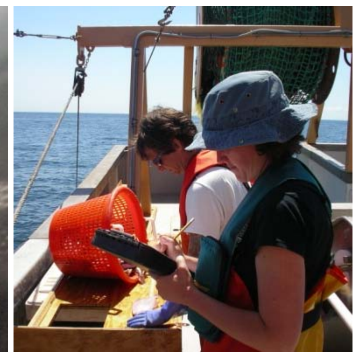
Northeast Consortium 2010 Annual Progress Report

DOGGRATE: Development of a Spiny Dogfish Excluder in a Raised Footrope Whiting Trawl

Project Development Award Number: 09-047





Period of Performance: 6/30/2009 - 6/30/2010

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Project Objectives

Our goal is to produce and test a spiny dogfish *Squalus acanthias* excluder grate within a whiting (silver hake) *Merluccius bilinearis* net. The primary goal of this project development award was to observe silver hake catch and spiny dogfish reaction to a grate using video in a whiting trawl. Additionally, we explored the usage of such a gear for an expanded silver hake fishery area and time of year. In order to accomplish the goals, the following objectives were identified:

1. Observe the behaviors of spiny dogfish and silver hake around excluder grates using underwater video;
2. Investigate and refine excluder grate properties gauged by target species catches and spiny dogfish exclusions;
3. Produce a prototype grate design to be used in follow-up commercial trials;
4. Make recommendations for an expanded silver hake fishery in Cape Cod Bay and Massachusetts Bay.

Methods, Work Plan, and Work Completed to Date (Previous 12 months)

This report includes all “Phase 2” work completed since July, 2009. Additional testing, conducted with support from Frank and Andrew Mirarchi and Massachusetts Division of Marine Fisheries (MA DMF) in 2008, with an earlier version of the grate, will be referred to in this report as “Phase 1” work.

Preparations were conducted leading up to and in between field work; some gear repairs occurred afterwards. MA DMF personnel purchased field and analytical equipment, modified camera cables, replaced net mensuration sensor batteries, sent the headrope and wing sensors to Notus Electronics Ltd. for repairs, and the winch and power unit were sent to Pine Hill Equipment, Inc for necessary maintenance and repairs. Industry partners purchased the new raised footrope whiting net and mounted the constructed grates within the net's extension.

Gear

A new 4-panel box net was constructed by Levin Marine Supply Co. in conformance with a standard raised footrope whiting net design (Figure 2).

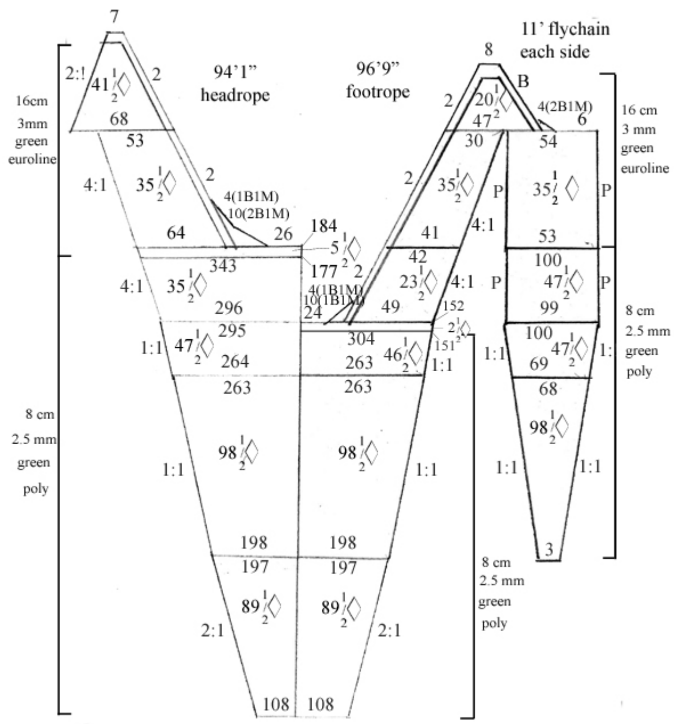

Figure 1: Net plan for the Phase 2 whiting net.

Phase 2 trials were conducted using the two re-designed high density polyethylene grates (black and white colored respectively), both with 50 mm (2.0 in) bar spacings (Figure 2). The re-design occurred due to structural warping of the original design during the Phase 1.

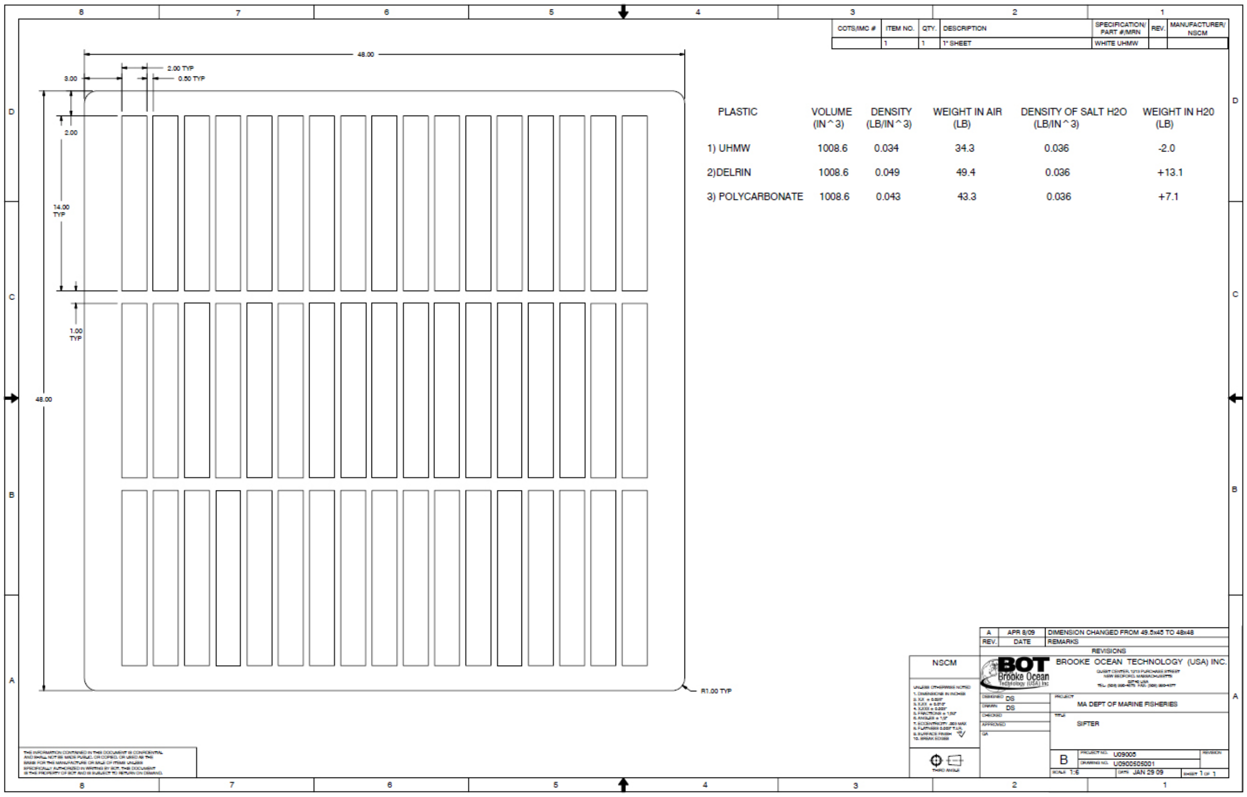

Figure 2: Schematic of the excluder grates used during Phase 2.

The white grate and black grate were tested in various configurations (3-6, below) to see if the colors and/or orientations changed the fish reactions within the extension. The following tows and gear configurations were completed (Phase 1 arrangements are also included for clarity):

- (Phase 1) Arrangement 1, Tows 1-6: White prototype grate, top of grate forward facing 45° angle, upward guiding panel, and bottom escape vent.
- (Phase 1) Arrangement 2, Tows 7-9: White prototype grate, top of grate forward facing 35° angle, upward guiding panel, and bottom escape vent.
- Arrangement 3, Tows 10-15: Black grate, top of grate forward facing 45° angle, upward guiding panel, and bottom escape vent.
- Arrangement 4, Tows 16-21: Black grate, top of grate aft facing 45° angle, downward guiding panel, and top escape vent.
- Arrangement 5, Tows 22-28: White grate, top of grate aft facing 45° angle, downward guiding panel, and top escape vent.
- Arrangement 6, Tows 29-33: White grate, top of grate forward facing 45° angle, upward guiding panel, and bottom escape vent.

Field Work

Field work was performed in July-August, 2009 on the F/V *Barabara L. Peters* outside the Gulf of Maine MA Special Access Program (SAP) Whiting Area (between 42°12'W lat. and 42°30'W lat.) (Figure 3). Twenty-four tows were completed over nine days in July and August 2009, supervised by MA DMF biologists.

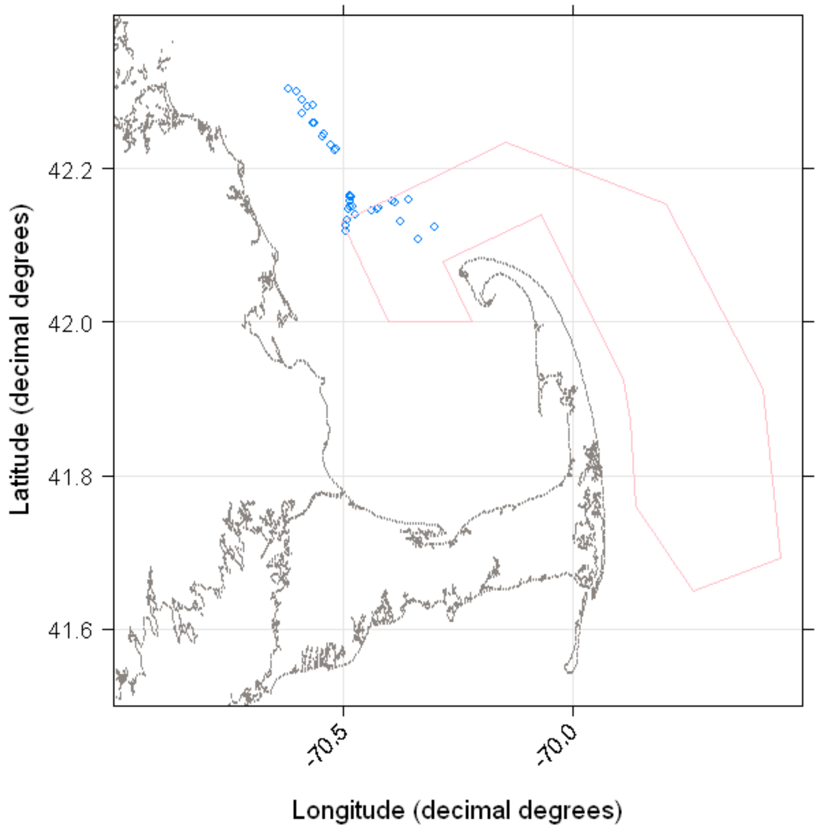

Figure 3: Start of tow locations during Phase 1 and Phase 2 research in Massachusetts Bay. The area outlined in pink is the raised footrope exemption area where Phase 1 work occurred.

Only day tows were conducted following typical fishing practices for silver hake. Adherence to experimental design, sampling protocols, and EFP reporting requirements were overseen by MA DMF personnel.

Target tow times were less than one hour but were also influenced by real time video observations of the fish, depth sounder fish marks, and unexpected occurrences. Operational data (location, weather, time, duration, etc.) were recorded for each haul. Catch composition and weights were determined for all species retained in the codend and lengths were recorded for s selected catch. Sub-samples were taken as time required. Data were recorded and entered into a customized Microsoft Access database.

In Phase 2, the underwater camera was attached forward of the grate looking aftward. For most tows, a second supplemental camera was situated in various locations and used to observe fish and their behaviors around the escape vent. Additionally, net mensuration data were collected for exploratory analyses. Video and net data were recorded, post-processed, and later reviewed using Adobe Premiere and Notus Trawlmaster software respectively.

Data Analysis

Catch weights and length frequency distributions were adjusted by tow lengths (catch per unit effort (CPUE)). Sub-samples were scaled to the entire catch weight for analysis.

Performances of the grates were judged by their abilities to exclude spiny dogfish even at high rates of encounter while allowing target species to pass through the bars. To estimate performance, we attempted to measure the rate at which species of interest entered the field of view of the camera.

Effectiveness of the different grate configurations was estimated by the ratio of spiny dogfish excluded to dogfish retained. The number of dogfish excluded was estimated during Phase 2.by randomly sub-sampling video divided into 10 minute blocks (or whatever the remainder time was at the end of each tow under 10 minutes). One minute segments were chosen randomly within blocks and, if the video quality was adequate and spiny dogfish were present in the clip, recorded from mini-DV tapes to AVI files using Adobe Premiere. Dogfish viewed in the video clip were counted once they entered the field of view of the camera. Behaviors were individually categorized until they were lost off the camera, lost from view, escaped, or passed through the grate. The dogfish counts from sampled clips were adjusted to account for the total duration of the tow. Tows where the grate became blocked were too concentrated with dogfish to provide a count estimate. The count estimates per tow were compared against the numbers of spiny dogfish that passed through the grates.

Within sampled clips (one minute intervals within blocks) clear and perceived intentional behaviors of dogfish were recorded when possible and included the following ten categories:

- Swim to side
- Swim up
- Swim down
- Swim forwards (towards front of net)
- Swim backwards (aft)
- Bump net with nose
- Bump grate with nose
- Wedge head into grate
- Body impinged on grate
- Body twists on grate

Once spiny dogfish became impinged on the grate, twisted on the grate, or escaped through the vent, we then recorded the area of the body where the dogfish contacted the grate and the head orientation. The final body position and facing was recorded only after the dogfish settled into those movements.

General behavioral observations for other selected species were made from the video collected and with respect to the different gear configurations when possible.

Videos were compiled of the grate while fishing for NEC, Andrew Applegate (NEFMC), and the New Bedford Working Waterfront Festival (September 26-27, 2009).

Unexpected Difficulties and Project Alterations

Some unexpected difficulties arose during the field trials:

- The video cable was disconnected during tow 2 and no video was collected.
- Malfunctions of the imaging equipment had occurred during some tows and caused us to end tow 33 early (the last tow). After later inspection of the gear, we found that the problems were due to a mix of faulty cables and the winch's slip ring, which was later repaired.
- Four tows from Phase 2 became blocked with spiny dogfish: tows 21, 23, 26, and 31. All

of these tows except 21 were stopped early; tow 21 became clogged close to the planned end of the tow. Tow 21 used gear arrangement 3; tows 23 and 26 used arrangement 5; tow 31 used gear arrangement 6. In each case, extension meshes were cut and dogfish had to be discarded before the extension and codend were brought on board.

- A portion of the chain sweep was detached from the footrope during tow 28 causing a foul tow. This was likely caused by contact with a ghost lobster trap (caught in the starboard wing) which we believe occurred in conjunction with a speed reduction and collapsed door spread during the tow.
- The temperature logger that was attached to the net during Phase 2 was lost during field work. Therefore, no temperature data was analyzed.
- At the end of the project, the footrope sensor was found to be malfunctioning during the Phase 2 research; these data (vertical openings) were removed.

Minor modifications to the gear consistent with normal fishing operations had occurred prior to particular tows based on the industry partner's recommendations:

- Tow 11: Two floats were removed from each wingend. A 63.5 cm (25.0 in) setback was added to the lower bridle chain to bring the net down more.
- Tow 16: The bottom bridle was changed from 3/8 inch to 1/2 inch wire.
- Tow 18: Two 20.3 cm (8.0 in) floats were added onto the upper sides of the grate (four floats total).
- Tow 19: Four additional 5/16 inch vertical chains were added to the sweep. Each chain was 1.1 m (42.0 in) long and spacings between vertical chains were approximately 1.2 m (4.0 ft).

Results

Researchers and the vessel crew completed twenty-three Phase 2 tows over nine days west and northwest of the SAP (Figure 3).

Video data were reviewed for all tows in which it was collected (seven tows from Phase 1 and 23 tows from Phase 2).

Data auditing and analyses continued for both Phase 1 and Phase 2 research. We began to assemble the final report.

Catch Results

Thirty-seven species or species groups were caught during Phase 1 and 2 research in approximately normal commercial quantities (presented in final report). Results for selected species captured (adjusted to lbs/hr) are presented in Figure 4. Tow 28 is excluded from the plot because it was considered a foul tow from a foreign gear interaction. Tows in which the grate became blocked by spiny dogfish are included in these catch data sets. The industry partners claimed that the target species retained were generally of very high quality and can be representative of commercially feasible tows.

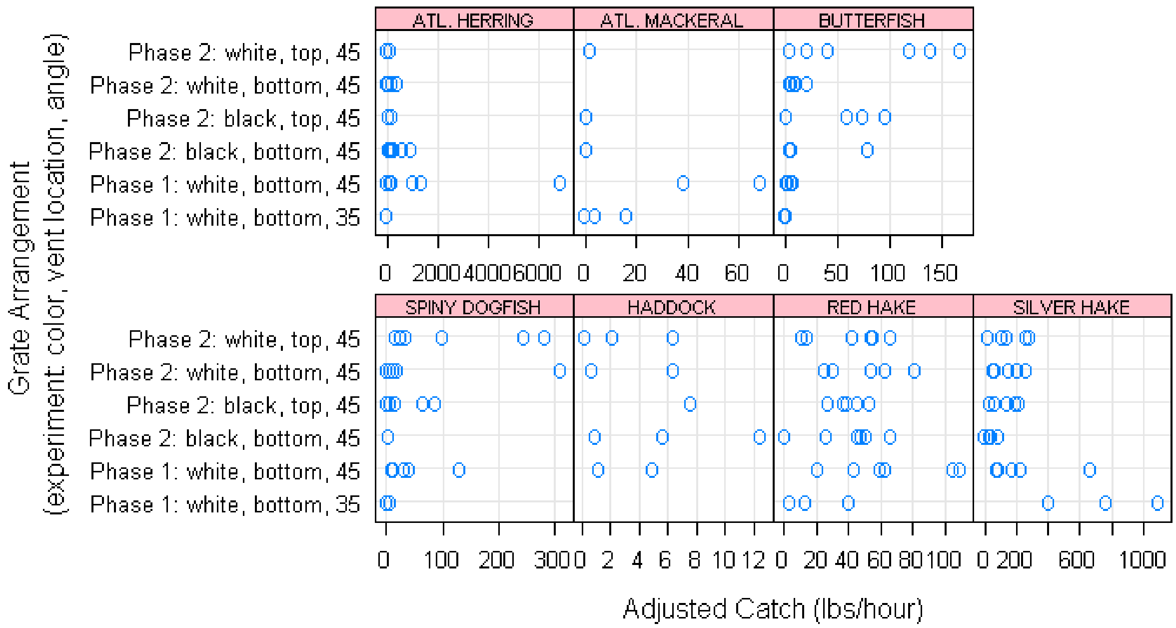

Figure 4: Adjusted catch (lbs/hour) of selected species per gear arrangement. ATL=Atlantic.

Comparisons, limited by the design of the study, suggested that catches were not strongly affected by different grate arrangements.

Length frequency distributions (Figure 5) showed some differences in size distributions for spiny dogfish. The hakes generally showed very similar results over all gear arrangements; some variations in sizes were seen during Phase 1 research with smaller sizes captured in the grate angled at 35°.

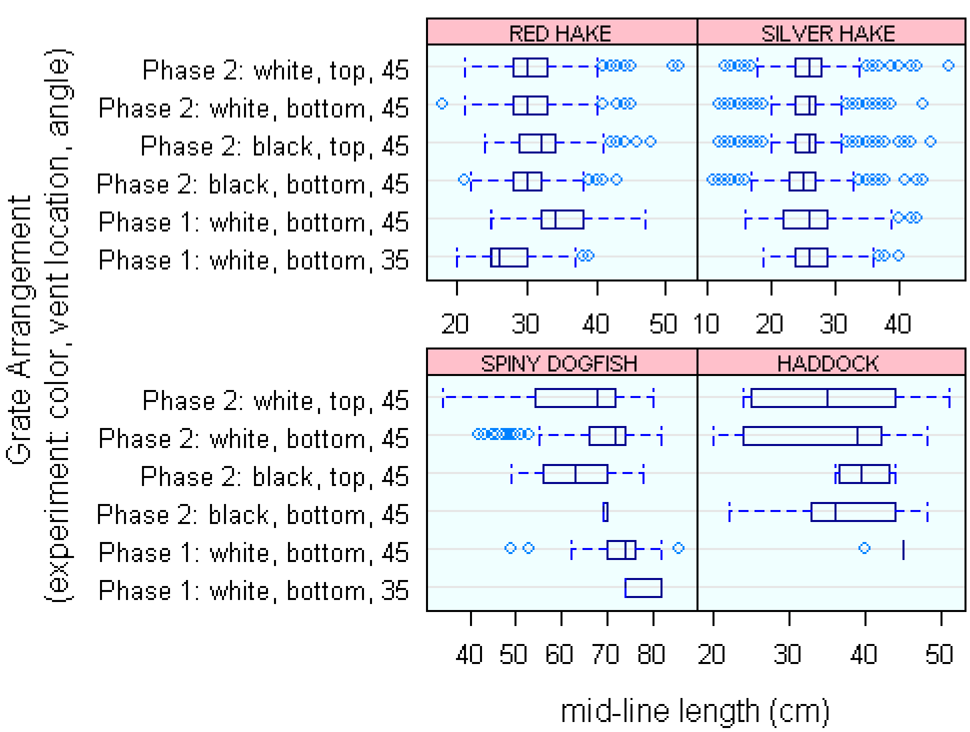

Figure 5: Box and whisker length frequency plot for selected species per gear arrangement

Spiny dogfish counts showed that more than 90% of the dogfish that entered the extension were excluded by the grate (except in one instance just under 90%), regardless of color or gear configurations (Figure 6). Other species were more difficult to track in video and therefore, these catches were not further analyzed for grate efficiencies.

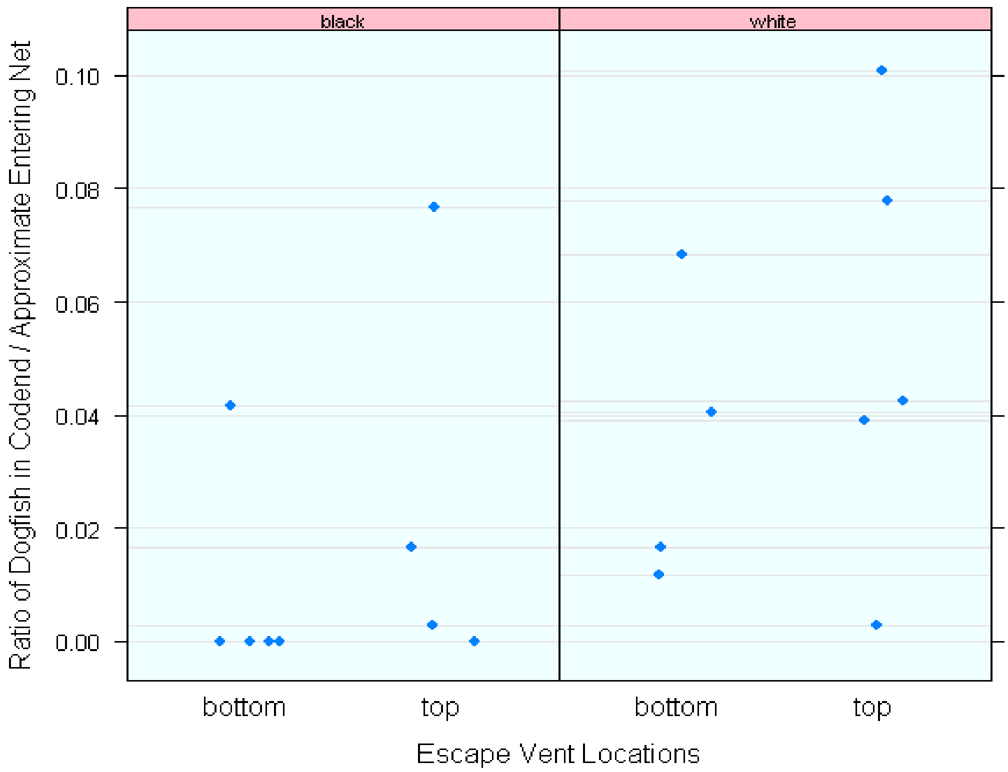

Figure 6: Dot-plot of the ratio of spiny dogfish retained in the codend versus the estimated numbers that entered the net for each gear configuration and grate color. Values along the x-axis are jittered (x=-1).

The black grate with a bottom escape vent showed the largest reduction (Figure 6) although the smallest numbers of dogfish were caught in these tows overall (Figure 4).

Behavior

Generalizations of behaviors were made for selected species in front of the excluder grates. However, based on the limited field of view and the small area within the extension of the net, true behavioral patterns for most species are difficult to confirm. It is our belief that many species react differently within the extension when schooling, near a school, and when concentrations and species compositions of fish change.

We also observed behaviors directly around the grate. Smaller fish, including Atlantic herring, river herring *Alosa sp.*, butterfish, and silver hake, were generally seen passing through the grates' bars with ease on the primary camera's video. Although often unknown, little or no contact was observed with the grate for these small species. Wedging behaviors, for all fish, was almost never witnessed in the videos. Fish were rarely seen swimming forward back out and past the grate. Fine scale changes in behaviors for the discussed species (with the exception of spiny dogfish) due to the gears orientations or color of the grates were not expressly observed as these fish were generally difficult to track on video.

Spiny Dogfish

We observed the behavior of 462 spiny dogfish in front of the grate and recorded 1,686 total actions, divided into the ten behavior categories (see Methods) and a non-action category. However, it was determined that the categories “Bump net with nose”, “Bump grate with nose” and “Wedge head into grate” could not be assessed adequately from video.

We were able to analyze three groups of behaviors (seven behaviors) for spiny dogfish; direction of swimming in front of the grate (backwards, forwards, side, down, up), impingement area on the body (either side, dorsal, belly, unknown), and twisting on the grate (area on the body that the dogfish settles against the grate - either side, dorsal, belly, unknown). Boxplots indicated that no differences were found within these categories, or between grate configurations; these plots will be presented in the final report.

In general, we could not discern any differences in spiny dogfish behaviors between grate configurations. Additionally, we observed that behavior could be altered by the presence of other species. For example, dogfish generally stayed lower in the extension when found in low concentrations, especially when large schools of herring were present although deviations from this behavior were also common. In the highest dogfish concentrations (arriving in the field of view at about one individual per second), all fish behaviors appeared erratic.

Video from the secondary cameras in Phase 2 showed general behaviors around the vent opening. It was unclear whether spiny dogfish actually attempted to avoid the flap covering the escape vent or the escape vent itself. They would often become temporarily snagged or delayed in the flap. Once dogfish actually escape through the vent, they demonstrated a variety of behaviors including swimming with the net, to the sides and then up, down, or off the camera to the side, or backwards against the direction of the net.

Spiny dogfish seem to display a more varied behavior than most other species. Generally, the behaviors of other fish seemed to be disrupted by the presence of dogfish including other dogfish and would generally manifest as a chaotic swimming reaction. During blockages, dogfish might have been punctured from spines from other dogfish, based on small points observed in their dorsal surfaces.

Silver hake

Silver hake were generally seen in light concentrations, and were difficult to distinguish in large herring concentrations. However, silver hake were observed to be present lower down, below herring, and exhibited forward and side swimming with darting movements. Silver hake often swam with the net along the bottom or middle of the extension.

Few silver hake escaped through the vent, based on video taken by the secondary camera.

Herring

Herring (mostly Atlantic herring) generally stayed high in the extension, especially true when in large schools. They nearly always swam in the direction of the tow. Other species’ behaviors, such as spiny dogfish and butterfish, seemed affected by large herring schools and generally stayed below them. When large herring concentrations were not present, other species seemed more often found in the entire area of the extension.

Herring in large schools, which had passed through the grates, were rarely observed to swim back through in large numbers even though they appeared to be physically capable of doing so. Exceptions to this behavior were witnessed during periods of slow down (such as haul backs). Schools were occasionally viewed swimming with the grate after having passed through the bars.

As with silver hake, we infer that most herring passed through the grates (since relatively few were seen escaping in the secondary video). Those seen escaping quickly darted out of the field of view.

Red hake
Red hake generally stayed low in the extension independent of fish concentrations. They demonstrated sustained swimming and would often block the camera, presumably an area protected from stronger water flow. Eventually, red hake drifted back or were displaced by other fish (commonly spiny dogfish), causing the red hake to turn toward a side or the codend.

Butterfish
Butterfish generally stayed below large schools of herring and used more of the extension when herring were not present. Infrequently, these fish were seen escaping through the vent and quickly out of view of the secondary camera.

Gear
Net mensuration data were obtained for the door spread, wing spread, headline height, footrope height, square height, and ranges from each of these related sensors to the hydrophone for Phase 1 and Phase 2 nets. The data were used to assess net performances and estimates of these parameters are not reported. No tows were excluded during other analyses because of poor geometry. This data will be provided in the final report.

Grid angles obtained during the Phase 1 research for (tows 4-9) increased during the duration of the tow, although at varying rates. This data will be shown in greater detail in the final report.

Summary
Independent of color, angle, or gear orientation, the grates were successful at excluding spiny dogfish while retaining adequate catches of silver hake and other smaller target species. Dogfish were also seen escaping on the primary and secondary videos, and the low amounts of dogfish in the codend, demonstrated the effectiveness of the grate. Sharks are reported to have excellent spatial capabilities that may have assisted their ability to escape (Montgomery and Walker, 2001). Survival of excluded dogfish is likely to be very high, as the mortality from stress or injury induced by the grate is likely to be far less than the mortality of 5.9% for discard bycatch (Mandelman and Farrington, 2007a, 2007b).

The catch of silver hake appeared to be of high quality, but the quantity lost is unknown. The industry partners on this project already judge that the exclusion of the dogfish has significantly reduced their total fish handling time, and improved the quality of their catch while obtaining commercial quantities of target species; they have adopted this design to use during their normal silver hake season and have generated further interest in the fishing community.

The grates' 50 mm (2.0 in) bar spacings appeared to be appropriate to allow for commercial-sized catches with nearly no fish becoming wedged between the bars. Possible loss of larger target fish, if any, is a concern with any grate in a trawl fishery.

Based on observations made during Phase 1, grates set at 45° produced adequate exclusions of spiny dogfish while retaining satisfactory target catches compared to the 35° angle. Therefore, we subsequently set the grates at 45° (in both directions leading to either a top or bottom escape vent). The limited scope of the project did not permit a more thorough examination of optimal grate angle.

While all configurations effectively excluded dogfish, the optimal gear arrangement may depend on the species desired. Since herring appear to generally remain high in the extension, an arrangement with a bottom escape vent is suggested if herring are a primary target. Additionally, this arrangement would support the exclusion of moderate concentration of spiny dogfish (which generally seem to stay lower). We theorized that spiny dogfish would attempt to avoid a highly visible grate (within their visual capabilities). However, the grate colors seem to have had little impact on spiny dogfish behaviors based on the video observations. Conversely, a color that is not strongly visible to target species might have minimal exclusionary effects; other species' behaviors with respect to grate color are inconclusive at this time.

Future Work

The final report will be completed and submitted to the NEC. A manuscript based on a presentation to International Symposium on the Biology, Harvesting, Management and Conservation of Hakes (May 11-12, 2010) will be completed and submitted to the conveners for inclusion in a Symposium journal issue.

Impacts and Applications

The results were very positive. Although we are not able to accurately quantify the number of spiny dogfish that were excluded while using the grate, we have observed large numbers of dogfish entering the net which were not present in the codend. At the same time, high quality silver hake have been retained, but the quantity lost is unknown. The industry partners on this project already feel that the exclusion of the dogfish have significantly reduced their total fish handling time, and improved the quality of their catch while obtaining commercial quantities of target species; they have adopted this design to use during their normal silver hake season and have generated further interest in the fishing community. Furthermore, this method likely reduces the dogfish mortality that would otherwise occur through discards or unwanted required landings.

Other industry members have taken note of the success of this project through word-of-mouth and publication of an article in Commercial Fisheries News. Some have expressed interest in using these or other dogfish-excluding grates. We are developing a research plan in co-ordination with Ken La Valley of New Hampshire Sea Grant that will expand use of the DOGGRATE.

References Cited

Mandelman, J.W. and M.A. Farrington. 2007b. The estimated short-term discard mortality of a trawled elasmobranch, the spiny dogfish (*Squalus acanthias*). Fisheries Research. 83: 238-245.

Montgomery, J. and M. Walker. 2001. Orientation and navigation in elasmobranchs: which way forward? Environmental Biology of Fishes. 60: 109-116.

Partnerships

The cooperative efforts between MA DMF and the industry partners, Frank and Andrew Mirarchi, have brought together complementary skill sets. The fishermen's gear understanding has been invaluable to the MA DMF researchers. Communications between Chosid, Pol, and Frank and Andrew Mirarchi have been strong in defining the research needs and practical gear designs for good fishing operations. They jointly considered logistics of deck handling of the grate, camera and sensor equipment, and the fish catch. The Mirarchis provided the lead on determining timing of the fishing activities, tow locations, and have primary responsibility for determining safe working conditions due to weather and deck activity. Chosid was responsible for acquiring all the necessary permitting for conducting the research. Chosid and Pol provided the lead on the experimental design, database development, data analysis, and report writing. Chosid and Szymanski led the sea sampling. The Mirarchis also assisted in processing the catch and led informal outreach efforts to other fishermen.

Overall, the cooperative process increased our understanding of the other partners' skills and challenges.

Additional researchers who assisted during day trips included: Rachel Feeney (NEC), Doug Zemeckis (SMAST), Andrew Applegate (NEFMC), Tyler Staple (NOAA), and Steve Voss (MA DMF).

Presentations

The results of this research were presented by Chosid at the International Symposium on the Biology, Harvesting, Management and Conservation of Hakes (May 11-12, 2010). The title of the presentation was: "Video Observations of a Whiting Net Bycatch Reduction Device".

Published Reports and Papers

At the time of this report, a manuscript was near completion for submittal to the Hake Symposium journal issue.

Data

Additional supplements will be included with the final report and will contain the project database, images, and selected sample one-minute clips of the video blocks analyzed. Additional video will be available upon request to the MA DMF.

David Chosid 6/30/10

Signature Date