# Summary of flume tank gear modification trip to help prevent Killer Whale entanglements in Bering Sea deepwater flatfish fishery

## March 4-6, 2024 St. John's Newfoundland

Attendees:

AKSC: Sarah Webster; John Gauvin

Oregon State University: Dr. Hannah Myers

Dantrawl: Poul Pedersen

Captains and company personnel from AKSC member companies

Location: Marine Institute of Memorial University, St. John's Newfoundland

Objectives for AKSC's work on killer whale entanglement prevention net modifications:

1) Develop modifications for commonly used Bering Sea deepwater flatfish (DWF) nets to cover/block a large portion of the entrance to net (e.g. >80%) to help prevent killer whale takes with minimal impact to catch rates for target species.
2) Gear modifications must be practical and avoid problems for fishing (e.g. catching derelict crab pots in the panel at entrance to net; tangling during deployment; gilling target fish or skates/squid in panel)
3) Incorporate marine mammal expert Dr. Hannah Myers' understanding of killer whale behavior and their size, shape and movement to make gear modifications as effective as possible. The hydrophone data collected on a DWF fishing trip last summer was collect to be useful for this purpose.
4) Evaluate potential for use of sound reflective materials to help killer whales detect the panel blocking the entrance to the net.
5) Make step-wise adjustments to gear modifications based on feedback from captains, Dr. Myers, our net designer (Poul Pedersen), and Memorial University (MU) tank measurement engineers to come up with the "most promising" design for use in DWF fishing in the Bering Sea starting in May 2024 when the fishery opens.

Background: What is/Why use a flume tank? (for those who are not already familiar)

A flume tank is a large water tank where specialized pumps are used to create a fully-controlled flow of water throughout the tank. The MU flume tank is the world's largest, measuring 8 m (width) x 4 m (depth), 22.25 m in length.

Flume tanks are used for many marine research purposes. For studies involving trawl nets, flume tanks are used to accurately simulate towing a net through water in order to evaluate the specific shape and flow parameters. This is useful for improving target species catch as well as bycatch reduction. Net models using bridles and doors are attached to mechanical stanchions. For large-scale models, booms are typically used to spread the wings of the trawl model.

Our testing involved several ¼-scale models built from actual trawl netting materials used in the fishery. Booms were used to spread our model to about 6 meters between the wings.

Flume tanks provide very large underwater windows allowing attendees to view an entire side of the net from top to bottom and front to back. Additionally, the MU tank can extend mechanical arms to deploy underwater cameras and flow meters anywhere in or around the tank and models. These allow views, shape measurements, and multi-direction flow measurements anywhere inside the model or around it. Towing speeds for most trawl fisheries can be achieved in scale at the MU tank. This allows modifications to trawl nets to be evaluated for shape and flow across the entire length and width of the model net.

The main advantage of working on trawl gear development or net modification in a flume tank is that participants can evaluate effects of changes to the net rapidly and more comprehensively than from a boat at sea where views are limited to camera angles and water visibility can also be limiting. The tank allows fishermen, gear manufacturers, tank engineers, and other experts to iteratively explore ideas used to change the shape and water flow of nets at full towing speed or during setting and hauling. Shape and water flow measurements in a flume facility will transfer into full scale on a fishing vessel as long as scaling and materials differences are accurately accounted for. Participants come away with information that allows them to modify actual nets to achieve desired net shape and flow when they implement these into full-scale nets.

Overall, flume tanks are an excellent way to design or evaluate gear modifications so that trials on fishing vessels will start with the intended shape and flow parameters. Flume tanks do not resolve how target and bycatch species will react to the net modifications, so that stage of gear modification research must be done under real fishing conditions.

Steps to achieve our objectives:

After introductions and a brief overview of the killer whale entanglement situation for the tank engineering staff and Dr. Paul Winger (MU's Marine Institute Director), participants evaluated net designs discussed at the AKSC captains' meeting last January. Participants agreed to begin with a review of the killer whale entanglement deterrence panel that was trialed on a vessel in the fishery last summer. All gear configurations to deter killer whales from entering nets that were evaluated in the flume tank will hereafter be referred to as "panels."

The panel trialed last summer was attached to the riblines just aft of the trawl wings by four bridles (two on each side of the net). This panel covered approximately 35% of the opening of a Dantrawl "Fiska" flatfish net. Based on video obtained on the vessel last summer, we determined that the panel flew directly above the footrope at towing speed and was located a few meters back into the trawl during setting and haulback (when the net has a rounder shape as the wings come together). The panel did not negatively affect DWF catch rates during the trial. Also, the one derelict crab pot encountered during the trial didn't hang up in the panel.

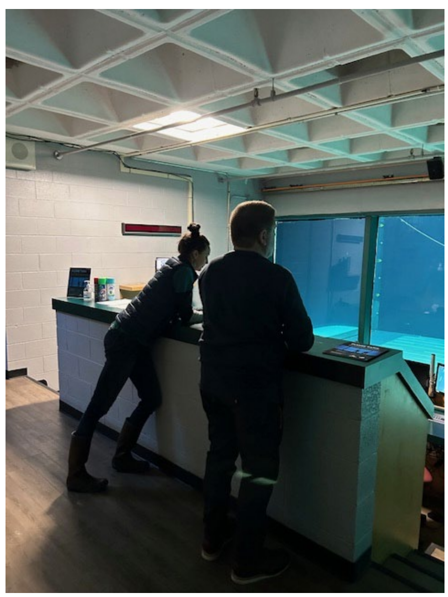
Based on discussions with the AKSC captains, the initial gear modification deployed and evaluated at the flume tank covered approximately 60% of the width of the opening of the net. Flatfish nets in this fishery open approximately 26 meters (wing to wing) so the panel used as a starting point for the flume tank would scale up to ~13 meters in width.

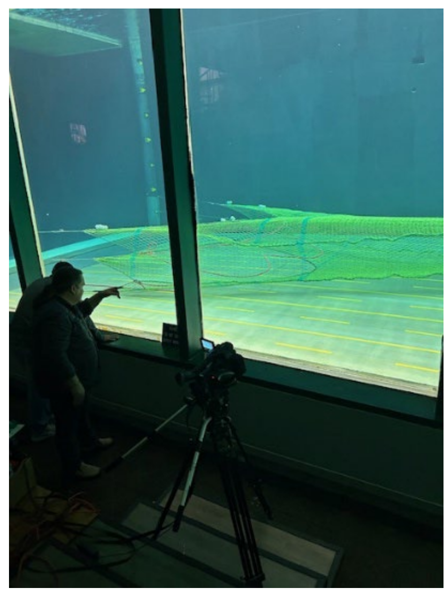
After evaluating the model with the panel covering 60% of the net opening, attendees received feedback from Dr. Myers that it would be safer for the killer whales if the panel covered a greater portion (~80%) of the net width. Likewise, she suggested that it should be located forward of the footrope instead of flying directly above it. Dr. Myers' recommendations were based on factors including killer whale size, swimming speeds, and turning ability relative to the boat's towing speed and the relatively fast taper of DWF nets. Essentially, Dr. Myers advised evaluating a wider panel rigged to fly ahead of the footrope because once a killer whale is at or behind the footrope it would have a hard time turning around fast enough to avoid entrapment. This change would give a killer whale more time to turn to avoid entering a net when towed at 3 knots.

Responding to Dr. Myers' advice, attendees adopted an approach to block access to the net well ahead of the footrope. This could be done by shortening the panel's bridles or moving the point of attachment to the wings further forward. As a practical matter, doing this would also help prevent components of the panel from becoming tangled in the footrope during setting and fishing.

Additionally, after seeing the original version used last summer, several captains thought it would be better to fly the panel a little higher up above the fishing line/footrope to provide even more clearance for crab pots/debris that might enter the net and avoid these objects getting hung up in the panel. They also agreed to come up with a way to safely block off access below the panel once they looked over the model with the panel as described above.

Pictures of attendees evaluating various configurations of the panel during the flume tank research






Closing off the area above the panel

At towing speed, the net has a relatively rectangular shape and the model showed there was little room above panel for a killer whale to enter. But using the tank to simulate setting and haulback when the net was rounder, Dr. Myers pointed out that there might be sufficient space for a killer whale to go above the panel. This was of particular concern and needed to be addressed. After several potential configurations were evaluated, the approach to blocking off the area above the panel that worked the best was to attach lines running from the headrope to the top of the panel. These were rigged to drop to the panel at ~45 degree angles, thus creating “cross pieces” or what are essentially large diamond meshes above the panel.

To evaluate whether these cross pieces sufficiently blocked off the area above the panel, the flume tank towing speed was repeatedly reduced to ~1.5 knots (scaled water speed) and the wings of the net model attached to sliding booms of the flume tank were brought closer together to simulate the trawl doors coming together during haulback. In this manner the group evaluated several iterations of lengths of the cross pieces and attachment points to the panel and headrope. The final versions covered the space above the panel as evenly as possible. The meshes created by the cross pieces were scaled such that even juvenile killer whales would be unlikely to be able to enter the net through the gap at the top of the panel.

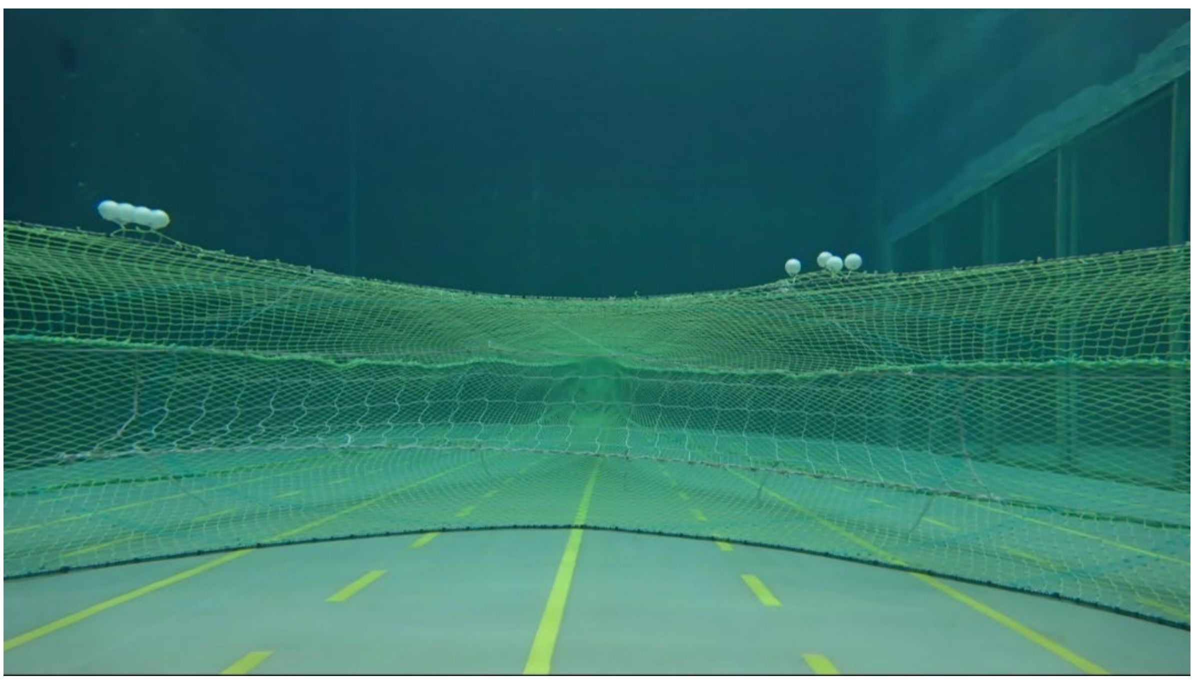
Closing off the area below the panel

Attention turned next to blocking off the area below the panel. At haulback (or setting), the larger vertical opening creates considerable room below the panel. Using cross pieces attached from the footrope to the panel would not be practical as it would create a rigid connection from top to bottom and would increase the potential for crab pots or other debris to hang up in the panel instead of entering the mouth of the trawl. A rigid connection would not provide enough “give” at the entrance to the net and could result in damage to the side panels of the trawl, the killer whale deterrence panel, or both if a crab pot were encountered.

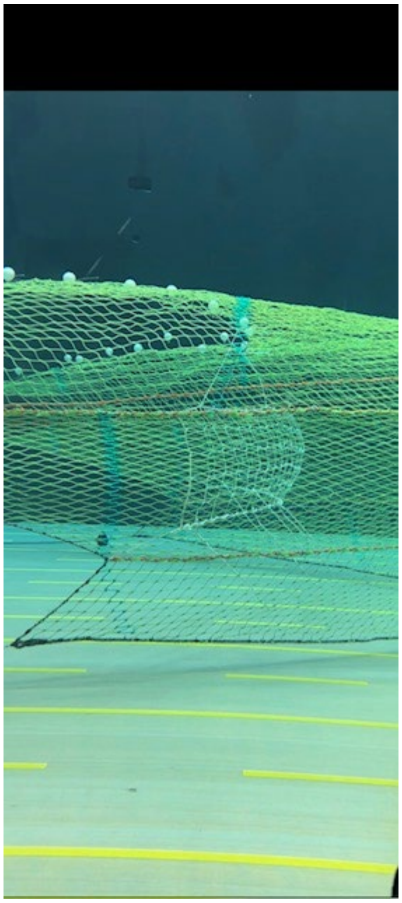
The need to avoid a rigid connection from the panel to footrope was addressed by attaching individual pieces of leadline to the bottom of the panel spaced to be vertical “droppers.” The weight in the leadline causes these pieces to hang down towards the footrope. At haulback, when the water speed is slow, the leadlines hang nearly vertically to block off the space under the panel. At fishing speed (3 knots), these pieces trail back somewhat towards the footrope, but given the rectangular shape of the panel at full door spread, the net has relatively little space below the panel. Based on the size of killer whales, it is unlikely that one would go below the panel during fishing. Dr. Myers indicated that, while not rigid to prevent entrance into the net, contact with the dropper lines was likely sufficient to alert killer whales to the presence of the net and they would be unlikely to continue past the droppers.

The droppers hanging vertically was evaluated by the simulated haulbacks. After confirming a vertical hang, several iterations of spacing of the leadlines were trialed during simulated haulbacks to ensure the spacing was sufficient to block off the area below the panel. Feedback from Dr. Myers on spacing was based on body dimensions of adult and juvenile killer whales. The pictures below illustrate the panel with cross pieces and leadline droppers at towing speed and during haulback.

The killer whale deterrence panel (white) seen from the front with cross pieces above and leadline droppers at 3 knots towing speed equivalence.



Side view of the killer whale deterrence panel during a simulated haulback and rounder shape of net. Note the panel is well ahead of the footrope and leadlines fill the space below the panel



Making the panel more "visible" to killer whales (echo-reflective)

There is no natural light at fishing depths in the DWF. This means that when a net is fishing a killer whale can only detect the gear if its calls/clicks reflect back off the netting (gear, panel, line). The relatively small amount of hydrophone data collected in our studies thus far indicates that killer whales are at times close to the net during setting, net retrieval, and when the net is fishing (even at depths in excess of 450 meters). But we cannot definitively know whether captures are attributable to one or more of these different fishing processes nor specifically whether captures occur during times when natural light is not sufficient for killer whales to see the net components.

For this reason, we have looked at ways to make webbing reflect sound so killer whales are able to echolocate gear components. One way to potentially do this is to apply a coating of barium sulfate or iron sulfide to the gear and deterrence panel to make it more reflective to sound as was done for gillnets in Canada. Our communications with scientists who worked on this research to avoid dolphin catches in Atlantic Canada has revealed, however, that their testing of materials did not specifically include reflectivity at the frequencies used by killer whales. In our discussions with these Canadian scientists, they agreed that our idea to use "Eurostone" (a material with basalt additive to net webbing and line) could work to make our deterrence panel more echo-reflective than our typical netting materials.

“Eurostone” is a very resilient webbing and is relatively stiff, which is desirable for a webbing gear modification to help avoid tangling. For this reason, Dantrawl has purchased Eurostone webbing in 32-inch square mesh. This size mesh is what our flume tank panel scales up to at full scale. It is a size that is too small for killer whales to pass through and is unlikely to interfere with target fishing.

In addition to using Eurostone, captains indicated that they might also wrap thin gauge stainless steel wire on the some of the mesh, cross pieces, and droppers to hopefully increase the “visibility” of the panel to killer whale calls/clicks.

Summary

Through work with captains, a killer whale expert, a gear designer, tank experts, and other attendees at the flume tank, we have developed the first generation of a gear modification for DWF trawls to reduce the likelihood of killer whale entanglements. This modification will block the entrance to the net to killer whales by using a large mesh panel made of echo-reflective materials with cross lines to the headrope and weighted droppers to the footrope. This design achieves a shape during setting, fishing, and haulback that is consistent with deterring killer whales based on their size and what we know about their behavior around our nets at this time. Our expectation is that this design will have minimal impact to fishing activities. We intend to use this modification for all vessels fishing in the DWF in the Bering Sea and continue to improve its design in future years based on additional information collected in 2024 on killer whale behavior around the nets, target species catch rates, and other feedback from captains and gear and marine mammal experts.