APPENDIX 11. Email Comments to the Trawl Warp Workshop from Gary Loverich

To Warp Differential Workshop
Woods Hole, Mass
09/30/02

At the risk of being called the "dear Abby" of the trawl industry I am sending a brief letter instead of attending in person. However I thought it might be worthwhile to add my comments to an interesting and important workshop.

Having been involved in studying, designing, testing, simulating and troubleshooting trawls for the past 33 years I am all too aware that any single observation or observation technique will never give the complete picture of our trawl gear. Because of the size of the gear and poor visibility we can only hope to get localized details of trawl gear and few of those details simulataneously. And it is only by putting together the fragments of these images that we can expect to gain some understanding of what is happening. And after 33 years I am still learning. I chose to believe that the gear is difficult to understand rather than my being slow witted. So I would like to make some comments that might serve to help the discussions.

1a) The physics and engineering of trawl gear can be studied separately from fish behavior. If we can understand the physics then we have a possibility of understanding how fish behave to the trawl gear and we can then improve trawl gear. If we don't understand the physics of trawls how or why we catch fish becomes "black magic" where any theory or any numerical value has nearly equal credibility.

1b) Speaking from the perspective of a diver having made over 300 dives on trawl gear, once in front of or on the net it is very difficult to get oriented and only a small portion of the net is usually visible at a single time. We can judge distance by float spacing and mesh sizes. Angles can only be approximated within +-15 deg, and small changes in rigging are often difficult to assess. It all becomes more difficult as speed increases and visibility decreases
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From a fish perspective orientation and reaction is everything. They orient to localized areas of the trawl, not to the system or some engineering goal of symmetry, or shape (overall or local) or flow. They can be caught by a mis-shapen net as well as by a perfectly formed net. Fish do not know whether they are inside the net or outside or anything about the net. A fish cannot sense small wing angles changes any better than a diver, but there is some threshold angle where they will no longer swim in front of or along the wing and instead will go over it. In order to catch fish eliminate localized avenues of escape and once inside the net fish only need to be retained, even if the meshes are distorted over the whole area the of the trawl. And even in perfectly engineered nets (if those exist), fish will escape.

The question before the workshop is how much distortion will be acceptable before catch is significantly reduced.

With this in mind I will make a few comments on warp differential and trawl performance.

2) Warp differential should be measured as a percentage of the total line length between doors. This includes backstraps, cookie gear, bridles and headrope. To justify this definition consider a chain suspended between two points. The suspension points are the major characteristics of the system and they are the points where the major displacements will take place. For example, the suspension point that is offset will have the greatest displacements. As we measure each point along the suspended chain the displacements will decrease until we reach the other side where the displacements will be zero, ie no change. Consider the doors as equivalent to the suspension points. It is the doors that are initially offset since everything behind them is assumed to be the correct length. The wings will be offset a lesser amount than the doors in all cases except when there is no door spread. Although I don't have the exact figures for the Albatross survey gear, it appears that the total line length between doors is about 136 ft, the offset in 300 m of warp is about 6 ft so the offset percentage is 4.4%.

3) As the warp differential becomes larger the trawl deforms to the point where a portion of the footrope may lift of bottom and the net will be skewed eventually to the point where fish can locally escape the net. One wing angle becomes less and the other becomes greater. The differential where the footrope lifts off bottom has much to do with the weight of the footrope, the amount of floatation and the towing speed. In 1971, Bill High and I made diving observation where we varied the warp differential for a trawl as much as 100 ft. (as per my diving log) The results of those observations are reported in Cruise report 71-8 of the Exploratory Fishing and Gear Research Base in Seattle. I do not have a copy of that report. However, two things should be considered. The total line distance between doors during that test was probably greater than that used for the Albatross sampling gear, however I would guess the differential to be about 5%. The other significant item would be that the footrope used on cruise 71-8 was considerably lighter than that being used on the Yankee trawl. If you have a copy of the cruise report and feel it is worth considering calculate the warp differential percentage and consider that the 71-8 net would lift off bottom relatively quickly compared to the Yankee.

4) In 1987, I made some training tapes for use of our Bering Sea Combination trawl using a 1/6 scale trawl and doors. Here we studied warp differential and took videos of the net deformation. In this video we used a tire gear footrope which is relatively heavy and as seen in the video the net deformed significantly without lifting the footrope. The model net (1/6 scale) used 15 ft bridles, 15 ft of cookie gear, 6 ft backstraps and had an 18 ft headrope. Warp length was 50 ft. in 10 ft of water. The warp differential less than 5 ft was not thought to cause any catch reduction based upon footrope contact. The threshold warp differential of 5 ft would give a 5.5% differential percentage.

5) Most trawlers fishing the Bering Sea use auto trawl winches which adjust warp length to equalize tension between the two sides. For these boats the winches are always paying warp in and out depending upon the many factors affecting the warp tension. Differentials of 2-3 fathoms are common, but these vessels also have very long line

lengths between doors, so the warp differential percentages (as I defined them above) are likely to be compartively low and in the range of 1%-2%.

6) I have examined a earlier warp offset FEA (finite element analysis) computer simulation of a 2 seam net with short (22m bridles). In that simulation, the offset was nearly 20% and I believe a similar real net rigged similarly is still capable of catching fish as long as the footrope is heavy enough to stay on bottom. Local mesh distortions, wing angles, and offsets are not enough to keep significant numbers of fish out of the net.

7) Strong side currents or winds can offset a trawl from the tow path causing one door to operate at a different angle of attack than another. The up current warp tension being higher causes the door to be lighter on bottom or even to lift off bottom. It is possible that a side current or wind in the correct direction would offset any negative affects of a small warp differential as well as enhance the negative affect. Because the doors are so close to the net for the Albatross sampling gear, any significant change in door behavior will have a nearly immediate affect on the wings of the net. For example, a door lifting off bottom momentarily or one falling over. Whereas with longer cookie gear and bridles, the affect on the net is long delayed.

8) If one door is set faster than the other, one of the doors will operate at a greater angle of attack and pull the entire gear off center. If have witnessed this many times in the model basin and it does not appear to be any tendency for the “dominant” door to give up its greater attack angle, ie the gear remains off center for the entire tow. This is particularly true for short sampling tows. We might then conclude that the way the doors are set will negate or enhance the adverse affects of a warp differential.

9) If the doors are set at equal rates and the warps have a built in differential, the unequal tensions on the warps will allow the door connected to the longer warp (less tension) to acheive the greater attack angle and pull the gear off center negating some of the affects of the warp differential.

Conclusions:
I am familiar with the Yankee 36 although I have never studied it beyond the construction and rigging diagrams. I do know that its’ design is rather crude and is probably older than me. There may be design or construction characteristics that make it more or less sensative to warp differentials than gear I usually work with. However, looking at the evidence available to me I believe that a warp differential (as defined above) on the order of 5% would not greatly impact the cumulative catch of the Yankee 36 used aboard the Albatross.

Recommendations:
1) Longer line lengths between doors will minimize the adverse affects of warp differentials that occur by accident or when the trawl is towed offset from the tow path. I believe this and other changes might eliminate some sensitivity to rigging and operating conditions.

2) I believe that a fuller understanding of the physics of trawl gear will only be achieved when results from a) instrumentation, b) visual observations, c) flume tank tests, d) model towing basin tests and e) computer simulations are combined and presented to the stake holders. Items a-c are commonly used techniques but can be very limiting because they rarely give a system wide perspective. Item d) achieves modeling of the entire trawl system from trawl winch to cod end in a large towing basin such as David Taylor. However, even then experiments are somewhat limited because deep water and long cookie gear lengths are sometimes impractical unless small models are used. Item e) computer simulations can give a great amount of detail and can be applied to fishing in great depths and/or with long cookie gear. Simulations are now at least as good as model tests and promise to be better in the near future. Right now simulations provide more detailed information than model tests.

I personally never trust any single one of the above observations techniques or any single observation unless compared to results from all the others. I believe it would be worthwhile for the NMFS sampling gear to be fully tested in a model towing basin (item d) and with computer simulations (item e). This would complete the circle when combined with experience on the grounds. The result should be an operations manual discussing all significant engineering performance characteristics of each sampling system.

Sincerely,
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