Northeast Fisheries Science Center Reference Document 02-15

Report of the Workshop on Trawl Warp Effects on Fishing Gear Performance

Marine Biological Laboratory
Woods Hole, Massachusetts
October 2-3, 2002

October 2002

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Northeast Fisheries Science Center
Woods Hole, Massachusetts

October 2002

Northeast Fisheries Science Center Reference Documents

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This document may be cited as:

[Northeast Fisheries Science Center.] 2002. Report of the Workshop on Trawl Warp Effects on Fishing Gear Performance, Marine Biological Laboratory, Woods Hole, Massachusetts, October 2-3, 2002. *Northeast Fish. Sci. Cent. Ref. Doc.* 02-15. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

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Introduction

On 3 September 2002, in response to a concern raised by a member of the fishing industry, the trawl cables ('warps') on the NOAA Ship *ALBATROSS IV* were inspected and found to have inaccurate 50-meter markings. That is, the marks were not exactly at true 50-meter intervals over the first 1,000 meters of the warps. The difference in marks from the true values ranged between less than 1 inch to 38.4 inches. Also, some of the marks were not evenly matched between the port and starboard cables. The cables were mismarked by the vendor upon installation in February 2000 and were used in eight bottom trawl surveys beginning with Winter 2000 and ending with Spring 2002. Thus, at times during these surveys, more cable may have been deployed on one side of the bottom trawl than on the other. The difference between the two warps is a matter of inches at shallower fishing depths but increases as more cable is set out. For example, when 100 meters (328 feet) of cable are deployed, the warp lengths differ by about 1 inch; when 300 meters (984 feet) are let out, the warp lengths differ by about 6 feet. Approximately 75% of the sampling tows accomplished in the bottom trawl surveys use 300 meters or less of cable.

Due to the warp offsets, the survey trawl gear may have fished differently during the eight bottom surveys than during previous surveys, and this may have affected survey catch rates and related survey data used in stock assessments. To evaluate the possible impacts of the warp offsets, data from the last two year's of surveys are being reanalyzed by species, geographic area and depth to detect any changes in catchability that may have occurred . Additionally, the survey results are being compared to the results from other trawl surveys (*e.g.*, Canadian Georges Bank bottom trawl surveys; NMFS sea scallop surveys) conducted during the winter 2000-spring 2002 time period. The sensitivity of groundfish stock assessment results to possible changes in survey catch per tow indices that may have been induced by the warp offsets is also being examined by arbitrarily increasing the catches in the eight surveys by 10%, 25% and 100%, redoing the assessments and then determining the improvement, if any, in the fits of the assessment models. All of the above analyses will be summarized in the *Report of the Groundfish Assessment Review Meeting (GARM*) that will be available and distributed at the end of October 2002.

During 25-27 September, a series of field experiments using different starboard and port trawl warp offsets (0, 2, 4,6, 12 and 18 feet) was conducted in Southern New England waters aboard the NOAA Ship *ALBATROSS IV* using underwater video cameras and trawl sensors to observe and document the performance of the 'Yankee 36' survey trawl gear. The objectives of this work were to: (1) provide initial qualitative observations of the effects of differential offset warps on net geometry and fishing gear performance; and (2) provide a quantitative evaluation of the effects of offset warps on net wingspread, door spread, and head rope height. Six commercial fishing industry representatives served as members of the scientific crew aboard the *ALBATROSS IV* during the 3-day field investigation and directly observed all operations.

Planning activity for the **Workshop on Trawl Warp Effects on Fishing Gear Performance** began in mid-September 2002 when about 30 fishing industry representatives and outside technical experts were contacted about their availability to participate in a 2-day workshop to evaluate the information on trawl warps that was presently available and the information likely to be available from the *ALBATROSS IV* field experiments. By bringing together a broad cross section of expertise from fishermen, gear specialists and other scientists at the Workshop, it was envisaged that the

Workshop could, in a collaborative and constructive fashion, review and discuss the video and sensor gear performance data obtained during the *ALBATROSS IV* cruise and develop a written consensus on the trawl warp offset situation and on any research work required to further resolve this matter.

Based on an overwhelming favorable response from the individuals contacted, invitations for the **Workshop** were sent out (via email) in late September to 37 Workshop Participants (19 industry representatives; 8 outside technical experts; 2 'other' individuals; and 8 staff from the Northeast Fisheries Science Center). Included with the invitation was the Workshop Agenda (Appendix 1) and a brief document describing effective elements for consensus building (Appendix 2).

As noted in the Agenda, the objectives of the **Workshop on Trawl Warp Effects on Fishing Gear Performance** were to:

(1) evaluate world-wide experience and expertise in the issue of trawl warp length offsets and their effects on trawl performance;

(2) review the results of experimental manipulation of trawl warp lengths conducted aboard the NOAA R/V *Albatross IV* during 25-27 September;

(3) based on the above, consider the likely impacts of trawl warp offsets as measured on *Albatross IV* in terms of trawl geometry and consider the implications for survey catches;

(4) develop appropriate research plans for further evaluation of the issue, if deemed necessary; and

(5) provide a written consensus report regarding trawl warp offset issues.

The **Workshop** was sponsored by the NMFS Northeast Fisheries Science Center (NEFSC) and held at the Marine Biological Laboratory in Woods Hole, Massachusetts during 2-3 October 2002. Dr. Fredric M. Serchuk (Chief, Resource Evaluation and Assessment Division, NEFSC) served as Chairman of the Workshop.

A total of 85 participants attended the Workshop (Appendix 3) with affiliations from a wide variety of fishing industry, academic, science, conservation, management, government and stakeholder organizations.

Prior to the start of the first session of the Workshop at 9:00 AM on Wednesday, October 2nd, participants could view an actual "Yankee 36" trawl used in NEFSC bottom trawl surveys on display in the courtyard adjacent to the Whitman Auditorium (the venue for the Workshop).

Workshop, First Day, 9:00 AM - 12:30 PM, 2 October (Whitman Auditorium)

Dr. Wendy Gabriel (Chief, Fisheries and Ecosystem Monitoring and Analysis Division, NEFSC) opened the Workshop by welcoming all of the participants and presenting background information on the survey trawl warp offset issue. She also outlined the Workshop process and the expected short-term and long-term products (Appendix 4). She observed that the Workshop participants possessed considerable experience and expertise, and expressed her desire that the discussions and interactions during the next two days would be open, candid and constructive. To this end, she gave a short presentation on "Successful Ground Rules for New Groups" (Appendix 4) which concluded by noting that (1) *None of us is as smart as all of us*; and (2) *We all need to build for the future*.

Dr. Gabriel then asked each participant to identify themselves and provide a brief description of their expertise and particular interest in the Workshop. She then introduced Dr. Fred Serchuk, the Workshop Chairman.

Dr. Serchuk welcomed the participants on behalf of the Northeast Fisheries Science Center and said it was an honor to serve as the Workshop Chairman. He indicated his intention that the Workshop would be conducted in an honest, transparent, and civil manner. He encouraged all attendees to contribute positively to the discussions and offer their thoughts and ideas in a helpful, enlightening manner. He explained that anyone wishing to make a comment or intervention during the Workshop would be able to do so by simply raising their hand and then be recognized by the Chair.

Dr. Serchuk viewed the Workshop as an opportunity for scientists and fishermen to constructively collaborate in identifying, tackling and resolving some difficult problems, as well as a springboard for future cooperative interactions between NMFS and the fishing industry, and other stakeholders. He indicated that he was optimistic that the Workshop would reach a consensus regarding the various trawl warp offset issues based on the willingness and determination of virtually all the participants to work towards a common goal. The success of the Workshop, he noted, depended on such synergy.

The Chairman then gave a short presentation reviewing the Workshop objectives (*i.e.,* terms of reference) and the Workshop agenda (Appendix 5). He informed the Workshop that a website had been established (http://www.nefsc.noaa.gov/survey_gear) providing background information and data on the trawl warp offset and survey gear performance situation, and that the consensus of the Workshop would be placed on this website after the end of the meeting. As well, he noted that the Report of the Workshop - when finalized - would also be placed on the website.

The Chairman briefly reviewed a number of administrative and logical issues pertaining to the Workshop and encouraged participants who had not yet signed-in at the Workshop Registration desk to do so and obtain a Workshop booklet. The booklet (and accompanying inserts at the Registration desk) included the Workshop Agenda , the elements (behaviors) for consensus building and various data summaries relating to: (a) the trawl warp offset and amounts of wire out at stations and depths fished in the spring 2002 NEFSC bottom trawl survey (Appendix 6); (b) the wire out/depth scope values used at depths from 18-366 meters in all NEFSC bottom trawl surveys using the '36 Yankee' trawl (Appendix 7); (c) the cumulative distributions of cod, haddock and yellowtail flounder catches in the 2001 autumn and 2002 spring NEFSC bottom trawl surveys in relation to water depth and trawl warp offset values (Appendix 8); (d) a trigonometric calculation/depiction of how much the front profile of the '36 Yankee' net would be expected to change based on 6 foot and 12 foot trawl warp offsets (Appendix 9); and (e) the construction specifications of the NEFSC standard '36 Yankee' bottom survey trawl (Appendix 10). Also contained within the booklet was a 9/30/02 email letter from Gary Loverich (Senior Engineer, Applied Fish Gear Technology, Bainbridge Island, WA) offering his comments to the Workshop on warp differential and trawl performance issues (Appendix 11). Gary had received an invitation to the Workshop but could not attend.

The Chairman then introduced Dr. Joe DeAlteris (Professor, Department of Fisheries and Aquaculture, Univ of Rhode Island, Kingston, RI) and invited him to present a review of worldwide experiences with trawl warp offsets to the Workshop. The Chairman noted that Dr. DeAlteris was exceptionally qualified to provide such a review as he has been actively involved with fisheries gear and harvesting technology research in New England for the past two decades, and was extremely familiar with regional fisheries management and conservation issues.

Dr. DeAlteris expressed his appreciation for being asked to review the state of knowledge worldwide on the effects of trawl warp offsets at the Workshop. He indicated that he would also be providing information on several related topics including: (1) factors affecting trawl survey variability; (2) bottom trawl systems and the effects of warp offsets; (3) a summary of the scientific literature on warp length offsets; and (4) the advice and experience of national and international fisheries technology researchers who had been canvassed for their views on the effects of trawl warp offsets. Dr. DeAlteris indicated that he had brought with him a scale model of a '36 Yankee' survey trawl (which was positioned on one of the walls of the Auditorium) which could be used to illustrate various offsets and net configuration effects. He noted that a copy of his PowerPoint presentation (Appendix 12) was included in the Workshop booklet, along with the cruise announcement/ report of the *R/V John N. Cobb* which had conducted a field study of differential trawl warp offsets in autumn 1971 (Appendix 13) and an excerpt of a chapter "*Effect of Difference in Warp Length on the Working of a Trawl"* from a book by V.P. Kondratev entitled *"Modeling Commercial Fishing Gear by the Method of Analog Mechanisms"* (Appendix 14).

A summary of Dr. DeAlteris' presentation to the Workshop **"Factors Affecting the Performance of a Survey Bottom Trawl"** is as follows:

> A survey bottom trawl is a funnel shaped net towed behind a research vessel, and is designed to sample demersal fish on the seabed. The survey trawl is an adaptation of a bottom trawl that is used in commercial fishing, except that the net is usually smaller than that used in a commercial application and it has a smaller mesh size or small mesh liner so as to retain smaller fish. The trawl mouth is opened horizontally by otter boards and vertically by floats on the headrope. A survey trawl is designed to collect a representative sample of the fishery resources on the seabed at a particular location. Additionally if the survey trawl is operated in a consistent manner, the results of a survey can be considered a relative index of fishery resources abundance with time.
>
> The data collected in trawl surveys is characteristically highly variable. Measurement variability is due to variability in trawl performance. Fishery resources are contagiously distributed on the seabed, resulting in spatial variability in the data. Finally, environmental variability affects both trawl performance and spatial distributions of fish. Bottom trawl performance can be measured in terms of catch efficiency (catchability) and trawl system geometry. While trawl system geometry (otter board spread, wing spread, and vertical opening of the trawl mouth) is important to monitor, it is the catch

retained in the codend that is used in the stock assessments; and therefore catch efficiency must be maintained at a constant level.

The bottom trawl system consists of the following components: towing vessel, towing warp, otter boards, ground gear and net bridles, net headrope, footrope/sweep, and webbing. The bottom trawl system can be considered to be a system of flexible lines that transfer towing force from the vessel to the webbing in the net. A feedback system also exists to balance forces that are temporarily unbalanced, adjusting warp caternaries, otter board angle of attack, and headrope and footrope/sweep caternaries. A balanced survey bottom trawl is towed using warps of equal length, so as to balance the loads on the otterboards and on the net frame.

The purpose of this report is to present the results of a literature search and canvass of outside experts on the effect of an offset in the length of a towing warp of the performance of a survey bottom trawl. It was recently discovered that one of the towing warps on the *R/V Albatross IV* was incorrectly marked. The error ranged from 0 feet at 0 meter warp length, to about 9 feet at about 900 meter warp length. This resulted is a warp offset that varied with station depth and the resulting warp length. Approximately 75% of the survey tows conducted by the R/V Albatross IV in the typical groundfish survey in the New England and Mid-Atlantic regions use warp lengths of 600 meters, or less, and therefore the offset was 6 feet or less. The survey trawl used for the New England and Mid-Atlantic groundfish survey is a Yankee 36 trawl, (60 foot headrope and 80 foot sweep), and the net is equipped with 30 foot bridles and a roller sweep so as the allow access to a wide variety of habitats.

The results of the literature search conducted by Claire Steimle at the NMFS Sandy Hook NJ Laboratory identified over 100 potential citations, however most were not relevant to the subject. Several papers addressed general questions regarding survey trawl performance, but only one section in a single book addressed the specific question of the effect of a trawl warp length offset. In a Canadian publication on Bottom Trawl Surveys (Doubleday and Rivard, 1981), several chapters considered sampling techniques, and factors that contribute to variability in the data. Several authors in the book refer to survey trawls as a "quantitative sampling tool" that must be calibrated. The authors note that measurement variability must be reduced if the precision of survey results are to be increased. Additionally, they state that it is impossible to separate variability due to fish distributions from measurement error. Two other references DeAlteris et al. (1989) and Lauth et al. (1998) considered a wide variety of factors that could affect the performance of a survey trawl. Both papers investigated catch efficiency and trawl geometry, as measures of trawl performance, and the treatments include differences in rigging, towing scope, towing speed, and even net design. Interestingly both papers conclude that while most of the treatments considered affected trawl geometry, few of the treatments affected catch efficiency. Finally, in a translation of the Russian book entitled, Modeling of Commercial Fishing Gear by Analog Mechanisms, by Kondratev (1973), the author addresses the question: "When a trawl breaks down, fishermen usually first verify the warps. Can we justify such demands on the warps, and the associated loss of fishing time to re-measure the warp?" To answer the question, model and full-scale tests were made on a 96 foot trawl. The results of the model experiments indicated that the trawl mouth geometry is only measurably affected when the difference in the warp exceeds 20% of the length of the headrope. The results of full-scale experiments on the 1RB-99 indicate that with a difference warp length up to 15 % of the headrope length, the distance between the trawl boards and the catch efficiency did not change appreciably. On the Yankee 36 trawl a warp offset of 15% of the headrope is 9 feet, and a warp offset of 20% of the headrope is 12 feet.

The canvass of outside experts initiated by Henry Milliken of the NEFSC, NMFS, and continued by me, resulted in more that 75 individuals being contacted. Most indicated no experience with the warp offset issue. Several indicated opinions based on experience with model nets. However, both Dr. Lee Alverson of NRC consultants, formerly with NMFS and Gary Loverich of Ocean Spar, formerly of NETS and NMFS had participated in fishing experiments aboard the R/V Cobb on the west coast in the 1970s. Based on that experience Dr. Alverson stated that he believed an offset up to 6 feet would have minimal impact on catch. Gary Loverich proposed that we must consider the warp offset in the context of the entire length of the ground gear and sweep. He estimated that a 6 foot warp length offset on the

Yankee 36 survey trawl was 4.4% of the total length of the ground gear and sweep, and that based on his experience including model testing, an offset up to 5.0% would not result in a catch reduction. He also noted that auto-trawl winches often result in a 1-2% offset in warp length in order to match warp tension, and that other operational factors may also result in a skewed net.

Thus, I conclude based on my review of the literature and my canvass of outside experts, that a trawl warp offset is another source of measurement error. The magnitude of the error is a function of the relative magnitude of the warp offset to the length of the headrope or ground gear and sweep. While trawl geometric performance is probably more measurably affected by a warp length offset, the effects on catch performance (efficiency or catchability) are more subtle, and more difficult to measure due to the inherent variability in catch performance. Therefore, I believe that warp length offsets up to 6 feet may affect catch performance, but the effect is minimal, and will be difficult to measure. Further, I believe that warp offsets greater than 6 feet become increasingly problematic in terms of catch efficiency, but again they may also be difficult to measure.

Literature cited:

DeAlteris, Recksiek, and others. 1989. Comparison of the performance of two bottom sampling trawls. Trans. Amer. Fish. Soc. 118:119-130.

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Kondratev. 1973. Modeling of commercial fishing gear by the method of analog mechanisms. Translated from Russian.

Lauth, Syrjala, and McEntire 1998. Effects of gear modifications on the geometric performance and catching efficiency of the west coast upper continental slope ground fish survey trawl. Marine Fisheries Review. 60: 1-26.

Summary of Discussion on: Factors Affecting the Performance of a Survey Bottom Trawl

Joe DeAlteris emphasized that there are two distinct aspects to evaluating effects of the warp offset: (1) effects on gear geometry and (2) effects on catch efficiency. Several examples from the literature show that changes in gear configuration affect gear geometry, but most treatments did not affect catch efficiency. Several participants pointed out that although effects on catch efficiency have not been demonstrated, they must exist but are difficult to see due to inherent variability in trawl performance and fish availability. Two points of view were expressed: (1) if you can't demonstrate a difference, then the effect is not a concern (2) just because you can't measure it doesn't mean it isn't real, and this simply means you need a large number of replicates to demonstrate the effect.

The point was raised that the issue at hand is evaluation of how the warp offset has affected performance of the gear relative to its standard configuration, not the overall question of the efficiency of the gear. Baseline data exist on configuration and performance measures such as bottom contact time, and can be used to help with the evaluation. Sampling gear for the new NOAA research vessel (launch expected in 5 years) will be designed with industry input.

There was extensive discussion of how warp offsets may affect other aspects of gear configuration and/or interact with gear deployment protocols (e.g. scope ratio). Concerns were raised over impacts on door offset, angle of attack and net elevation, and how these might magnify an effect of warp distortion. Relatively subtle effects may be important, *e.g.,* if a door is offset, the silt cloud raised may not meet the wing and herding fish may escape through the opening, similar to effects of a cross-current. These factors need to be considered in studies to evaluate a warp offset effect.

The issue of differential species- and size-dependent effects was discussed. Species with different behavior (e.g. bottom-hugging tendencies, tendency to be herded) will be affected differently. Smaller fish may escape under an elevated sweep more readily than larger fish of the same species. Experiments and analyses need to consider individual species as well as the aggregate catch, and evaluate effects on species size composition estimates.

Questions were raised concerning general protocols within NEFSC for monitoring gear condition and maintaining gear, and whether there have been similar problems in the past that were never discovered. NMFS personnel indicated that fishermen working on board survey ships and land-based gear experts visually inspect the gear and replace parts as they wear out. The survey vessel always carries an extra set of doors in case replacement is needed during a survey. Historical protocols for measuring warps are being documented. Concerns that one warp may become more stretched than the other due to scallop survey work where only one warp is used are being addressed by having a contractor take wire diameter and lay measurements. Measurements have been made and NMFS expects a report from the contractor on Nov. 1st. Specific protocols are being developed for checking wires; these will apply to all NOAA vessels. The source of wire is a potential source of variation, as wires of the same size may have different weight depending on whether purchased from a domestic or foreign manufacturer. Wire weight affects weight on the doors and thus door spread.

A general inaccuracy in warp alignment may be introduced by the way wire on the *R/VAlbatross* is measured using marks at 50-meter increments. When a mark is not visible, winch operators use line counters, which only read in whole meters, thus introducing more room for error. There was a request for statistics to indicate how often this type of error might occur.

Questions were raised concerning how calculations based on area swept come into the assessments because a major factor likely to be affected is the area swept by the net, especially for species that are herded. The answer was that for most species, including groundfish, areas swept calculations are not used at all. Abundance trends are inferred from relative indices (*e.g.,* mean kg/tow). The indices are not expanded to absolute estimates.

An observation was made that the fall 2002 and spring 2003 surveys may provide insight into the magnitude of the warp problem, since the warps were corrected prior to the fall 2002 survey. While this may be true, such interpretations must be tempered with recognition of the natural variability in the survey data.

An important consideration in evaluating the importance of the warp offset is the distribution of the biomass with respect to depth. If warp effects only become serious at offsets greater than about 6 ft (72 in), then only about 26% of survey stations would have been affected (*e.g.*, see Appendix 6). But if most of the biomass of a species is within those depth zones, then the overall impact on indices could be great even if only 26% of the stations are affected (*e.g.*, see Appendix 8).

Workshop, First Day, 2:00 PM - 6:00 PM, 2 October (Whitman Auditorium)

The Chairman reconvened the Workshop after lunch. He informed the participants that he just received a fax (Appendix 15) from Mr. Daniel Furlong, Executive Director, Mid-Atlantic Fishery Management Council, which indicated that the Mid-Atlantic Council has passed a motion that morning (at its meeting in Wilmington, Delaware) strongly recommending that

> *"NMFS' response to the trawl warp issue include that NMFS require the NEFSC to begin flume tank and tow tank testing of the standard 36 net to determine effects of the misaligned tow cables within 60 days. Upon completion of tank testing, analyze data and determine if research protocols have been affected."*

The fax further indicated that Trawl Warp Workshop participants should be informed of the Council's action and position on this matter, and that it was hoped that a similar request for flume/tow tank testing would be an outcome/recommendation from the Workshop.

The Chairman indicated to the Workshop that copies of the fax were available for all participants at the Workshop Registration desk.

The Chairman then continued with the next Workshop Agenda item, and introduced **Dr. Russell Brown (Chief, Ecosystem Surveys Branch, NEFSC) and invited him to present to the Workshop a summary of the objectives, design and sampling protocols used in the *R/V Albatross IV* trawl warp field experiments conducted during 25-27 September 2002.**

Dr. Brown presented the information via a PowerPoint presentation (Appendix 16). He indicated that

> In response to concerns about the potential effects of trawl warp offsets on trawl efficiency, NOAA Fisheries, in conjunction with key commercial fishery advisors conducted an exploratory cruise from September 24-27, 2002 aboard the *R/V Albatross IV*. Six commercial fishery industry advisors participated in the cruise [Bud Fernandes; Stephen Lee; Jim Lovgren; Sam Novello; Jim Odlin; and Matt Stommel] designed to collect video images and trawl mensuration information under a series of even and trawl warp offset manipulations. The cruise had two primary objectives: (1) provide initial qualitative observations of the effects of offset warps on net geometry and fishing gear performance; and (2) provide a quantitative evaluation of the effects of offset warps on net wingspread, door spread and head rope height.

The experimental approach involved evaluating the trawl with even warps, and then sequentially manipulating the trawl warps on the starboard and then the port side by letting out an additional 2, 4, 6, 12, and 18 feet of trawl warp. Simrad ITI sensors were deployed on the head rope, wing tips, and doors to quantitatively measure wing spread, door spread and head rope height. Quantitative measures of trawl geometry were recorded at 30 second intervals. An underwater video camera was mounted on either the head rope or the starboard wing and video images were transmitted through a third wire setup. Experimental tows with a head rope video camera deployment were made at depths ranging from 25, 45, 52, 60, 71 and 92-m depths, but poor visibility at the 25-m site prevented evaluation of trawl performance. In addition, one experimental tow was made with a starboard wing camera deployment for a tow with an average depth of 51-m.

Qualitative evaluations of trawl performance were made through observation of net shape and geometry, roller and footgear tending, and fish behavior. Pan and tilt capability on the video camera allowed for capture of images of the roller sweep and starboard and port wings during most warp manipulations. Representative samples of video images were compiled for presentation at the workshop.

Following his presentation, Dr. Brown introduced **Ms. Lisa Hendrickson (Population Dynamics Branch, NEFSC) and invited her to provide a synopsis of the gear performance and mensuration data obtained during the *R/V Albatross IV* trawl warp experiments**. Using a PowerPoint presentation (Appendix 17), Ms. Hendrickson related that

The effects of trawl warp length offsets on the gear performance of the R/V *Albatross* were assessed during a controlled experiment, conducted on September 25-26, 2002, at six stations ranging in depth from 46-91 m. During each tow, gear performance was assessed through videotaping and logging of gear mensuration data from Simrad sensors mounted on the doors and the trawl wing ends and headrope of the '36 Yankee' survey net. In addition, several other variables logged by the Simrad ITI system (such as speed over ground, vessel location and water depth) were evaluated.

During each tow, warp length offsets of 0 ft. (even warp lengths), 2 ft., 4 ft., 6 ft., and 12 ft. were paid out from the starboard side of the vessel, followed by the port side of the vessel. An additional offset of 18 ft. was fished at the deepest station sampled (station 907). At each station, the trawl winches were locked and the trawl was allowed to reach the bottom and stabilize before beginning the experiment. During each tow, the trawl remained in the water throughout all offset changes, and after consistent sensor readings were observed, allowed to fish for variable periods of time.

Changes in trawl geometry were evaluated graphically and statistically. Wing spread and headrope height readings from each station were graphed over time, between the winch lock and re-engage period, and each warp offset change was denoted. No headrope height readings were obtained at station 904. Door spread was not evaluated because the door sensors did not operate consistently. However, door spread is geometrically related to wing spread and wing spread data were evaluated.

In summary, graphs of headrope height and wingspread were similar across warp offset treatments (horizontal trend) and there was no indication of a change in this trend across stations (depths).

Headrope height and wingspread data, for port and starboard offsets were also evaluated statistically. At each station, the means and standard deviations of headrope height and wingspread were calculated separately, for port and starboard offsets for each warp offset time interval. Headrope height and wingspread data collected at stations 904 and 905 represent single readings, so no statistical evaluation of these data was conducted.

In summary, port and starboard wingspread means for each warp offset treatment were similar. The same was true for headrope height means. In addition, there was no significant difference detected between wingspread means for warp length offsets of 0-6 ft. at depths of 49-91 m. The same was true for headrope height means. Differences between headrope height means for even warps and warp length offsets of 12 ft. varied in significance between stations. The same was true for wingspread means. At the deepest station (91 m), there was no significant difference between headrope height means at warp length offsets from 0-18 ft. The same was true for wingspread means for the starboard side.

Summary of Discussion on: Description of Protocols Used in *Albatross IV* Trawl Warp Experiments, and Description of Sensor Data from *Albatross IV* Experiments

Concerns were expressed about whether the possible effect of warp differences was tested adequately. During experimental tows, warp offsets were changed while the net was being towed on the bottom. It was suggested that the effects might be stronger, or last longer, when an offset exists from the time the net is being set out.

Other concerns identified were whether the net was towed in a straight line behind the vessel, and whether the towing speed was the same as that used during surveys. To protect the sensors, a slower vessel speed may have been used during at least part of the experimental tows.

Questions were raised about how to interpret "blips" in the headrope height sensor data. It was unclear whether these blips represented random noise or indicated the net coming off the bottom. This could possibly be addressed by examining the video and sensor data simultaneously. It was noted that because the net is configured with lots of floats, this makes the net light and more likely to skip over obstructions. This reduces gear damage, but the net may not tend bottom as well.

Comments were made as to why the wingspread data had so many outliers, and whether the odd values could result from one of the sensors being behind the other. It was pointed out that other types of sensors exist that are capable of collecting data and produce a 3-D picture of net geometry. The group thought this 3-D imaging capability would be useful.

To better understand how to interpret the sensor data, a query was made about the logging rate and refresh rate of the Simrad sensors. It was noted that the brackets on the doors may cause interference between the sensors, and a recommendation was made to move the sensors to a better location.

Regarding the graphs which summarized the sensor data with mean values and bars to indicate variance, a question was asked about the statistical test(s) used to draw conclusions about significant differences between treatments. A comment was made that it seemed hard to know how large of a difference matters to the performance of the net. Given that none of the data were close to 0, a suggestion was offered that the graphs be changed so that the y-axis did not begin at zero. This change would allow for a better visual evaluation of the results.

Following the gear mensuration/sensor discussion, the Chairman introduced **Henry Milliken (Ecosystem Surveys Branch, NEFSC) who provided the Workshop with an overview of the videotape data collected during the field work.** Approximately 7-8 hours of video was shot during the experiments, of which 100 minutes were prepared (and viewed) at the Workshop.

As the video was being viewed at the Workshop, Henry Milliken described the footage being presented and the characteristics of the video system. He noted that

> The Northeast Fisheries Science Center's low light, wide-angle, CCD camera system was deployed on the Yankee 36 trawl net for six deployments (stations) at different depths during the experimental cruise held on September 25-27th. The camera was mounted on the headrope of the trawl and was attached to a pan-and-tilt unit that allowed the direction of the camera to be changed during the operation of the system. The system utilizes a third wire that affords the operator to view the footage in real time as the gear is being fished.
>
> Weather and wave conditions were not ideal for this type of work, yet a large percentage of the footage that was taken was clear enough to easily ascertain the performance of the gear. The footage shows the sweep, including the roller gear, and the "cookies" in the wings. In addition, the webbing of the trawl, headrope performance and the direction of both the trawl and fish into the trawl can be determined in much of the footage. At each station, port and starboard offsets were investigated as well as the net with the warps marked even. These offsets were 2, 4, 6, and 12 feet in length, and at one station, 18 feet.
>
> While screening the video, participants were asked to look at the sweep, gore line, wings, mesh, and headrope to determine if any differences could be seen between the operation of the gear with even warp lengths versus when offsets were in place. Participants commented on the performance of the gear as it was designed as well as observations of the gear when the warps were offset to either port or starboard. No interpretations of the performance of the gear were offered. This presentation was designed to show the video data and have the participants comment on what they saw.

After the Workshop had viewed the videotape for about an hour, the Chairman allowed for a brief coffee break. After the break, discussion was initiated on the videotape already viewed while the remaining portion of the video ran on the large screen and television monitoring systems.

Summary of Discussion on: Video Evaluation of Warp Offset Experiments

Several participants noted that the roller gear did not appear to be rolling when the net was deployed over smooth bottom, even when there were no warp offsets, except when the net hit some bottom obstruction. It was noted that a similar phenomenon occurred in previous video taping of the 'Yankee-36' trawl conducted about 12 years ago. A comment was made that even with commercial fishing nets, the roller gear do not roll as much as many people think (*i.e.,* they only roll when they hit something)

It was noted that some of the weather conditions experienced during the experimental work included 28 kn of wind and 8' swells. Typically, survey vessel sampling operations are suspended when winds exceed about 30 kn.

The ‘Yankee 36' trawl, as rigged, has an abrupt transition from the rollers to cookies on the sweep. This apparently creates a bend in the traveler wire that contributes to the sweep not touching bottom at this transition. This also may be a contributing cause to the lightness with which the cookie sweep touches bottom, even with no offsets.

The position of the “traveler” wire (fishing line on the footrope) relative to the sweep apparently moves around under most conditions, but nothing conclusive could be determined from the video with regards to the orientation of the traveler in relation to offsets.

The mesh size in the wings of the net is 5”. With this mesh size, gilling of animals should occur and this is generally considered one of the best indicators of a mis-shapen net in relation to the orientation of fish. While the number of tows examined was few, and fish encounters in the video were few, there did not appear to be obvious differential gilling visible in the videos.

One participant observed that when there is no offset, the gore line is an even line of tension; however, when offsets occur, the bow in the wing was reduced and there seemed to be more puckering in the lower twine.

It was suggested that by making a turn with the vessel in 6’ offset mode, the impacts on wing contact might be more pronounced and observable. There was no indication in the videos that the twine in the body of the net or the wings rolled under the sweep, but this might occur during a vessel turn.

One gear researcher summarized the situation with the trawl and offsets thusly: The cookies barely tend bottom on both sides when the warps are even. The rollers tend bottom lightly, there is loose twine in lower parts of the wings. This was similar to when the trawl was observed 12 years ago, and these conditions were indicated by computer models of trawl performance (loose webbing, etc.). When offsets occur on one side, the opposite side cookies may not be tending as well, but the short side cookies tend bottom better. Likewise, the rollers tend to fish harder on the short side. At the largest offsets, the rollers should be offset a similar amount to the warp offset if there was no compensation due to the other components of the fishing system (e.g., warp catenaries, door pressures, etc.). However, based on the videos, a direct offset of the rollers as a function of warp differential is not observed. For example, with a 12’ warp offset, there is not a proportional 12’ offset in the sweep on the side with the long warp. This is supported by the relatively constant wing spread and head rope height measurements.

It was noted that the total area swept by the trawl could be different depending on the change in the effective mouth opening and changes in bottom contact.

One participant made some rough calculations and concluded that there was an over emphasis on the amount of catenary that occurs in shallow water.

At this point in the discussion, **Dr. Pingguo He (University of New Hampshire) informed the Chairman that he had in his possession a 15-minute videotape of trawl warp offset trials that had recently been conducted on a model 'Yankee 41' trawl at the flume tank facility in Newfoundland**. The Chairman indicated that the Workshop would very much like to see this tape, and the video was subsequently viewed on the large screen in the auditorium.

Dr. He indicated that

> The preliminary test of the effect of the warp offset on trawl geometry on a Yankee 41 model was carried out by Harold Delouche, George Legge and Carl Harris of Memorial University of Newfoundland at the request of Pingguo He of the University of New Hampshire. The purpose of the test was to illustrate how longitudinal shifts of the trawl door resulting from uneven warp lengths can affect the geometry of a trawl system. The Yankee 41 model was chosen because a Yankee 36 model was not available at the Newfoundland flume tank. Geometry of the scale model was measured and video recordings were made at three warp offset lengths of 5.5', 11.3' and 17.3', and at even trawl warps. Video recordings showed varying degrees of distortion of the shape of the trawl at various warp offset values. The result of this test demonstrates the possibility of visualization of the trawl shape with changing gear rigging variations including uneven warps. The result, however, should not be used to predict the geometry of full scale Yankee 36 under discussion at this Workshop. While full credits are given to colleagues at the Memorial University for carrying out the test in a very short notice, Pingguo He will bear responsibility for interpretation or misrepresentation of the video and test results. Test conditions and results are summarized in the following table.

Trawl: Yankee 41 (1/6 scale)				
Trawl door: Perfect - PF7				
Warp in tank: 5 m, Bridles: 1.34 + 3.08 m				
Towing point Height in tank = 0.7 m, Mast spread in tank = 4.8 m				
Towing speed (full scale equivalent) = 3 knots				
Simulating 18 m water depth with 80 m warp in full scale				
FULL SCALE TRAWL GEOMETRY (FEET)				
Extra warp on port	0.0	5.5	11.3	17.3
Distance of door behind boat	255.5			
Door longitudinal shift	0.0	5.7	11.6	17.7
Upper wingend longitudinal shift	0.0	5.5	11.5	16.8
Upper wingend height - starboard	5.7	5.5	5.3	5.3
Upper wingend height - port	5.7	5.9	5.9	5.7
Upper wingend spread	39.3	39.8	40.0	39.5
Upper Wingend spread as perceived by acoustic sensors	39.3	40.2	41.6	43.0
Lower wingend spread	43.0	43.0	43.4	43.6
Headline height	8.9	8.3	7.9	7.9
Door Spread	84.2	84.4	84.7	85.3
Door spread as perceived by acoustic sensors	84.2	84.5	85.5	87.1

> This was a 1/6 scale model, with not as many cans on the headrope as the Yankee-36 trawl. The tow speed in the flume was 3.0 kn.

In the subsequent discussion, it was noted that during the video the 41-Yankee trawl maintained bottom contact in all trials, and no appreciable change occurred in wing spread or headrope configuration in any of the trials. The trawl was progressively deflected to the side with increasing offsets.

Several participants noted that the offsets observed in tow/flume tanks may over emphasize the actual situation because not all components of the trawling system (*e.g.*, warp catenaries) are included in the simulations. It was also noted that under the proper conditions the whole trawling system could be modeled if the scale of the model was small enough and the tow points and warp lengths properly scaled.

Computer modeling based on sophisticated and available software was suggested as a relatively cheap and potentially useful way to gain insight into the issues presented by offsets.

One potential experimental approach identified was to study the problem in an exaggerated sense to get a notion of what to look for when the offsets were clearly influencing trawl behavior.

Some suggestions were also made on the rigging of the ITI sensors to calculate the length of the centenary in relation to the amount of wire out were made.

One participant suggested that in the 1970s (and later) trawl mensuration studies had been made on the *R/V Albatross IV*, and these data could be compared to current readings as an indication of relative trawl performance then and now. In response to a question, NEFSC staff indicated that these comparisons were examined, and current (2002) readings were very similar to those obtained previously.

One participant noted that while there is good value in flume tank studies, computer models with good information can produce important information as well.

Another participant suggested that small flow meters could be sewn into the net to evaluate the direction and strength of flow in relation to warp offset lengths.

Discussion occurred on the impact on video observations of attempting to keep the trawl centered behind the *R/V Albatross IV* during the field experiments. During the trials, the rudder was centered and it did not appear that the skipper had to adjust the rudder to maintain the trawl behind the vessel.

One participant noted further that the effects noted in the flume studies were not always characteristic of those that occurred in the sea (*e.g.,* net distortion). However, the video can only "see" a portion of the net system at any one point. Scanning (sonar) technologies exist that can monitor the geometry of the trawl and doors and provide a picture of all components in relation to offsets.

It was noted that the relation of warp offsets to wing offsets was not as simple as indicated in the chapter of the book by Kondratev (Appendix 14). The level of distortion observed in the *R/V Albatross IV* at-sea video of the '36 Yankee' trawl was not as severe as that observed in the flume video of the '41 Yankee' trawl. The suggestion was made to apply a combination of complex tools to find the mechanical aspects of the problem.

One participant speculated that the viewing angle provided in the *Albatross IV* video (headrope mount) might change along with the distortion of the net resulting in little apparent distortion. Other participants contended, however, that this was not a significant bias.

One potential indicator of net distortion was the seam of the net from the gore to the belly. This seam and its potential distortion could be an effective and stable indicator of trawl changes in relation to offsets.

One participant concluded that the net appeared not to be crabbing to the short side because sand plumes from the rollers and wings appeared to go along the axis of the net. Additionally, squids appeared to be dropping back directly into the net, and this should be a good clue concerning water flow within the net. One observation from the video was of an 18' offset where dogfish swimming in front of the roller sweep appeared to be more prevalent on one side of the net than the other. At this large offset, this could be an indication of fish behavior although more observations would be required. Other participants were cautious of this interpretation due to potential for camera angle orientations, water flow and sand cloud dynamics.

One participant noted that the skew may or may not influence fish catch and the only real way to know is to conduct field experiments of relative fish catch in relation to offsets.

The issue of warp tension on the doors in relation to the offsets was discussed in detail. Warp tension could be a useful way to monitor trawl performance and to see if problems exist due to short warps. If tension measurements are available for the *R/VAlbatross IV*, it was suggested they be examined. In tank studies, it was noted that the doors do not drop. One additional tank experiment might be to change the angle of attack of the doors.

One participant noted that given the offset problem during the past two years now might be the time to change survey protocols anyway. Others noted the value of the long time series, and the fact that observations beginning in fall 2002 would be compatible with the time series irrespective of the potential effects of the offset problem on fish catches during the eight surveys conducted between winter 2000 and spring 2002.

Considerable discussion centered on the contention that the rollers lost bottom contact at larger offsets. Some participants in the *R/V Albatross IV* cruise contended that they could see this phenomenon, while others did not. The videos presented at the workshop did not provide a clear indication of this. One participant observed that the resolution of projected video may not be sufficient to discern this phenomenon.

One participant observed that the center line of the sweep (rollers) did not appear to be shifted with the offset warps, but the doors and their behavior could not be observed by the camera.

One participant summarized that Workshop participants were getting subjective interpretations of sweep offsets and bottom contact of various parts of the net under varying conditions of offsets. In the final analysis, the issue is fish catch efficiency and how many tows must be experimentally conducted to detect real differences in catch per tow (and fish size composition) due to offsets.

One experienced captain noted that with 6' warp offsets fish catch declines and the doors drop. It was agreed by the participants in the *R/V Albatross IV* cruise that there was no indication of door drop during any of the experiments conducted.

One participant noted that the potential effect on catch rates would be the loss of larger fish, not necessarily a reduction in overall fish catch.

Numerous participants concluded that a designed field trial would be necessary to answer questions regarding effects of warp offsets on fish catch since, as noted in the Loverich email letter (Appendix 11), even a distorted net can catch fish efficiently.

Workshop, Second Day, 9:00 AM - 12:45 PM, 3 October (Lillie Auditorium)

The Chairman reconvened the Workshop and expressed his appreciation to everyone for adjusting to the unexpected change in venue (*i.e.,* the Lillie Auditorium instead of the Candle House which was unavailable for such a large group of participants). The Chairman indicated that he was encouraged by the candid discussions and cooperative spirit that had earmarked the first day of the Workshop and hoped that open communication and commonality of purpose would occur throughout the second day of the Workshop as well.

The Chairman welcomed all new attendees to the Workshop and again requested that anyone that had not signed-in at the Registration desk to please do so at their earliest convenience.

The Chairman then introduced Dr. John Boreman (Acting Science and Research Director, NEFSC).

Dr. Boreman extended his greetings to the Workshop participants and welcomed them to Woods Hole. He had been unable to attend the 1st day of the Workshop yesterday as he had been at the Mid-Atlantic Fishery Management Council briefing the Council on the status of the trawl warp situation. He was encouraged to learn that the Workshop deliberations had been positive and constructive, and looked forward to participating in similar interactions today.

Dr. Boreman then replied to a number of questions concerning what activities and actions the NEFSC and the National Marine Fisheries Service were doing to address various issues related to the trawl warp problem. The Chairman thanked Dr. Boreman for his frank responses and for his continued support of the Workshop.

The Chairman then informed the Workshop that he had asked if a presentation could be made by Mr. Matt Stommel on behalf of the six industry members who were aboard the *R/V Albatross IV* during the trawl warp experiment to provide their collective at-sea observations on the trawl warp issue and related matters to the Workshop. The Chairman indicated that this was certainly appropriate and probably should have been scheduled as part of the Workshop Agenda. **He then invited Mr. Stommel (together with Mr. Bud Fernandes) to address the Workshop and detail the observations and findings of the industry participants involved in the trawl warp experiment.**

In his presentation Mr. Stommel indicated

(1) It was the opinion of fishermen that the following observations could be made of the trawl at various warp offsets:

a. 2 ft: Discernable difference in trawl geometry, catchability may not be affected but certainly possible.

b. 4 ft.: Significant distortion of trawl, slack bunt starting to lift off bottom, catchability definitely affected.

c, 6 ft.: Larger distortion of trawl, slack bunt lifting regularly, efficiency of trawl dramatically reduced.

d. 12 ft.: Distortion very bad, efficiency very low.

(2) There were times during trawling operations when winch operators had no visible marks on trawl wires and had to rely on line counters. Because the line counters read only in whole meters it would be possible to mistakenly put trawl wires into offset positions of up to 1 meter. So, while generally, trawl wire mark problems were thought not to occur in shallow water more severe distortions could happen due to the line counters.

(3) We thought the trawl to be abnormally light. Door to door distance of hardware including backstraps, legs, and sweep was established at 152 ft. We thought that maximum bottom contact throughout this distance was on1y 10 ft., just on the 19 rollers in the middle of the sweep. There was no shine observed on the legs or hardware where shine would normally be found. Because the trawl is so light we thought it to be unusually prone to distortion caused by wire offsets. The lightness of the trawl raised a host of other issues including its inability to catch various species, size selectivity, etc. The point was raised that the trawl may be so inefficient that it cannot supply large enough samples to make accurate measurements.

(4) Concern was raised by the observation of the net leaving the bottom during moderate weather conditions. We then asked if the NEFSC could review trawl logs to determine the incidence of rough weather and apply it to trawl survey results.

(5) Upon boarding the Albatross, the fishermen immediately noticed that the shine on the trawl doors was different. During video observations, we thought that the camera always tended to the port side of the net when the trawl wires were even. This led the fishermen to believe that the starboard door was not working correctly. We were concerned, that despite NEFSC being aware of door problems, the autumn trawl survey was resumed with the suspect doors.

(6) Trawl tow speed was also brought up. We thought that tow speeds were too high for the net, especially one in this light condition. The fishermen suspect that bias has been introduced into the survey, throughout its history, due to improvements in navigational equipment.

(7) At the beginning of the cruise, the fishermen observed a snarl in the net as it was being set, i.e. the cans on one wing dipped through the footrope and sweep. They waited until they were absolutely certain that the ship's crew had missed it and that the doors were about to be set before bringing it to the crew's attention. This incident was followed by an inspection of the cans that showed strong evidence that this snarl had gone unnoticed many times. A snarl of this type will lead to a collapse of the net. The fishermen felt that the lack of gear handling protocols and inspections led to sloppy procedures. It should be noted that the design of the stern of the Albatross makes it difficult for the crew to see problems with the net at night.

(8) Measurements of wing spread, door spread, and headrope height were taken throughout the cruise. These measurements indicated little changes in point to point distances. Headrope height measurements stayed relatively constant as well. Questions were raised about the effect the camera and its rigging and cable would have on the headrope. We felt that the headrope may have been held in an artificial position by the camera equipment. The wing and door measurements only show point to point distances and are not indicative of true geometry. We felt these measurements were misleading when referenced to the obvious distortions seen in the net, in offset positions.

(9) Fishermen were concerned that a major change had been made in the way the footrope and traveler were lashed together. Up to approximately 2 years ago the hanging line had been lashed to the traveler with twine. Apparently, the crew of the ship had difficulty in maintaining the lashings and rather than try a different manner of lashing decided to lash the hanging line directly to the drop chains off the sweep. This change leaves the traveler loose in the drop chain rings and negates its intended use. What difference this change makes to the efficiency of the net is very hard to say. This change probably has an effect on catchability. It could also have an effect on the net's ability to get over rough ground. This is a major change to the design and rigging of the net and should have been well calibrated before it was implemented.

(10) We felt that the survey has so many problems that identifying the effect of a single problem, such as wire offsets, through a review of the data would be impossible. We believe that the validity of the data is seriously compromised. We felt that though the survey may be adequate in looking at long term trends it did not meet the demands of the current law. We felt that the survey problems should be dealt with immediately and that an industry survey should be designed and implemented right away. We felt that industry surveys should be permanently instituted to supplement or replace NMFS surveys. The fishermen felt that if sensitivity analyses were done to estimate the effects of the described flaws on stock assessments, then those analyses should range up to 1000%.

(11) After the presentation of the fishermen's observations and the attendant discussion, scientists from NEFSC proposed that a calibration study be done. This study would be accomplished by using 2 comparable vessels towing distorted nets and optimum nets. A lot of discussion was devoted to what tests would be representative of concerns raised by the fishermen. The thinking was that an upper limit could be established to the effect of flaws on the survey. Some fishermen felt this was an appropriate plan. Others had strong doubts that this study could come close to calibrating the problems raised by the industry. It was pointed out, that of the eight major problems identified, only two would be addressed by a calibration study. NEFSC scientists tried to demonstrate that some of the problems might be within what was described as a "range of variability." The fishermen felt that the range of variability was large enough to be a big problem in itself and that individual flaws should not be set aside in any study. Because of the time constraints and NEFSC oversight of the study, many were uncomfortable with the idea.

Summary of Discussion of: Fishermen's Observations During *Albatross IV* Experiments

A participant asked if Mr. Stommel could see the net collapsing in the video. Mr. Stommel explained that this was not visible in the video but would occur if a can is snarled in the footrope.

Mr. Stommel was asked if he knew how many nets the cans had been used on. He replied that the wear he observed on the cans was evidence that the cans were ridding on the bottom. He was questioned if this could have been caused by wear as the net is dragged across the deck. Matt explained that this was due to improper setting of the gear.

Another participant asked why hanging the net to the rings would affect the performance of the trawl as compared to hanging the footrope directly to the traveler. Matt explained that he did not know what effect this change would have but that it would affect the performance of the trawl.

Regarding the hanging of the footrope, it was indicated that this change had been reviewed before it was implemented and was not believed to be a serious issue.

A participant mentioned that if the net is 1/10th as efficient as it should be, it would be easy to detect this difference in a comparison study. Matt explained that if all the problems were lumped together, it would be hard to tell what effects have resulted in underestimating the catch.

Another industry member aboard the *R/V Albatross IV* stated that with the footrope hung to the rings, the frame gets lifted and bring the wings off the bottom. An additional participant who had previously sailed on the *R/VAlbatross IV* expressed his belief that all these factors may be greatly influencing the performance of the gear. This participant stated that the survey had tracked the decline and increase of the fish populations over time, but recently there has been neglect in the survey and the net is now an antique. The system has many errors and the time to change the net is now. The day of the best available scientific data should be replaced by the best scientific data attainable.

Concern was raised about an industry survey that was conducted alongside the *R/V Albatross IV* using different and larger gear. The catches were described as not being similar. It was explained that the catches should not be expected to be similar because the vessels used different gear. Although one participant explained that the catches were not similar, he felt that they were not representative. Reference was made to the cooperative monkfish survey that was conducted in 2001 and how this survey was able to add precision to the NMFS survey.

The side by side work with industry vessels was said by one individual to have been halted by NMFS, although NEFSC staff indicated that this was not the case.

A participant stated that the survey gear is highly variable and the survey catches are so low that the data are not representative. Any comparisons that attempt to adjust the survey data will have a problem because catches of zero are still zero, and hence cannot be properly adjusted. A concern was raised that true sensitivity analyses may not show true differences, which is a concern of the fishing industry.

A participant suggested that a possible solution would be to take the survey gear and put it in the best possible shape and compare it with the present gear. This individual indicated he would be willing to live with the 'Yankee 36' trawl if it was put back in the same shape as it was 25 years ago. However, another participant asked what an overhauled net should be compared with in calibrating the time series.

A concern was raised about the doors and the industry participants aboard the *R/V Albatross IV* were asked if the backstraps were measured and if the door brackets were measured. It was stated that no difference was found in the rigging between all four doors on the vessel. A participant noted that commercial fishermen occasionally find that even a new door may not fish well and that some new doors are discarded because of this.

Another participant asked the fishermen who were aboard the two-day *R/V Albatross IV* survey to comment on what they observed at sea on the video. One of the fishermen mentioned that the footrope rolled on top of the sweep and that the sweep dug in on the short side and was lighter on the long side. Another industry participant commented on bunching of the mesh in the wing-ends when the offset occurred. This should have resulted in a reduced headrope height.

There was support from several participants for the idea of testing an overhauled net with a 'typical' net used in recent NMFS surveys. In response to the concern that the nets should be redesigned to the NMFS specifications, it was explained that these nets are already designed to NMFS specifications.

A question was raised as to the speed at which the survey gear is fished and how this speed was determined in the past. A participant who formerly served as Captain of the *R/V Albatross IV*, explained that when he was skipper a North Star 6000 system was used and prior to this, speed was determined using Doppler speed through the water.

A participant wanted to know when the Fishery Management Councils and the public will be told that the confidence intervals for the survey catch data are large. It was explained that such measures of precision are already contained in public documents submitted to the Councils. A concern was expressed that the Councils have not sufficiently addressed the issue of the data adequacy.

There was further discussion of testing overhauled survey gear with 'typical' survey gear, and that such a test should be accomplished in areas where catch rates are high.

With respect to testing the effects of trawl warp offsets on fish catches, it was felt that large differences would be easy to detect, while smaller differences would require more tows. One participant suggested that the offset that should be tested should be the extreme (18') to determine if a difference in catches could be detected. It was stated that the study could take place in closed areas. Some other participants considered that it would be impossible to detect differences in the catch rates for different species and that a trawl warp study could be a waste of time. Another participant explained that the design of the test is critical and that there are examples of successfully implementing these types of study projects.

A concern was raised that the video camera attached to the trawl might have acted as a kite lifting the headrope. In response, mention was made that the readings from the ITI sensors showed headrope measurements similar to those obtained without the camera system.

A concern was expressed about the trawl warp offset in very deep waters and it was explained that data from very deep tows (> 366 meters) are not used as part of the assessments; these tows are used principally to determine biodiversity and range.

Another participant indicated that the survey had no catch of large codfish and hence the survey gear has serious problems that need to be fixed.

Summary of Discussion on: Trawl Survey Issues

Following a coffee break, a larger discussion of survey trawl issues ensued in relation to the goals of the Workshop.

One participant encouraged all parties to work together, and that it was the combination of fishermen and scientists that were needed to solve problems not limited to the warp issues.

The relative importance of different approaches to study the warp issue (*e.g.,* flume tank experiments, paired towing, sensors in nets, etc.) was discussed. One person suggested that, ultimately, it will be in the codend where the tale will be told (*i.e.,* through field experiments).

Several participants noted that the ship resources available in the short term were limited and that commercial vessels might be used for experiments.

One participant suggested that if resources are limited, we should give up on the 40-year time series and wipe the slate clean. However, in response, another participant noted the importance of preserving the time series and improving its precision. There are 'big picture' issues that relate to long-term changes in populations that are well documented by the surveys.

One participant noted that if nothing quantitative can be concluded about the effects of warps on fish catch rates, that at least limits should be evaluated on how warp offsets impact assessments. He further suggested forming a committee to look at long-term issues for new sampling systems, and supported using commercial vessels in calibrations.

One workshop participant indicated that while the Workshop was organized to address the trawl warp offset issue, larger issues needed to be discussed. The current survey nets worked in their time and day, but there is a need to create a new net or nets (two sweeps), and to standardize the format with assistance from the industry. He stated that 40 years of data (*e.g.,* using the current gear) are relevant, and, like an almanac, provide historical pictures and perspectives. This is the time for beginning a new era, and we should use some ideas from the way surveys are conducted in the Pacific. We need to complement/augment NMFS by lending a hand in the surveys, not by throwing anything away.

One participant noted that trawl warp differential problems and issues relating to the hanging of the webbing could be subjected to experiments. However, it is impossible to know with precision how accurate warp measurements were in the past (*e.g.,* there may always have been some variability).

A general convergence between the current studies and the need to adhere to standard protocols (as advocated by the head of NOAA) was noted. The most pressing needs were to evaluate standards and how much tolerance in these standards is practical and allowable without compromising the sampling system. Protocols need to be reviewed and updated, as necessary.

One participant supported a "package deal" to include experiments regarding warps, and 'standard' vs. 'altered' net configurations. However, he wondered where to draw the line between subjective standards and ones that actually influence the trawl catches.

One participant wondered if re-writing protocols was sufficient, "why re-write protocols for an antique gear"?

Several participants focused on what should be addressed immediately, in the medium term and in the long term. Some individuals suggested narrowing the scope of short-term studies to those issues necessary in the assessment process.

A question was raised again on how many paired tows it would take to be able to detect a statistically significant difference between tows made with properly measured warps versus offset warps.

To address this matter, **the Chairman called upon Dr. Michael Fogarty (who had been investigating this issue recently as a research problem) to give a short presentation to the Workshop.**

Using a PowerPoint presentation (Appendix 18), Dr. Fogarty discussed various design and sample size requirements for trawl warp experiments conducted at sea. He indicated that:

> To address issues related to determining the potential effect on catch of discrepancies in trawl warp measurements, design and sample size requirements were examined using information derived from previous fishing power experiments conducted by the Northeast Fisheries Science Center. A paired tow design has been extensively used in fishing power experiments designed to derive calibration coefficients for the effects of vessels or gear type and is considered the most efficient design for trawl warp offset experiments.
>
> To determine the likely sample size requirements for such an experiment, it is necessary to decide on:
>
> (1) **The magnitude of the effect we wish to detect.** The larger the expected effect, the smaller the sample size required. We were particularly interested in the sample size required to detect 25% and 50% declines in catch when trawl warps were offset in comparison to catch rates with aligned warps. Larger magnitude declines would require fewer samples.

(2) **The level of statistical significance to be employed**. In this experiment, we wish to have no more than a 5% chance of coming to a wrong conclusion concerning the effect of the trawl offset. Sample size requirements would be less if we were willing to accept a 10% chance of coming to a wrong conclusion.

(3) **The probability of being able to detect a statistically significant result**. In planning for this experiment, we wish to have at least a 90% chance of being able to detect a statistically significant result where we will have no more than a 5% chance of coming to the wrong conclusion. Sample size requirements would be lower if we were to accept a smaller probability of being able to detect a statistically significant result.

(4) **The level of variability expected in the experiment**. We need advance estimates of how variable we expect the observations on the difference between catches with aligned and unaligned trawl warps to be. The higher the expected variability, the higher the sample size requirement.

To address the last issue, we examined the results of paired comparisons between the *R/V Delaware II* and the *R/V Albatross IV* conducted in the spring of 2002 on Georges Bank and the Gulf of Maine. In this experiment, the trawl warp measurement problem on *Albatross IV* was present but had not been identified and quantified. A total of 133 paired tows were completed in this experiment. We focused on the sample size requirements to detect an effect of trawl warp offsets on cod to illustrate this procedure. Cod were caught in 78 of the paired tows in this experiment. Levels of variability for cod were higher than for most other major groundfish species and therefore should require higher sample sizes.

For cod, we estimate that 62 paired tows would be required to have a 90% probability of detecting a statistically significant result (with a 5% chance of coming to the wrong conclusion) for a 50% decline in catch with offset trawl warps. We estimate that 240 paired tows would be required to detect a 25% decline of cod under the same conditions.

We expect that these estimates give upper bounds to the sample size requirements. The estimates of expected levels of variability to be encountered include the effects of trawl warp offset and the effects of differences in fishing power between *Albatross IV* and *Delaware II.* An experiment in which aligned and unaligned warps are tested on *Albatross IV* alone may result in lower variability and therefore require fewer samples. Explicit controls on the degree of warp offset may also result in lower variability.

Summary of Discussion on: Design and Sample Size Considerations for Trawl Warp Experiments

In response to a question, Dr. Fogarty speculated that only about 10 paired tows would be required to see a 1000% difference in catch rates between warp configurations.

One participant questioned how the depth effect of the warps could be incorporated in experiments, while another participant noted that there are likely differences in the effects of warp offsets by species.

One participant posited that if two identical commercial vessels were used in the comparative fishing trials, that this would be a good experiment. However, an NEFSC staff member noted that it was important to have the *Albatross IV* and *Delaware II* involved in these experiments since it is the times series from these vessels that may require calibration for the warp offset issue.

One participant suggested that twin trawling could be an efficient method for conducting such experiments. However, a gear researcher with experience related that there is significant difficulty in conducting warp offset experiments using twin trawls.

It was suggested that sensitivity analyses from stock assessments (*e.g.*, how sensitive the assessment results are to the field study results) could put us in the ballpark regarding how precise a correction factor is required for the potential warp offset catch differences. For example, if there is a 50% difference due to warp offset, how much would the quota change?

One researcher stated that an effective strategy for studying warp effects was to conduct the field experiments, acquire the data, and then fine tune the protocols so that enough samples (*e.g.,* tows) are taken to detect differences if they are real. Others participants related that knowing the types of differences that we are trying to evaluate (*e.g.,* their magnitude) is important in designing appropriate experiments (*e.g.,* 50% order of magnitude, etc.).

Several participants discussed the relative merits of using NMFS vessels and the role of industry vessels in experimentation. One participant noted the importance of seasonality when doing any vessel experiments.

Given the various ideas and suggestions offered by the Workshop participants concerning the design and logistics for the trawl warp field experiments, the Chairman proposed that an *ad hoc* group of interested Workshop participants meet over lunch with Dr. Gabriel and develop a strawman proposal for research options. The Chairman charged the rest of the Workshop participants with crafting consensus points for the final discussion, and with formulating additional points related to the research plan.

Workshop, Second Day, 2:30 PM - 6:00PM, 3 October (Lillie Auditorium)

Summary of Discussion on: **Trawl Survey Issues and Development of Workshop Consensus Statements**

Considerable discussion ensued regarding the magnitude of changes in fish catches (in relation to gear performance) that would have to occur in order in order to detect such changes experimentally. One approach recommended by a participant was to evaluate gear changes through an adaptive strategy. If, after a few days it was obvious that the changes were large, then there would be no need to pursue the matter further. Alternatively, if the effects were small, additional gear testing would continue.

The issue of warp offsets was expanded to a discussion of other potential issues related to the survey. One participant suggested that the current maintenance of the net with regard to its design specifications was not as rigorous as in the past. If so, an experiment could be conducted using the 'historical' net (e.g. tuned to specification standards) vs. an 'off the shelf' net from NMFS' warehouse. Testing the 'standard off the shelf vs. the 'historical' net would allow evaluation of the largest possible differences due to drift against the standards.

One participant suggested that these experiments could be conducted aboard two identical vessels (*e.g.,* with same wire size, etc.). Each boat would carry two complete sets of gear (*i.e.,* four nets and four sets of doors).

The location of such gear experiments was suggested as Closed Area I on Georges Bank as reasonable mix of flatfish and cod occur in this area. Sets of established protocols would need to be developed before the field work as the outcome of such experiments (and their applicability) critically depend upon the experimental design.

It was suggested that the first goal of the experiments should be to quantify if catch differences actually occur *(e.g.*, due to the warp offsets, nets, etc.). If differences do exist, the next priority would be to estimate correction coefficients.

It was noted that during a two-week experiment, there would be only enough ship time to place an upper bound on the scale of the problem (the lower bound is generally agreed to be zero), but more time and experimentation would probably be necessary to understand the matter fully.

One individual suggested that cameras NOT be used in catch comparison experiments since the effect of the cameras themselves on gear performance is not known. Another participant detailed the mounting specifications for the cameras and suggested the cameras had little potential for influencing net geometry.

It was suggested that at least one non-herding species be targeted for some experimental work. Similarly, it was noted that even though a few species could be the principal focus of the field experiments, information should be still collected on a number of other species captured, and indicator species may be a useful approach in this regard.

One participant asked about the time frame for the development of new net systems for the surveys, and suggested that it would only require about two weeks to develop such designs. Other participants indicated it would take considerably longer to test, refine and implement a new fish catching system to accommodate the needs of the next 40 years.

An additional operational factor suggested for testing in the field experiments was the speed of the vessel. Current speed is about 3.8 kn. There was much speculation regarding speeds used in the survey in the past; there was little agreement - other than noting that technology has markedly improved in recent years to measure vessel speed through the water and over ground.

One participant suggested that the set-out speed, scope (ratio of wire out to depth), and bottom contact time were important variables to consider in the field experiments. NEFSC staff noted that the same scope ratios had been used over time in the survey, and that inclinometer data indicate an actual bottom contact of 31-33 minutes during a standard 30 minute tow.

One participant noted that it was important that the field experiments be designed to test 'apples vs. apples', rather than 'apples vs. oranges'. It was important to understand what we need to know about gear performance at the moment (*e.g.,* short-term issues). The larger issue is to develop a sampling gear that catches fish more consistently, and then to determine how much of the apple is still missing.

One participant noted that the experiments considered so far did not address general 'sloppiness' of procedures, the speed issue, or the issues related to doors, However, he said these issues should be addressed under 'standard gear handling practices'.

Another participant noted that we needed a meeting of the minds to address details of experimental design for both short-term and long-term issues. Yet another participant noted that we should try to stop time, and use four fishing vessels and two government vessels to understand these problems.

In response, a NMFS participant noted that we needed a commitment to use the guidance from the Workshop and move forward. He stated, referring to the survey bottom trawl gear, "There's an old saying - if it ain't broke, don't fix it. Well, folks, it's broke and we need to fix it". Further, he noted that there was an immediate need to evaluate the warp issue for possible effects on abundance indices. The *ad hoc* group working on experimental protocols during the lunch break was a good start. The participant noted that the demand for both data and precision in recent years had outstripped the original design of the survey. He said that we should start now to develop new gear and survey designs to give us the tools to understand the ecosystem, and to give industry more confidence in our ability to take representative samples in the future.

One participant noted that the issues are complicated by the current litigation, and that the judge should be notified of these issues.

In summarizing the current situation, one participant noted that we have to go with the best information, even if that information potentially underestimates the relative size of the current stock. He further noted that if experimental results indicated that the survey missed fish, then quotas would increase (in the case where gear efficiency is lower due to the warp effect). Thus, there is little, if any, downside for the industry of short-term experimentation. He further noted that ignoring the trawl survey and starting from scratch was not taking account of reality since the trawl survey had proven its worth over time.

One participant suggested that an advisory panel of expert fishermen be formed to meet periodically and provide their observations for incorporation into the system. Another participant noted that other science matters can be discussed in joint meetings with fishermen and it was important to get such information on the table.

One participant indicated that most fishermen are now observing large increases in fish abundance (except for a few species). As such, it should not be problematic to take a 'year off' from the proposed management regulatory schedule to study the issues deliberated at the Workshop, as the threats to the resources of such a delay would be minimal.

Workshop Consensus Statements

During the last several hours of the Workshop, participants worked diligently to craft consensus statements regarding the trawl warp offset and related issues discussed during the Workshop. Various suggestions were offered, refined, and perfected on specific language to include in the consensus conclusions of the Workshop. After extensive constructive deliberations, the Workshop came to consensus agreement on the following Findings and Recommendations of the Workshop.

Findings and Recommendations of the Workshop

The trawl warp offset has had an effect on the survey trawl performance; however, at this time the workshop cannot determine the magnitude or scale of that effect.

The existing survey gear has a number of design and operational problems. There is an immediate need to calibrate survey trawls for the identified problems and to update protocols.

Further, to meet the needs of management (more precise estimates of fishing mortality and stock size) and to improve understanding of ecosystem functioning, more precise sampling systems (including research vessel and industry based surveys) are required to be deployed over a wider range of habitats. There is an immediate need for NOAA Fisheries, in conjunction with stakeholder groups, to develop and implement these new systems. This is a high priority and should be implemented as soon as possible.

The new survey design should be calibrated with the current design to ensure compatibility/comparability with that time series.

Fishers and other stakeholders should be integrally involved in the planning and implementation of future research surveys.

A working group that reflects the diversity of the fishing industry and other stakeholders should be established immediately to assist in the implementation of these recommendations.

Completion of the Workshop and Concluding Remarks

The Chairman noted that the 'Findings and Recommendations of the Workshop' would be placed on the NEFSC Trawl Warp Website during the next day. He also indicated that paper copies of the 'Findings and Recommendations' would be available for participants to take with them at the
end of the meeting. He noted that the Rapporteur's summaries of the various discussion sessions would be emailed to participants within the next few days for review and comment. After the comments were received, the Report of the Workshop would be prepared. Once it was finalized, the Workshop Report would be placed on the Trawl Warp Website for public dissemination.

In closing, the Chairman thanked all of the Workshop participants for their cooperation, assistance, and collaborative efforts during the meeting. He also expressed his appreciation to all of the presenters, rapporteurs, crew/participants involved in the *R/V Albatross IV* cruise, and technical and administrative support staff for their many contributions in ensuring the success of the Workshop. He hoped that the communications and cooperative interactions that materialized at the Workshop between scientists, fishermen and other stakeholders would grow stronger in the future to the benefit of everyone.

The work of the Chairman was then acknowledged by the participants.

The Chairman wished everyone a safe trip home and adjourned the Workshop.

APPENDIX 1. Workshop Agenda

Workshop
Trawl Warp Effects on Fishing Gear Performance

October 2-3, 2002, Whitman Auditorium, Marine Biological Laboratory
Woods Hole, Massachusetts

Objectives: (1) evaluate world-wide experience and expertise in the issue of trawl warp length offsets and their effects on trawl performance, (2) review the results of experimental manipulation of trawl warp lengths conducted aboard the NOAA R/V *Albatross IV* during 25-27 September, (3) based on the above, consider the likely impacts of trawl warp offsets as measured on *Albatross IV* in terms of trawl geometry and consider the implications for survey catches, (4) develop appropriate research plans for further evaluation of the issue, if deemed necessary, and (5) provide a written consensus report regarding trawl warp offset issues.

Chair: Dr. Fredric Serchuk, Chief, Resource Evaluation and Assessment Division, National Marine Fisheries Service, Woods Hole

Agenda

First Day (Whitman Auditorium)

0800-0900 Full-Scale Display of Yankee-36 Trawl (outside venue near the Auditorium)

0900 Welcome, background, and ground rules for consensus building – Dr. Wendy Gabriel, Chief, Fisheries and Ecosystem Monitoring and Analysis Division, NEFSC, Woods Hole

0915 Introduction of Participants and brief descriptions of expertise– All

0930 Description of Workshop Terms of Reference, intended products, schedule, questions regarding workshop scope – Dr. Fredric Serchuk

1000 Background Discussion Presentation – Worldwide Experiences in Trawl Warp Offsets – Dr. Joe DeAlteris (URI)

-Coffee on the fly

1100-1200 Discussion of general conclusions of previous work

1200-1300 Lunch

1300 Description of Protocols used in *Albatross IV* Trawl Warp Experiments – Dr. Russell Brown, NEFSC

APPENDIX 1 (CONTINUED).

1330-1345 Description of sensor data from *Albatross IV* Experiments and keys to reading handouts – Ms. Lisa Hendrickson, NEFSC

1345-1530 Video evaluation of warp offset experiments – Discussion led by Mr. Henry Milliken, NEFSC

1530-1700 Group discussion on significance of results and preliminary evaluation – Dr. Fredric Serchuk, NEFSC

Second Day (Candle House)

0830-0845 Comments and Observations – Dr. John Boreman, Acting Science and Research Director, NEFSC

0845-1200 Continuation of discussion from previous day and drafting of consensus statements on observations

-Coffee on the fly

1200-1300 lunch

1300-1700 Continue work on consensus regarding results and development of report When completed, develop specifications for additional experimentation and analysis, as deemed necessary by the group

Rapporteurs:

- Dr. Anne Richards
- Dr. James Weinberg
- Dr. Steve Murawski

Behaviors to Benefit the Group

Be a good Listener

Ask for clarification about why people think or feel as they do. Never interrupt. Ask questions to clarify why the issue exists and what the goals are.

Be solution Centered

Don't just criticize; provide solutions and ideas for solving problems.

Be open to outcome

Don't come with "THE PLAN" come with "an idea". Then see where the group expands it and be open to the change. Don't own ideas; give them away to the group. Don't set limits.

Look equally at all sides

Look fairly and equally at all the pros and cons of all ideas. Ask the group for a listing of both pros and cons. When it's your idea, ask the group to list both the pros and cons.

Be concise

Think out what you are going to say before you say it and then be brief. Don't ramble; don't repeat what others have said. If you think the same as someone else who has already spoken, then simply say, "I agree with ___".

Be Patient

Ask if group members need more time. Others may need more time to understand, or need more information.

Take a dose of humility

Just because you think you have the answer does not mean it's the best answer for everyone, or that what meets your needs meets the needs of others. Ask questions to ensure the answer meets the needs of as many as needed. Be willing to examine your own prejudices and values and not apply them to others, or expect that others have the same values as you.

Take ownership of your feelings

If you feel unhappy, or uncomfortable say so and try to pinpoint why. Also don't forget to say you are happy or grateful as well.

Take a long term view

Many decisions and proposals are learning experiences for things you have not yet done. If it does not work, you can change it later. Try things out. Experiment. Suggest trying new ideas or processes for a certain time period.

Learn when to let go

Don't get hung up on small details, let the decision go forward and then examine it later to see if your misgivings were justified or not. Be willing to let the group go ahead so they can learn, even it means the group might make a mistake or two.

Use I statements to define your needs

When you have things you want or need, tell the group what they are by using I statements such as "I need covered parking because I have an old car that leaks".

Give the reasons behind your thinking

Whenever you state an opinion, you can add valuable information by giving others the reasons for your opinion. Be open to questions and comments about your opinions.

Clean up your messes

When you say the wrong thing, or act in a way that hurts, angers or alienates others, talk later to discuss what happened and why, with those affected.

Do your homework

Don't wait until the meeting to get or give information. Call people, hold small gatherings, etc. Read everything you are given closely and think about it before the meeting.

APPENDIX 3. **Trawl Warp Workshop Participants**

Trawl Warp Workshop Participants

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APPENDIX 3 (CONTINUED).

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APPENDIX 4. PowerPoint Presentation given by Wendy Gabriel

Workshop on Trawl Warp Effects on Fishing Gear Performance

2-3 October 2002
Woods Hole, Ma

Product and Process

- Immediate product: Trawl warp review
- Long-term product: Establish a track record we can use for future interactions
  - Benefits of cooperative research are substantial: best new gear for new research vessel, turn gear research into reasonable gear regulations to allow fisheries to continue

---

Successful Groundrules for New Groups

Developed and "field-tested" in Take Reduction Team meetings between fishing industry, environmental groups and federal scientists and managers

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Be a good listener

- Ask for clarification about why people think or feel as they do.
- Never interrupt.
- Ask questions to clarify why the issue exists and what the goals are.

Be solution-centered

- Don't just criticize.
- Provide solutions and ideas for solving problems.

Be open to the outcome

- Don't come with "THE PLAN" – come with "an idea."
- Then see where the group expands it and be open to the change.
- Don't own ideas – give them away to the group.
- Don't set limits.

APPENDIX 4 (CONTINUED).

Look equally at all sides

- Look fairly and equally at all the pros and cons of all ideas.
- Ask the group for a listing of both pros and cons.
- When it's your idea, ask the group to list both the pros and cons.

Be concise

- Think out what you are going to say before you say it, and then be brief.
- Don't ramble.
- Don't repeat what others have said. If you think the same as someone else who has already spoken, then simply say "I agree with _____."

Be patient

- Ask if group members need more time.
- Others may need more time to understand, or need more information.

Take a dose of humility

- Just because you have the answer does not mean it's the best answer for everyone, or that what meets your needs meets the needs of others.
- Ask questions to ensure the answer meets the needs of as many as needed.
- Be willing to examine your own prejudices and values and not apply them to others, or expect that others have the same values as you.

Take ownership of your feelings

- If you feel unhappy, or uncomfortable say so, and try to pinpoint why.
- Also, don't forget to say you are happy or grateful as well.

Take a long-term view

- Many decisions and proposals are learning experiences for things you have not yet done.
- If it does not work, you can change it later.
- Try things out. Experiment.
- Suggest trying new ideas or processes for a certain time period.

APPENDIX 4 (CONTINUED).

Learn when to let go

- Don't get hung up on small details, let the decision go forward and then examine it later to see if your misgivings were justified or not.
- Be willing to let the group go ahead so they can learn, even if it means the group might make a mistake or two.

Use "I" statements to define your needs

- When you have things you want or need, tell the group what they are by using statements such as "I need covered parking because I have an old car that leaks."

Give the reasons behind your thinking

- Whenever you state an opinion, you can add valuable information by giving others the reason for your opinion.
- Be open to questions and comments about your opinion.

Clean up your messes

- When you say the wrong thing, or act in a way that hurts, angers or alienates others, talk later to discuss what happened and why, with those affected.

Do your homework

- Don't wait until the meeting to give or get information.
- Call people, hold small gatherings, etc.
- Read everything you are given closely and think about it before the meeting.

Please join hands with the persons on either side of you.

We will now sing "Kumbaya."

(just kidding.....)

APPENDIX 4 (CONTINUED).

Nuts and Bolts Groundrules

- Hold the questions and discussion until the presentation is finished.
- Please wait until recognized by the Chairman before speaking.
- The Chairman will recognize panelists first, and then accommodate other comments as possible.

Nuts and Bolts Groundrules

- Please introduce yourself each time you speak.
- When speaking, please turn to face as many people as possible.

Parting Thoughts

- None of us is as smart as all of us.
- Build for the future.

Introductions

- Panelists
- Rapporteurs
- Public attendees

APPENDIX 5. PowerPoint Presentation given by Fred Serchuk

Terms of Reference (Our Jobs)

Day One:

(a) Evaluate world-wide experience and expertise on the issue of trawl warp length offsets and their effects on trawl performance,

(b) Review results of the experimental manipulation of trawl warp lengths conducted aboard the NOAA R/V *Albatross IV* during 25-27 September, 2002,

(c) Based on the above, consider the likely impacts of trawl warp offsets as measured on Albatross IV in terms of net geometry, and consider implications for survey catches.

(discussion to carry over to Day Two)

Day Two:

(d) Based on the above, consider the likely impacts of trawl warp offsets as measured on Albatross IV in terms of net geometry, and consider implications for survey catches (continued...),

(e) Develop appropriate research plans for further Evaluation, if deemed necessary,

(f) Provide a written consensus report regarding trawl warp offset issues.

Agenda (Day One - Morning)

0800-0900:	Display of Yankee-36 Trawl
0900-0915:	Welcome, Background, Ground Rules Dr. Wendy Gabriel, NEFSC
0915-0930:	Introduction of Participants & Expertise
0930-1000:	Terms of Reference, Products, Schedule, Conduct of Meeting - Dr. Fred Serchuk (Chair, NEFSC)
1000-1100:	Background Discussion Presentation Dr. Joe DeAlteris (Univ. of Rhode Island)
1100-1200:	Discussion of General Conclusions of Previous Work (Dr. Anne Richards, Rapporteur)

Agenda (Day One - Afternoon)

1300-1330:	Description of Experimental Protocols Dr. Russell Brown
1330-1345:	Description of Sensor Data Ms. Lisa Hendrickson
	(Dr. James Weinberg, Rapportuer)
1345-1530:	Video Evaluation of Warp Offsets Mr. Henry Milliken
1530-1700:	Discussion on Significance of Results Dr. Fred Serchuk
	(Dr. Steve Murawski, Rapporteur)

Agenda (Day Two - Candle House!)

0830-0845:	Comments and Observations Dr. John Boreman, Acting Science & Research Director, NEFSC
0845-1200:	Continue Discussion from Previous Day & Draft Consensus Summary (including Rapporteur's summaries)
1300-1700:	Finish Consensus Report and Develop plan for additional research, if required

http://www.nefsc.noaa.gov/survey_gear/

APPENDIX 6. Trawl Warp Offset and Survey Stations at Different Amounts of Wire Out.

Trawl Warp Offset and Survey Stations at Different Amounts of Wire Out

Wire out (m)	Warp Offset (in)	Spring Survey 2002 Percentage Stations	Spring Survey 2002 Cumulative % Stations	Depth fished (m)
0	0			
50	16	0%	0%	
100	1	30%	30%	33
150	24	14%	44%	50
200	39	9%	53%	67
250	49	9%	62%	83
300	67	8%	70%	100
350	69	4%	74%	117
400	81	5%	79%	133
450	94	3%	82%	150
500	107	5%	87%	200
550	124	7%	94%	220
600	131	2%	96%	240
650	117	1%	97%	260
700	150	1%	98%	280
750	158	1%	99%	300
800	164	0%	99%	320
850	172	1%	99%	340
900	188	0%	99%	360
950	214	0%	100%	380
1000	200	0%	100%	400

APPENDIX 7. NEFSC 36 Yankee Net Wire Out to Depth Scope

NEFSC 36 YANKEE NET WIRE OUT TO DEPTH SCOPE

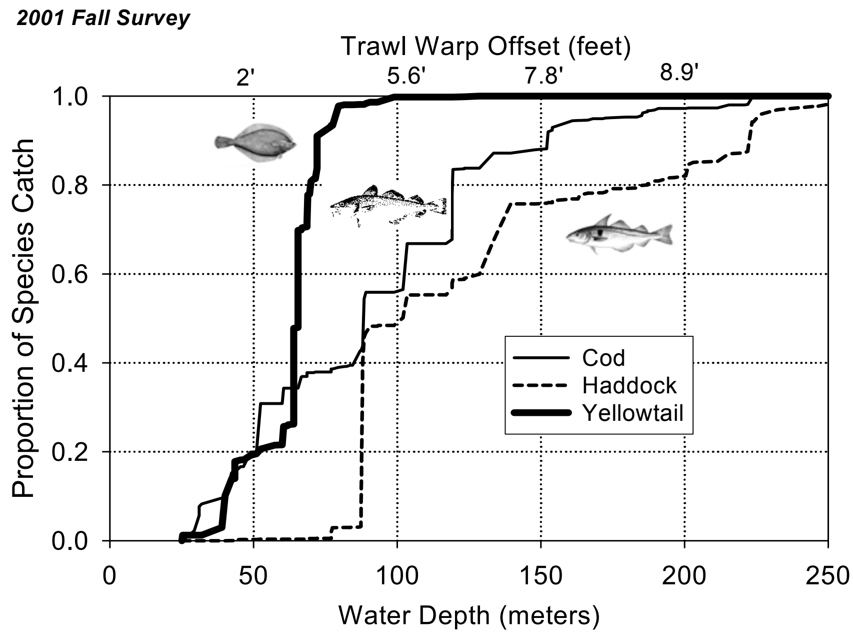
AMOUNT OF WIRE MEASURED FROM THE TRAWL DOORS TO THE SURFACE

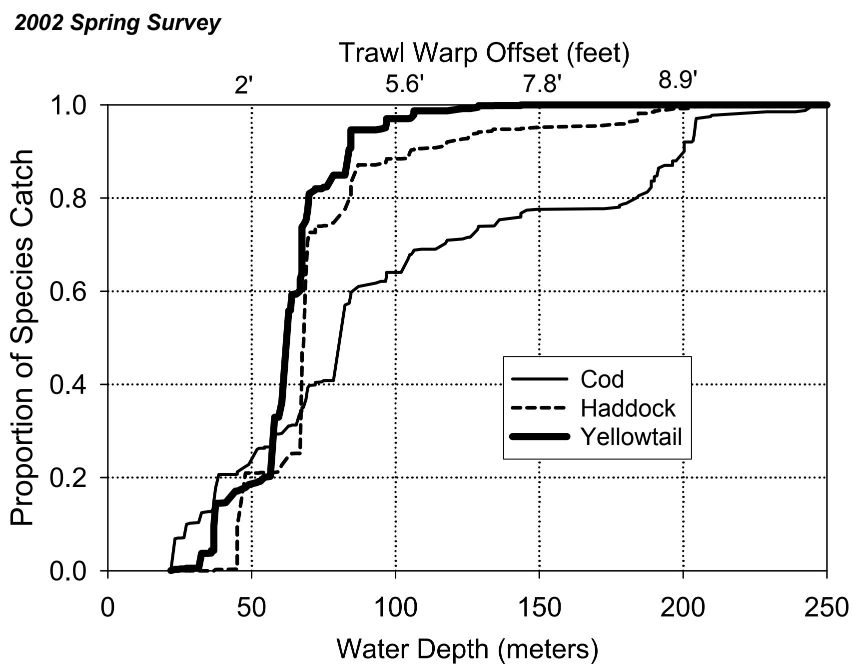
DEPTH M	WIRE OUT M	DEPTH M	WIRE OUT M	DEPTH M	WIRE OUT M	DEPTH M	WIRE OUT M	DEPTH M	WIRE OUT M	DEPTH M	WIRE OUT M
<18	**73**	78	**234**	138	**414**	198	**495**	258	**645**	318	**795**
19	**76**	79	**237**	139	**417**	199	**498**	259	**648**	319	**798**
20	**80**	80	**240**	140	**420**	200	**500**	260	**650**	320	**800**
21	**84**	81	**243**	141	**423**	201	**503**	261	**653**	321	**803**
22	**88**	82	**246**	142	**426**	202	**505**	262	**655**	322	**805**
23	**92**	83	**249**	143	**429**	203	**508**	263	**658**	323	**808**
24	**96**	84	**252**	144	**432**	204	**510**	264	**660**	324	**810**
25	**100**	85	**255**	145	**435**	205	**513**	265	**663**	325	**813**
26	**104**	86	**258**	146	**438**	206	**515**	266	**665**	326	**815**
27	**108**	87	**261**	147	**441**	207	**518**	267	**668**	327	**818**
28	**84**	88	**264**	148	**444**	208	**520**	268	**670**	328	**820**
29	**87**	89	**267**	149	**447**	209	**523**	269	**673**	329	**823**
30	**90**	90	**270**	150	**450**	210	**525**	270	**675**	330	**825**
31	**93**	91	**273**	151	**453**	211	**528**	271	**678**	331	**828**
32	**96**	92	**276**	152	**456**	212	**530**	272	**680**	332	**830**
33	**99**	93	**279**	153	**459**	213	**533**	273	**683**	333	**833**
34	**102**	94	**282**	154	**462**	214	**535**	274	**685**	334	**835**
35	**105**	95	**285**	155	**465**	215	**538**	275	**688**	335	**838**
36	**108**	96	**288**	156	**468**	216	**540**	276	**690**	336	**840**
37	**111**	97	**291**	157	**471**	217	**543**	277	**693**	337	**843**
38	**114**	98	**294**	158	**474**	218	**545**	278	**695**	338	**845**
39	**117**	99	**297**	159	**477**	219	**548**	279	**698**	339	**848**
40	**120**	100	**300**	160	**480**	220	**550**	280	**700**	340	**850**
41	**123**	101	**303**	161	**483**	221	**553**	281	**703**	341	**853**
42	**126**	102	**306**	162	**486**	222	**555**	282	**705**	342	**855**
43	**129**	103	**309**	163	**489**	223	**558**	283	**708**	343	**858**
44	**132**	104	**312**	164	**492**	224	**560**	284	**710**	344	**860**
45	**135**	105	**315**	165	**495**	225	**563**	285	**713**	345	**863**
46	**138**	106	**318**	166	**498**	226	**565**	286	**715**	346	**865**
47	**141**	107	**321**	167	**501**	227	**568**	287	**718**	347	**868**
48	**144**	108	**324**	168	**504**	228	**570**	288	**720**	348	**870**
49	**147**	109	**327**	169	**507**	229	**573**	289	**723**	349	**873**
50	**150**	110	**330**	170	**510**	230	**575**	290	**725**	350	**875**
51	**153**	111	**333**	171	**513**	231	**578**	291	**728**	351	**878**
52	**156**	112	**336**	172	**516**	232	**580**	292	**730**	352	**880**
53	**159**	113	**339**	173	**519**	233	**583**	293	**733**	353	**883**
54	**162**	114	**342**	174	**522**	234	**585**	294	**735**	354	**885**
55	**165**	115	**345**	175	**525**	235	**588**	295	**738**	355	**888**
56	**168**	116	**348**	176	**528**	236	**590**	296	**740**	356	**890**
57	**171**	117	**351**	177	**531**	237	**593**	297	**743**	357	**893**
58	**174**	118	**354**	178	**534**	238	**595**	298	**745**	358	**895**
59	**177**	119	**357**	179	**537**	239	**598**	299	**748**	359	**898**
60	**180**	120	**360**	180	**540**	240	**600**	300	**750**	360	**900**
61	**183**	121	**363**	181	**543**	241	**603**	301	**753**	361	**903**
62	**186**	122	**366**	182	**546**	242	**605**	302	**755**	362	**905**
63	**189**	123	**369**	183	**549**	243	**608**	303	**758**	363	**908**
64	**192**	124	**372**	184	**460**	244	**610**	304	**760**	364	**910**
65	**195**	125	**375**	185	**463**	245	**613**	305	**763**	365	**913**
66	**198**	126	**378**	186	**465**	246	**615**	306	**765**	366	**915**
67	**201**	127	**381**	187	**468**	247	**618**	307	**768**		
68	**204**	128	**384**	188	**470**	248	**620**	308	**770**		
69	**207**	129	**387**	189	**473**	249	**623**	309	**773**		
70	**210**	130	**390**	190	**475**	250	**625**	310	**775**		
71	**213**	131	**393**	191	**478**	251	**628**	311	**778**		
72	**216**	132	**396**	192	**480**	252	**630**	312	**780**		
73	**219**	133	**399**	193	**483**	253	**633**	313	**783**		
74	**222**	134	**402**	194	**485**	254	**635**	314	**785**		
75	**225**	135	**405**	195	**488**	255	**638**	315	**788**		
76	**228**	136	**408**	196	**490**	256	**640**	316	**790**		
77	**231**	137	**411**	197	**493**	257	**643**	317	**793**		

M	SCOPE
<18	73M
19-27	4:1
28-183	3:1
184-366	2.5:1

APPENDIX 8.

Cumulative percentage of catches of cod, haddock and yellowtail flounder in relation to water depth in NEFSC 2001 autumn and 2002 spring bottom trawl surveys. Also indicated is the trawl warp offset associated with the water depths sampled.





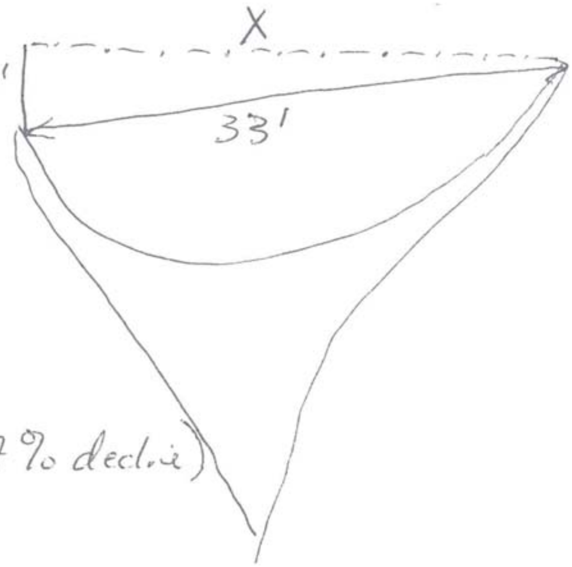
APPENDIX 9. Some simple geometry. How much does the front profile of the net change with offsets (extreme proportional change)?

Some Simple Geometry

How much does the front profile of the net change with offsets (extreme proportional change)?

Normal net – 33 foot wing spread

6' offset:



$$33^2 = 6^2 + X^2$$

$$X^2 = 33^2 - 6^2$$

$$X^2 = 1089 - 36$$

$$X^2 = 1053$$

$X = 32.45'$ (1.7% decline)

12' offset

$$33^2 = 12^2 + X^2$$

$$X^2 = 33^2 - 12^2$$

$$X^2 = 1089 - 144$$

$$X^2 = 945$$

$X = 30.74'$ (6.8% decline)

APPENDIX 10. Specifications for Construction of NEFSC Standard #36 Bottom Survey Trawl

UPDATED ON 8/12/2002

Specifications for Construction of NEFSC Standard #36 Bottom Survey Trawl (601 - 801)

COMMENTS NET ID______ DATE_____________ INSPECTOR________________

Body of the Net

Dimensions of the sections are shown on the attached net plan and cutting diagram. Webbing for wings, square, and bellies is 5" stretched mesh measured knot center to knot center (or 4 ¾" inside measurement). It is single selvedge, stretched, and stabilized. The webbing is woven with white #96 (3 mm), 16-carrier virgin braided nylon twine. Webbing in the codend is 4 1/2" stretched mesh, center-to-center, single selvedge, stretched and stabilized. Twine for the codend webbing is white #180, 16-carrier virgin braided nylon.

Net sections are joined together by sewing a half mesh row of double twine of a contrasting color for easy identification of sections.

The top and bottom sections of the net are joined together at their sides by a gore or laceage. Gathering 6 knots from each of the top and bottom sections makes the gore. These are seized every foot and wrapped in between the Seizings using single #120 thread-braided nylon twine.

Dog-ear meshes are mended onto top and bottom wings with double #120 thread-braided nylon twine.

Gore Lines

Gore lines are 3/4" diameter polypropylene ropes that run from the after end of the codend to the top of the wing end where the rope is tied into the head rope eye splice. The gore line is slightly shorter than the laceage and is seized to the laceage at intervals of about 1'.

Footrope

The footrope is constructed from 120' (20 fathom) total length of 3/4" diameter polydacron (polyplus) rope. This length is used to construct the 100' (16.67 fathom) footrope including eye splices, and the seven-foot up-and down lines. The remainder of the rope at each end is tied into the wing end eye of the head rope, with the excess seized back down the door end line. Lower wings are hung in 45' (7½ fathom) lengths while the lower belly is hung in a 10' (1.67 fathom) length.

Belly Lines

Belly lines are two strengthening lines on the bottom belly made of 3/4" polypropylene. They are seized to the footrope at the corner and run out and back to the gore line on the bar of the belly webbing. They are seized to the webbing and to the gore line.

APPENDIX 10 (CONTINUED).

Headrope

The headrope is made of 7/8" diameter nylon or polypropylene and steel combination rope with a fiber core. It consists of three 20' ($3^1/_3$ fathom) sections. Each section has eyes spliced at each end without thimbles and sections are joined by 1/2" hammerlock links. The square is hung in 12’ (2 fathom) and the wings are hung in 24’ (4 fathom) lengths.

Hanging

The dogs on the wings are hung to the headrope and the footrope with hanging meshes of double #182 braided nylon twine. The belly and the square selvedge meshes are evenly hung on the bosom sections of the footrope and the headrope with #132 braided nylon twine. The hanging lengths for the wings and bosom on the headrope and footrope are shown on the attached plan. Each dog is seized to the headrope with bar-tight seizings.

Up-and Down

Door end meshes of the bottom wing are evenly hung on the seven-foot up-and-down line that runs from the footrope to the headrope. The end meshes of the top wing are gathered together and seized into the headrope eye splice.

Floats

There are 36 eight-inch spherical aluminum floats. The floats have a 5/8" polypropylene line threaded through their double beckets. This poly line is then seized to the headrope. Float arrangement: 20 floats evenly spaced on the center 20' ($3^1/_3$ fathom) section of headrope, and 8 floats evenly spaced on each 20' ($3^1/_3$ fathom) side section. Float line is seized to backside of the headrope, so floats lie above the webbing and behind the headrope.

Traveler
(Fishing line)

The traveler is made up of five lengths of 5/8" diameter combination rope with eyes spliced in each end without thimbles and joined with 1/2" hammerlocks. These lengths, from wing end to wing end are 23’(3.83 fathom), 9½' (1.58 fathom), 16'(2.67 fathom), 9½'(1.58 fathom), and 23'(3.83 fathom). Measurements are total overall length, including eye splices. Combination rope is a combination of nylon or polypropylene strands and steel wire with a fiber core.

Sweep

The sweep is made up of five sections of 3/4" diameter 6 x l9 fiber core, galvanized wire rope. The sections have eyes without hammerlocks at each end. The sections are joined with 5/8" shackles. The lengths of the sections from wing end to wing end are 22½'($3^3/_4$ fathom), 9½'(1.58 fathom), 16'(2.67 fathom), 9½'(1.58 fathom), and 22½'($3^3/_4$ fathom). Dimensions are total lengths including splices.
The wing end sections 22½ feet each, have 4" diameter rubber tire stampings cookies) on their entire length with 7 link roller chains (toggles) every 2'. The roller chains consist of a 3" I.D. ring of 3/8" steel rod at each end linked together by 7 links of 5/16" chain. The distance between the end rings is 8". The footrope is passed through the ring at one end of the roller chain. The traveler is

passed through the ring at the other end of the roller chain, except for the roller chains located at joins of the traveler or the footrope; then the ring is inserted in the split link or the shackle used to join the two sections.

The two 9½' (1.58 fathom) long sections and the center 16' (2.67 fathom) section have 16" diameter by 5" wide "Fenner" or equivalent solid, hard rubber (no spokes) rollers on them. Two rubber spacers, each 7″ in length by 5″ in diameter, separate these rollers. They have a 2¼" hole through the center. Between each pair of spacers a roller chain is strung on the sweep. The rollers and spacers are arranged on the sweep sections so there is a single spacer at each end of the center 16′ (2.67 fathom) sections. On each of the 9½′ (1.58 fathom) sections there are two spacers at the outer, wing, end and no spacers at the inner end that is adjacent to the center section. Each outer section has five rollers and ten spacers on it and the center section has 9 rollers with 18 spacers. There is a 4½" diameter steel washer at each end of each of the 5 sections of the sweep.

<u>Seizings</u>

The footrope is seized to the pear shaped rings that are used to attach the droppers to the sweep. The traveler passes through the pear shaped rings that the footrope is seized to. This eliminates the problem of the seizings slipping and bunching of the footrope.

<u>Liners</u>

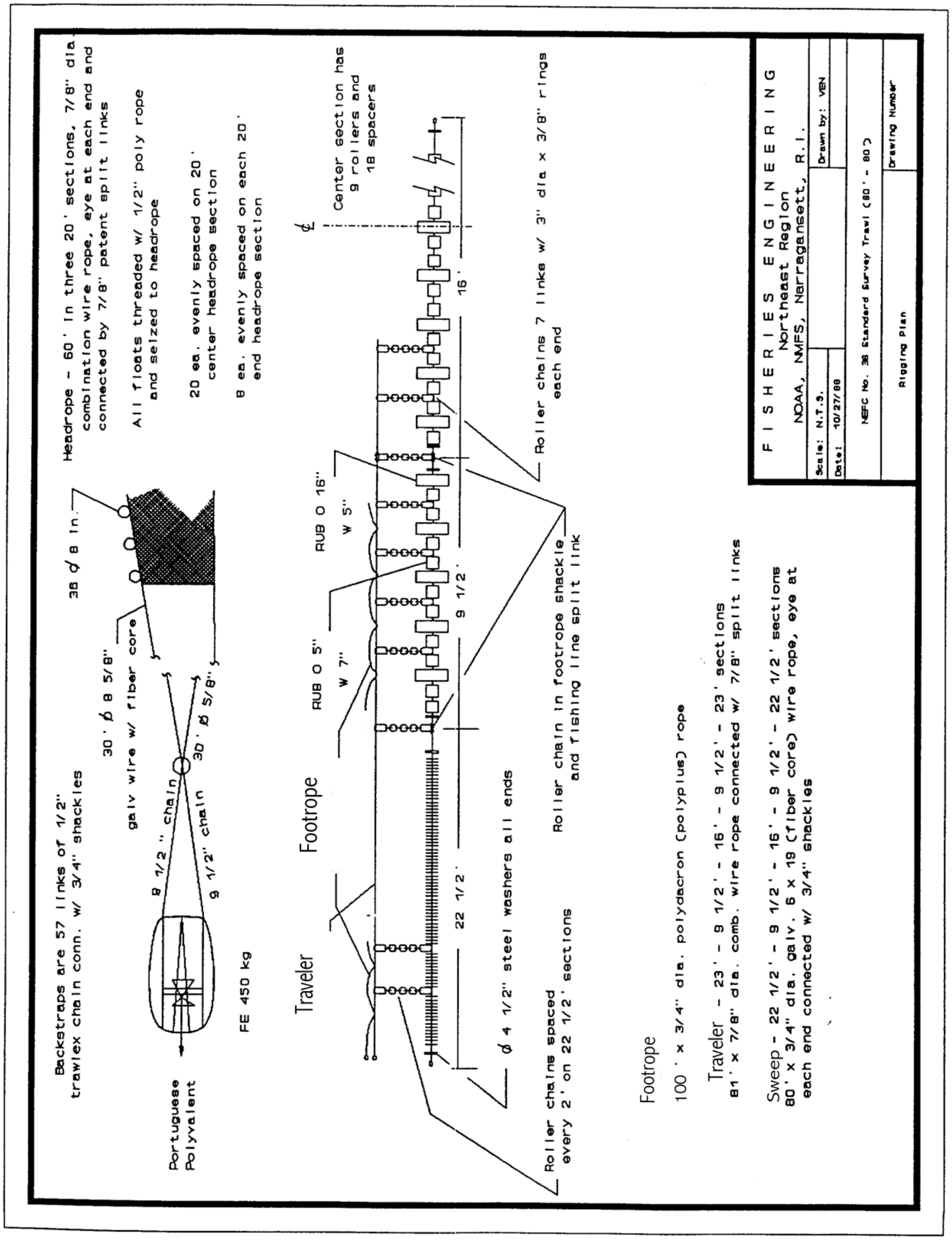
The after part of the upper belly is lined with ½" mesh liner material, as is the entire codend. Both liners are made of ½" mesh #147 knotless white nylon webbing, Nylon Net Co. or equivalent. The belly liner is 30′ (5 fathoms) across the leading edge, 21′ (3½ fathoms) down each side, and 18′ (3 fathoms) across the after edge. The codend liner is 30′ (5 fathoms) around by 24′ (4 fathoms) long. These measurements are made with the meshes open but without stretching the webbing tightly. The belly liner is reinforced along the leading edge and down each side by gathering and seizing a 1/2' diameter roll of liner material. This roll of material is then seized to 54-thread strengthener that is knotted with an overhand knot every 8" along its length. The top belly liner is attached to the inside of the top belly 35 meshes up from the after end of the belly. It is also seized down the sides off the belly, 1 mesh in from the gore. The after end of the belly liner is not seized.

The codend liner is also reinforced along the forward edge by gathering and seizing a 1/2" roll of the material and then seizing a knotted 54-thread strengthener to it. This same technique is used down the gore of the liner where the two edges are joined, and down a false gore opposite the join. The after end is not reinforced. The codend liner is attached inside the codend to every mesh around the codend. This is done one and one-half mesh back from the codend - belly join.

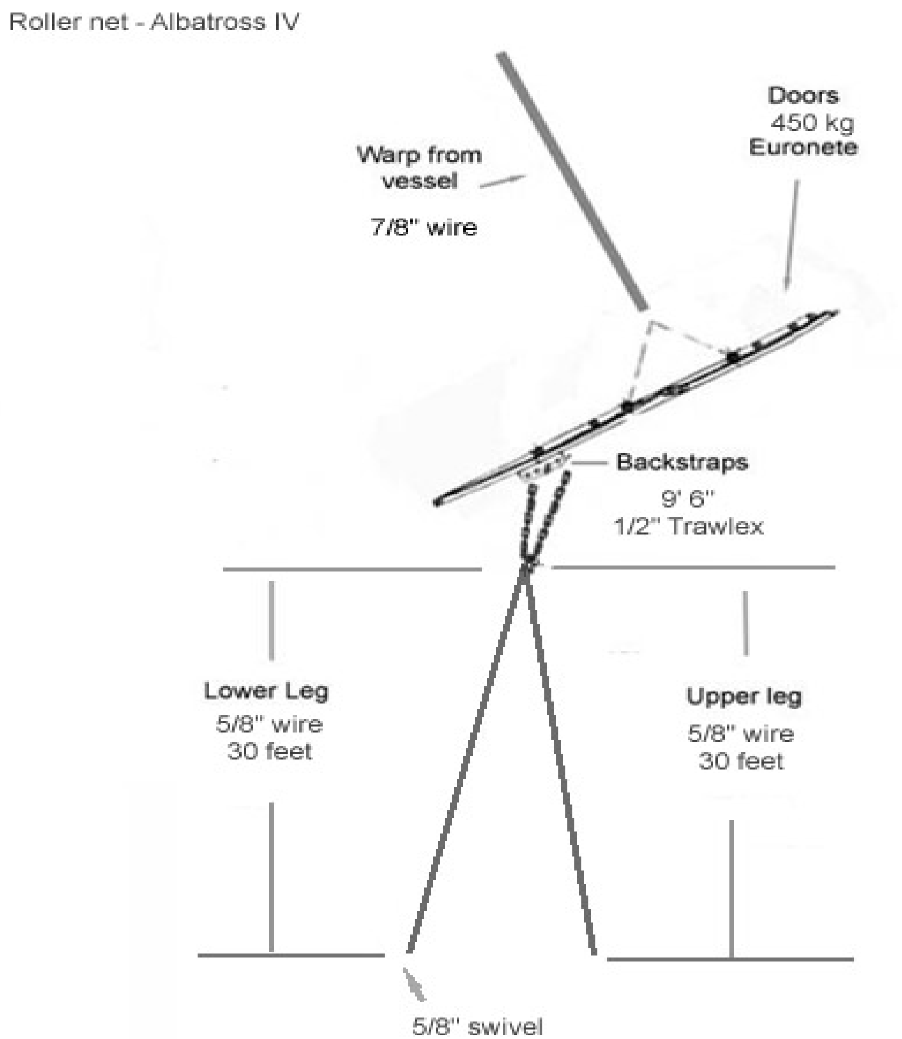
<u>Codend</u>

Rings are hung to the codend with codend twine at a ratio of one ring for each 3 meshes. Rings are 2" diameter galvanized steel made from 5/16" rod stock. The codend measures 50 meshes deep by 80 meshes in circumference. Chaffing mat is constructed from 4½″ nylon and is 30Wx35D.

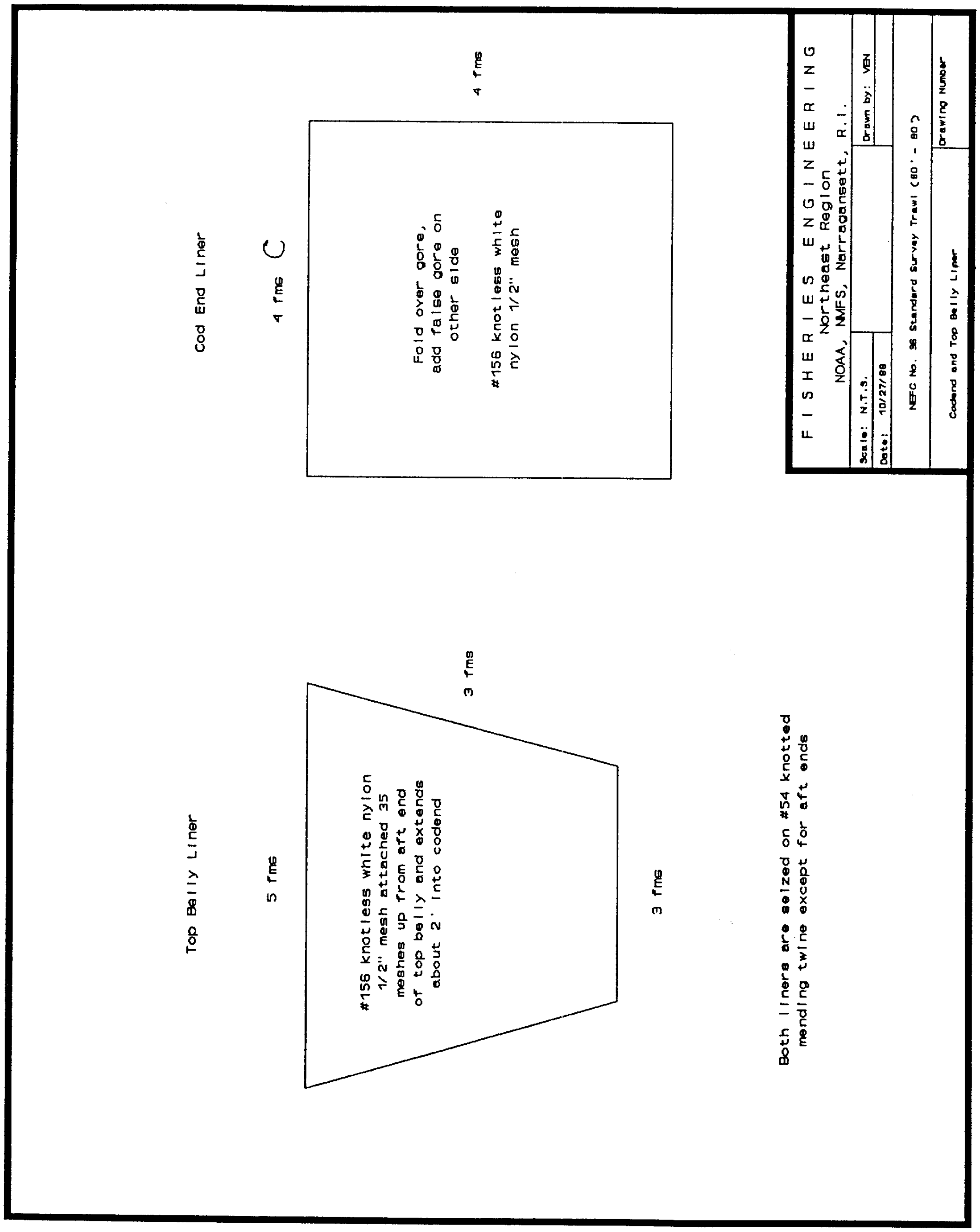
APPENDIX 10 (CONTINUED).



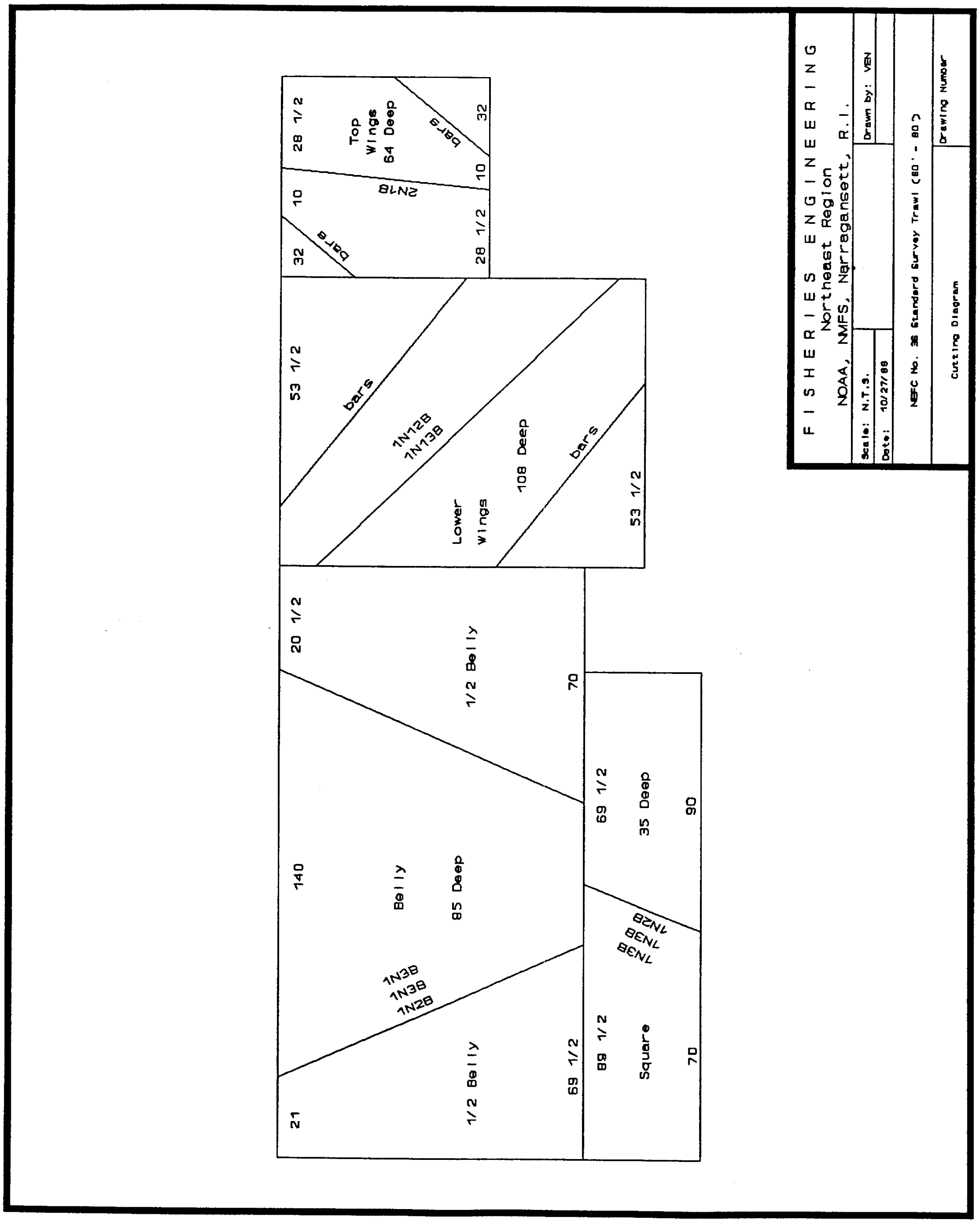
APPENDIX 10 (CONTINUED).



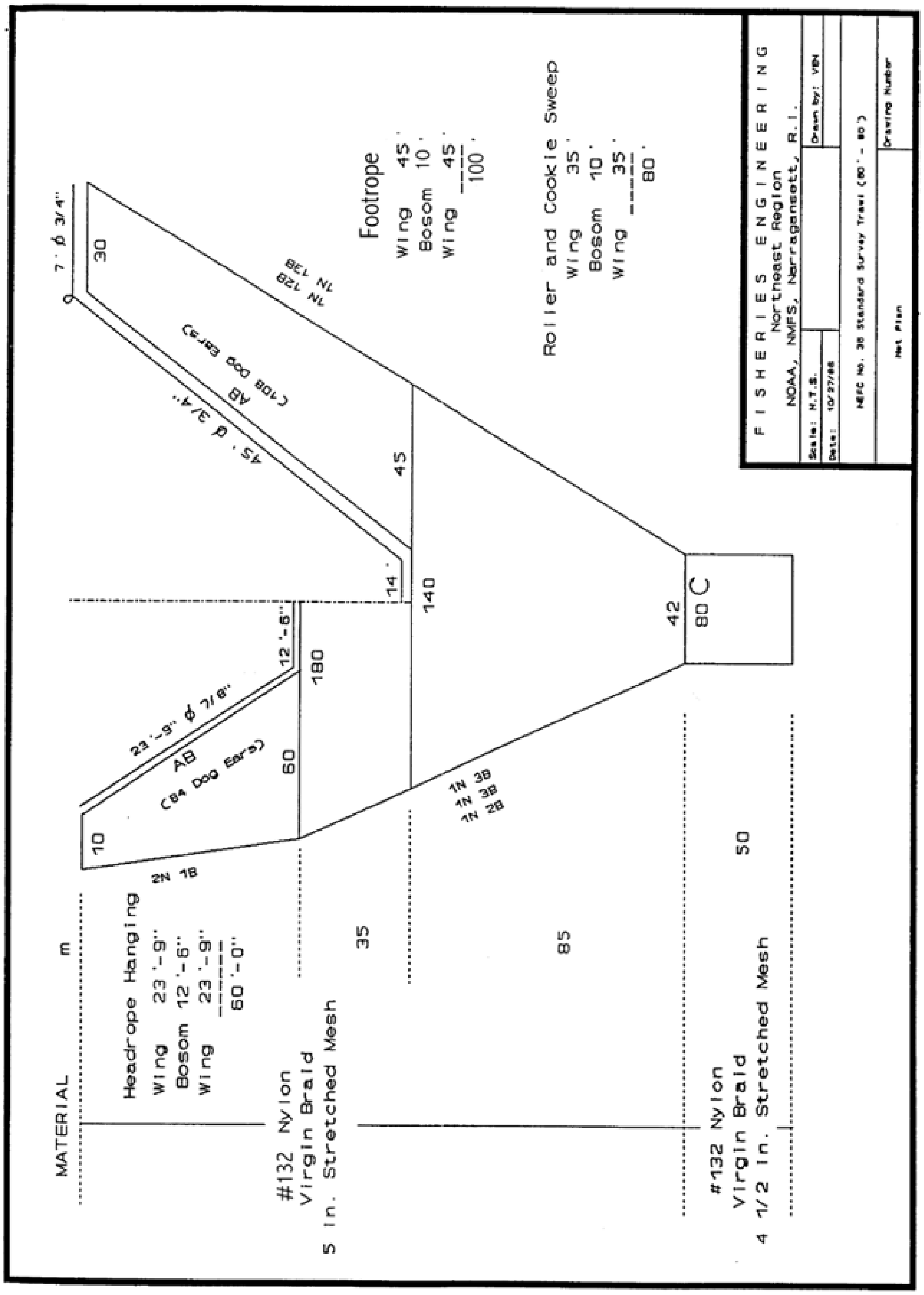
APPENDIX 10 (CONTINUED).



APPENDIX 10 (CONTINUED).



APPENDIX 10 (CONTINUED).



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
.
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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APPENDIX 12. PowerPoint Presentation given by Joe DeAlteris

Factors Affecting the Performance of a Survey Bottom Trawl

Joseph DeAlteris

Department of Fisheries
University of Rhode Island
Kingston, RI 02881

Acknowledgements

- Henry Milliken- NEFSC, NMFS, initially contacted more than 40 members of the ICES, Fishing Gear and Fish Behavior Working Group.
- Claire Steimle- NMFS Sandy HooK Laboratory, conducted a computer literature search.

Presentation Outline

- Factors affecting trawl survey variability
- General and specific questions to be addressed
- Bottom trawl system and the effect of a warp offset
- Search of literature
- Canvass of experts
- Summary and Conclusions

Factors Affecting Variability in Trawl Survey Data and Results

- Measurement variability due to variability in survey trawl performance.
- Spatial variability due to fish availability as fish are contagiously distributed.
- Environmental variability interacts with both trawl performance and fish availability to the survey trawl.

Reference: Byrne, Azarovitz, and Sissenwine, 1981

General Questions Related to Bottom Survey Trawl Performance

- What is the effect of net design?
- What is the effect of trawl rigging including doors, ground gear, net sweep and flotation, etc,?
- What is the effect of trawl operation including towing speed, current speed and direction relative to tow direction, sea state, etc.?
- What are the effects of fish behavioral response to the gear including day/night differences, habitat differences on sweep capture efficiency, etc.?

Specific Question Related to Bottom Survey Trawl Performance

- What is the effect of an offset or differential in the length of the towing warp?

APPENDIX 12 (CONTINUED).

Measures of Bottom Survey Trawl Performance

- Catch efficiency (catchability) is the most important factor.
- Trawl system geometry including door spread, wing spread and vertical opening of the net mouth.

Evaluation of Bottom Survey Trawl Performance: Standard versus Altered Configuration

- Catch efficiency
  - At sea observations of trawl capture process by divers or with underwater video.
  - On deck catch comparisons.
- Measurements of trawl system geometry using model or full-scale gear.

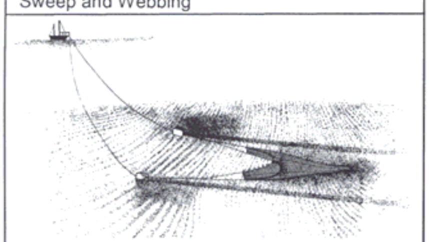
Goal with Regard to Bottom Survey Trawl Performance

- Consistent catch efficiency so that at a given survey station, catch retained in the codend truly reflects fish abundance and size distribution at that location.

Bottom Trawl System

- System of flexible lines that transfer towing force from the vessel to the webbing in the net.
- Components: towing warp, otter boards, ground gear and net bridles, and net headrope and footrope/sweep, and webbing.
- A feedback system exists to balance forces that are temporarily unbalanced adjusting warp catenaries, door angle of attack, and headrope and footrope/sweep catenaries.

Bottom Trawl System: Towing Vessel, Warp, Otter Boards, Ground Gear, and Net Headrope, Sweep and Webbing

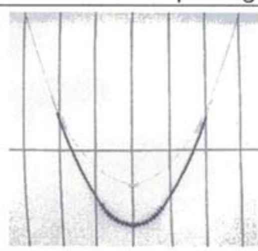


Effect of a Warp Length Offset on Trawl Mouth Geometry

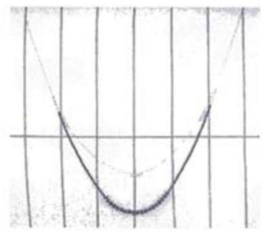
- Standard configuration: equal warp length to the otter boards, 9 ft. backstraps, 30 ft. bridles, 60 ft. headrope and 80 ft. sweep.
- Altered configurations:
  - 3 foot offset
  - 6 foot offset
  - 9 foot offset

APPENDIX 12 (CONTINUED).

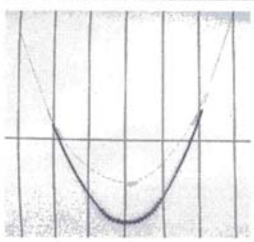
No Offset in Warp Length



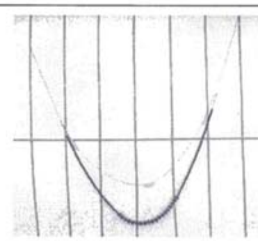
3 foot Offset in Warp Length



6 foot Offset in Warp Length



9 Foot Offset in Warp Length



Results of Literature Search

- Over 100 citations in books, journals, trade magazines, and gray literature.
- Most not relevant to either the general or specific questions previously identified.
- Several papers address the general questions regarding trawl performance.
- One chapter in book addresses the effect of warp length offset.

Summary of Literature Search (contd.)

- Doubleday and Rivard. 1981. Bottom Trawl Surveys. Can. Spec. Pub. 58. 273 p.
  - Sampling Techniques:
    - Fish Catching Process
    - Catch Variability due to Variations in Trawl Behavior
    - Factors Affecting Variability of Trawl Surveys

APPENDIX 12 (CONTINUED).

Results and Conclusions: (Doubleday and Rivard)

- Trawl is a quantitative sampling tool that must be calibrated, but even so there will be variable catch efficiency.
- Measurement variability due to vessel, fishing gear and environmental factors.
- Impossible to separate variability due to fish distributions from measurement error.

Summary of Literature Search (contd):

- Lauth, Syrjala, and McEntire. 1998. Effects of Gear Modifications on the Trawl Performance and Catching Efficiency of the West Coast Upper Continental Slope Groundfish Survey Trawl. Marine Fisheries Review 60:1-26.

Results and Conclusions: (Lauth, Syrjala and McEntire)

- Experiment distinguishes between engineering performance and catch efficiency.
- Treatments were door-bridle rigging, ground gear weight and scope length.
- All treatments affected engineering performance.
- Few treatments affected catch efficiency.

Summary of Literature Search (contd):

- DeAlteris, Recksiek and others. 1989. Comparison of the Performance of Two Bottom Sampling Trawls. Trans. Amer. Fisheries Society 118:119-130.

Results and Conclusions: (DeAlteris, Recksiek and others)

- Compared two designs of scientific sampling trawls, with various rigging and operational parameters.
- Measured geometric performance and catch efficiency.
- Found net design, rigging and operation all affected trawl geometric performance, but most treatments did not affect catch efficiency.

Summary of Literature Search (contd.)

- Kondratev. 1973. Modeling of Commercial Fishing Gear by the Method of Analog Mechanisms. Translated form Russian.
  - Chapter: Effect of Difference in Warp Length on the Working of a Trawl.

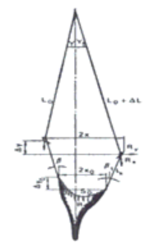
APPENDIX 12 (CONTINUED).

Question Addressed: (Kondratev)

- "When a trawl breaks down fishermen usually first verify the warps."
- "Can we justify such demands on warps and the associated loss of fishing time to re-measure the warp?"
- "To answer this question, tests where made on a 31m (96 feet) trawl".
  - -Model tests
  - -Full scale fishing trials

Warp Length Offset Problem

Fig. 48. Distortion of trawl for varying warp scope.



Results and Conclusions: (Kondratev)

- Conducted model and full scale fishing evaluations.
- Results of model experiments indicate that trawl mouth geometry is only affected when "the difference in warp length exceed 20% of the length of the headline".
- On the Yankee 36 trawl net, this would be 12 feet.

Results and Conclusions: (Kondratev, contd.)

- Conducted model and full scale fishing evaluations.
- Results of full scale experiments on the "1 RB-99 with a difference in warp length up to 15% of the length of the headline, the distance between the trawl boards and the fishing efficiency did not change appreciably".
- On a Yankee 36 trawl net, this would be 9 feet.

Results of Canvass of Professionals in Fisheries Technology

- More than 75 individuals were contacted both nationally and internationally.
- Of those that responded, most had some experience with the general survey trawl performance problems.
- A few had real experience with the specific question, and could offer advice.

Advice and Experience of Experts

- M. Ben-Yami of Israel- Warp offset of 6 feet or more may be problematic. There may be a catch difference of 10-15 %, but it will be difficult to measure.
- C. Goudey of MIT- Observed the effect of small offsets in model nets, but difficult to obtain reliable results in model testing.

APPENDIX 12 (CONTINUED).

Advice and Experience of Experts

- Lee Alverson of NRC Consultants- Offsets of up to 6 feet should have minimal impact on catch. Recalled some experiments on the R/V Cobb in the 1970s on the west coast, small offsets had no effect on catch.
- Dick Ferro of Marine Laboratory, Aberdeen, Scotland- An offset will affect ground gear tension, thus affect sweep contact, and may affect catch efficiency.

Advice and Experience of Experts

- Steve Walsh of Canadian DFO- Suspects that there is little effect on catch with small offsets, but to confirm this will require many paired tows of standard and altered configuration gears.

Advice and Experience of Experts

- Gary Loverich of Ocean Spar, formerly NETS, and NMFS.-
  - Proposes that the offset must be considered in the context of the entire length of ground gear and sweep.
  - A 6 foot offset is 4.4% of this on the Yankee 36 survey trawl net.
  - The result of the offset is a skewed footrope, that may be elevated in sections.

Advice and Experience of Experts

- Gary Loverich of Ocean Spar, fomerly NETS, and NMFS. (contd)
  - Results of model tests suggest up to a 5.5% offset would not result in a catch reduction.
  - Auto-trawl winches often result in a 1-2% offset required to balance warp tension.
  - Other operational factors result is a skewed net.

Advice and Experience of Experts

- Gary Loverich of Ocean Spar, fomerly NETS, and NMFS. (contd)
  - Conclusion: "looking at all the evidence available to me, I believe that a warp differential on the order 5% would not greatly impact the cumulative catch of the Yankee 36 used aboard the R/V Albatross."

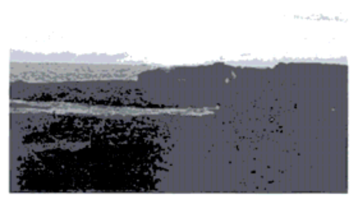
Summary and Conclusions (I)

- A trawl warp length offset is another source of measurement error.
- The magnitude of the error is a function of the relative magnitude of the offset to the length of the headrope or ground gear and sweep.

APPENDIX 12 (CONTINUED).

Summary and Conclusions (II)

- General consensus of those who have attempted to measure the effect is that a warp length offset of up to 6 feet on the R/V Albatross IV using the Yankee 36 will minimally affect catch efficiency. Offsets greater that 6 feet become increasingly problematic in terms of catch efficiency. Although, this may be also difficult to measure.



Effect of Trawl Warp Offset

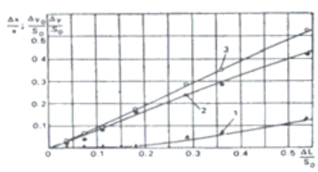


Fig. 49. Dependence of trawl distortion on difference in warp scope: $1-\frac{\Delta x}{x}$; $2-\frac{\Delta y_0}{S_0}$; $3-\frac{\Delta y}{S_0}$.

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
National Marine Fisheries Service
Seattle, Washington

October 27, 1971

CRUISE ANNOUNCEMENT
Cruise No. 71-8
NMFS Vessel John N. Cobb

The National Marine Fisheries Service research vessel John N. Cobb will depart Seattle November 8, 1971 for a 14-day gear research cruise in Puget Sound.

Area of Operation: The principal area of operation will be in mid-Puget Sound. Operations will be conducted between Battle Point and Agate Pass and off Karkeek Park. If conditions require it, some operations may be conducted between Port Angeles and Dungeness Spit, near the south shore of Hoods Canal, or Saratoga Passage.

Objectives:

1) To determine the effects of a length differential in the towing cables on the overall performance of otter trawls.

2) To compare the performance of a NMFS modified 400-mesh eastern trawl to that of a standard 400-mesh eastern trawl. The trawls will be compared on the basis of working configuration, ability to tend bottom and relative drag.

3) To observe the performance of a BCF shrimp separator trawl with a newly designed separator panel. The performance of the trawl will be determined in relation to the overall configuration, variations in bridle length, ability to tend bottom, and relative drag.

4) To establish basic information on the technique of towing two trawls side by side from a single vessel, using three towing cables.

Equipment:

1) Trawls -- other than those trawls mentioned above, a Mark I Universal trawl, and a Gulf of Mexico shrimp trawl will be used on this cruise. Standard V-doors will be used with all nets.

2) Instrumentation -- Data will be taken using 2 Dillon dynamometers (0-20,000 lbs.) a Marine Advisors ducted flowmeter, depth telemetry and standard cable meters.

3) Computer -- A PDP-11 computer and teletype will be used to reduce data on board.

Method of Operation: All trawls will be towed (a) in mid-water; (b) in deep water on bottom, and (c) at diver depth on bottom. Diver observations of the gear will supplement data taken with instruments on each of the nets.

For further information contact: Dr. F. M. Fukuhara, Acting Director, Marine Fish, Shellfish, and Oceanography, National Marine Fisheries Service, 2725 Montlake Boulevard East, Seattle, Washington 98102 (Telephone: 442-7729).

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Fisheries Center
2725 Montlake Blvd. E.
Seattle, Washington 98102

December 15, 1971

CRUISE REPORT
Cruise No. 71-8

NMFS Vessel John N. Cobb

The NMFS research vessel John N. Cobb completed a 16-day gear research cruise in Puget Sound on November 23, 1971.

OBJECTIVES

The major objectives of the cruise were to (1) study the effects of a trawl warp length differential on trawl-type gear and to determine whether or not tension in the trawl warps can be used as an accurate indication of relative warp lengths, (2) obtain warp load data and rigging data on a standard 400-mesh Eastern bottom trawl and a newly constructed modified 400-mesh Eastern, (3) obtain warp load data and rigging data on a 57' Gulf of Mexico shrimp trawl with separator panel and the BCF 10-53 shrimp separator, (4) obtain data and experience towing two trawls from a North Pacific trawl boat.

DESCRIPTION OF GEAR

The warp differential length studies were carried out on three different trawls, a standard 400-mesh Eastern, a Mark I Universal (midwater), and a 57-foot Gulf of Mexico shrimp trawl converted to a separator trawl. Trawl warps were measured using two pairs of cable meters calibrated in fathoms and tenths of fathoms. Tension measurements were taken using two dynamometers (0-20,000 lb.). The dynamometers were attached directly to the trawl warps using 5/8" "come alongs." A ducted flowmeter was used to measure velocity through the water. The flowmeter was suspended over the side of the vessel to a depth of approximately 50 feet. Relative tension between the two trawl warps was also measured by using a chain to deflect the warps inward and measuring the distance that the center of the chain deviated from the centerline of the vessel.

Scuba divers were used extensively to make evaluations and comparisons on the trawl gear where instrumentation would prove inadequate. Two sets of steel V-doors were used during the cruise. The 5'x7' V-doors weighed 820 lbs. each and the 6'x9' V-doors weighed 1,250 lbs. each.

1871 A Century of Fish Conservation 1971

RESULTS

Warp Length Differential Studies: Relative calibration of the cable meters showed these meters to give readings that are generally less than 0.2 F (fathoms) different for warp lengths of 200 F. The relative meter readings were tested for and proven to be independent of warp velocity and winch-induced shock loads.

Measurements of warp loads were taken for warp length differentials of 0 to 10 F and are shown in Figures 1 and 2. All measurements were taken in mid-water with the rudder set on center. Measurements of relative warp load were taken using chain to deflect the warps inward. The difference in deflection of each warp is shown in Figure 3.

To observe the effects of a warp length differential on the performance of a trawl, four dives were made on a 400-mesh Eastern. On each dive the relative warp lengths were changed using differentials of 0, 3, 5, and 10 F. Designating the 0 F condition as the standard, changes in the shape of the net occurred for each differential tested. As the length differential was increased, the mouth opening appeared to become smaller and at 10 F differential 50% of the footrope was off bottom. On each of the four dives bottom debris was observed to enter the net even though the net was not functioning properly.

Comparison of a Standard 400-Mesh Eastern Trawl and the NMFS Modified 400-Mesh Eastern Trawl

Warp load measurements on both nets were completed in mid-water, as shown in Figure 4. Diving observations on both nets were made to compare the overall configuration, load distribution on the webbing, positioning of the footrope relative to the bottom, and to obtain dimensions of the mouth opening. Although both nets are very similar, the design changes made in the NMFS 400-mesh Eastern produced a measured mouth opening of 38'x10' as opposed to a mouth opening of 34'x4' for the standard 400-mesh Eastern. When the NMFS 400-mesh Eastern was towed using 6'x9' V-doors, a mouth opening of 46'x8' was measured.

Rigging experiments with diving observations were recorded on the NMFS 400-mesh Eastern. Under the conditions of the experiments, diver observations showed that the bottom bridle on each wingtip should be lengthened by one foot to make the footrope tend bottom properly.

During a tow where all the headrope floats were removed, diving observations revealed that the NMFS 400-mesh Eastern was completely collapsed vertically, showing no tendency to open itself due to water pressure.

Observations of Shrimp Separator Trawls: Midwater warp load measurements were recorded for two shrimp separator trawls. The results are shown in Figure 5. 10 F bridles were used on each net. Eighteen-inch extensions were added first to the top bridle and in turn to the bottom bridle. Under the conditions of the experiment the 57' Gulf of Mexico separator trawl tended to fly off bottom when the extensions were added to the top bridles and showed a tendency to remain tighter on bottom with the extensions added to the bottom bridles. The BCF 10-53 (10 ft. vertical opening and 53-ft. footrope) separator trawl showed exactly the opposite response to the bridle extensions.

After a series of diving observations on the BCF 10-53, it became apparent that the midline and riblines were too short and should be redesigned. All other aspects of the BCF 10-53 appeared to perform properly, including the trash chute.

Multiple Net Harvesting System: A technique for rigging and setting two bottom trawls was developed. The only change to the rigging of the vessel was the addition of a third towing wire (300 F) onto the net reel. Two 400-mesh Eastern trawls were shackled together along the two common breastlines. The doors were attached as normal on the two remaining wings, using 10 F bridles. A 100- to 150-pound weight was attached to the end of the third wire, which in turn was fastened to a third pair of 10 F bridles shackled to the common breastlines. Figure 6 describes the rigging technique used.

Midwater warp load measurements were made on the double net system as shown in Figure 7. Diving observations showed that these two nets operated independently of each other and together covered over twice as much area as a single trawl towed at an equivalent speed.

Personnel Assignments:	Gary F. Loverich, Field Party Chief	Nov. 8-23, 1971
	Jerry Jurkovich, Fishery Biologist	Nov. 8-23, 1971
Diving Personnel:	Gary F. Loverich, Ocean Engineer	
	William L. High, Fishery Biologist	
	Daniel J. Twohig, Electronics Technician	
	Ian Ellis, Fishery Biologist	
	Larry D. Lusz, Engineer	
	Jo Ann Duffy, Fishery Graduate Student, U. of W.	

For further information contact: Dr. F. M. Fukuhara, Acting Director, Marine Fish, Shellfish and Oceanography, National Marine Fisheries Service, 2725 Montlake Blvd. E., Seattle, Washington 98102. (Telephone: 442-7729).

APPENDIX 14. Chapter Excerpt from Book by V.P. Kondratev

TT 75-52015

Modeling Commercial Fishing Gear by the Method of Analog Mechanisms

[Modelirovanie Orudii Promyshlennogo Rybolovstva Metodom Mekhanicheskikh Analogii]

V.P. KONDRAT'EV

PISHCHEVAYA PROMYSHLENNOST' PUBLISHERS
MOSCOW, 1973

TRANSLATED FROM RUSSIAN

Published for the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, United States Department of Commerce and the National Science Foundation, Washington, D.C., by Amerind Publishing Co. Pvt. Ltd., New Delhi
1980

APPENDIX 14 (CONTINUED).

tear on the warps. The above condition is also important because modern commercial fishermen have started equating warps according to the tension at the points of suspension. Here the difference in the resistance of boards can lead to a situation where the warp from the side of the board with greater resistance will have more payout than the other.

Let similar type of quantitative evaluation of trawl parameters not be always irrefutable but at present it is more important that they allow qualitative consideration of a series of practical problems. They help, in particular, understand why the trawl occasionally moves away from the vessel. Test results allow us to judge how some deviation from normal rigging affects the operation of the trawl. Tests showed that the difference in the shear force of trawl boards has a strong influence but the difference in resistance hardly affects the horizontal opening of the mouth of the trawl or its displacement. Since displacement of the trawl increases proportionally with trawling speed and the shear force of the trawl boards is proportional to its square, then with any increase in speed the effect of a difference in shear force is more strongly felt. Therefore in rapid trawling it is necessary to pay special attention to accurate adjustment of the boards and regulation of the angles of attack.

Of course, here a somewhat simplified version of design layout will be considered. In reality everything is more complicated with the prototype trawl. In particular, with a change in the shear force or resistance of one of the boards its angle of attack may change and consequently the magnitude of the difference, too. However, apparently these are minor corrections to the layout in question.

Effect of Difference in Warp Length on the Working of the Trawl. When a trawl breaks down repairmen-technicians usually first verify the warps. A half-meter difference in the length of the warps (when their length is 500–700 m) is considered inadmissible. Can we justify such demands on warps and the associated loss of commercial fishing time to make partial measurements? To answer this question the effect of a difference in length of veered warps on the horizontal opening of a 31 m trawl was determined by the method of mechanical simulation.

Initial data. Length of headline and leadline along the net 28 m, length of free ends 1.5 m, length of bridles 50 m; hauling instruments: oval Matrosov trawl boards; area of trawl boards 4.5 m^2, trawling speed 4.5 knots, difference in warp length up to 5 m.

Since the effect of a difference in the warp length on the working of the trawl is greatest for a small length, the tests were conducted for a warp length of 300 m. The working of the trawl was simulated in the vertical plane and it was assumed that under the conditions of study of the difference in warp length the working of the trawl boards was not affected [35]. Let the left warp be shorter than the right warp by 5 m and let the left end of the headline exceed the right by 15% of its length along the net. From graphs for the determination of tension in flexible wire at points of suspension it is obvious that in this case the horizontal component of tension on the left end of the line practically does not change but the vertical component increases by approximately 15%.

Our tests also showed that the change in tension on the bridles practically does not alter the attitude of the trawl boards (see Fig. 21).

Basic data for the model. Taking into account the length of the lines and warps and the dimensions of the experimental setup, the linear scale of the model was taken $\lambda = 0.01$. Accordingly the model has a length of chain simulating lines of 0.28 m and lengths of wires simulating free ends of lines and warp of 0.015 and 2.85 m respectively.

Thin steel wire 0.2 mm in diameter weighing 0.27 N per 100 m was used to represent warps and bridles. The force scale τ was determined from the ratio of the load on the model to the resistance of the net part of trawl. The resistance of the trawl net was taken equal to 80 kN, the total weight of chain as 4.85 N. Thus the force scale was $\tau = 1 : 16500$, i.e. 1 N of the model corresponded to 16.5 kN on the full-scale version.

The value of the weights simulating shear force and resistance of trawl boards was 0.824 and 0.488 N respectively.

Experimental procedure and results. First the horizontal opening of a trawl with equal-length warps was measured. The distance between the trawl boards after conversion to full-scale values was found equal to 41.8 m, the distance between the free ends of lines 16.3 m, and the horizontal opening along the net 15.5 m. These data are close to the results of full-scale tests, which testifies to the suitability of the method of analog mechanisms for the solution of the problem.

We then determined the change in the horizontal opening of the trawl and the lag of one trawl board behind the other as a function of the difference in the length of the veered warps (Fig. 48), using a cathetometer.

The difference in warp length was determined from the ratio of its absolute value ΔL to the length of the headline S_0 along the net. The lag of trawl boards Δy and ends of lines Δy_0 was also determined on the basis of the ratio to the length of the headline. Results of simulation after conversion to full-scale values are shown in Fig. 49. Tests by mechanical simulation showed the change in the horizontal opening of the trawl to be significant only in the case where the difference in warp length exceeds 20% of the length of the headline.

When there is a difference in warp length the trawl lines take the form of catenary along the net with the point of suspension at different heights. With any further divergence in the length of the warps the inclination of the ends of the lines to the direction of trawl motion decreases on the shorter cable

APPENDIX 14 (CONTINUED).

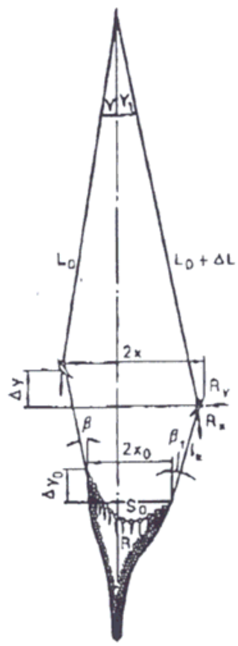


Fig. 48. Distortion of trawl for varying warp scope.

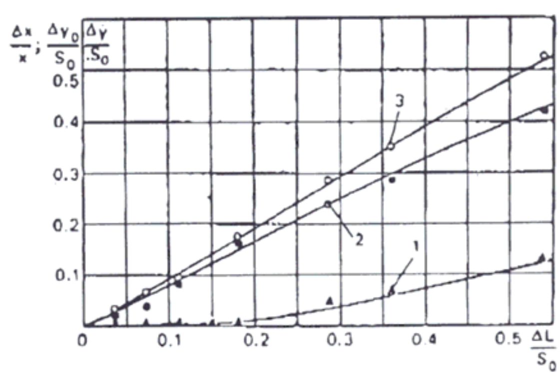


Fig. 49. Dependence of trawl distortion on difference in warp scope:

$1—\frac{\Delta x}{x}$; $2—\frac{\Delta y_0}{S_0}$; $3—\frac{\Delta y}{S_0}$.

side and increases on the longer cable side. The center of the lines is displaced toward the shorter warp (for example, by 3–4 m for a difference of 5 m). As a result the net may be deformed, the netting may be deflected and net 'bags' may form on the side of the longer warp. The net part of the trawl is deformed, the entrance to the dag and sack is constricted and the efficiency of fishing is reduced.

With any increase in the difference in the length of warps the distance between the trawl boards also increases somewhat. This is explained by the fact that the long warp is not as tight as the short one. As a result the trawl board on that side deviates more widely from the centerline plane of the vessel. When the difference in warp length is 10 m the trawl board on the side of the longer warp is at a distance of 26.8 m from the centerline plane. When the difference in length is 15 m, it is 30.2 m; from the shorter warp the trawl boards are at distances of 18.1 and 16.2 m, respectively. The ends of lines deviate from the centerline plane of the vessel by 9 and 10 m for the longer warp and by 7.5 and 6.4 m from the shorter warp.

When the warp lengths differ the trawl is asymmetric. The inclination of the warps to the direction of motion differs accordingly: the longer warp is inclined at a greater angle than the shorter. Since one trawl board lags behind the other their shear forces act in the horizontal plane but not along a straight line, and the trawl deviates from the centerline plane of the vessel toward the side of the longer warp (see Fig. 48). For example, when the difference in warp lengths is 5 m it is displaced by 2.4 m. If the trawl is moving in a mass of water an analogous picture is observed in the vertical plane too. Moving at different depths (deeper on the side of the longer warp than on the side of the shorter), the trawl boards create shear forces acting in different planes and the trawl is deformed in the vertical plane.

When the difference in warp lengths is appreciable there is a danger of the trawl gear getting tangled up.

A difference in warp lengths also results in nonuniform loading on them. The short warp is more loaded than the longer and is tighter. As a result residual strain may appear, altering the warp length. Computations show that this difference in elongation of the warps is considerably less than the initial difference in length and cannot compensate it.

Let the horizontal opening between the trawl boards be $2x$ and along the net $2x_0$. For $\frac{2x_0}{S_0}=0.5$, when the difference in the length of warps is 20% of the length of the headline the tension on the shorter warp increases by 20%. In the longer one it decreases by the same amount when compared to the tension on cables of identical length. Naturally, there is a redistribution of loads on the bridles and the trawl net too. These data tally with experimental results obtained at SEKB on the RT *Muksun* and in our experiments [34] on the *IRB-99* in the Bay of Kursk.

APPENDIX 14 (CONTINUED).

The dependence of the vertical component of tension in a flexible wire on the difference in height of points of suspension with $\frac{2x_0}{S_0}=0.5$ is shown in Fig. 50 with a thick line. The mean experimental data are indicated by dots.

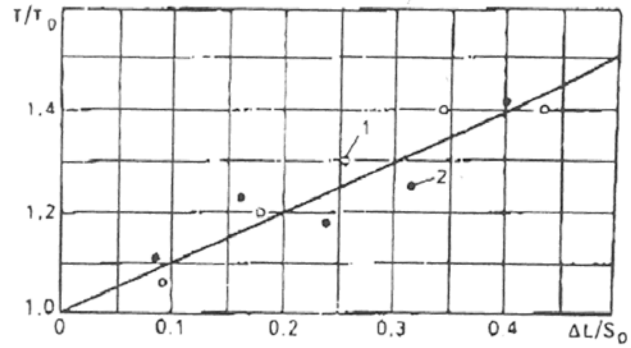


Fig. 50. Dependence of tension of warps on difference in length: *1*—RT *Muksun* SEKB (25 m trawl); *2*—*1RB99* KTI (11.6 m trawl).

In the tests on the *1RB-99* with a difference in warp length of up to 15% of the length of the headline the distance between the trawl boards and fishing efficiency did not change appreciably. With a larger difference in warp length (more than 30% of the length of the headline) fish were caught in the trawl wing on the side of the longer warp. An analogous situation is observed when there is a difference in the length of the bridles. In this case the change in the horizontal opening of the mouth of the trawl is somewhat more pronounced than when there is a difference in warp length. When the difference in warp length is larger one wing of the trawl moves ahead of the other, taking on a greater load. It is possible for the knots of the netting canvas to creep across and twist the trawl.

During underwater observation of a trawl from the bathyplane *Atlant* attached to the RT *Muksun* V.K. Korotkov noted that when there is a difference in warp length the sack twists. This is apparently to be explained by the fact that when there is a difference in warp length the flow becomes asymmetric and the tension on the fishing line appreciably weakens on the side of the longer warp. Under the impetus of an initial twist it continues to twist, engulfing the netting of the sack. Actually in tests from the trawler *Muksun* the sack always twisted around the fishing line on the side of the shorter warp.

APPENDIX 15. Fax Received from Mid-Atlantic Fishery Management Council

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

Ricks E Savage
Chairman

Ronal W. Smith
Vice Chairman

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Tel 302-674-2331
Toll Free 877-446-2362
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Daniel T. Furlong
Executive Director

Christopher M. Moore, Ph.D.
Deputy Director

October 2, 2002

Dr. Fred Serchuk, Chairman
Northeast Trawl Warp Workshop
Northeast Fisheries Science Center
National Marine Fisheries Service
166 Water Street
Woods Hole, MA 02543

Dear Dr. ~~Serchuk~~: Fred

At its meeting today in Wilmington, DE, the Mid-Atlantic Fishery Management Council passed the following motion:

"Move that the Council strongly recommend that NMFS' response to the trawl warp issue include that NMFS require the NEFSC to begin flume tank and tow tank testing of the standard 36 net to determine effects of the misaligned tow cables within 60 days. Upon completion of tank testing, analyze data and determine if research protocols have been affected." (Ruhle/Augustine - carried, 19 yes w/RA abstaining)

During discussions on this motion, it was recommended that this Council action be immediately brought to your attention so that you could inform your workshop participants of our position on this matter. It is hoped by us that a similar request for such flume tank and tow tests will be one of the outcomes/recommendations from your workshop.

Your positive consideration of this action will be appreciated.

Sincerely,

Daniel T. Furlong
Executive Director

DTF/j

APPENDIX 16. PowerPoint Presentation given by Russ Brown

Experiment Cruise to Examine Gear Performance with Offset Warps

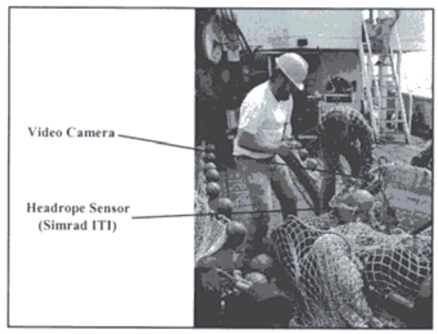
- September 24-27, 2002
  - Video & Mensuration work completed on September 25-26
- Six Industry Participants
  - Bud Fernandes
  - Stephen Lee
  - James Lovgren
  - Sam Novello
  - James Odlin
  - Matthew Stommel

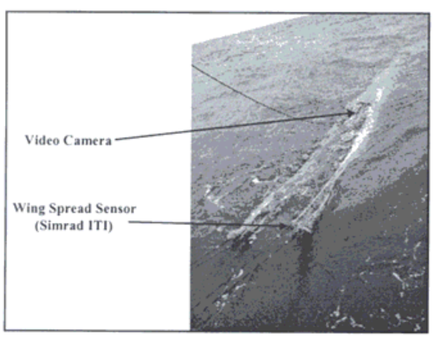
Trawl Warp Experiment

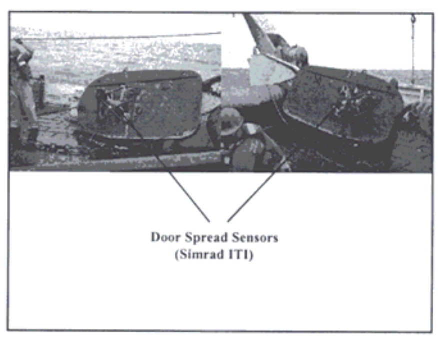
- Two Primary Objectives
  - Provide initial qualitative observations of the effects of offset warps on net geometry and fishing gear performance
  - Provide a quantitative evaluation of the effects of offset warps on net wingspread, door spread and head rope height

Experimental Approach

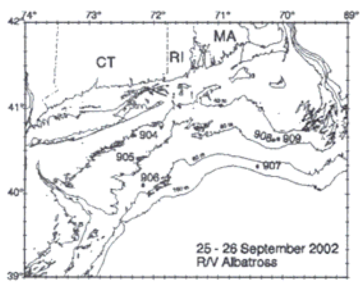
- Intentional Manipulation of Trawl Warp Lengths
  - Even Warps
  - Starboard and port offsets of 0, 2, 4, 6, 12, 18 feet
- Qualitative Evaluation of Trawl Performance through Video Observation
  - Net shape and geometry
  - Roller and foot gear tending
  - Fish behavior
- Quantitative Evaluate of Trawl Geometry through Net Sensor Measurements
  - Wing Spread
  - Door Spread
  - Headrope Height







APPENDIX 16 (CONTINUED).



Locations of Video and Sensor Experiments of Trawl Warp Offsets

Video Images & Sensor Data

Water Depth (m)	Starboard Longer ←					Even Warps				→ Port Longer	
25 - m		*Poor Visibility*				Even			*Poor Visibility*		
45 - m			6-ft		2-ft	Even	2-ft		6-ft	12-ft	
51 - m	*Wing Camera Deployment – Full Sensors, Limited Video*										
52 - m		12-ft	6-ft	4-ft	2-ft	Even	2-ft	4-ft	6-ft	12-ft	
60 - m		12-ft	6-ft	4-ft	2-ft	Even	2-ft	4-ft	6-ft	12-ft	
71 - m		12-ft	6-ft	4-ft	2-ft	Even	2-ft	4-ft	6-ft	12-ft	
92 - m	18-ft	12-ft	6-ft	4-ft	2-ft	Even	2-ft	4-ft	6-ft	12-ft	18-ft

Video Images Collected

- Roller Sweep
- Starboard Corner and Wing
- Port Corner and Wing
- Transitional Clips
  (during changes in warp length)

Results Presentations

- Net Mensuration Data (Lisa Hendrickson)
- Video Images (Henry Milliken)
  - Sampling of video images from each tow
    - Transition from previous to new warp length (when available)
    - Roller sweep
    - Port and starboard wings

APPENDIX 17. PowerPoint Presentation given by Lisa Hendrickson

Measuring Gear Performance
on the
R/V *Albatross IV*

Trawl Performance

Monitored during each tow

Data from sensors mounted on doors, wings and headrope are transmitted to the ship and logged into a computer file at set time intervals

Quantitative Sensor Measurements

- **Headrope Height** – distance between the headrope and footrope, vertical opening of net
- **Wing Spread** – distance between the wings
- **Door Spread** – distance between the doors
- **Other parameters** – trawl speed, depth, and location

Trawl Performance

Monitored during each tow

Data from sensors mounted on doors, wings and headrope are transmitted to the ship and logged into a computer file at set time intervals

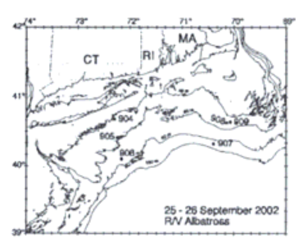
Sensor data can be used to determine whether the net is operating properly

We will examine sensor data from the trawl warp offset study to evaluate gear performance

Gear Performance Charts

Data from six stations are presented in order of shallow to deep locations (46-91 m depth)

Station Locations



Locations of Video and Sensor Experiments of Trawl Warp Offsets

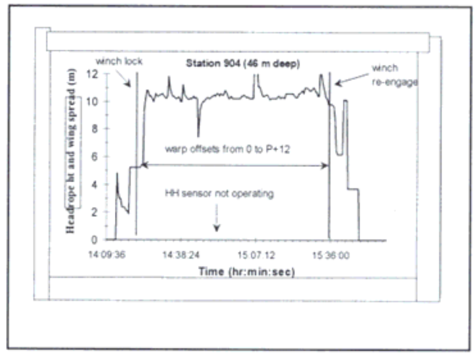
APPENDIX 17 (CONTINUED).

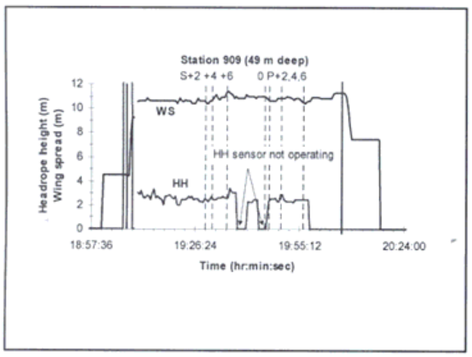
Gear Performance Charts

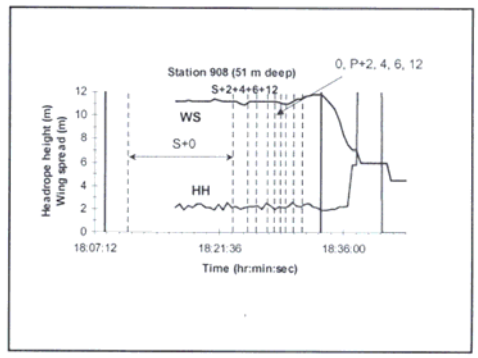
Data from six stations are presented in order of shallow to deep locations
(46-91 m depth)

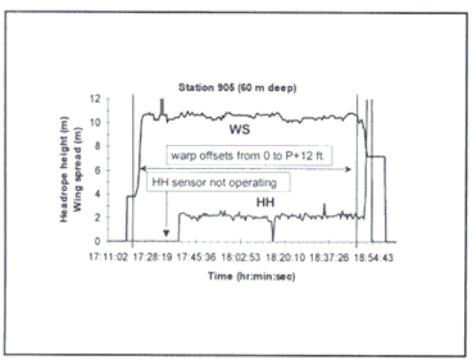
Changes over time, in HH and WS, are presented along with demarcations indicating the timing and type of trawl warp length offsets

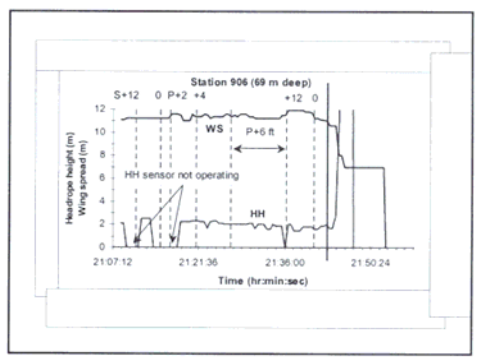
DS and WS have a geometric relationship with one another; only WS data will be presented today



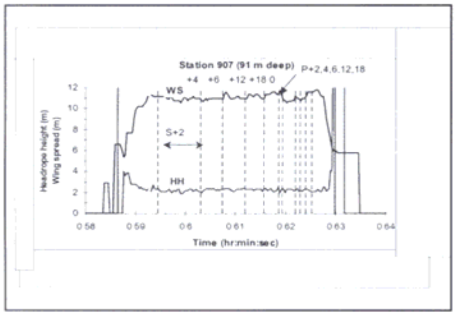


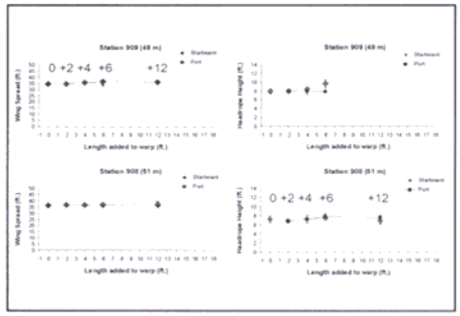


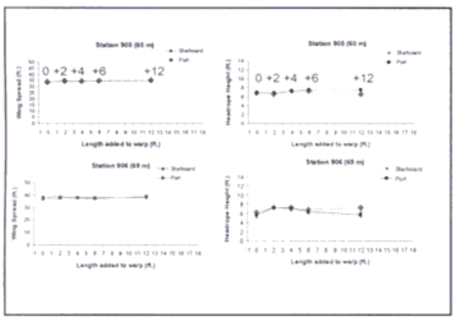


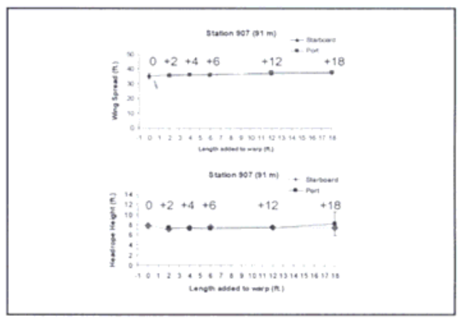


APPENDIX 17 (CONTINUED).









Summary

Mean HH and WS values were similar for port and starboard warp length offsets

There was no significant difference detected between WS means for warp length offsets of 0-6 ft. at depths of 46-91 m

There was no significant difference detected between HH means, at all but one station, for warp length offsets of 0-6 ft. at depths of 46-91 m

Summary

HH and WS means for warp length offsets of 12 and 18 ft. were not significantly different for some stations, but were for other stations

APPENDIX 18. PowerPoint Presentation given by Mike Fogarty

Comparative Fishing Trials

Trawl Warp Offset Experiments

Design and Sample Size Considerations

Experimental Design

- •Paired Tows
- •Control (No Offset)
- •Treatment (Several Offset Levels)

Measurements

- •Catch Differences (Numbers and Weight)
- •Size Composition Differences
- •Net Mensuration
- •Environmental Conditions

How Many Paired Tows are Enough?

Need to Decide on:

- •How much of an effect do we want to detect?
- •What is the chance of detecting a statistically significant effect?
- •Are we interested in a directional change?

Need Information on the variability expected in the catch differences

To get a first cut estimate of required sample size we examined comparative fishing trials between Albatross IV and Delaware II in the spring of 2002 conducted on Georges Bank and the Gulf of Maine (133 Paired Tows)

Cod caught in 78 paired tows

Should give upper-end estimate of sample size needed

Cod Results: Upper-End Sample Size Requirements

To have a 90% chance of detecting a statistically significant difference for a 50% decline in cod catch in weight would require **62 paired tows**.

To have a 90% chance of detecting a statistically significant difference for a 25% decline in cod catch in weight would require **240 paired tows**.

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Northeast Fisheries Science Center
National Marine Fisheries Service, NOAA
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Publications and Reports of the Northeast Fisheries Science Center

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NOAA Technical Memorandum NMFS-NE -- This series is issued irregularly. The series typically includes: data reports of long-term field or lab studies of important species or habitats; synthesis reports for important species or habitats; annual reports of overall assessment or monitoring programs; manuals describing program-wide surveying or experimental techniques; literature surveys of important species or habitat topics; proceedings and collected papers of scientific meetings; and indexed and/or annotated bibliographies. All issues receive internal scientific review and most issues receive technical and copy editing.

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Fishermen's Report -- This information report is a quick-turnaround report on the distribution and relative abundance of commercial fisheries resources as derived from each of the NEFSC's periodic research vessel surveys of the Northeast's continental shelf. There is no scientific review, nor any technical or copy editing, of this report.

The Shark Tagger -- This newsletter is an annual summary of tagging and recapture data on large pelagic sharks as derived from the NMFS's Cooperative Shark Tagging Program; it also presents information on the biology (movement, growth, reproduction, etc.) of these sharks as subsequently derived from the tagging and recapture data. There is internal scientific review, but no technical or copy editing, of this newsletter.

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