37.3571

Table 7. Student's 't' for Paired Sample Means and for Two-Sample Assuming Unequal Variances. Tests for difference in mean catch weight/tow for nine species of fish, for both boats combined and for each boat individually, for the New Generation Trawl versus the New Generation Trawl with the Sort V grate. Values in blue with "" represent statistical difference at 95% confidence limit, values in red with "*" represent statistical difference at 90% confidence limit and black with no "*" represents no statistical difference. The mean catch weights per tow in kilograms for the nine species are also shown for both boats and for each boat individually.**

		t-Test: Two-Sample Assuming Unequal Variances		t-Test: Two-Sample Assuming Unequal Variances			
		Boat	Boat		Boat	Boat	
Species	Gear Type	Theresa & Allyson p-values	Jamie & Ashley p-values	Both Boats Combined p-values	Theresa & Allyson Mean Weight in KG	Jamie & Ashley Mean Weight in KG	Both Boats Combined Mean Weight in KG
White Hake	New Generation Trawl	**0.000406912875303151	0.539215884	**0.000455818016706273	22.3	41	30
White Hake	NGT w/ Grate	**0.000406912875303151	0.539215884	**0.000455818016706273	82.5	51.9	68.1
Cod	New Generation Trawl	0.969604248	0.322168657	0.42728198	7.3	29.6	15.2
Cod	NGT w/ Grate	0.969604248	0.322168657	0.42728198	7.5	11.9	9.5
Haddock	New Generation Trawl	*0.0867316061882288	0.145396156	*0.0564273231498834	1.2	0.2	0.8
Haddock	NGT w/ Grate	*0.0867316061882288	0.145396156	*0.0564273231498834	27.3	4	16.4
Pollock	New Generation Trawl	**0.0263472295494369	0.35579822	0.106811143	254	570.2	366.9
Pollock	NGT w/ Grate	**0.0263472295494369	0.35579822	0.106811143	12.2	296	145.7
Dabs	New Generation Trawl	**0.0063734179526124	0.383147906	**0.0107181576648079	2.2	0.8	1.7
Dabs	NGT w/ Grate	**0.0063734179526124	0.383147906	**0.0107181576648079	32.2	2	18
Gray Sole	New Generation Trawl	0.547717228	0.949923674	0.579993259	2.8	2.3	2.6
Gray Sole	NGT w/ Grate	0.547717228	0.949923674	0.579993259	2	2.2	2.1
Redfish	New Generation Trawl	0.109047798	0.271729769	0.14767822	5.5	32.5	15.2
Redfish	NGT w/ Grate	0.109047798	0.271729769	0.14767822	14.1	87.6	48.7
Monkfish	New Generation Trawl	0.680972868	0.613763615	0.561944535	51.2	59.8	54.2
Monkfish	NGT w/ Grate	0.680972868	0.613763615	0.561944535	47.4	52.1	49.6
Dogfish	New Generation Trawl	**0.00386503844481455	0.525023318	**0.0184405411197594	23.7	75.1	42
Dogfish	NGT w/ Grate	**0.00386503844481455	0.525023318	**0.0184405411197594	88.5	109.1	98.2

Table 8. ANOVA. Tests for difference in mean length in centimeters for nine species of fish, for the New Generation Trawl (NGT) versus the New Generation Trawl with the Sort V grate (NGT w/Grate). Boat difference, gear type difference and boat*gear type interaction difference were evaluated for both boats. If a significant difference in boat or boat*gear type interaction was detected, then the gear type difference was looked at for each boat individually. Significant differences (p-value less than 0.05) are shown in blue print with "*" and non significant differences are in black print with no "*".

Species		Both Boats Combined	Boat Theresa & Allyson	Boat Jamie & Ashley
White Hake	Boat (p-value)	0.064		
White Hake	Gear Type (p-value)	*0		
White Hake	Boat * Gear Type (p-value)	0.495		
White Hake	NGT Mean Length in cm	*70.5		
White Hake	NGT w/Grate Mean Length in cm	*62.3		
Cod	Boat (p-value)	*0.001		
Cod	Gear Type (p-value)	0.196	0.058	*0.005
Cod	Boat * Gear Type (p-value)	*0		
Cod	NGT Mean Length in cm	67.5	67.2	*67.6
Cod	NGT w/Grate Mean Length in cm	64.5	82.3	*60.5
Haddock	Boat (p-value)			
Haddock	Gear Type (p-value)	0.419		
Haddock	Boat * Gear Type (p-value)			
Haddock	NGT Mean Length in cm	59.0		
Haddock	NGT w/Grate Mean Length in cm	61.6		
Pollock	Boat (p-value)	*0		
Pollock	Gear Type (p-value)	*0	*0	*0.002
Pollock	Boat * Gear Type (p-value)	*0		
Pollock	NGT Mean Length in cm	*72.1	*71.9	*72.2
Pollock	NGT w/Grate Mean Length in cm	*73.4	*79	*73.2
Dabs	Boat (p-value)	0.481		
Dabs	Gear Type (p-value)	0.800		
Dabs	Boat * Gear Type (p-value)	0.077		
Dabs	NGT Mean Length in cm	36.4		
Dabs	NGT w/Grate Mean Length in cm	39.0		
Gray Sole	Boat (p-value)	0.431		
Gray Sole	Gear Type (p-value)	*0.011		
Gray Sole	Boat * Gear Type (p-value)	0.497		
Gray Sole	NGT Mean Length in cm	*39		
Gray Sole	NGT w/Grate Mean Length in cm	*37.3		
Redfish	Boat (p-value)	0.966		
Redfish	Gear Type (p-value)	*0	*0	0.233
Redfish	Boat * Gear Type (p-value)	*0		
Redfish	NGT Mean Length in cm	*27.8	*26.7	28.1
Redfish	NGT w/Grate Mean Length in cm	*28	*29.2	27.9
Monkfish	Boat (p-value)	0.930		
Monkfish	Gear Type (p-value)	0.388		
Monkfish	Boat * Gear Type (p-value)	0.230		
Monkfish	NGT Mean Length in cm	43.6		
Monkfish	NGT w/Grate Mean Length in cm	44.8		
Dogfish	Boat (p-value)	*0.009		
Dogfish	Gear Type (p-value)	0.277	*0.002	0.059
Dogfish	Boat * Gear Type (p-value)	*0.007		
Dogfish	NGT Mean Length in cm	73.9	*77.4	71.2
Dogfish	NGT w/Grate Mean Length in cm	73.0	*73	73.1

Table 9. Percent sub-legal fish and percent legal fish for the New Generation Trawl catches versus the New Generation Trawl with the Sort V grate, for seven species of fish. The total number of sub-legal fish measured, total number of legal fish measured and the total number of fish measured for the standard groundfish trawl and the New Generation Trawl are also reported.

Species	Gear Type	Total Catch % Sub-legal	Total Catch % Legal	Number of Fish Measured Sub-legal	Number of Fish Measured Legal	Number of Fish Measured Total
Cod	NGT	10.8	89.2	7	58	65
Cod	NGT w/Grate	28.6	71.4	14	35	49
Haddock	NGT	0	100	0	7	7
Haddock	NGT w/Grate	6.1	93.9	7	107	114
Pollock	NGT	0	100	0	1187	1187
Pollock	NGT w/Grate	0	100	0	528	528
Dabs	NGT	39.7	60.3	23	35	58
Dabs	NGT w/Grate	28.3	71.7	145	367	512
Gray Sole	NGT	23.8	76.2	29	93	122
Gray Sole	NGT w/Grate	27.7	72.3	28	73	101
Redfish	NGT	12.8	87.2	86	586	672
Redfish	NGT w/Grate	15.8	84.2	407	2161	2568
Monkfish	NGT	60.5	39.5	242	158	400
Monkfish	NGT w/Grate	53.7	46.3	211	182	393

Table 10. Number of sub-legal fish, number of legal fish and total number of fish per tow for the New Generation Trawl (NGT) catches versus the New Generation Trawl with the Sort V Grate (NGT w/Grate) for seven species of fish.

Species	Gear Type	Number of Sub-legal Per Tow	Number of Legal Per Tow	Total Number Per Tow
Cod	NGT	0.5000	4.1429	4.6429
Cod	NGT w/Grate	0.9150	2.2876	3.2026
Haddock	NGT	0.0000	0.6000	0.6000
Haddock	NGT w/Grate	0.4529	6.9235	7.3764
Pollock	NGT	0.0000	84.7857	84.7857
Pollock	NGT w/Grate	0.0000	31.0588	31.0588
Dabs	NGT	2.7381	4.1667	6.9048
Dabs	NGT w/Grate	12.3203	31.1830	43.5033
Gray Sole	NGT	2.2440	7.1964	9.4404
Gray Sole	NGT w/Grate	2.0588	5.3676	7.4264
Redfish	NGT	6.7013	45.6623	52.3636
Redfish	NGT w/Grate	23.9412	127.1176	151.0588
Monkfish	NGT	17.2857	11.2857	28.5714
Monkfish	NGT w/Grate	12.4118	10.7059	23.1177

Figure 1. Length frequency per tow of cod for the standard groundfish trawl catches versus the New Generation Trawl catches. The legal size limit is also on the graph to show sub-legal cod per tow and legal cod per tow.

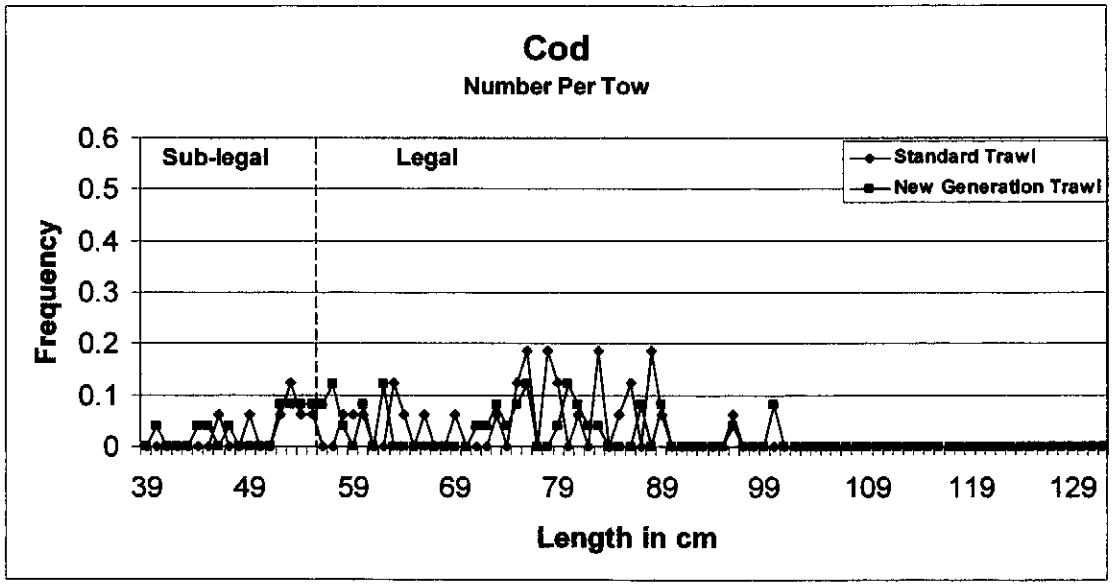


Figure 2. Length frequency per tow of cod for the New Generation Trawl catches versus the New Generation Trawl w/ Sort V Grate catches. The legal size limit is also on the graph to show sub-legal cod per tow and legal cod per tow.

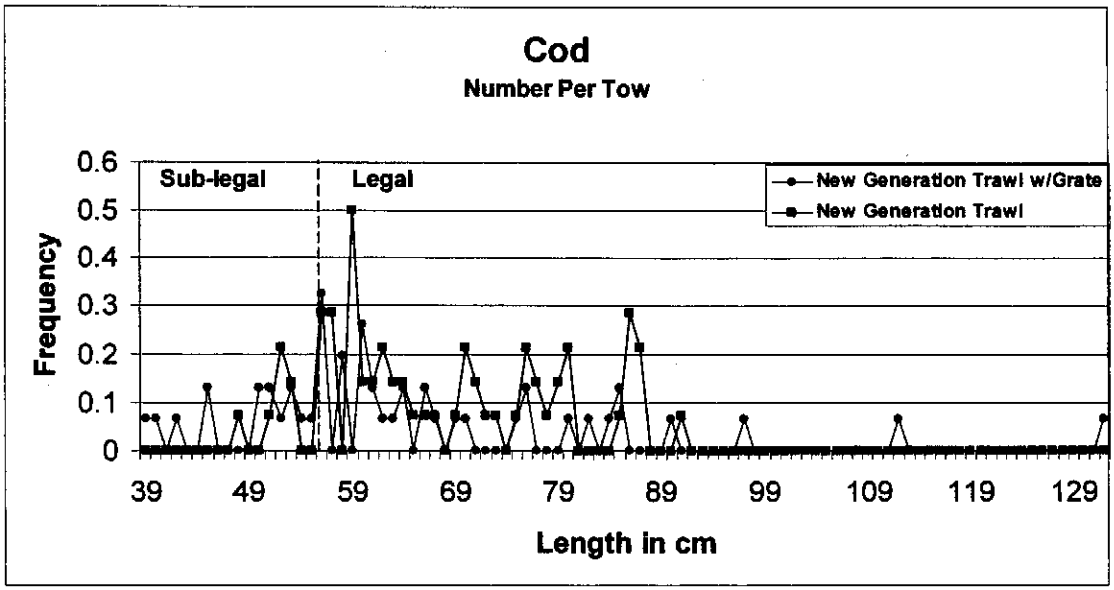


Figure 3. Length frequency per tow of haddock for the standard groundfish trawl catches versus the New Generation Trawl catches. The legal size limit is also on the graph to show sub-legal haddock per tow and legal haddock per tow.

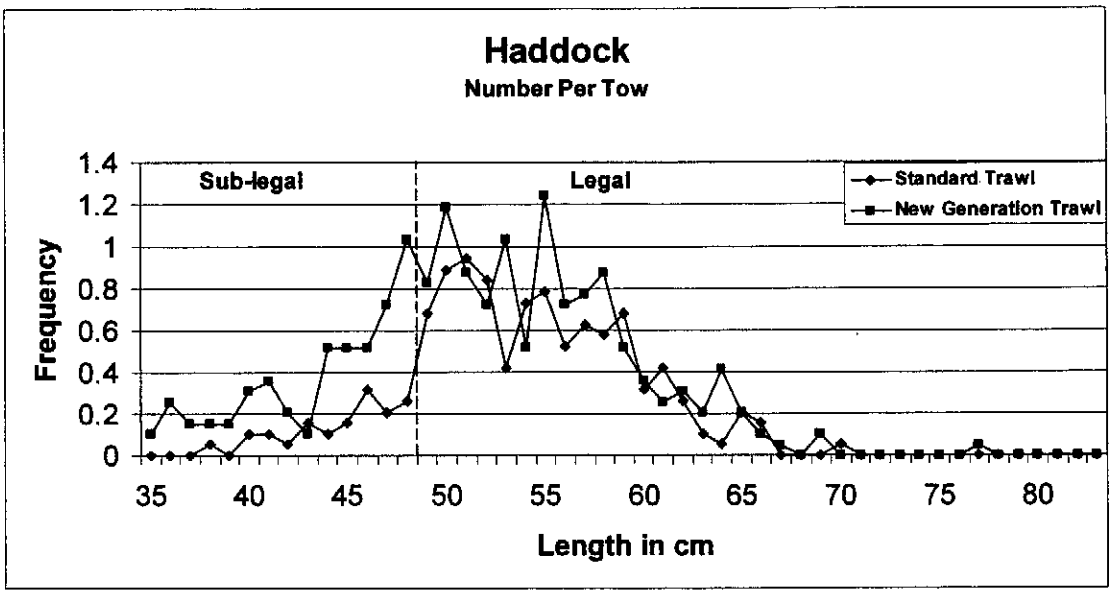


Figure 4. Length frequency per tow of haddock for the New Generation Trawl catches versus the New Generation Trawl w/ Sort V Grate catches. The legal size limit is also on the graph to show sub-legal haddock per tow and legal haddock per tow.

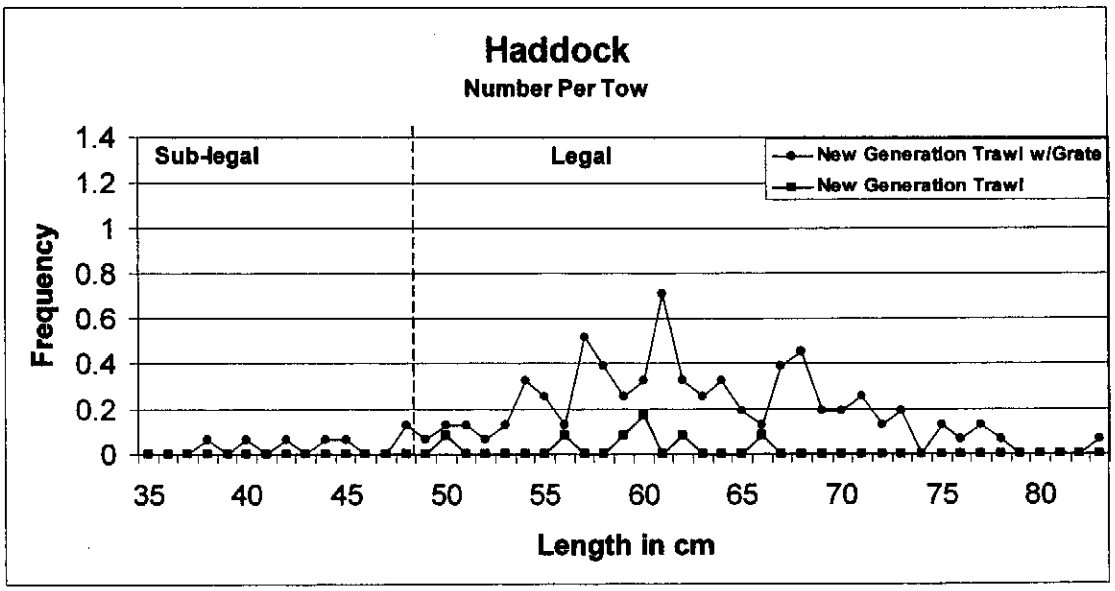


Figure 5. Length frequency per tow of pollock for the standard groundfish trawl catches versus the New Generation Trawl catches. The legal size limit is also on the graph to show sub-legal pollock per tow and legal pollock per tow.

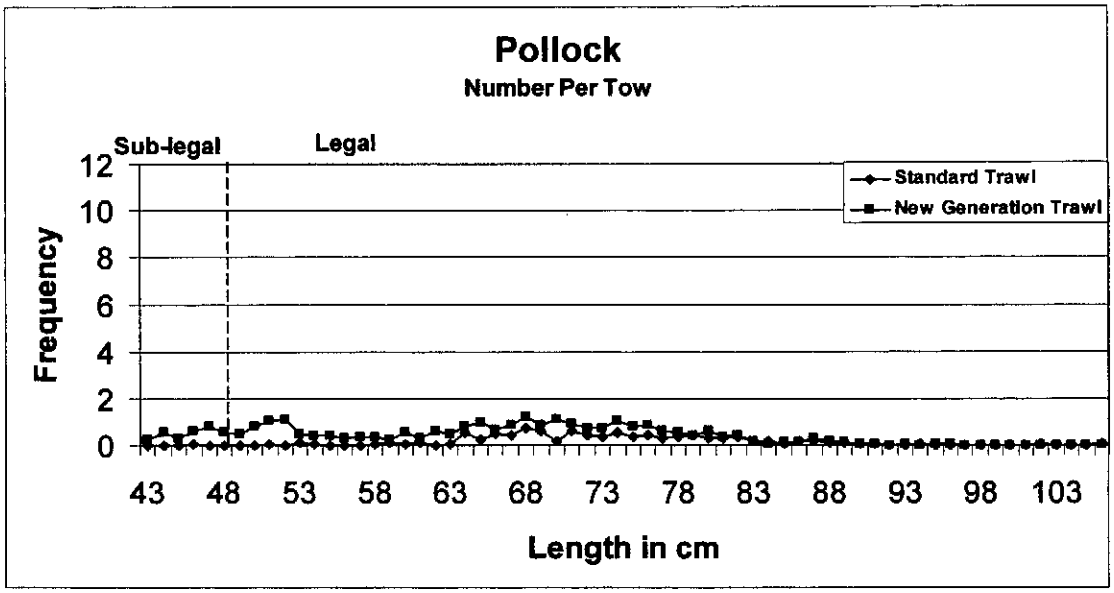


Figure 6. Length frequency per tow of pollock for the New Generation Trawl catches versus the New Generation Trawl w/ Sort V Grate catches. The legal size limit is also on the graph to show sub-legal pollock per tow and legal pollock per tow.

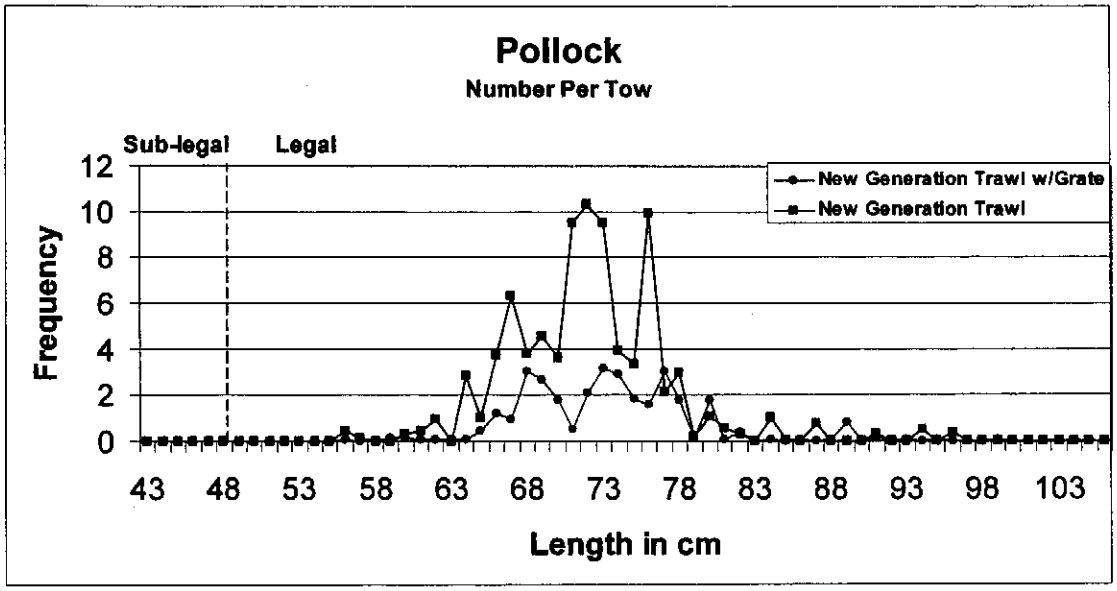


Figure 7. Length frequency per tow of dab for the standard groundfish trawl catches versus the New Generation Trawl catches. The legal size limit is also on the graph to show sub-legal dab per tow and legal dab per tow.

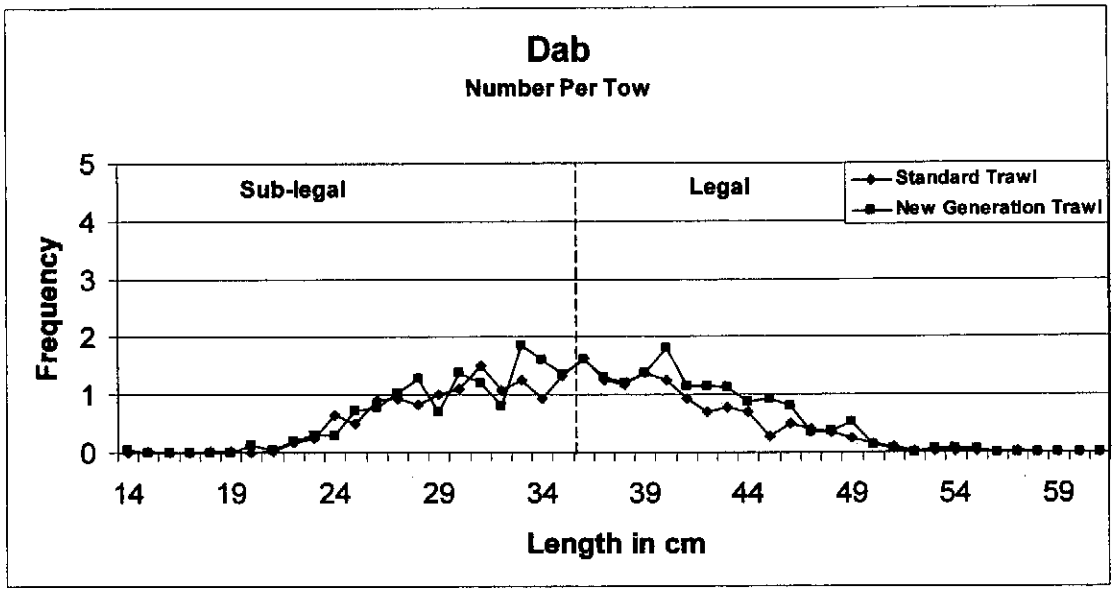


Figure 8. Length frequency per tow of dab for the New Generation Trawl catches versus the New Generation Trawl w/ Sort V Grate catches. The legal size limit is also on the graph to show sub-legal dab per tow and legal dab per tow.

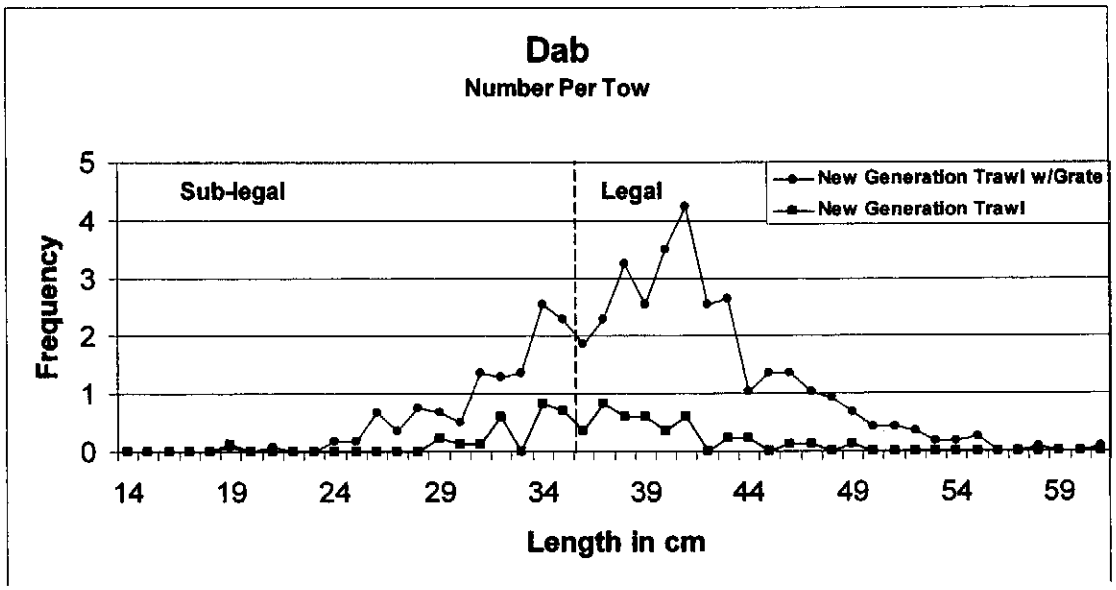


Figure 9. Length frequency per tow of gray sole for the standard groundfish trawl catches versus the New Generation Trawl catches. The legal size limit is also on the graph to show sub-legal gray sole per tow and legal gray sole per tow.

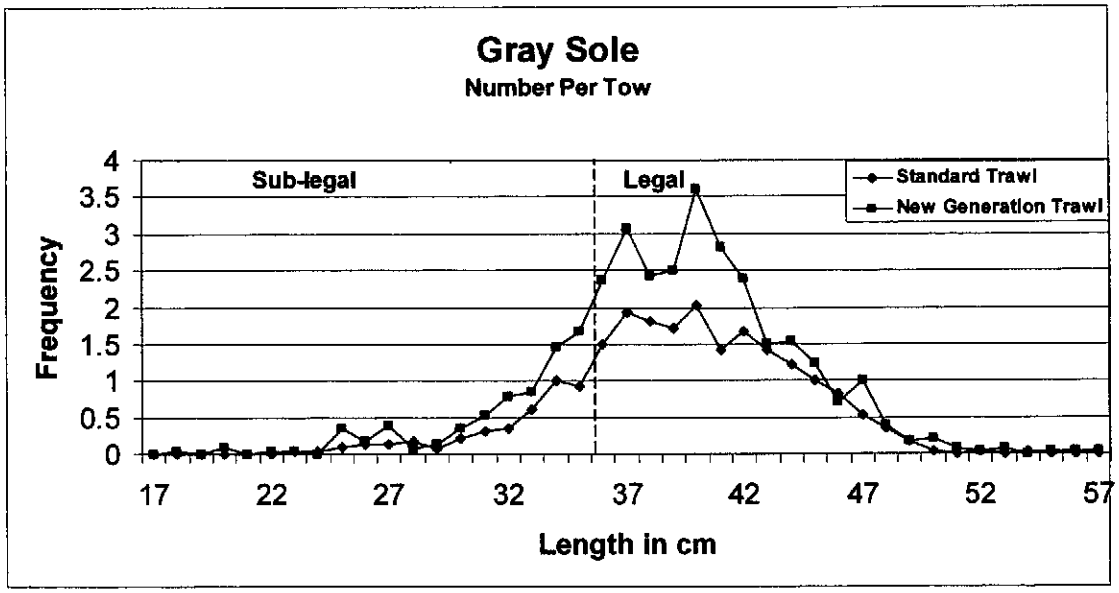


Figure 10. Length frequency per tow of gray sole for the New Generation Trawl catches versus the New Generation Trawl w/ Sort V Grate catches. The legal size limit is also on the graph to show sub-legal gray sole per tow and legal gray sole per tow.

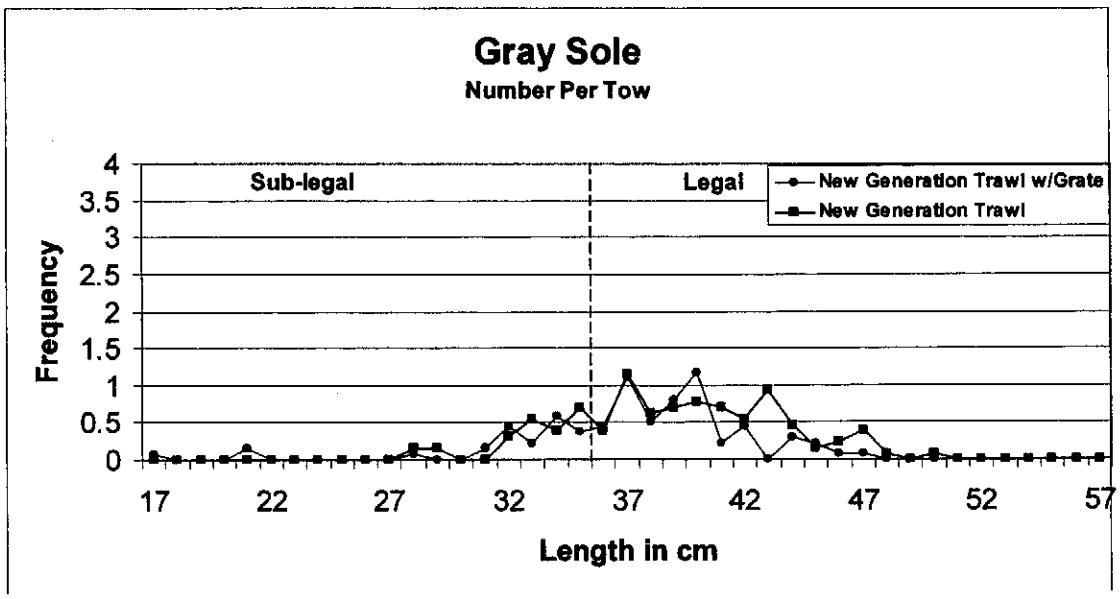


Figure 11. Length frequency per tow of redfish for the standard groundfish trawl catches versus the New Generation Trawl catches. The legal size limit is also on the graph to show sub-legal redfish per tow and legal redfish per tow.

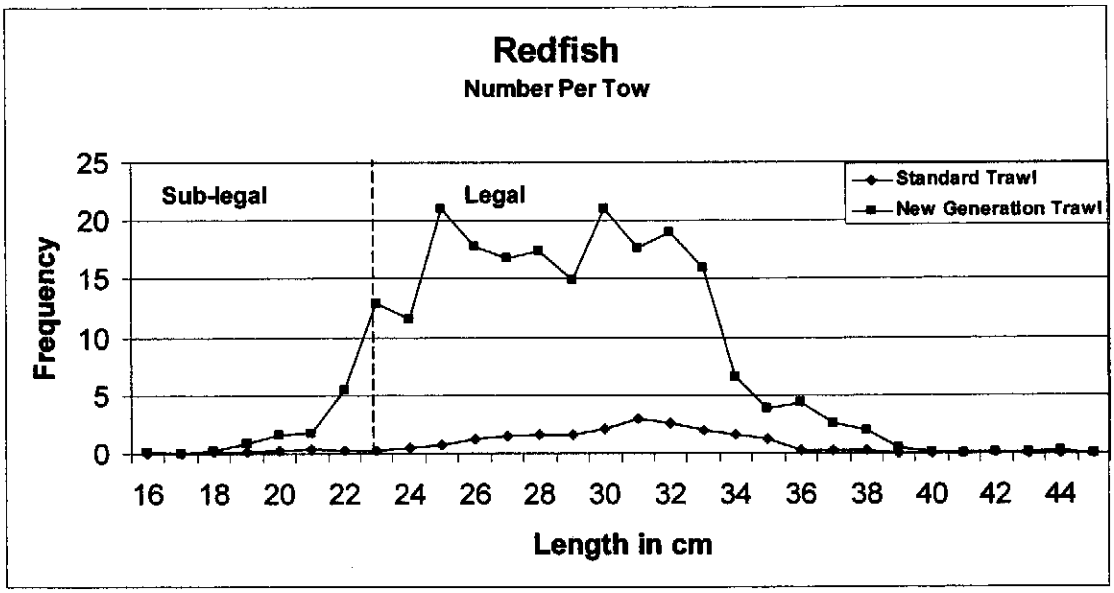


Figure 12. Length frequency per tow of redfish for the New Generation Trawl catches versus the New Generation Trawl w/ Sort V Grate catches. The legal size limit is also on the graph to show sub-legal redfish per tow and legal redfish per tow.

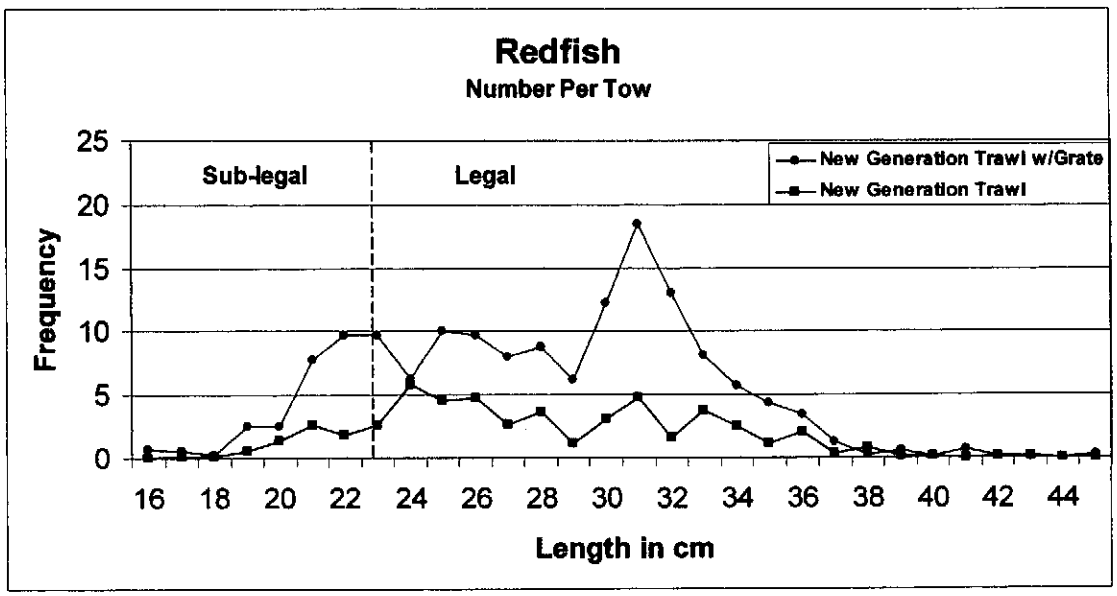


Figure 13. Length frequency per tow of monkfish for the standard groundfish trawl catches versus the New Generation Trawl catches. The legal size limit is also on the graph to show sub-legal monkfish per tow and legal monkfish per tow.

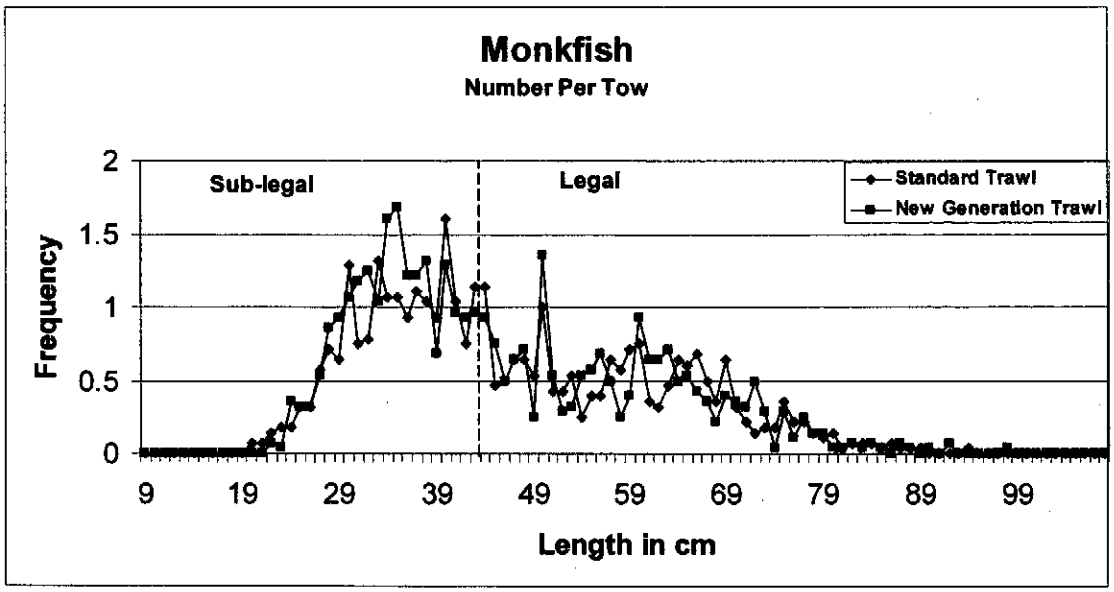


Figure 14. Length frequency per tow of monkfish for the New Generation Trawl catches versus the New Generation Trawl w/ Sort V Grate catches. The legal size limit is also on the graph to show sub-legal monkfish per tow and legal monkfish per tow.

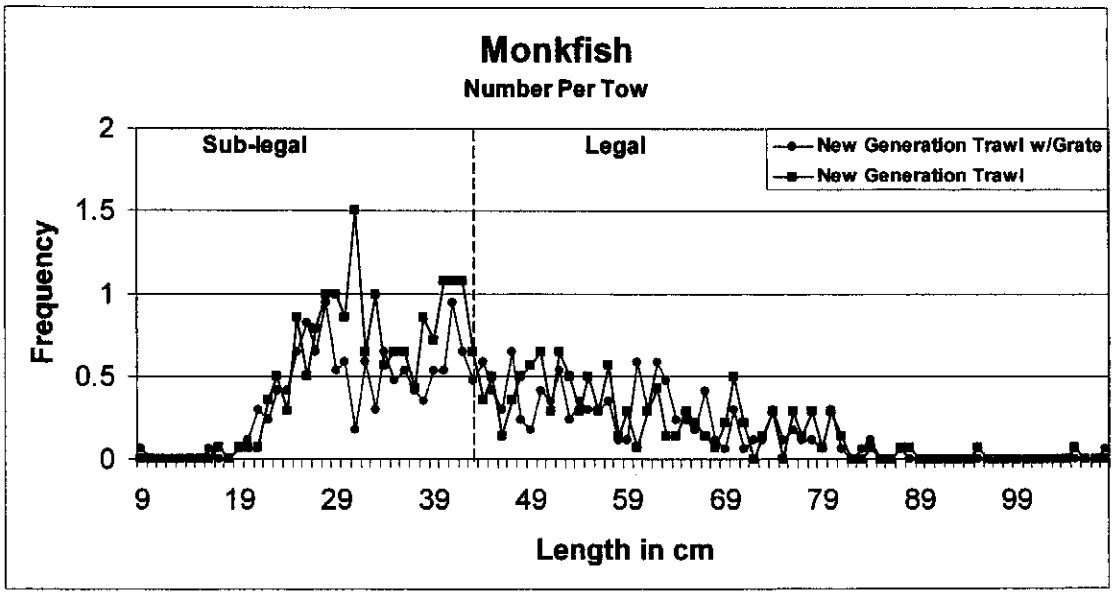


Figure 15. Length frequency per tow of white hake for the standard groundfish trawl catches versus the New Generation Trawl catches.

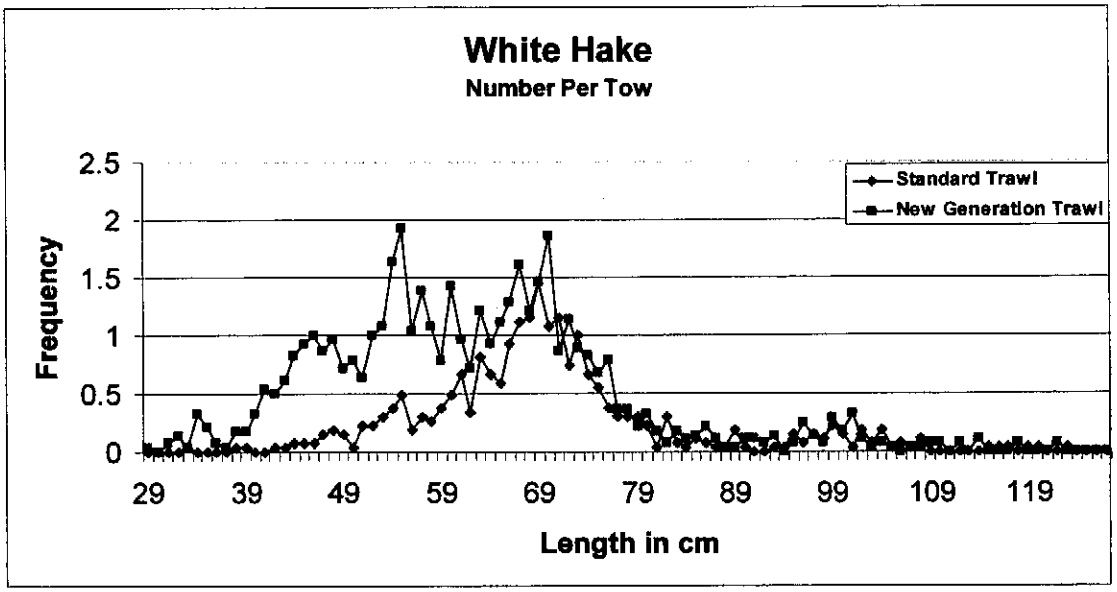


Figure 16. Length frequency per tow of white hake for the New Generation Trawl catches versus the New Generation Trawl w/ Sort V Grate catches.

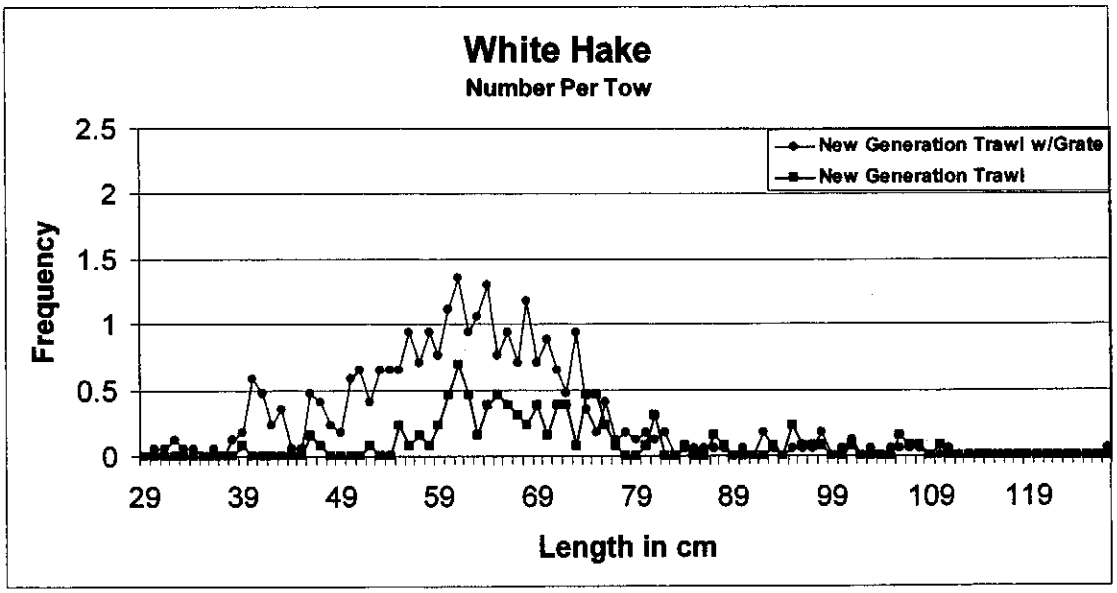


Figure 17. Length frequency per tow of dogfish for the standard groundfish trawl catches versus the New Generation Trawl catches.

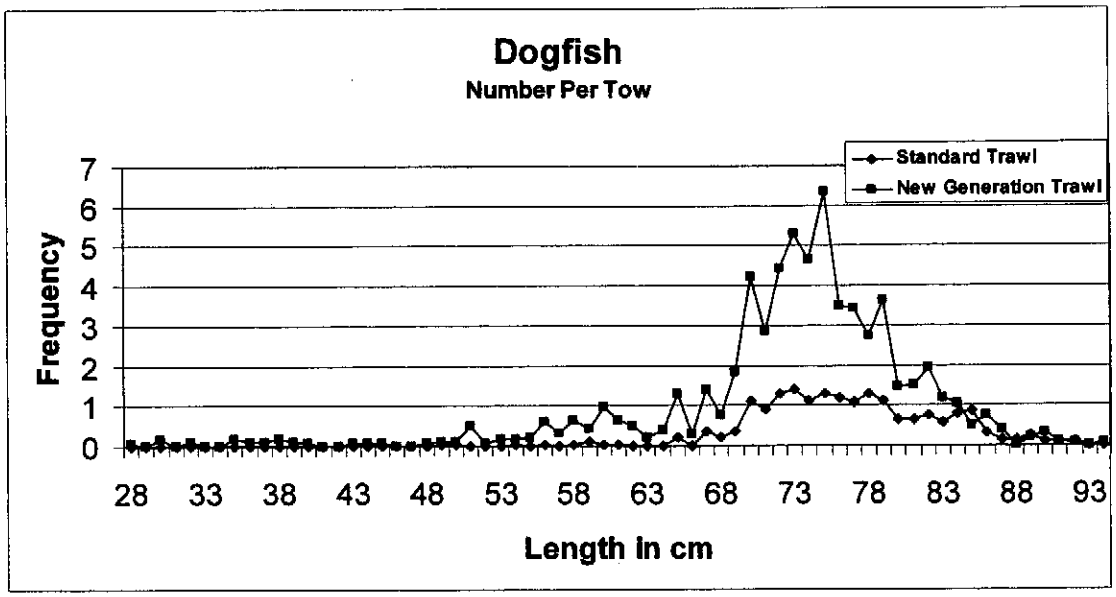
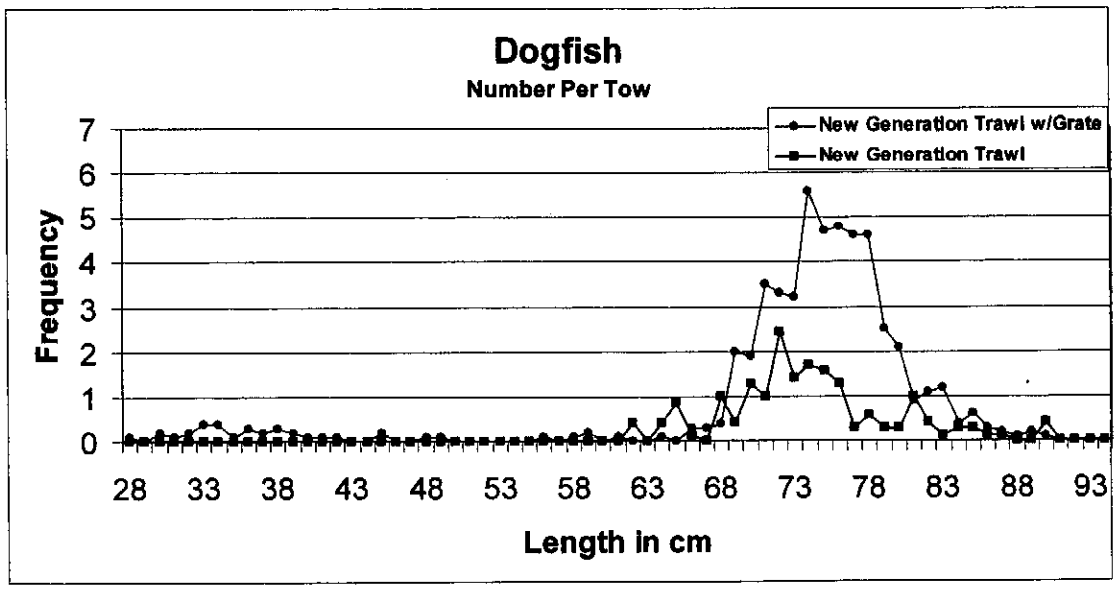
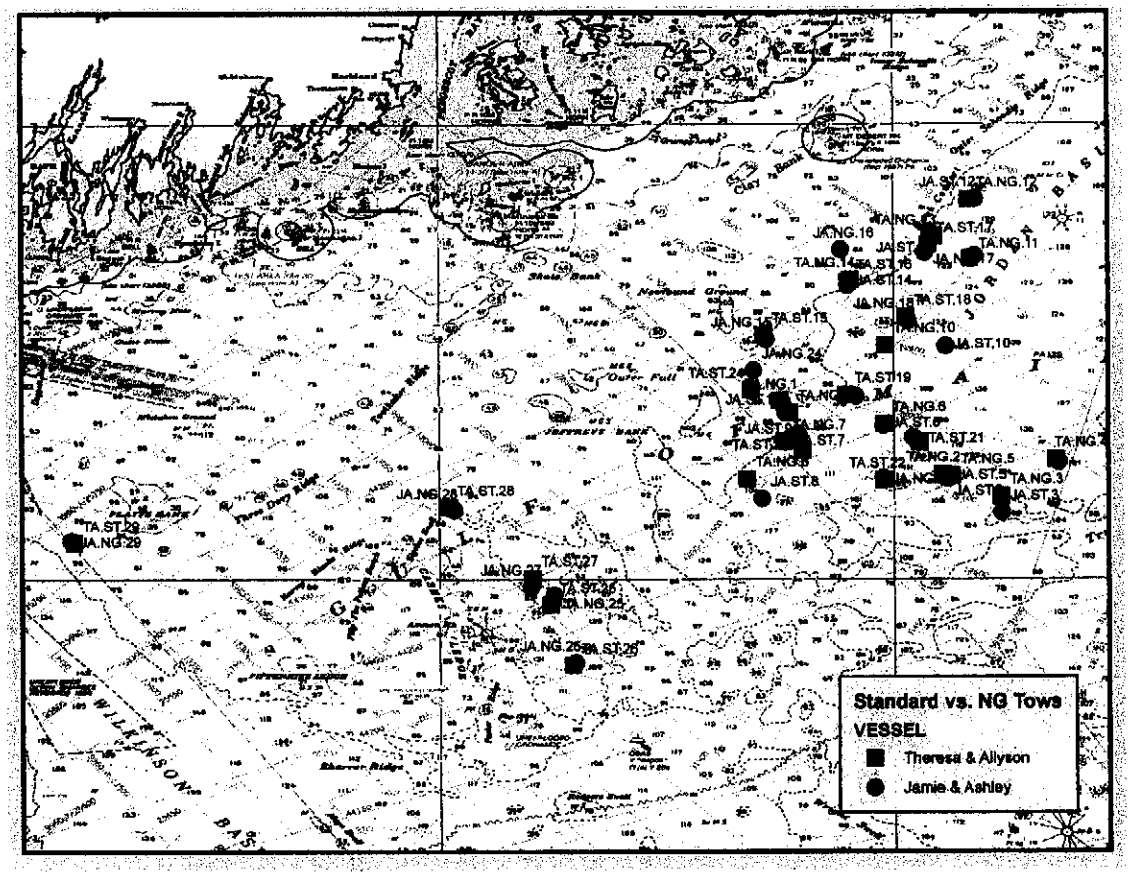
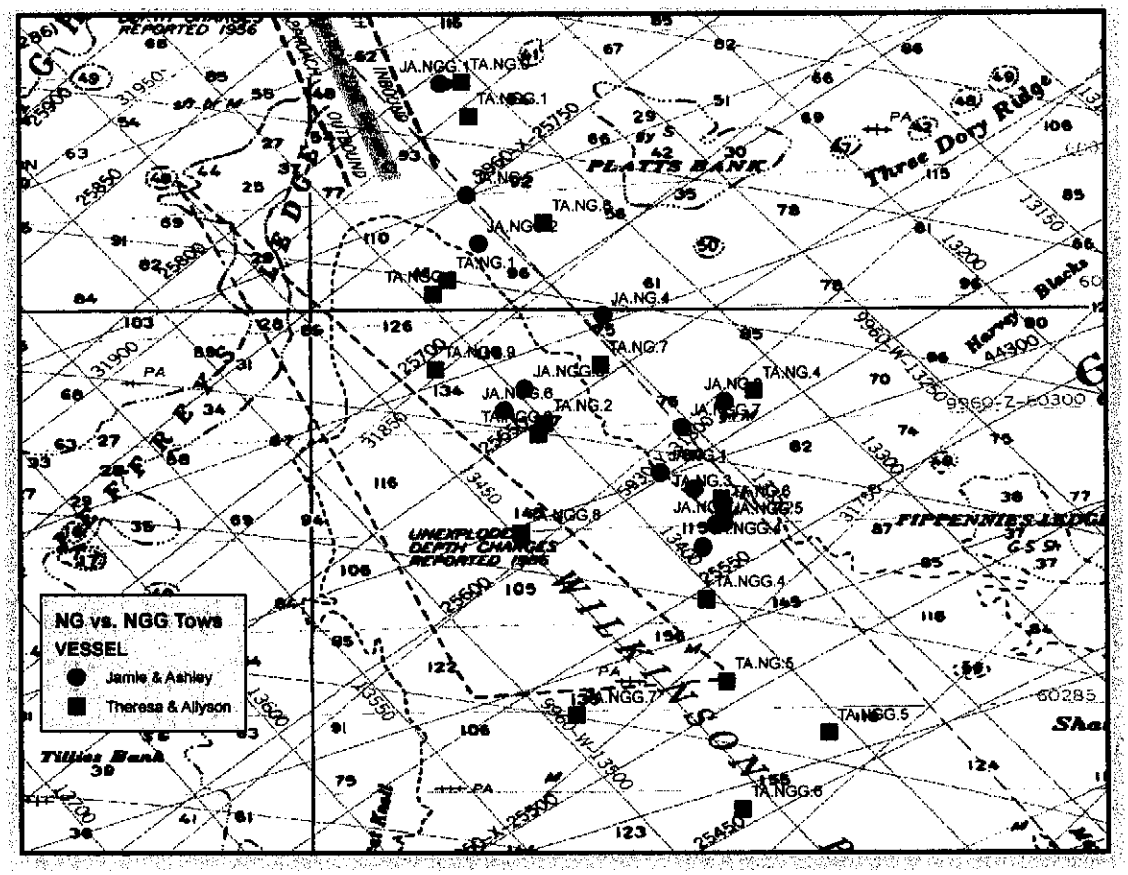


Figure 18. Length frequency per tow of dogfish for the New Generation Trawl catches versus the New Generation Trawl w/ Sort V Grate catches.



Map 1. The standard trawl vs. New Generation Trawl experiments were conducted between the dates of May 24, 2006 and June 2, 2006, in the depth range of 89-134 163-245 m) **fathoms. In this map the points are labeled with the boat name TA (Theresa & Allyson) or JA (Jamie & Ashley) first, then the gear type ST (Standard Trawl) or NG (New Generation Trawl) and then the tow number. The Theresa & Allyson tows are labeled with a green square and the Jamie and Ashley tows are labeled with a red circle.**



Map 2. The New Generation Trawl vs. New Generation Trawl with Sort V Grate experiments were conducted between the dates of October 16, 2006 and October 25, 2006, the latitudes of 42.50 and 43.23, the longitudes of 69.48 and 69.88 and in the depth range of 73-146 fathoms (134-267 m)**. In this map the points are labeled with the boat name TA (Theresa & Allyson) or JA (Jamie & Ashley) first, then the gear type NG (New Generation Trawl) or NGG (New Generation Trawl with Sort V Grate) and then the tow number. The Theresa & Allyson tows are labeled with a green square and the Jamie and Ashley tows are labeled with a red circle.**