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Final Report

Design and Test of a Semi-pelagic Shrimp Trawl to Reduce Seabed Impact

Final Report

Submitted to:

The Northeast Consortium
142 Morse Hall
University of New Hampshire
Durham, NH 03824

July 2006 **UNH-FISH-REP-2006-029**

Design and Test of a Semi-pelagic Shrimp Trawl to Reduce Seabed Impact

by

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Design and Test of a Semi-pelagic Shrimp Trawl to Reduce Seabed Impact

Abstract. Bottom trawling including shrimp trawling alters physical and biological structure of the seabed. While the effect of alteration on benthic ecosystems and fish/shellfish populations may vary with seabed type, bottom complexity, benthic community structure, and oceanographic conditions of the fishing grounds, reducing alteration to the seabed by fishing activities would be viewed positively by all concerned with the marine environment and fishery. This project is the second phase of the project "Reducing Seabed Impact of Trawling". The first phase involved gear design and model tests of a semi-pelagic shrimp trawl in a flume tank (He *et al.*, 2002). This report describes the second phase which involved sea trials of a new semi-pelagic shrimp trawling system on board commercial shrimp trawlers in the western Gulf of Maine. In 2003, catch of shrimp from the experimental trawl was compared with the average of the vessels fishing in the same general area. In 2004, another commercial trawler (F/V "Janice Marie") was contracted to fish side by side with F/V "Lady Regena" fishing with the experimental semi-pelagic trawl. Catch results were variable, indicating that the semi-pelagic trawling system with trawl doors off bottom had potential to catch a similar amount of shrimp, but the system is very sensitive to depth change, tidal current and turning. Though similar catch rates can be realized with carefully controlled rigging and monitoring, with the existing deck machinery and fishing conditions in the Gulf of Maine, application of the semi-pelagic fishing method is not recommended in this fishery. However, it has potential for application in other pink shrimp fisheries where more sophisticated deck equipment is available, fishing areas are larger and sea bottom is flatter.

1. INTRODUCTION

Trawling is one of the major fishing methods for harvesting groundfish, flatfish, and shrimps in New England waters. According to Dorsey and Pederson (1998a), the area swept by trawls in the Gulf of Maine equals to the area of the gulf itself, ie. every square meter of the gulf is swept once every year. Concentrated trawling areas such as Georges Bank have reported to have been swept three to four times every year during the last decade. There are many, often contradictory, opinions and results regarding the effect of trawling on fish population and biodiversity, but they are generally on the negative side. With the Essential Fish Habitat requirement in the 1996

Sustainable Fishery Act, evaluation of the effect of trawling on fish habitats and devising means to reduce negative effects has become a priority in fisheries research.

The International Council for the Exploration of the Sea (ICES) Working Group on Ecosystem Effect of Fishing Activities (ECO) and the Working Group on Fishing Technology and Fish Behavior (WGFTFB) have been examining trawling effects for many years. ICES WGFTFB meetings held in St. John's, Newfoundland in 1999 and in Haarlem, the Netherlands in 2000 discussed extensively the alteration of the seabed caused by towed gears such as bottom trawls, beam trawls and shellfish dredges, and the potential impact of these alterations (ICES, 1999; 2000). Most recently, WGFTFB discussed a focus topic on mitigation measures to reduce seabed impact during fishing operations (ICES, 2004). Researchers in ICES member countries including those in the United States were encouraged to initiate or continue studies to evaluate impact or to reduce the potential impact of towed fishing gears on the seabed. In the United States, reducing seabed impact of fishing operations and protecting essential fish habitat is required in Sustainable Fishery Act (SFA). While physical alterations of the seabed by towed gears are evident, the effect of the alterations on benthic organisms and recovery rates of the alteration is variable depending on location, depth, and natural disturbance in the area. The researchers are making efforts to quantify the effects and to devise means to reduce alterations and their impact on the ecosystem.

Several studies have been completed and many are ongoing concerning the potential impact of fishing with bottom trawls on the seabed and marine habitat. The MIT Sea Grant conference held in 1997 (Dorsey and Pederson, 1998b) and the NOAA conference on "Effect of Fishing on the Seabed" held in 2002 (proceeding yet to be published) summarized progress in this country. While the impact of physical alterations of the seabed by bottom trawls on benthic organisms is not well understood, and varies with many factors, lessening the potential effect will be welcomed by all concerned with the issue. Another recent publication "Effect of Trawling and Dredging on Seafloor Habitat" by National Research Council (NRC, 2002) documented various effects of trawling and dredging. One of the recommendations by NRC's Committee on Ecosystem Effects of Fishing is to modify gear designs and operations to reduce seabed contact during fishing. The Committee further pointed out that development of new low impact gear should use fishermen's knowledge and experience to "ensure mitigation strategies are practical, enforceable, and acceptable to the fishing community" (NRC, 2002, p6).

The otter trawl is the primary fishing gear for harvesting shrimps in the world. Of shrimp trawling operations, the bottom otter trawl, with both trawl doors and the trawl on the seabed, is the most

important gear. Bottom trawls were developed for harvesting groundfish species. Sand clouds and bridles connecting the doors and the wingends herd fish toward the mouth of the trawl. Therefore, good bottom contact of the door and the bridle are very important for efficient harvesting of groundfish species, especially flatfish species. Shrimp, on the other hand, cannot be herded by sand clouds and wires due to poor swimming ability. The mouth area of the trawl determines, to a large extent, the amount of shrimp caught. Therefore, a trawl system with the trawl door off bottom and the trawl on the bottom should not reduce the capture efficiency of the gear, but it would reduce disturbance of the seabed by the trawl door. Such trawling system is called a semi-pelagic trawl. In addition, pelagic trawl doors working off-bottom offer good lift to drag ratio and can save fuel during trawling.

2. OBJECTIVES

The overall objective of the project was to eliminate seabed contact of trawl doors by using a pair of pelagic trawl doors operating off the seabed while keeping the ground gear on the seabed, thus maintaining the same harvesting efficiency. The project involved redesigning of the front part of a commercial shrimp trawl, choosing a pair of midwater trawl doors through flume tank simulations and commercial evaluation and field trials of a semi-pelagic shrimp trawling system. The specific objectives of the project were:

- To evaluate gear design and flume tank test results of a semi-pelagic shrimp trawl and to produce a practical design and rigging plan of a prototype semi-pelagic shrimp trawl (Phase I);
- To fabricate/select a prototype gear including a pair of midwater trawl doors suitable for an inshore shrimp trawler of 45-55' (Phase II);
- To conduct fishing trials on board commercial fishing vessels to evaluate operation and catch efficiency of a semi-pelagic shrimp trawl system (Phase II);
- To transfer semi-pelagic shrimp trawling technology to the commercial fleet in the Gulf of Maine and provide outreach and technical assistance to the industry (Phase III).

3. PARTICIPANTS

The Project participants included Pingguo He who was assisted by Rachel Hamilton, both of University of New Hampshire. The primary industry partner was George Littlefield of F/V "Lady Regena" based in Seabrook, NH. Richard Syphers of F/V "Janice Marie", also based in Seabrook participated in comparative fishing trials in 2004. Gear design and flume tank testing was assisted by Harold DeLouche and George Legge of Center for Sustainable Aquatic Resource of Memorial University. Mr. DeLouche also participated in sea trials in the 2003 fishing season. Bob Campbell of Yankee Fishermen's Coop supplied shrimp landing data of commercial fishing vessels fishing in the same area.

4. METHODS

4.1 Gear Design Concept

The bottom trawl is the primarily fishing gear for harvesting shrimps in the world. Bottom trawls were initially developed for harvesting groundfish species. Sand clouds and bridles connecting the doors and the wingends herd fish toward the mouth of the trawl. Therefore good bottom

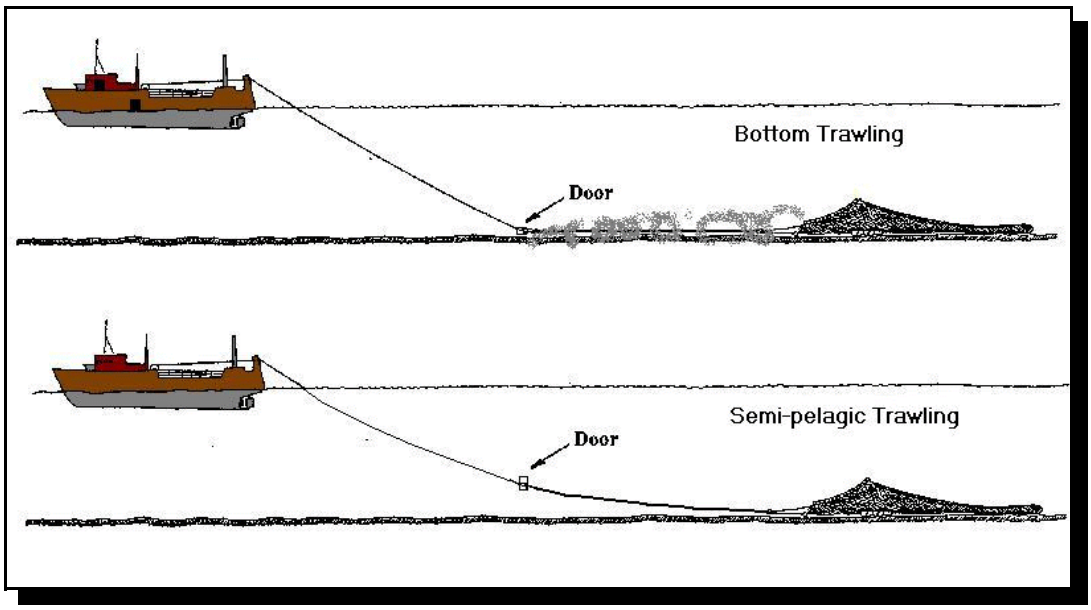

Exhibit 1. Illustration of bottom trawling and semi-pelagic trawling.

contact of the door and the bridle are very important for efficient harvesting of groundfish species, especially flatfish species. Shrimp, on the other hand, cannot be herded by sand clouds and wires due to poor swimming ability. The mouth area of the trawl determines the amount of shrimp caught. Therefore, a trawl system with the trawl door off bottom and the trawl on the bottom should not reduce the capture efficiency of the gear, but it would reduce disturbance of seabed by the trawl door. Such trawling system is called a semi-pelagic trawl (Exhibit 1). In addition, pelagic trawl doors working off-bottom offer good spread to drag ratio and can save fuel during trawling.

Based on the above concept, a four-panel trawl modified from a typical shrimp trawl used in Gulf of Maine inshore shrimp fishery was designed (Exhibit 2).

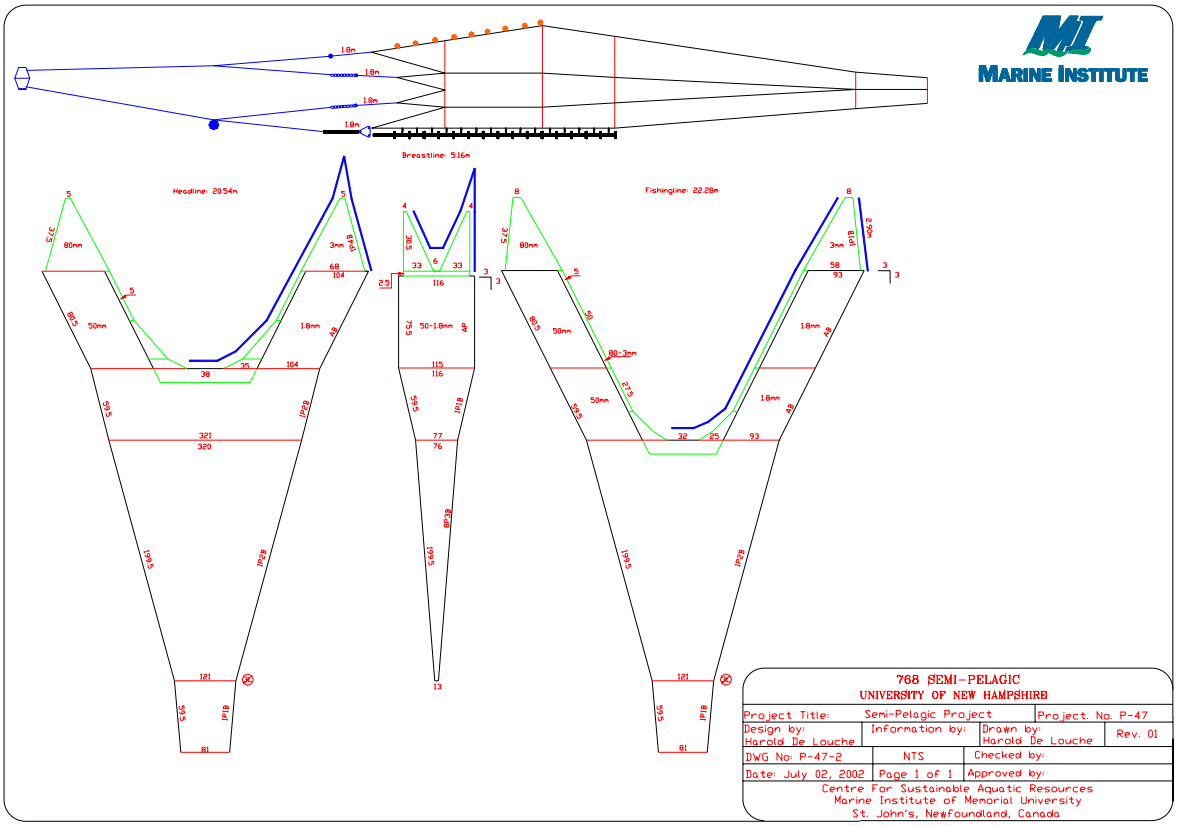

Exhibit 2. Net plan of the semi-pelagic shrimp trawl.

4.2 Tank Test

A 1:5 scale trawl model was constructed by the staff at the Fisheries and Marine Institute of Memorial University of Newfoundland, and was subsequently tested at its world-class flume tank

(Exhibit 3). We determined a combination of bridle lengths, weights, floats, and towing speeds, where the trawl would be steadily on bottom, while keeping the door at a distance from the bottom. A total of twelve rigs was tested during a two-day test period in June of 2002. Capt. George Littlefield and Dr. Pingguo He participated in flume tank tests in Newfoundland.

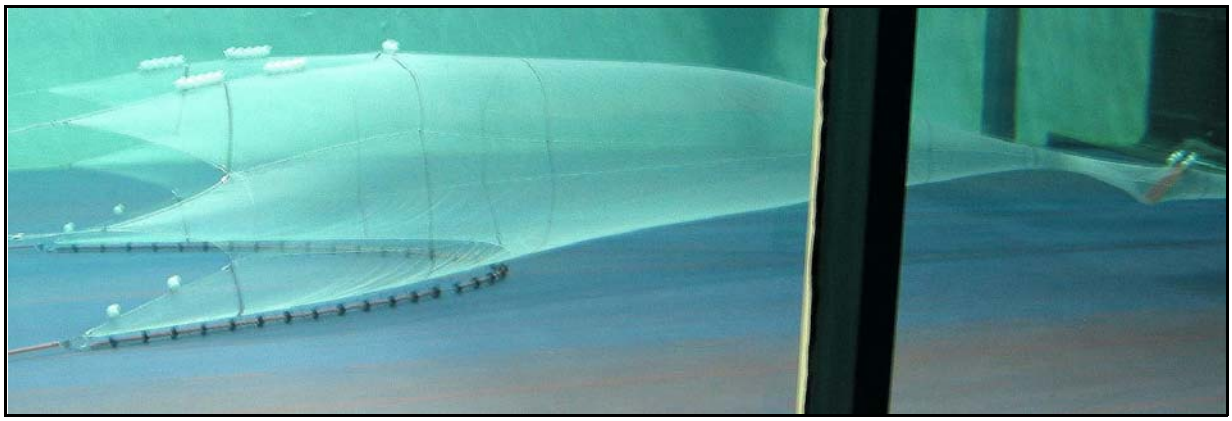

Exhibit 3. The shrimp trawl model as seen in a flume tank.

Another session of flume tank tests was conducted during the summer of 2003. Various kites were installed at different positions in the semi-pelagic trawl (Exhibit 4). The purpose was to demonstrate if kites could be used as "depressors" to help keep the wing section on the seabed without additional weight. It was found that the kites were not effective in keeping the trawl on the seabed. Subsequently, no sea trials were carried out on the kite use on the semi-pelagic trawl.

Exhibit 4. Kites in stalled in the semi-pelagic shrimp trawl model as seen in the flume tank.

4.3 Full Scale Trawl and Rigging

Trawl. The four-panel trawl was designed by Mr. Harold DeLouche with inputs from project participants and refined through flume tank tests. The rear part of the trawl, including Nordmore Grid, is similar to other shrimp trawls commonly used in Gulf of Maine. The front part of the trawl was designed in such a manner so that the lower part of the trawl mouth would tender the seabed while the trawl doors are towed off bottom. The trawl was fabricated by Trawlworks Inc. of Rhode Island as per specification.

Trawl doors. Selection criterions for the trawl door for the project included stable and efficient operation when the doors are on or off the seabed. While the aim of the project is to keep the doors off bottom, it was considered essential that the doors would not be damaged if it is in contact with the seabed. Such bottom contact is inevitable at early stages of experiment. Other consideration of selecting a pair of suitable doors included light weight, high lift coefficient, and high lift to drag ratio. With these considerations, a pair of 1.9 m^2 Poly-Ice® El Cazador doors (Hampidjan hf., Iceland) was selected for the project (Exhibit 5). Each door measured 1.660 m high and 1.245 m wide, and weighed 240 kg (528 lbs) in air.

Exhibit 5. Poly-Ice El Cazador trawl door used for semi-pelagic shrimp trawling experiment.

Bridle rigging. The initial bridle rigging included two bridles splitting to three at the wingends (Exhibit 6A). Upper and lower bridles were attached to the upper and lower attaching points of the doors via two 5 m backstrops. An idler chain connected both upper and lower bridles as per suggestions by the door manufacturer. Backstrops and idler chains were later replaced by

combination wires for easier operation. Total length of the bridles was 180' from the wingend to the door, excluding backstrop length. Upper bridles were made of 3/8" wire, while the lower bridles were of 5/8" wire. Wingend weight of 100 lbs was added at the start of the experiment as per flume tank tests. The amount of wingend weight was reduced as the experiment progressed. Rigging was changed to that shown Exhibit 6B for easy operation and adjustment during the second half of the 2003 season.

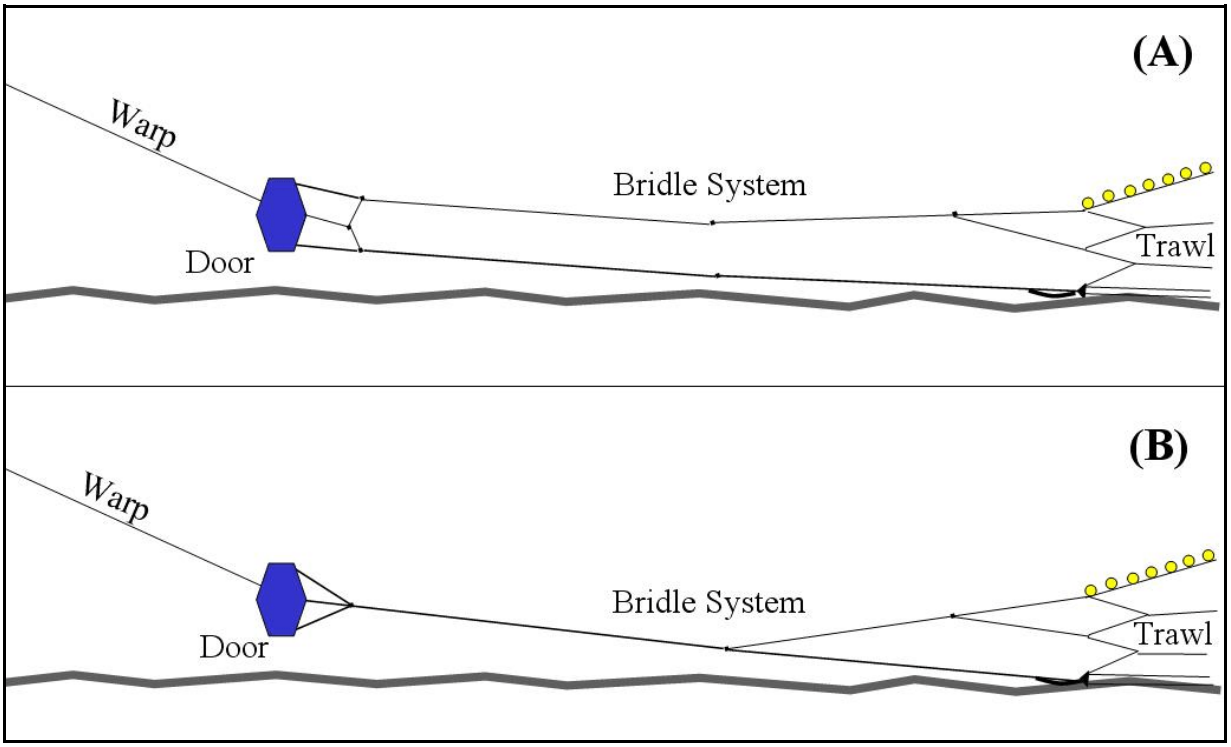

Exhibit 6. Two variations of bridle rigging tested during the sea trials.

Engineering trials were carried out in the summer of 2003 to examine whether bridles of 90' (conforming to current shrimp regulations) can be used instead of the180' bridles used in winter of 2003 shrimp season. Positive results led to flume tank tests in December of 2003 to further refine the short bridle rigging. Rigging used in the winter 2004 shrimp season can be seen in Exhibit 7.

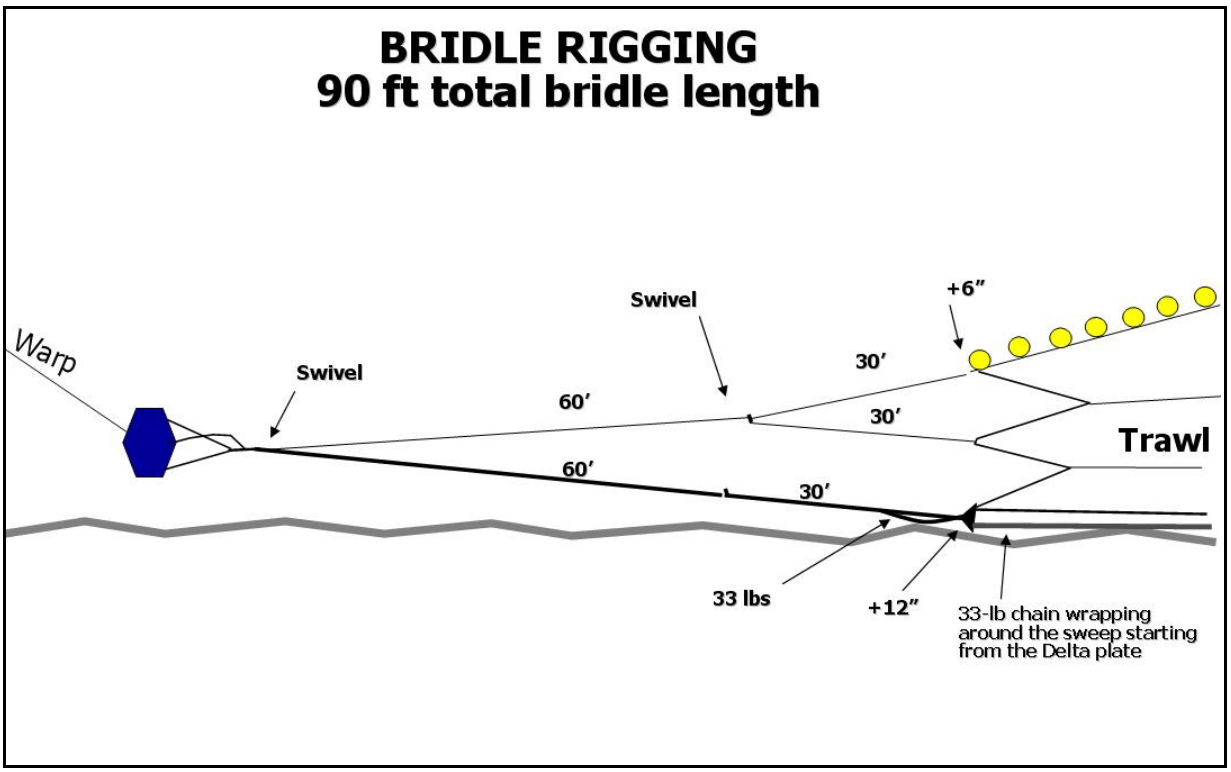

Exhibit 7. Ninety-foot bridle rigging used in 2004 shrimp season.

4.4 Sea Trials

Vessels. Two fishing vessels were used for the sea trials. During 2003 sea trials, F/V "Lady Regena" based in Seabrook, NH was used as research platform (Exhibit 8). F/V "Lady Regena" is a 55' LOA wooden vessel rigged for commercial shrimp trawling operations. The vessel was captained by Mr. George Littlefield of Kensington, NH, the industry partner. During the 2004 sea trials, another vessel F/V "Janice Marie" also based in Seabrook, NH was used to compare catch and bycatch with those of F/V "Lady Regena" using the experimental semi-pelagic shrimp trawl. F/V "Janice Marie" used commercial gear fishing on the bottom.

Exhibit 8. F/V "Lady Regena" (top), and F/V "Janice Marie", both based in Seabrook, NH.

Fishing Operations. Fishing was conducted between the end of January and the end of February, 2003 and 2004 off the coast of New Hampshire in western Gulf of Maine. The experimental period was limited by fishing season regulated by the Atlantic States Marine Fisheries Commission.

During 2003, F/V "Lady Regena" was used to determine suitability of the trawling system, and warp length/water depth ratios. During 2004, F/V "Lady Regena" and F/V "Janice Marie" did comparative fishing using the parallel tow method. In this later case, two vessels were kept in close proximity for most of the tows. Towing speed was kept at around 2.4 knots, though slight deviation occurred due to tides and currents. Tow duration was one hour for the majority of tows.

Fishing grounds. The area fished is shown as shaded in Exhibit 9. Effort was made to tow at a similar depth during each tow so that warp length would not have to be changed during towing. Frequent turning was required due to small suitable fishing areas. The depth strata fished were

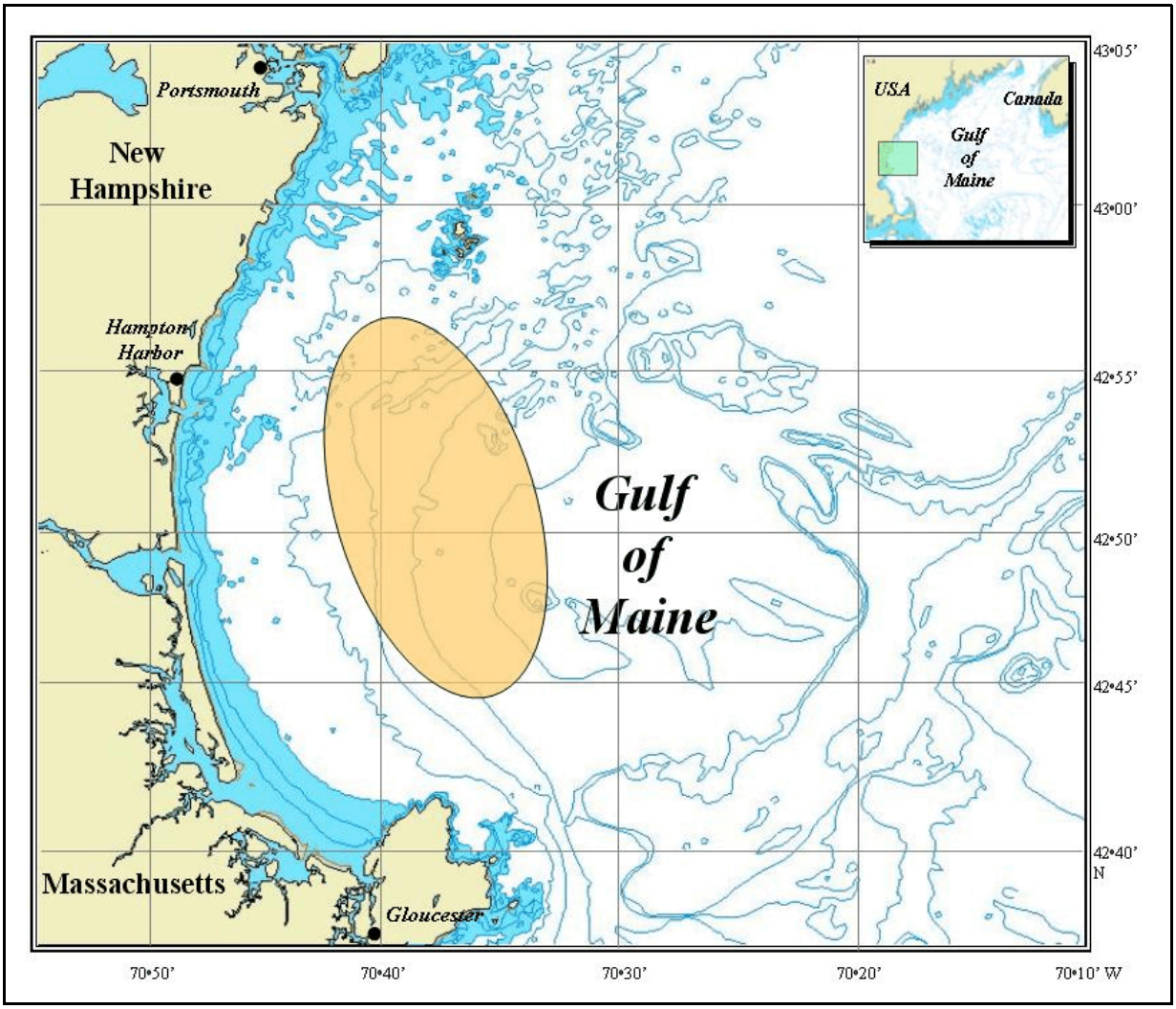

Exhibit 9. Fishing area (shaded) during 2003 and 2004 fishing seasons.

30~31 fm, 35~36 fm, 38~39 fm, and 49~50 fm. The majority of fishing was carried out in 30~31 fm, and 35~36 fm depth strata.

The warp-depth ratio was low compared with typical values previously used by F/V "Lady Regena" and other vessels fishing on the same grounds. Determining suitable warp-depth ratios to keep the doors off bottom while leaving the trawl sweep on the bottom was one of the subjects investigated, and will be reported in the results section.

4.5 Gear monitoring

Trawl door spread (distance between the doors) and door height off the seabed were monitored using NetMind® acoustic trawl monitoring equipment (Northstar Technical Inc., Canada). Wingend spread was also measured in some tows. For measuring door spread and door height, sensors were installed on the upper backstrops behind the doors. A receiver hydrophone was towed from a stabilizing arm. A notebook computer was used to acquire and log measured data.

4.6 Catch sampling and measurement

Catch of shrimp and bycatch species from each tow were weighed to the nearest pound. Major bycatch species were noted. To quantify shrimp size, the "count" (number per pound) was determined from the average of three samples of approximately one pound of shrimp were taken from each tow. Samples were also taken for measurement of carapace length and weight of individual shrimps to determine weight-length relations.

In 2003, the Yankee Fishermen's Cooperative provided landing data of other vessels fishing in the same general area, allowing comparisons of shrimp catch of the experimental gear with that of commercial operations to be made. In 2004, data from the comparative fishing trials involving two vessels were used for analysis.

5. DATA

Attached as appendix.

6. RESULTS

6.1 Tank test

The tests were carried out with respect to a change in towing speed from 2.0 knots to 2.6 knots, and with a change of door height of up to 30' off bottom. The distance of the footrope (sweep) off bottom, along with headline height, wingend height, door spread, and drag forces of the trawl system were measured. We were to achieve a stable footgear ground contact with a large range of door height variation. To achieve that, we found that we needed to:

- ✓ Extend the length of the bridle from 90' to 180'
- ✓ Move the 100 lbs of chain weights from the end of the lower mini-bridle to the end of lower wing

We also found that three mini-bridles would be more suitable for the trawl instead of initial four-mini bridles. The wingend will be accordingly redesigned to match the three-mini-bridle system. The final rig is illustrated in Exhibit 10 and also shown as a photograph in Exhibit 3.

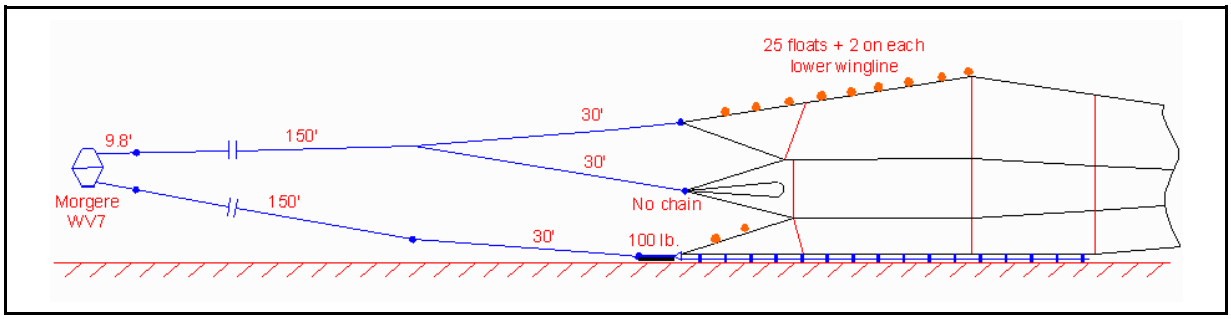

Exhibit 10. The final rig of the new semi-pelagic shrimp trawl for 2003 sea trials.

6.2 Gear refinements

The original two-bridle-split-into-three configuration required hooking and unhooking of two G-hooks for each door, and had potential for mismatches of upper and lower bridles during deployment. Furthermore, this rigging transferred all setback adjustment at the wingend to the door, resulting in changes to the door pitch. The modified bridle system was one-bridle split-into

three rigging as seen in Exhibit 6B. This change reduced the number of G-hooks to one per side, the same as commercial rigging. This rigging allowed for adjustment of wingend setbacks to change forces acting on the headline or the footgear.

The initial rigging included 100 pounds of weight on each side at the lower wingend (total 200 lbs) The weight was gradually reduced and redistributed during the experimental period. At the end of 2003 trials, 33 lbs of weight (each side) at the bridle and 38 lbs at the bosum (total 104 lbs). In 2004 trials, an additional 33 lbs of weight was added to each lower wing.

6.3 Warp-Depth Relation

The primary means used to bring trawl doors off bottom was to reduce warp length. Careful warp marks were made to record warp length to the nearest fathom. The warp length required to keep the doors off bottom was about 15 fm shorter than the length typically used by the commercial fleet at depths between 30 and 50 fm when using 55 m (180') bridles during 2003 trials (Exhibit

Water depth fished (fm)	29~31	34~36	37~39	49~50
Warp length typical (commercial, fm)	100	125	125	150
Warp length used (exp., fm)	75~85	90~110	75~110	125~135
Warp length recommended (exp. fm)	85	100	105	130

Exhibit 11. Warp lengths typically used during commercial operations with trawl doors on the bottom, and experimental operations with the doors off bottom.

11).

During the 2004 sea trials, the warp length for the experimental trawl was 3 to 10 fathoms less than the commercial length and the total bridle length was 90' which was the maximum allowed bridle length in shrimp regulations as stipulated in the Atlantic States Fisheries Management Commission (ASFMC).

6.4 Gear engineering performance

The Poly-Ice El Cazador trawl doors showed good promise in semi-pelagic shrimp trawling with respect to both operation and performance. The doors were easy to handle during retrieval and deployment. The doors were seen to spread soon after submerging from the water surface. NetMind acoustic sensors were mounted at the backstrops of doors, the headline, and the wingends. They measured door spread, door height above seabed, headline height and wingend spread. As expected, the door spread varied with water depth and warp length, but was normally within 45 to 50 m (148' - 164'). The wingend spread remained relatively consistent at around 10 m (33') and the headline height was about 4 m, comparable with data measured from flume tank tests.

Exhibit 12. Photograph showing polish marks of the starboard door shoe after 38 tows in the 2003 Gulf of Maine experiments.

In addition to monitoring the height of doors through instrumentation, visual inspection and photographic recording of door shoe conditions was made. After 38 tows fishing over eight days, only about 30% of the area of door shoes was polished, indicating very light and intermittent contact during turning and depth change (Exhibit 12).

6.5 Catch of shrimp - 2003 trials

Shrimp catches varied between days and individual tows. In 2003, catches ranged from zero when the net was not on bottom, to as much as 157 kg/hr. A total of 2,192 kg of shrimp was caught in 38 one-hour tows, averaging 57 kg/hr.

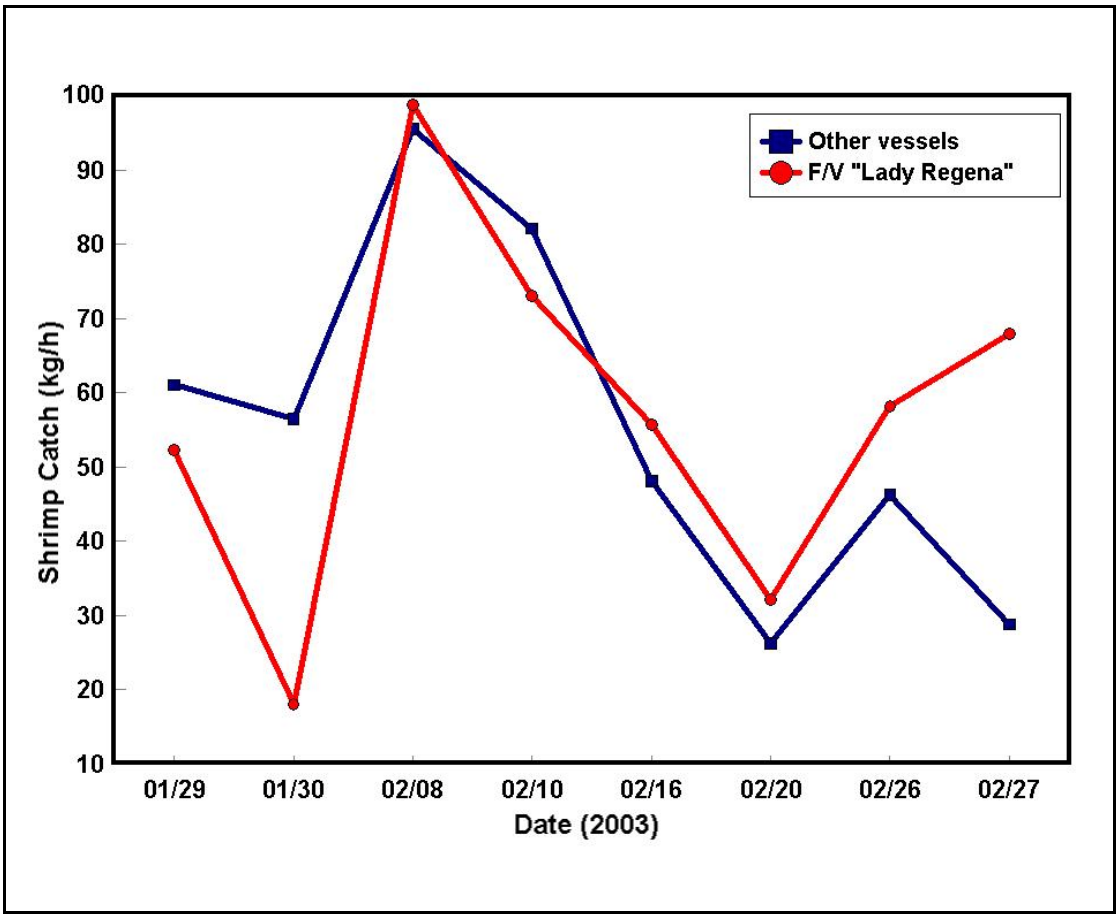

Exhibit 13. Catch rates of shrimps from the semi-pelagic trawl operated by F/V "Lady Regena" and those of commercial vessels during 2003 trials in the Gulf of Maine.

The catch rate of the experimental trawl and average hourly catch rate of other vessels landed at Yankee Fishermen's Coop in Seabrook, NH is shown in Exhibit 13. It can be seen that catch by the experimental trawl with trawl doors off bottom (F/V "Lady Regena") is comparable with the catch rate of other vessels and showed a trend of better catch rates toward the end of the fishing season when the experimental trawl was tuned up. However, comparison with the commercial

vessel catch should be viewed with caution as operations by the commercial vessels were not controlled, and their hours towed were estimated.

Shrimp size ranged from 38 to 42 count (number of shrimp per pound), with exception of one day when the shrimp size was much smaller (45 to 74 count). Relationship between weight and carapace length for shrimp samples in January and February 2003 is shown in Exhibit 14.

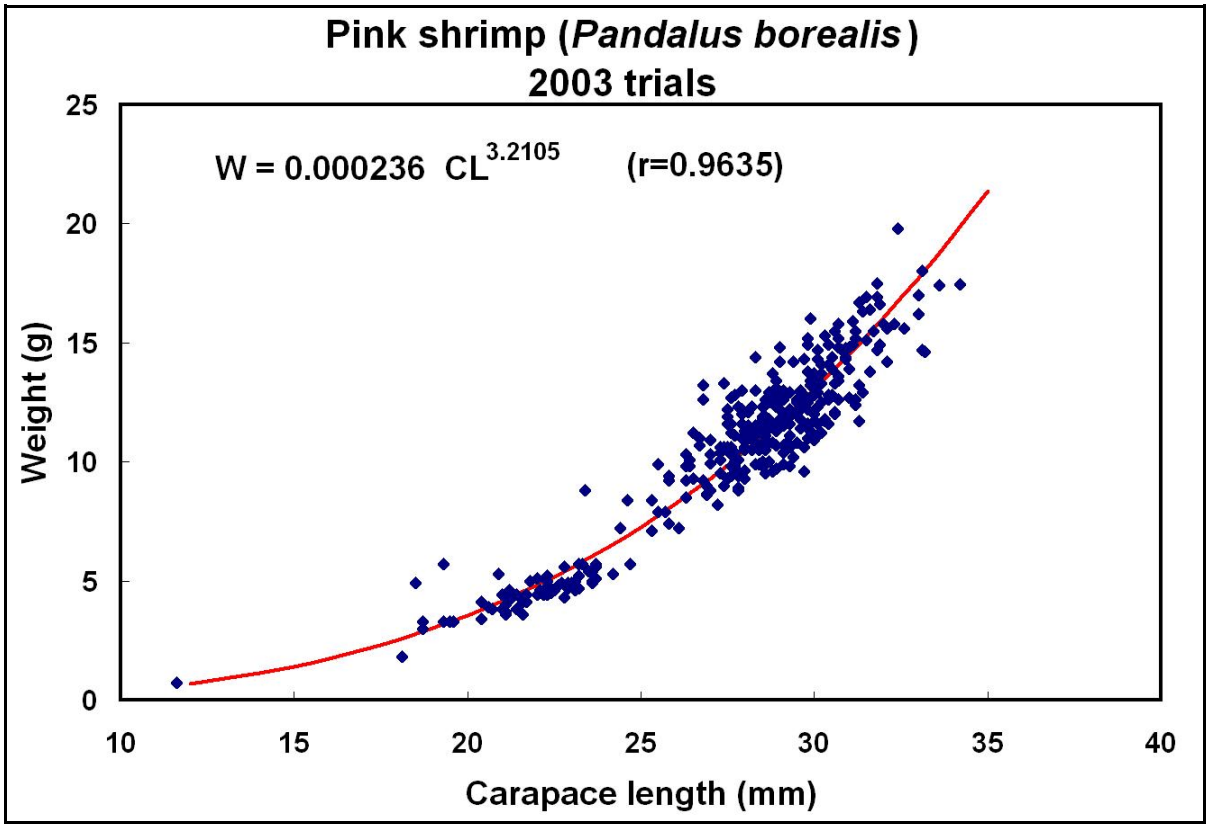

Exhibit 14. Weight and carapace length relation for the pink shrimp, *Pandalus borealis*, off New Hampshire during January and February 2003.

6.6 Shrimp Catch: two-vessel comparative fishing trials in 2004

Ninety-feet bridle lengths were used in the winter 2004 trials. Tow by tow comparison indicates that the experimental gear has lower catch rates than the commercial gear. Catch rates of the 2004

season are shown in Exhibit 15. Data pairs with depth differences more than 5 fathoms, average door height greater than 5 m for the experimental trawl, as well as tows with zero catch were excluded from the graph and analysis. There were a few tows that the experimental gear was not tuned up for the depth, resulting in very low catches. When properly tuned, the experimental gear with doors off bottom can catch as much shrimp as the commercial gear with doors on bottom as seen in the later part of the experiment (from Tow 20). The experimental gear caught significantly less shrimp (average 173 lbs/hr vs 255 lbs/hr) when all valid tows were considered (paired t-test, t=4.087, dof=20, P<0.001). But there was no significant difference during the later part of the experiment (after Tow 20) when the experimental gear was better tuned (paired t-test, t=1.836, dof=8, P>0.05). The size of shrimp caught by the experimental trawl was significantly larger than that of the commercial trawl (P<0.001). The experiment net retained shrimp of 48.7 count, compared with that of the commercial trawl at 53.5 count.

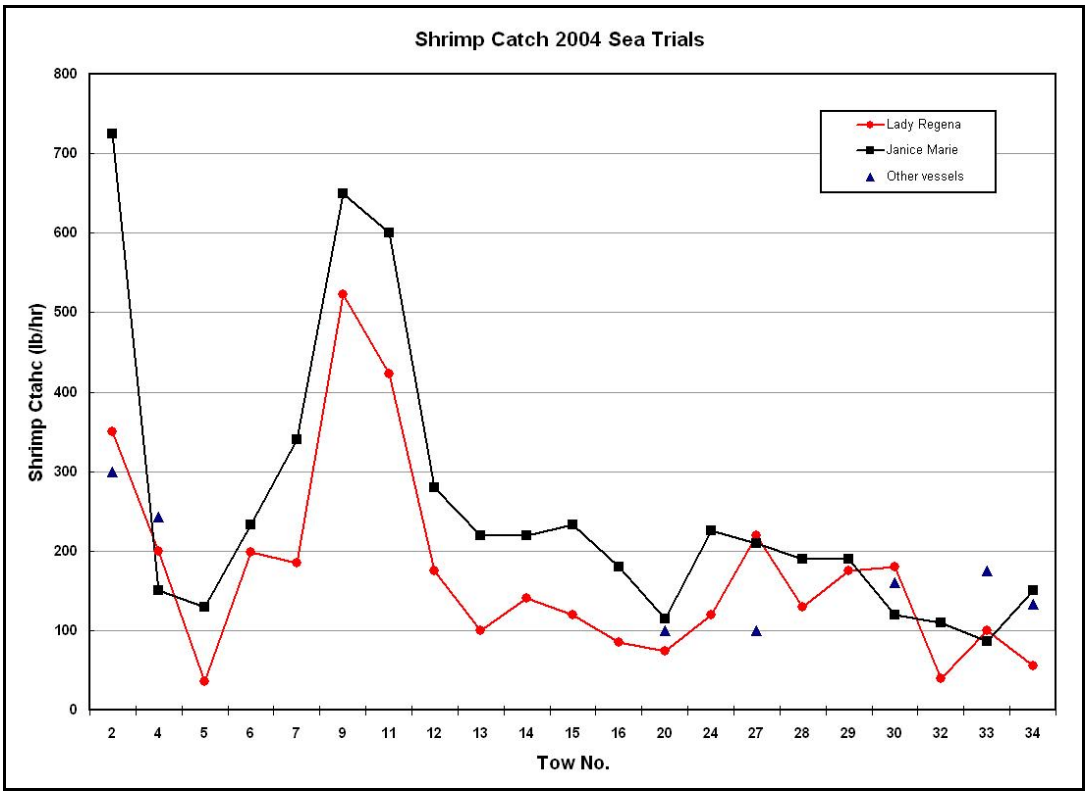

Exhibit 15. Catch rates of shrimps of the experimental semi-pelagic shrimp trawl (Lady Regena), a commercial trawl (Janice Marie), and other vessels during 2004 trials in the Gulf of Maine.

7. DISCUSSIONS

The length of bridles seems very important to maintain bottom contact of the wingend in an off-bottom trawl door system. The longer the bridles, the greater the scope of movement for the door without lifting the wingend. Unfortunately, there is a bridle length restriction of 90' in the Gulf of Maine pink shrimp fishery as specified by the Atlantic States Marine Fisheries Commission. The restriction was aimed at reducing groundfish species being herded by the bridles, thereby reducing potential bycatch of these species by the shrimp trawl.

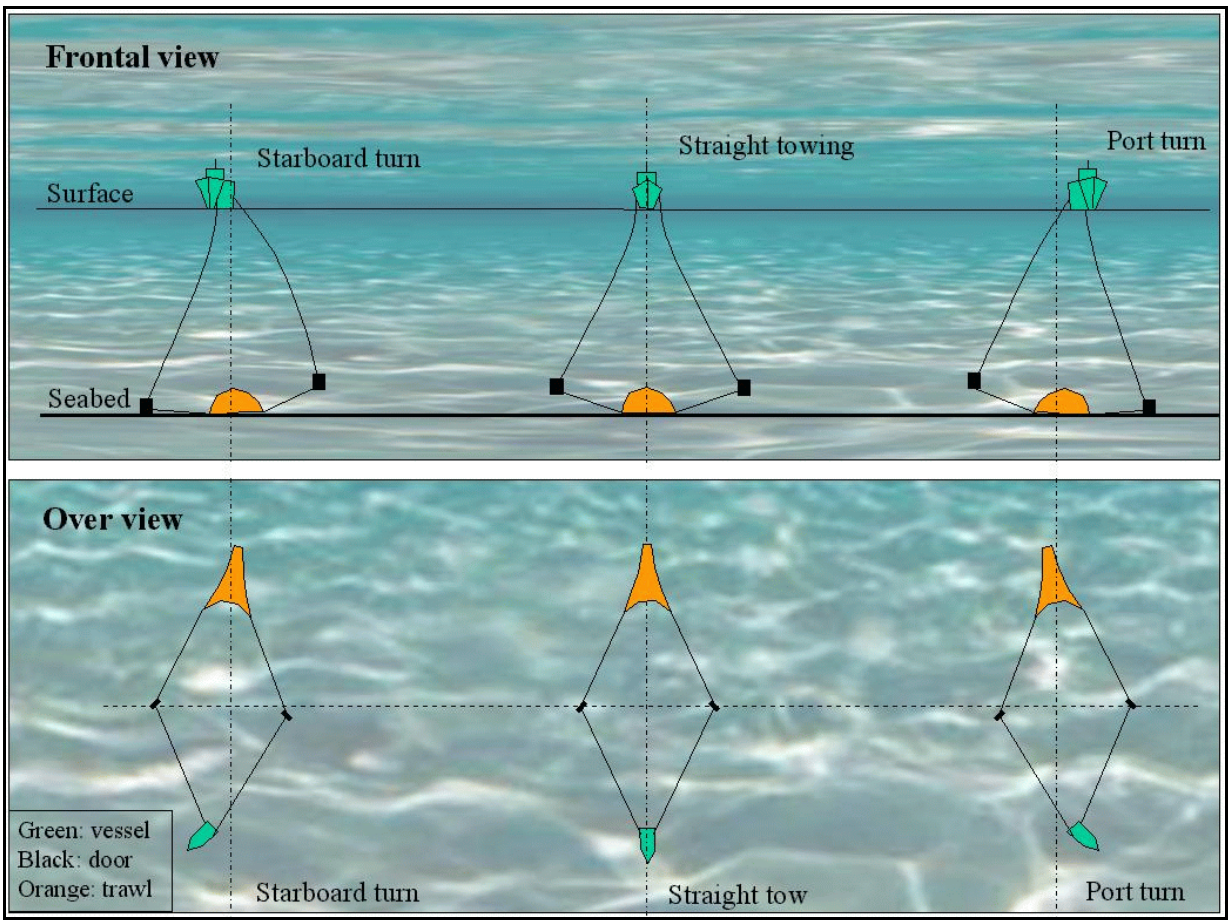

Exhibit 16. Schematic illustration of door behavior in semi-pelagic configuration in relation to towing track.

The height of the doors off the seabed and whether the doors were lifted off the seabed bottom were of the greatest interest to the project. The height of doors was monitored by sensors in real time. When the trawl was towed in a straight track, the doors could be kept off bottom. However, when the gear was towed in a curved track, one of the doors (on the inside of the curve) was observed to fall down to the bottom, while the other was lifted to a higher point in the water column as indicated by door height sensors (Exhibit 16).

It was interesting to find that shrimp caught in the experimental trawl were significantly larger than those caught by the commercial trawl. Shrimp may be distributed vertically by size. A multi-level experimental shrimp trawl tested in Newfoundland and used to assess vertical distribution of shrimp showed smaller shrimps were near the seabed. Our experimental trawl had a higher opening and very light bottom contact. Therefore, we may have missed some shrimp of relatively smaller size near the bottom.

Though similar catch rates can be realized with carefully controlled rigging and monitoring, with the existing deck machinery and fishing conditions in the Gulf of Maine, application of the semi-pelagic fishing method is not recommended in this fishery. However, it has potential for application in other pink shrimp fisheries where more sophisticated deck equipment is available and where fishing areas are larger and the bottom is flatter. Researchers in Newfoundland (H. DeLouche, Fisheries and Marine Institute, Newfoundland, pers. comm.) have started a semi-pelagic shrimp trawl project off northeast Newfoundland, targeting the same *Pandalus* species. The Newfoundland shrimp fleet is better equipped with gear monitoring systems and many have independent winch control. Newfoundland shrimp fishing grounds are much larger in area and much flatter with less depth change within a tow. It is therefore possible that the semi-pelagic shrimp trawl technology can be applied there.

8. PARTNERSHIPS

A strong partnership between Pingguo He of UNH and George Littlefield of F/V “Lady Regena” continued since the inception of the project, through flume tank testing in Newfoundland, and sea trials in the Gulf of Maine. The partnership with Newfoundland researchers has resulted in a similar project in that area.

9. IMPACTS AND APPLICATIONS

The semi-pelagic trawling system demonstrated similar catch rates of targeted pink shrimp with trawl doors being kept off the seabed. However, the system is very dynamic and difficult to control with the existing deck machinery onboard Gulf of Maine inshore shrimp vessels. Therefore, application of this technology in the Gulf of Maine is like to be very limited. Employing the semi-pelagic concept is possible in other pink shrimp fisheries such as the one in Newfoundland. Following our test in the Gulf of Maine, colleagues in Memorial University started semi-pelagic shrimp trawling project in the northeast Newfoundland. That project is still continuing.

10. RELATED PROJECTS

Reducing Seabed Contact of Trawling, 2001. Completed.

11. PRESENTATIONS

He, P. (2002). Reducing seabed contact of bottom trawls - flume tank tests and full scale sea trials. Symposium on "Effect of Fishing Activities on Benthic Habitat: Linking Biology, Geology, Socioeconomics, and Management", Tampa, FL. November 12-14, 2002.

He, P. & H. DeLouche. (2004). Reducing Seabed Contact of Trawling: Semi-pelagic Shrimp Trawling System Experiments in Gulf of Maine and in Newfoundland. ICES Working Group on Fish Behavior and Fishing Technology, Gdynia, Poland. April 20-23, 2004.

He, P. & H. DeLouche. (2004). Reducing Seabed Contact of Trawling: A Semi-pelagic Shrimp Trawl for Pink Shrimps. Fourth World Fisheries Congress. Vancouver, BC, Canada. May 2-6, 2004.

He, P. (2006). Technical measures to reduce seabed impact of trawling. Maine Fishermen Forum. March 2006.

12. STUDENTS PARTICIPATION

No students participated in this project.

13. PUBLISHED REPORT AND PAPERS

He, P. & G. Littlefield (2003). Reducing seabed contact of trawling: Sea trials of a semi-pelagic shrimp trawling system on board F/V "Lady Regena". Submitted to the Northeast Consortium. University of New Hampshire, Durham, NH.

He, P. & G. Littlefield (2004). Reducing seabed contact of trawling: Engineering trials and tank tests of a semi-pelagic shrimp trawling system. Submitted to the Northeast Consortium. University of New Hampshire, Durham, NH.

He, P., R. Hamilton, G. Littlefield & R. Sypheres (2004). Reducing Seabed Contact of Trawling: Further Sea Trials of a Semi-pelagic Shrimp Trawling System. A report submitted to the Northeast Consortium. University of New Hampshire, Durham, NH. UNH-FISH-REP-2004-008. 12 pp.

He, P. & H. DeLouche (2004). Reducing seabed contact of trawling: semi-pelagic shrimp trawling experiments in the Gulf of Maine and in Newfoundland. ICES FTFB Worksing Group, Gydnia, Poland.

P. He, P. Winger, R. Fonteyne, M. Pol, P. MacMullen, S. Løkkeborg, B. van Marlen, T. Moth-Poulsen, K. Zachariassen, A. Sala, W. Thiele, U. Hansen, E. Grimaldo, A. Revill, and H. Polet. (2004). Mitigation measures against seabed impacts of mobile fishing gears. ICES-FAO Working Group on Fishing Technology and Fish Behavior. Gdynia, Poland. April, 2004. Available online: http://www.imr.no/ftfb/He%20at%20al%20(File%202).pdf

14. IMAGES

Some of the images obtained from the project have been used by the Northeast Consortium in its various publications. Additional images are supplemented as an appendix.

15. FURTHER WORK

To ensure good bottom contact of the sweep of a shrimp trawl, hydrodynamic depressing devices may be used. These hydrodynamic devices can also compensate forces generated by variations in towing speed and the effect of tides. Rubber depressors are being tested in Denmark in groundfish trawls with promising results in expanding wingend (U. Hansen, pers. comm.). The device is also being tested in the Gulf of Maine groundfish trawls.

The multi-level shrimp trawl for assessing vertical size distribution as used in Newfoundland is being considered for application in the Gulf of Maine. The research would provide information on size distribution, and if larger shrimps are distributed more off-bottom, a raised footrope shrimp trawl or a "sweepless" shrimp trawl can be tested, further reducing seabed contact of trawling.

16. ACKNOWLEDGMENTS

The project is financially supported by the Northeast Consortium, a join initiative of the University of New Hampshire, University of Maine, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution. We would also like to thank Mr. Harold DeLouche of the Fisheries and Marine Institute for his advice and participation of sea trials in 2003, and Mr. Bob Campbell of Yankee Fishermen's Coop for providing catch data of other vessels landed at his plant.

17. LITERATURE CITED

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Dorsey, E.M. and J. Pederson (1998b, ed.). Effects of Fishing Gear on the Sea Floor of New England. Boston: Conservation Law Foundation.

He, P., B. McNeel & G. Littlefield (2002). Reducing seabed contact of trawling: design and test of a semi-pelagic shrimp trawl for the pink shrimp fishery. Submitted to the Northeast Consortium. University of New Hampshire, Durham, NH.

He, P. & G. Littlefield (2003). Reducing seabed contact of trawling: Sea trials of a semi-pelagic shrimp trawling system on board F/V "Lady Regena". Submitted to the Northeast Consortium. University of New Hampshire, Durham, NH.

ICES (1999). Report of ICES Fishing Technology and Fish Behavior Working Group. April 1999. St. John's, NF, Canada.

ICES (2000). Report of ICES Fishing Technology and Fish Behavior Working Group. April 2000. Haarlem, the Netherlands.

ICES (2004). Report of ICES Fishing Technology and Fish Behavior Working Group. April 2004. Gdynia, Poland.

NRC (2002). Effect of trawling and dredging on seafloor habitat. Washington, D.C.: National Academy Press.

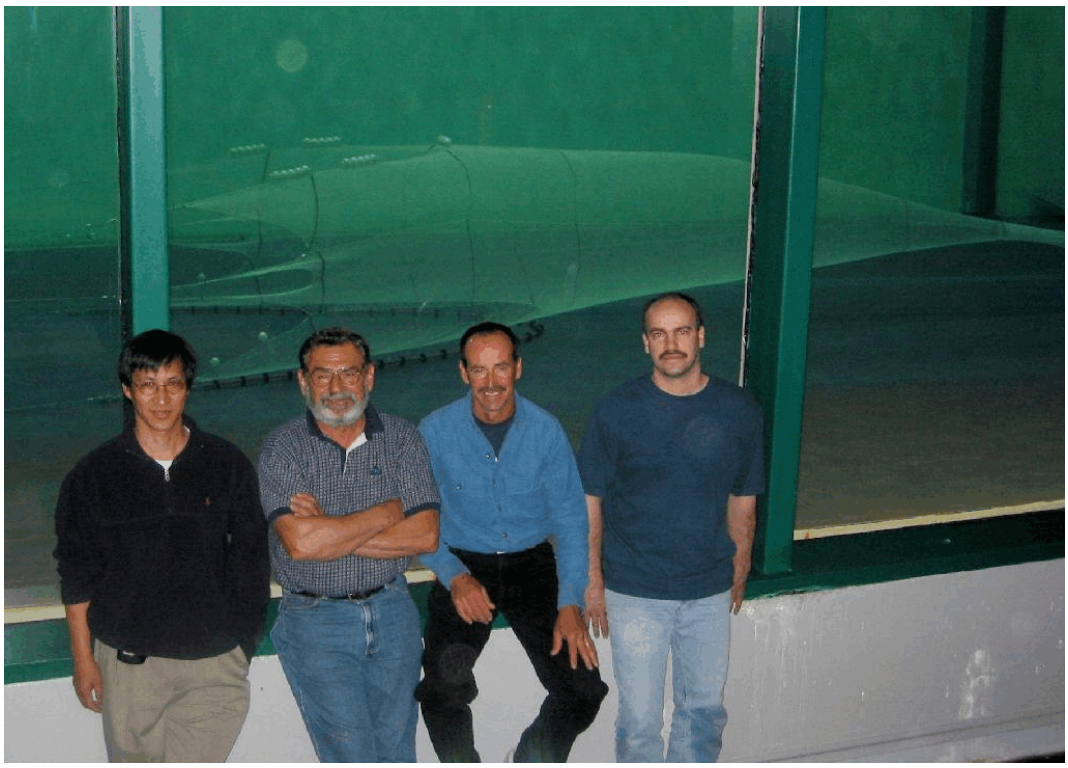
Appendices

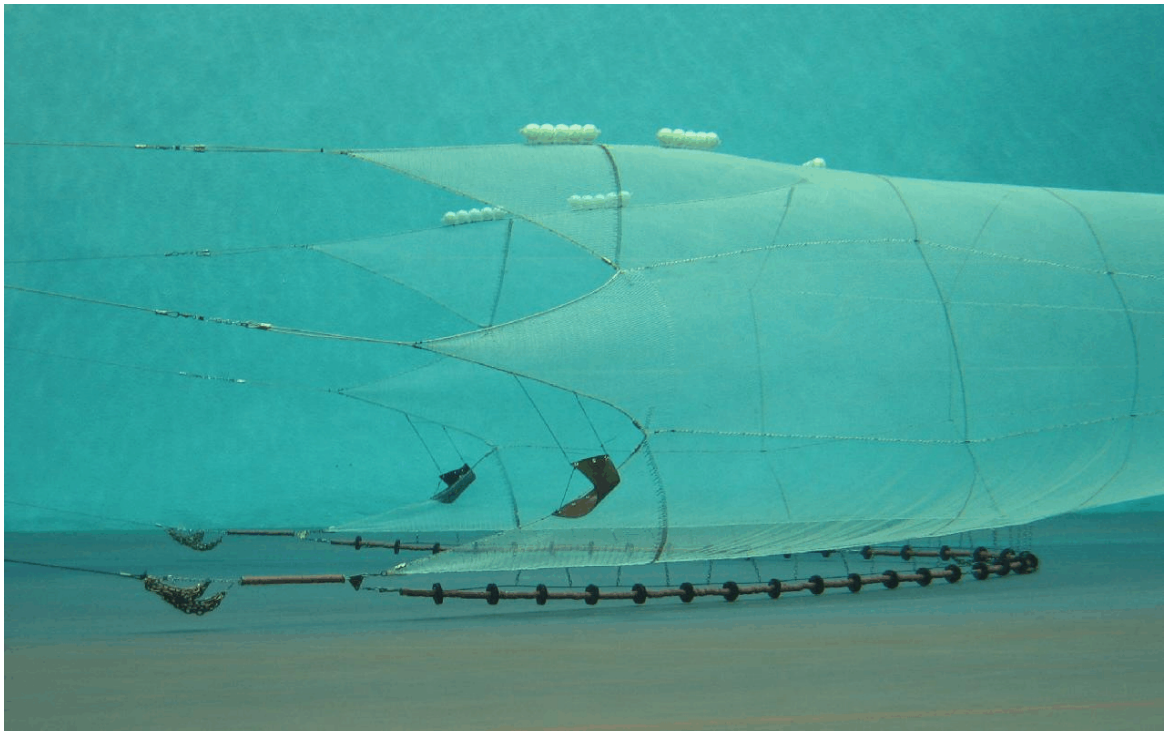
Appendix I	**Additional Photographs**
Appendix II	**Data from Tank Tests and Sea Trials**
Appendix III	**Oral and Poster Presentations**
Appendix IV	**Related Media Articles**

Appendix I

Additional Photographs

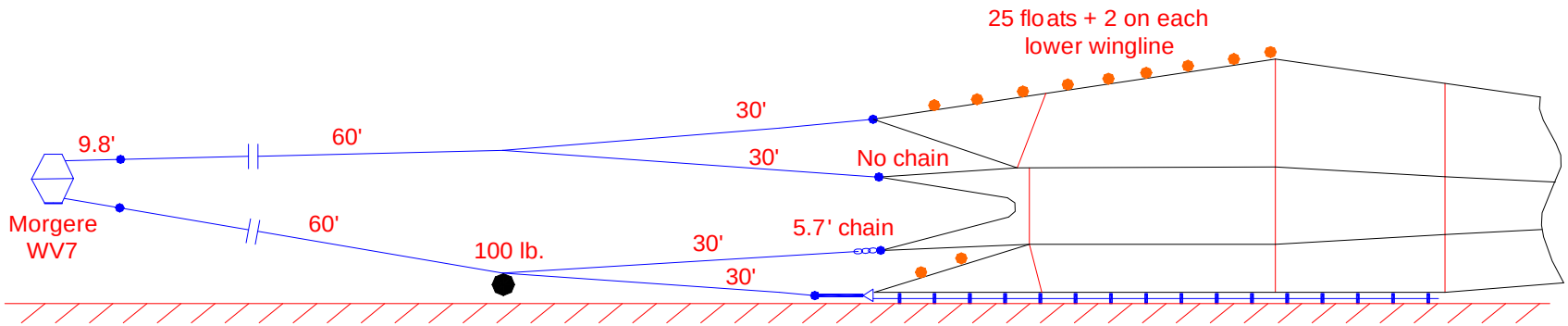
Full size images maybe available upon request.





Appendix II

Data from Tank Tests and Sea Trials



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE:	6/15/02	**File:**	**tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 1	**Standard - doors off bottom**

FULL SCALE VALUES (Imperial units)

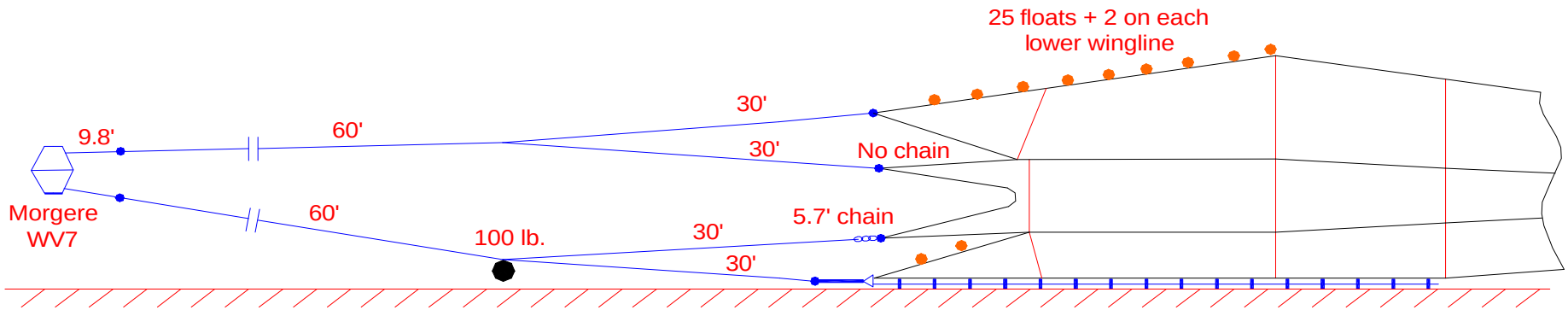
Rig 1

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*L. Breast line ext. (ft)*	*Mini-bridles (ft)*
60.0	**60.0**	**5.7**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	*SPREAD*				*HEIGHT*		*OPENING*		*TENSION*			*Mouth area (sqft)*	*Mouth drag lbs/sqft*	*Bridle angle (deg)*
	Door (ft.)	*U.wing (ft.)*	*L.wing (ft.)*	*Mean wing end (ft.)*	*Door (ft.)*	*Footrope (ft.)*	*Wing (ft.)*	*Headline (ft.)*	*Port (tonnes)*	*Stbd (tonnes)*	*Total (tonnes)*			
2.00	**83.1**	**31.9**	**36.9**	**34.4**	**3.4**	**0.0**	**8.5**	**15.4**	**0.5**	**0.5**	**1.0**	**529.9**	**4.0**	**14.1**
2.20	**84.0**	**32.2**	**37.2**	**34.7**	**6.4**	**0.0**	**10.3**	**16.1**	**0.6**	**0.6**	**1.1**	**557.9**	**4.4**	**14.3**
2.40	**84.3**	**32.7**	**37.7**	**35.2**	**9.0**	**0.0**	**11.5**	**16.2**	**0.6**	**0.6**	**1.3**	**571.4**	**4.9**	**14.2**
2.60	**86.3**	**33.3**	**38.5**	**35.9**	**11.8**	**0.7**	**13.8**	**16.1**	**0.7**	**0.7**	**1.5**	**577.0**	**5.6**	**14.6**



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE:	6/15/02
File:	**tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 2	**Same as rig 1 but varying door heights**

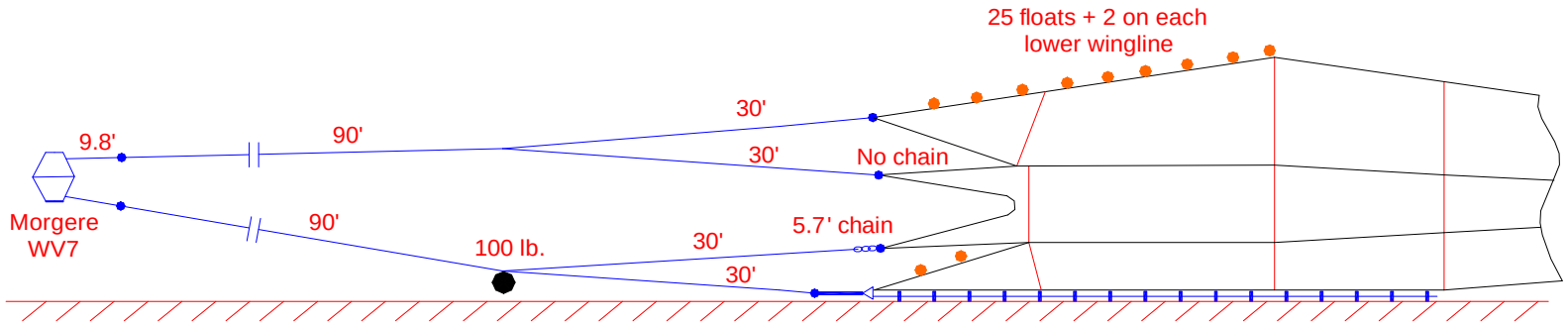
FULL SCALE VALUES (Imperial units)
Rig 2

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*L. Breast line ext. (ft)*	*Mini-bridles (ft)*
60.0	**60.0**	**5.7**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	*SPREAD*				*HEIGHT*		*OPENING*		*TENSION*			*Mouth area (sqft)*	*Mouth drag lbs/sqft*	*Bridle angle (deg)*
	Door (ft.)	*U.wing (ft.)*	*L.wing (ft.)*	*Mean wing end (ft.)*	*Door (ft.)*	*Footrope (ft.)*	*Wing (ft.)*	*Headline (ft.)*	*Port (tonnes)*	*Stbd (tonnes)*	*Total (tonnes)*			
2.40	**84.3**	**32.7**	**37.7**	**35.2**	**9.0**	**0.0**	**11.5**	**16.2**				**571.4**		**14.2**
2.40					**20.8**	**6.9**	**14.4**	**16.4**						
2.40					**14.6**	**0.8**	**14.6**	**16.4**						
2.40					**5.1**	**0.0**	**12.1**	**14.9**						



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE: 6/15/02	**File:** tank_data

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 3	**Additional 5 ftm bridles**

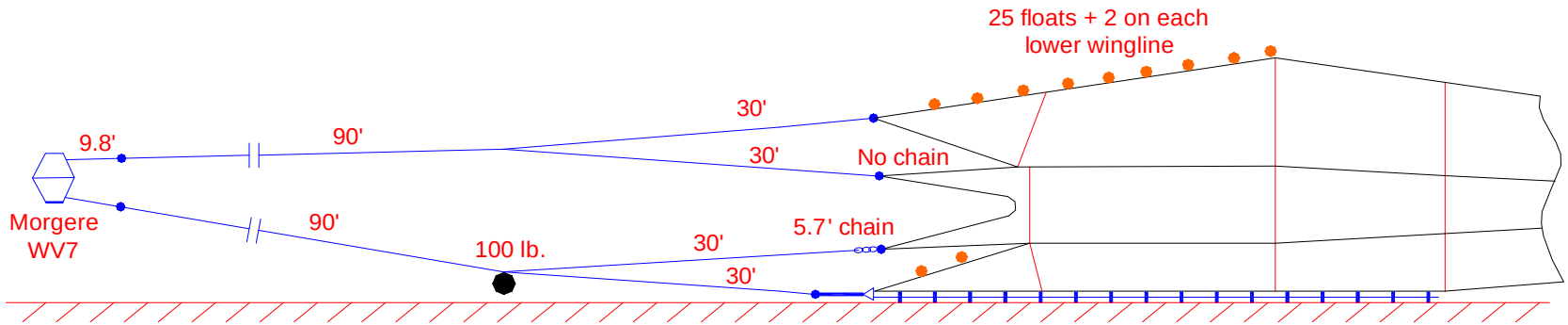
FULL SCALE VALUES (Imperial units)
Rig 3

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*L. Breast line ext. (ft)*	*Mini-bridles (ft)*
90.0	**90.0**	**5.7**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	*SPREAD*				*HEIGHT*		*OPENING*		*TENSION*			*Mouth area (sqft)*	*Mouth drag lbs/sqft*	*Bridle angle (deg)*
	Door (ft.)	*U.wing (ft.)*	*L.wing (ft.)*	*Mean wing end (ft.)*	*Door (ft.)*	*Footrope (ft.)*	*Wing (ft.)*	*Headline (ft.)*	*Port (tonnes)*	*Stbd (tonnes)*	*Total (tonnes)*			
2.00					**2.3**	**0.0**	**10.3**	**15.6**						
2.20					**5.9**	**0.0**	**12.0**	**15.4**						
2.40					**8.5**	**0.0**	**13.0**	**15.7**						
2.60					**11.3**	**0.0**	**14.1**	**15.9**						



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE:	6/15/02
File:	**tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 4	**Same as rig 3 but varying door heights**

FULL SCALE VALUES (Imperial units)

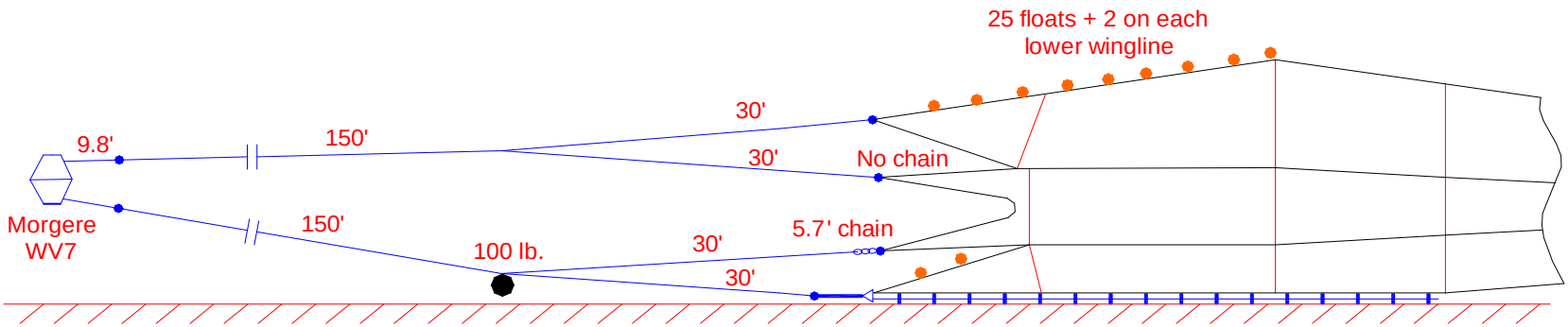
Rig 4

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*L. Breast line ext. (ft)*	*Mini-bridles (ft)*
90.0	**90.0**	**5.7**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	***SPREAD***				***HEIGHT***		***OPENING***		***TENSION***			***Mouth area (sqft)***	***Mouth drag lbs/sqft***	***Bridle angle (deg)***
	Door (ft.)	***U.wing (ft.)***	***L.wing (ft.)***	***Mean wing end (ft.)***	***Door (ft.)***	***Footrope (ft.)***	***Wing (ft.)***	***Headline (ft.)***	***Port (tonnes)***	***Stbd (tonnes)***	***Total (tonnes)***			
2.40					**19.8**	**0.7**	**15.4**	**17.2**						
2.40					**14.8**	**0.0**	**15.3**	**16.7**						
2.40					**8.5**	**0.0**	**13.0**	**15.7**						



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE:	6/15/02
File:	**tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 5	**Additional 10 ftm bridles (150' total)**

FULL SCALE VALUES (Imperial units)

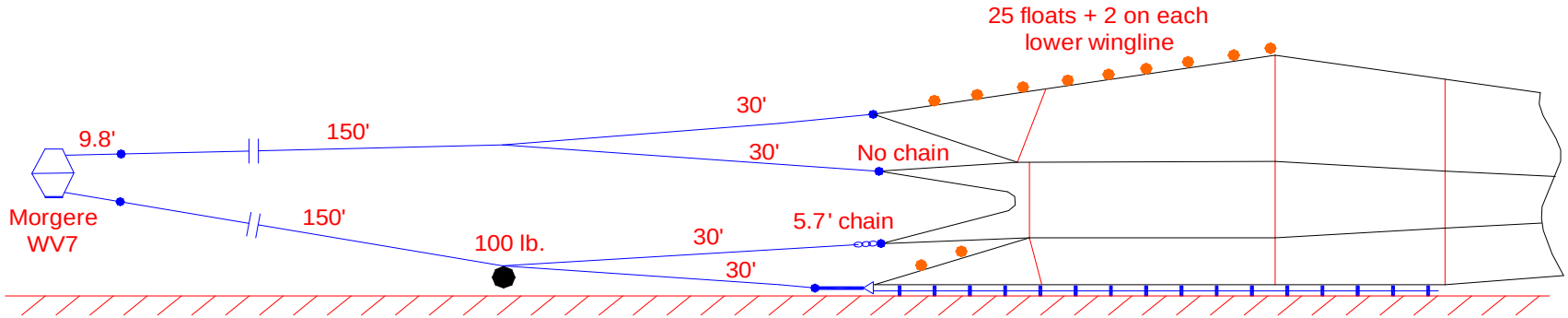
Rig 5

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*L. Breast line ext. (ft)*	*Mini-bridles (ft)*
150.0	**150.0**	**5.7**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	***SPREAD***				***HEIGHT***		***OPENING***		***TENSION***			***Mouth area (sqft)***	***Mouth drag lbs/sqft***	***Bridle angle (deg)***
	Door (ft.)	***U.wing (ft.)***	***L.wing (ft.)***	***Mean wing end (ft.)***	***Door (ft.)***	***Footrope (ft.)***	***Wing (ft.)***	***Headline (ft.)***	***Port (tonnes)***	***Stbd (tonnes)***	***Total (tonnes)***			
2.00	**111.5**	**29.2**	**35.6**	**32.4**	**3.4**	**0.0**	**9.0**	**14.1**	**0.5**	**0.5**	**1.0**	**457.2**	**4.7**	**12.0**
2.20	**114.3**	**29.8**	**35.6**	**32.7**	**6.6**	**0.0**	**9.8**	**14.1**	**0.6**	**0.5**	**1.1**	**461.3**	**5.2**	**12.4**
2.40	**115.0**	**30.2**	**35.4**	**32.8**	**9.7**	**0.0**	**11.2**	**14.3**	**0.6**	**0.6**	**1.2**	**467.8**	**5.9**	**12.5**
2.60	**115.8**	**30.6**	**35.5**	**33.1**	**12.3**	**0.0**	**12.3**	**14.6**	**0.7**	**0.7**	**1.4**	**483.2**	**6.4**	**12.6**



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE: 6/15/02	**File:**	**tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 6	**Same as rig 5 but varying door heights**

FULL SCALE VALUES (Imperial units)

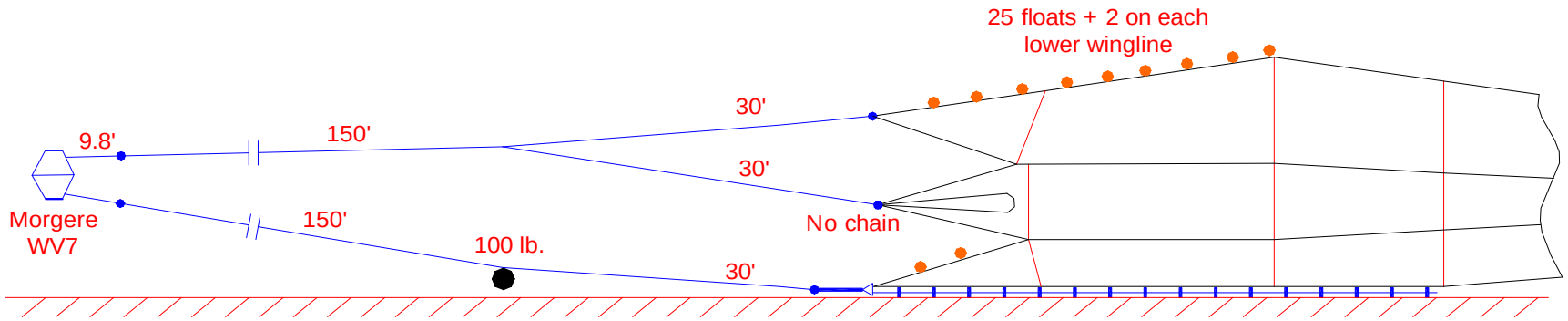
Rig 6

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*L. Breast line ext. (ft)*	*Mini-bridles (ft)*
150.0	**150.0**	**5.7**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	***SPREAD***				***HEIGHT***		***OPENING***		***TENSION***			***Mouth area (sqft)***	***Mouth drag lbs/sqft***	***Bridle angle (deg)***
	Door (ft.)	***U.wing (ft.)***	***L.wing (ft.)***	***Mean wing end (ft.)***	***Door (ft.)***	***Footrope (ft.)***	***Wing (ft.)***	***Headline (ft.)***	***Port (tonnes)***	***Stbd (tonnes)***	***Total (tonnes)***			
2.40	**115.0**	**30.2**	**35.4**	**32.8**	**9.7**	**0.0**	**11.2**	**14.3**				**467.8**		**12.5**
2.40					**19.8**	**0.0**	**13.6**	**15.7**						
2.40					**24.6**	**0.3**	**14.8**	**16.4**						
2.40					**30.0**	**0.7**	**15.6**	**16.9**						



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE:	6/15/02
File:	**tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 7	**Changed to 3 bridles**

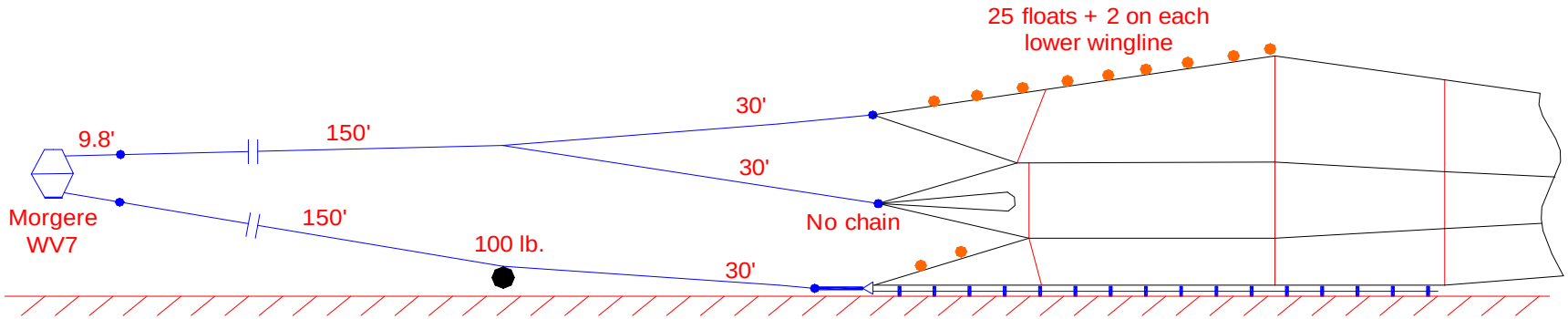
FULL SCALE VALUES (Imperial units)
Rig 7

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*Mid. Mini br. ext. (ft)*	*Mini-bridles (ft)*
150.0	**150.0**	**0**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	*SPREAD*				*HEIGHT*		*OPENING*		*TENSION*			*Mouth area (sqft)*	*Mouth drag lbs/sqft*	*Bridle angle (deg)*
	Door (ft.)	*U.wing (ft.)*	*L.wing (ft.)*	*Mean wing end (ft.)*	*Door (ft.)*	*Footrope (ft.)*	*Wing (ft.)*	*Headline (ft.)*	*Port (tonnes)*	*Stbd (tonnes)*	*Total (tonnes)*			
2.00	**112.4**	**29.4**	**35.5**	**32.5**	**2.6**	**0.0**	**9.4**	**14.4**	**0.5**	**0.5**	**1.0**	**468.5**	**4.6**	**12.2**
2.20	**114.6**	**29.9**	**35.6**	**32.8**	**5.9**	**0.0**	**10.5**	**14.8**	**0.6**	**0.5**	**1.1**	**483.6**	**5.0**	**12.4**
2.40	**115.9**	**30.3**	**35.4**	**32.8**	**9.2**	**0.0**	**11.5**	**14.9**	**0.6**	**0.6**	**1.2**	**490.0**	**5.6**	**12.6**
2.60	**117.1**	**30.7**	**35.4**	**33.1**	**11.6**	**0.0**	**12.3**	**14.9**	**0.7**	**0.7**	**1.4**	**493.4**	**6.3**	**12.8**



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE:	6/15/02	**File:**	**tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 8	**Same as rig 7 but varying door heights**

FULL SCALE VALUES (Imperial units)

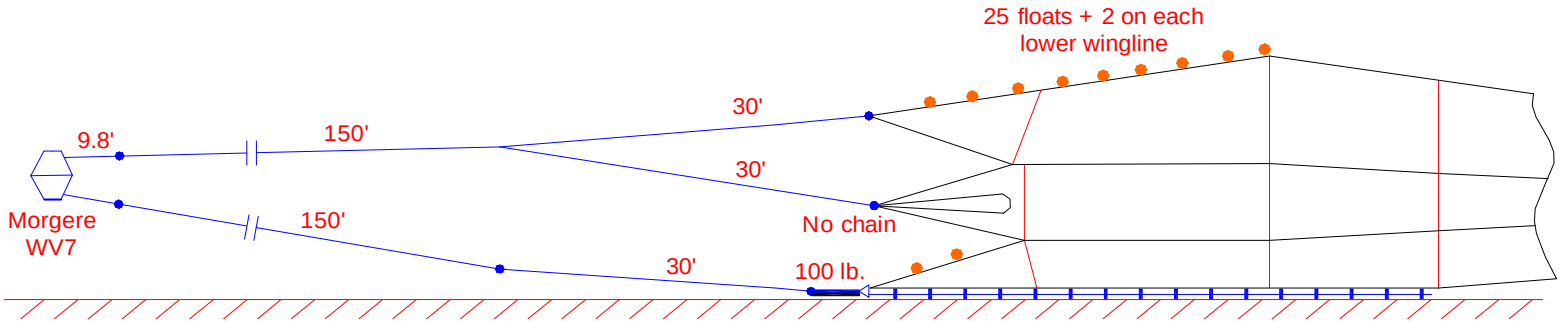
Rig 8

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*Mid. Mini br. ext. (ft)*	*Mini-bridles (ft)*
150.0	**150.0**	**0**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	***SPREAD***				***HEIGHT***		***OPENING***		***TENSION***			***Mouth area (sqft)***	***Mouth drag lbs/sqft***	***Bridle angle (deg)***
	Door (ft.)	***U.wing (ft.)***	***L.wing (ft.)***	***Mean wing end (ft.)***	***Door (ft.)***	***Footrope (ft.)***	***Wing (ft.)***	***Headline (ft.)***	***Port (tonnes)***	***Stbd (tonnes)***	***Total (tonnes)***			
2.40	**115.9**	**30.3**	**35.4**	**32.8**	**9.2**	**0.0**	**11.5**	**14.9**				**490.0**		**12.6**
2.40					**24.6**	**1.0**	**14.1**	**16.7**						
2.40					**19.8**	**0.5**	**13.5**	**16.1**						



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE:	6/15/02
File:	**tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 9	**Weights lashed from end of mini bridle to**
	delta plate - weights not hanging

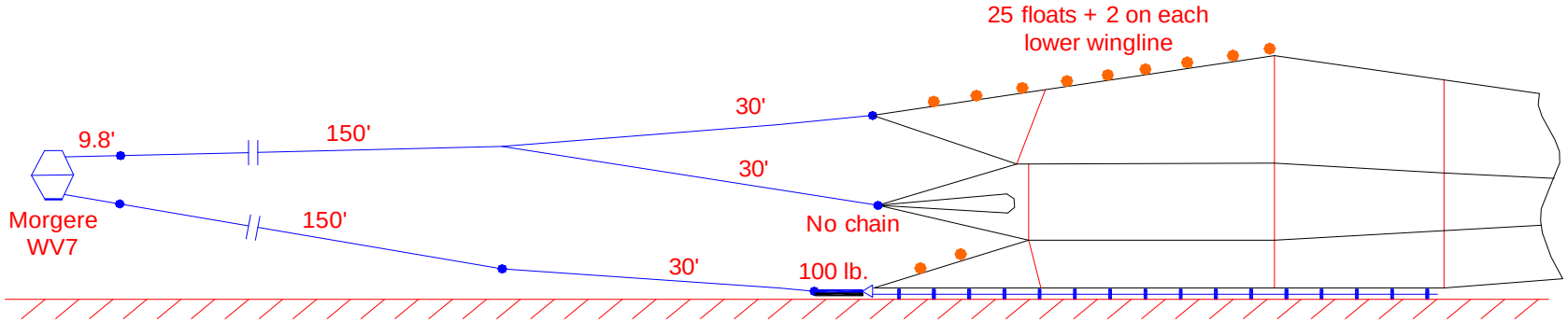
FULL SCALE VALUES (Imperial units)
Rig 9

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*Mid. Mini br. ext. (ft)*	*Mini-bridles (ft)*
150.0	**150.0**	**0**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	***SPREAD***				***HEIGHT***		***OPENING***		***TENSION***			***Mouth area (sqft)***	***Mouth drag lbs/sqft***	***Bridle angle (deg)***
	Door (ft.)	***U.wing (ft.)***	***L.wing (ft.)***	***Mean wing end (ft.)***	***Door (ft.)***	***Footrope (ft.)***	***Wing (ft.)***	***Headline (ft.)***	***Port (tonnes)***	***Stbd (tonnes)***	***Total (tonnes)***			
2.00	**112.2**	**29.5**	**36.5**	**33.0**	**3.1**	**0.0**	**9.7**	**14.8**	**0.5**	**0.5**	**1.0**	**486.9**	**4.4**	**12.0**
2.20	**114.2**	**30.0**	**36.3**	**33.1**	**6.4**	**0.0**	**10.8**	**14.8**	**0.6**	**0.5**	**1.1**	**489.2**	**5.0**	**12.3**
2.40	**115.1**	**30.2**	**36.0**	**33.1**	**9.4**	**0.0**	**11.6**	**14.9**	**0.6**	**0.6**	**1.2**	**494.0**	**5.5**	**12.5**
2.60	**117.6**	**30.7**	**36.1**	**33.4**	**11.8**	**0.0**	**12.6**	**15.1**	**0.7**	**0.7**	**1.4**	**503.8**	**6.2**	**12.8**



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE:	6/15/02
File:	**tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 10	**Same as rig 9 but varying door heights**

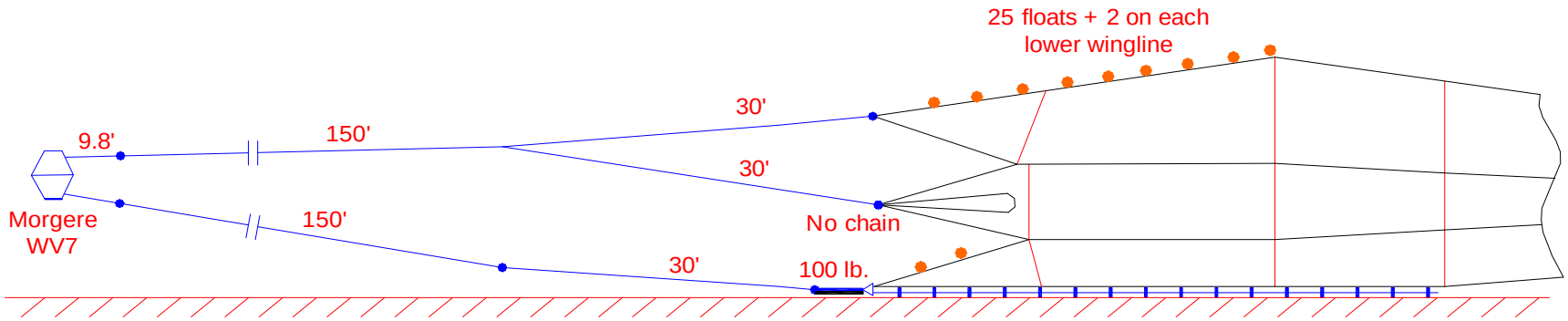
FULL SCALE VALUES (Imperial units)
Rig 10

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*Mid. Mini br. ext. (ft)*	*Mini-bridles (ft)*
150.0	**150.0**	**0**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	***SPREAD***				***HEIGHT***		***OPENING***		***TENSION***			***Mouth area (sqft)***	***Mouth drag lbs/sqft***	***Bridle angle (deg)***
	Door (ft.)	***U.wing (ft.)***	***L.wing (ft.)***	***Mean wing end (ft.)***	***Door (ft.)***	***Footrope (ft.)***	***Wing (ft.)***	***Headline (ft.)***	***Port (tonnes)***	***Stbd (tonnes)***	***Total (tonnes)***			
2.40	**115.1**	**30.2**	**36.0**	**33.1**	**9.4**	**0.0**	**11.6**	**14.9**				**494.0**		**12.5**
2.40					**24.6**	**0.0**	**15.4**	**16.9**						
2.40					**30.0**	**0.8**	**15.6**	**17.4**						



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE:	6/15/02

File: **tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 11	**Final rigging - tapered toggle chains**

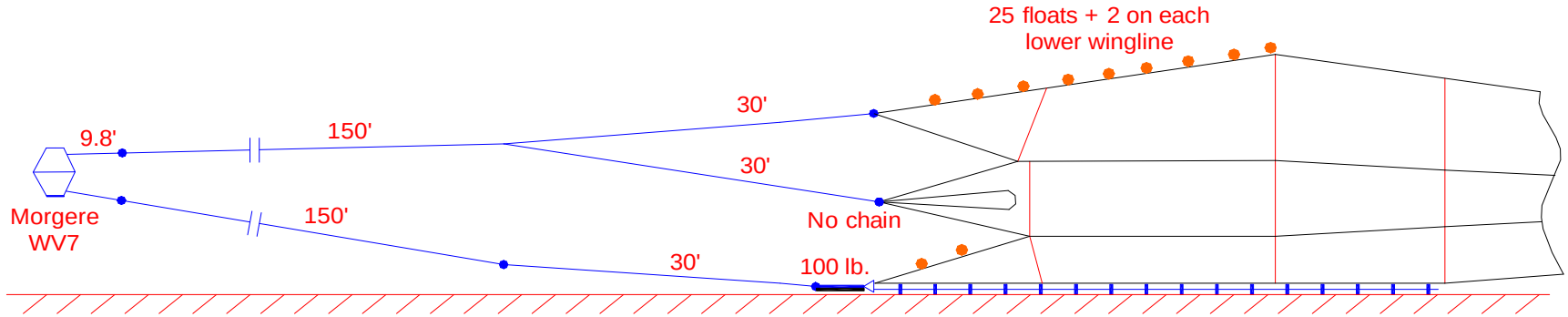
FULL SCALE VALUES (Imperial units)
Rig 11

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*Mid. Mini br. ext. (ft)*	*Mini-bridles (ft)*
150.0	**150.0**	**0**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	*SPREAD*				*HEIGHT*		*OPENING*		*TENSION*			*Mouth area (sqft)*	*Mouth drag lbs/sqft*	*Bridle angle (deg)*
	Door (ft.)	*U.wing (ft.)*	*L.wing (ft.)*	*Mean wing end (ft.)*	*Door (ft.)*	*Footrope (ft.)*	*Wing (ft.)*	*Headline (ft.)*	*Port (tonnes)*	*Stbd (tonnes)*	*Total (tonnes)*			
2.00	**112.2**	**29.6**	**36.4**	**33.0**	**2.8**	**0.0**	**10.0**	**14.6**	**0.5**	**0.5**	**1.0**	**481.9**	**4.4**	**12.0**
2.20	**114.2**	**30.2**	**36.0**	**33.1**	**6.2**	**0.0**	**10.7**	**14.8**	**0.6**	**0.5**	**1.1**	**488.1**	**4.9**	**12.3**
2.40	**115.6**	**30.4**	**36.0**	**33.2**	**9.4**	**0.0**	**11.5**	**14.9**	**0.6**	**0.6**	**1.2**	**495.6**	**5.4**	**12.5**
2.60	**117.1**	**30.7**	**36.0**	**33.4**	**11.6**	**0.0**	**12.5**	**14.8**	**0.7**	**0.7**	**1.4**	**492.7**	**6.2**	**12.7**



MARINE INSTITUTE FLUME TANK
TRAWL MODEL MEASUREMENTS

DATE:	6/15/02	**File:**	**tank_data**

Length	**scale 1: 5**
Sq.speed	**scale 1: 5**
Area	**scale 1: 24.86**

Company	**University of New Hampshire**
Trawl	**Semi pelagic**
Rig 12	**Same as rig 11 but varying door heights**

FULL SCALE VALUES (Imperial units)
Rig 12

Door type	*Door area (sq. m.)*	*Backstr. length (ft.)*
WV7	**2.3**	**9.8**

U.bridle length (ft.)	*L.bridle length (ft.)*	*Mid. Mini br. ext. (ft)*	*Mini-bridles (ft)*
150.0	**150.0**	**0**	**30**

Wingend weight (lbs)	*1 Float bouy. (lbs)*	*Float no.*	*Total bouy. (lbs)*
100	**6.2**	**29**	**179.0**

Towing speed (kts)	*SPREAD*				*HEIGHT*		*OPENING*		*TENSION*			*Mouth area (sqft)*	*Mouth drag lbs/sqft*	*Bridle angle (deg)*
	Door (ft.)	*U.wing (ft.)*	*L.wing (ft.)*	*Mean wing end (ft.)*	*Door (ft.)*	*Footrope (ft.)*	*Wing (ft.)*	*Headline (ft.)*	*Port (tonnes)*	*Stbd (tonnes)*	*Total (tonnes)*			
2.40	**115.6**	**30.4**	**36.0**	**33.2**	**9.4**	**0.0**	**11.5**	**14.9**				**495.6**		**12.5**
2.40					**24.6**	**0.0**	**15.7**	**17.1**						
2.40					**30.0**	**0.8**	**15.7**	**17.9**						

Semi-pelagic Shrimp Trawling Jan-Feb. 2003 - FV "Lady Regena"

Day	Date	Tow #	Time start	Shrimp (lbs)	Count (pcs/lb)	Bycatch (lbs)	Total Day	Average Hour	Other vessels (lbs)
1	01/29/03	1	8:15				575	115	134
		2	9:45	124	39	32			
		3	11:25	184	39	10			
		4	13:45	167	40	13			
		5	15:10	100	39	30			
2	01/30/03	6	8:15	87	38	22	198	40	124
		7	10:10	2		5			
		8	11:35	17	39	8			
		9	13:45	14		6			
		10	14:52	78	39	24			
3	02/08/03	11	8:45	221	38	4	1086	217	210
		12	10:20	177	39	25			
		13	11:50	41	38	5			
		14	13:25	347	41	5			
		15	14:55	300	39	6			
4	02/10/03	16	7:54	273	40	7	803	161	181
		17	9:15	175	42	15			
		18	10:53	71	40	3			
		19	12:18	119	40	13			
		20	13:49	165	39	11			
5	02/16/03	21	10:47	120	41	9	465	133	106
		22	12:24	160	40	12			
		23	14:09	160	41	16			
		24*	15:46	25		12			
6	02/20/03	25	9:20	49	46	11	283	71	58
		26	11:12	99	66	16			
		27	12:50	90	74	21			
		28	14:15	45	54	18			
7	02/26/03	29	8:05	75	42	8	640	128	102
		30	10:00	110	39	26			
		31	11:28	80	38	100			
		32	13:16	160	38	32			
		33	14:53	215	40	30			
8	02/27/03	34	8:00	130	37	28	747	149	63
		35	9:25	125	39	24			
		36	10:55	167	39	15			
		37	12:23	185	38	10			
		38	13:54	140	39	9			
			Total	4797		641	4797		
			Average	128	42	17	600	128	122

*Half hour tow. All other tows ares one hour in duration.

Shrimp carapace length (CL, mm) and weight (W (g) measurement

01/29/03		02/28/03		02/10/03		02/20/03	
CL (mm)	W (g)	CL (mm)	W (g)	CL (mm)	W (g)	CL (mm)	W (g)
28.3	11.2	27.0	10.3	30.4	14.1	26.9	8.6
29.0	11.8	26.8	12.6	27.7	11.1	27.9	9.4
34.2	17.5	26.3	9.2	25.5	7.9	33.6	17.4
27.7	9.8	28.6	9.9	30.4	14.9	28.6	10.9
28.6	10.5	31.1	14.9	28.6	10.9	22.8	4.3
26.3	8.5	27.9	12.0	30.7	12.6	25.8	7.4
27.0	9.9	31.3	16.7	30.1	11.1	22.0	5.1
29.3	12.9	30.5	14.4	28.9	12.3	22.8	5.6
28.0	9.6	31.9	16.6	28.6	10.7	30.1	11.6
28.5	11.8	29.7	12.8	27.8	9.5	24.7	5.7
26.9	8.7	30.1	13.2	30.2	11.2	19.5	3.3
30.9	14.8	28.3	13.0	29.8	12.2	20.4	4.1
30.0	10.9	32.0	15.8	29.6	13.0	22.3	5.0
28.9	13.4	28.9	11.4	30.1	14.7	21.7	4.4
30.2	14.1	29.1	11.8	30.6	15.5	27.8	8.8
28.9	12.6	28.1	11.2	28.6	9.5	22.2	4.6
32.4	19.8	27.7	9.8	29.1	10.7	23.0	4.8
28.1	11.1	28.5	12.3	26.8	9.2	22.7	4.9
25.8	9.2	31.0	14.8	23.1	5.0	19.6	3.3
24.6	8.4	26.4	9.8	24.4	7.2	21.2	4.4
27.6	11.6	30.0	13.7	28.7	11.8	28.9	9.7
30.0	13.7	27.8	9.6	29.9	12.7	29.7	9.6
27.6	10.6	28.3	13.0	30.5	12.8	23.7	5.7
28.9	13.1	29.5	12.1	33.1	14.7	30.6	12.1
28.3	11.5	31.3	11.7	32.1	15.6	22.2	4.4
28.8	11.5	28.6	10.5	28.6	11.3	21.6	4.3
28.7	11.5	27.0	10.9	27.0	8.8	23.6	5.0
28.0	11.3	29.4	10.2	29.8	11.6	18.7	3.0
27.3	10.6	29.8	13.8	28.6	11.1	29.3	10.6
26.4	10.1	30.4	12.8	31.2	12.4	27.8	9.4
21.4	4.4	31.0	12.7	31.8	14.7	23.7	5.1
25.5	9.9	28.8	9.6	32.6	15.6	21.0	4.4
33.1	18.0	29.9	13.2	28.3	10.8	28.9	10.7
28.8	10.8	33.0	16.2	27.6	12.7	22.0	4.4
27.5	11.9	29.0	12.2	28.9	11.3	21.1	3.6
26.8	13.2	27.2	8.2	28.5	9.8	26.1	7.2
28.3	11.1	28.1	11.5	27.3	9.5	22.6	4.8
28.5	11.7	29.3	12.2	29.5	12.6	22.4	4.7
29.0	14.2	33.2	14.6	21.6	3.6	27.7	10.0
29.4	14.2	28.3	11.2	30.2	13.7	23.3	5.7
28.6	12.4	28.3	11.3	29.7	10.6	29.3	11.1
18.5	4.9	22.1	4.6	28.9	13.0	21.1	4.0
29.7	12.7	28.2	10.5	30.3	11.7	23.7	5.6
31.2	15.2	31.8	16.9	30.0	12.8	21.7	4.1
29.2	12.0	30.3	11.8	29.7	12.3	22.9	4.9
23.5	5.4	28.4	10.5	27.9	12.2	22.3	4.5
21.0	3.8	29.7	14.3	29.6	11.4	30.0	11.7
28.6	12.6	30.7	14.8	29.0	14.8	22.3	5.2
29.0	12.2	31.4	16.3	31.0	13.9	20.6	3.9
29.6	12.9	30.0	12.0	29.6	11.8	21.6	4.1
27.6	11.2	31.5	15.1	28.0	10.6	23.2	5.7
27.7	12.8	28.1	11.0	30.3	15.3	28.7	10.0
23.1	4.6	29.6	12.2	27.6	10.3	31.3	13.2
25.3	8.4	28.5	11.9	30.5	13.9	29.3	9.8
27.4	13.3	32.3	15.8	29.1	11.9	29.3	11.9
29.9	11.3	29.8	14.9	33.0	17.0	23.2	4.7
31.2	15.5	30.1	12.3	30.4	12.6	27.4	9.0
28.4	9.9	27.8	10.1	28.2	12.3	29.1	9.9
31.8	17.5	29.1	11.9	29.8	12.5	21.8	5.0
28.8	11.5	28.8	12.8	31.7	15.5	30.6	12.0
26.5	11.2	28.7	12.9			21.2	4.2
29.9	16.0	29.1	11.5			24.2	5.3
19.3	5.7	29.3	11.9			22.3	5.0
30.0	13.5	27.9	11.0			21.1	3.6
28.7	12.5	31.6	16.4			31.2	12.6
28.6	11.9	29.0	12.2			19.3	3.3
26.9	9.0	32.1	14.2			28.3	9.9
29.8	15.2	29.9	13.4			30.6	13.3
30.7	15.2	28.6	12.6			31.6	13.8
26.5	9.3	29.5	12.5			28.0	9.3
27.3	10.4	30.7	13.4			30.4	11.6
28.1	12.1	27.9	11.6			23.6	4.9
30.1	12.9	30.7	13.6			29.6	11.8
29.1	13.0	27.0	10.3			22.3	4.5
28.9	12.4	27.4	10.6			21.1	4.3
30.9	14.3	29.2	12.0			20.4	3.4
27.8	12.3	31.9	14.9			29.1	10.4
29.1	12.6	27.3	10.1			22.7	4.9
30.1	14.3	28.5	10.8			23.2	5.2
30.9	14.4	27.5	10.6			23.6	5.4
26.3	9.8	28.7	11.4			27.8	8.9
21.2	4.4	28.9	11.3			27.6	9.4
23.4	8.8	28.5	11.4			28.5	10.0
28.3	14.4	30.8	14.7			11.6	0.7
21.2	4.6	29.3	11.6			22.4	4.5
22.9	4.7	30.2	12.5			18.7	3.3
26.3	10.3	28.8	13.7			31.4	12.9
31.5	16.9	27.7	10.4			23.0	4.9
28.6	10.8	29.7	12.8			20.7	3.8
27.5	12.2	25.7	7.9			29.8	11.0
27.5	11.6	28.6	11.5			18.1	1.8
25.3	7.1	26.7	10.7			21.1	3.7
28.9	12.8	29.6	12.7			22.5	4.6
30.7	15.8	23.1	5.0			29.2	10.8
27.9	13.0	27.6	9.8			22.3	4.4
31.1	15.9	30.2	13.3			21.6	4.1
25.8	9.4	28.0	10.5			21.2	4.2
20.9	5.3	28.4	11.3			21.4	3.8
29.5	10.8	27.5	9.3			22.2	4.4
28.5	10.7	26.7	11.0			22.4	4.6

Semi-pelagic Shrimp Trawl Sea trials Jan - Feb., 2004

F/V "Lady Regina" - Experimental trawl

Date	Tow #	Location			Depth	Warp	Duration	Shrimp	Count	Bycatch (lbs)	
		S/E	long 70	lat 42	(fm)	(fm)	(hr)	(lbs)	(#/lb)	controlled	other
1/21/2004	1	start	38.0	48.0	43	110	1	0		0	0
		end	37.7	46.5	43	110					
	2	start	37.9	46.5	42	120	1	350	50.33	4	36
		end	38.9	51.0	42	120					
	3	start	38.8	50.5	50	122	2	168	55.19	2	7
		end	37.6	46.3	51	122					
1/22/2004	4	start	39.1	49.9	39	125	1	200	46.97	2	25
		end	38.0	47.0	40	125					
	5	start	39.0	47.0	40	125	1	36	59.48	22	2
		end	39.0	49.0	40	125					
	6	start	39.0	50.0	39	122	1.5	298	52.41	3	17
		end	36.6	53.4	39	122					
1/27/2004	7	start	36.5	53.6	39	122	1	185	48.00	7	13
		end	39.4	50.8	42	122					
	8	start	36.8	53.2	32	122	1	155	54.33	8	3
		end	39.0	51.6	39	122					
	9	start	38.7	51.0	40	125	1	523	49.33	8	8
		end	36.3	52.9	45	125					
	10	start	36.4	52.8	45	122	1	30	53.77	2	1
		end	38.9	51.1	41	122					
	11	start	38.7	51.4	41	125	1	423	50.00	5	10
		end	36.3	53.0	45	125					
2/2/2004	12	start	39.2	45.5	40	125	1	175	49.00	7	2
		end	36.5	52.5	45	125					
	13	start	36.6	52.5	44	125	1	100	58.33	7	1
		end	39.3	51.3	38	125					
	14	start	38.8	51.7	39	125	1	140	49.67	7	1
		end	36.2	53.3	44	125					
	15	start	36.5	52.9	43	128	1	120	48.00	22	2
		end	38.0	51.0	40	128					
2/3/2004	16	start	38.6	48.9	42	125	1	85	48.33	2	2
		end	37.8	46.9	44	125					
	17	start	37.0	47.0	46	130	1	70	40.67	4	7
		end	35.0	46.0	47	130					
	18	start	37.6	46.4	42	125	1	138	51.33	5	78
		end	39.1	48.5	40	125					
	19	start	39.5	48.4	39	122	1	200	44.60	5	57
		end	70.4	46.1	37	122					
2/6/2004	20	start	39.1	49.7	39	122	1	74	45.67	3	3
		end	38.6	47.7	43	122					
	21	start	36.7	48.0	48	130	1	0	0.00	0	0
		end	36.1	50.9	53	130					
	22	start	35.1	47.1	52	140	1	85	43.67	6	8
		end	36.7	49.7	49	140					
2/10/2004	23	start	37.1	51.1	44	140	1	35	41.33	3	4
		end	36.0	49.1	49	140					
	24	start	35.9	48.6	49	147	1	120	50.00	11	17
		end	35.4	50.8	50	147					
	25	start	35.5	50.7	50	147	1	0		0	0
		end	35.7	48.4	51	147					
	26	start	25.6	50.8	50	150	1	80	43.00	3	13
		end	36.4	48.6	50	150					
2/11/2004	27	start	39.0	51.0	39	122	1	220	45.67	17	23
		end	36.9	52.9	41	122					
	28	start	37.0	52.0	41	122	1	130	45.33	7	10
		end	39.0	51.0	39	122					
	29	start	38.3	51.5	40	125	1	175	45.33	12	12
		end	36.0	52.7	46	125					
2/12/2004	30	start	38.9	51.0	40	122	1	180	45.00	11	12
		end	36.9	52.8	42	122					
	31	start	36.9	52.6	42	122	1	160	43.33	6	1
		end	38.4	51.0	41	122					
	32	start	37.8	50.9	43	140	1	40	53.33	2	1
		end	48.8	36.9	47	140					
	33	start	36.8	49.4	48	140	0.75	75	45.00	10	13
		end	37.4	50.7	45	140					
2/17/2004	34	start	39.9	49.5	37	122	1	55	-	7	12
		end	39.8	47.1	37	122					
	35	start	40.0	46.2	32	95	1	0	0.00	20	25
		end	40.3	48.6	31	95					
	36	start	40.2	48.4	34	92	1	0	0.00	1	2
		end	40.1	46.0	29	92					

Semi-pelagic Shrimp Trawl Sea trials Jan - Feb., 2004

F/V "Janice Marie" - Control trawl

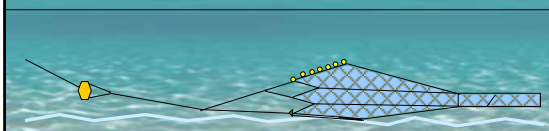
Date	Tow #	Location			Depth	Duration	Shrimp	count	bycatch (lbs)		Other vessels Shrimp
		S/E	long 70	lat 42	(fm)	(hr)	(lbs)	(#/lb)	controlled	other	(lbs/hr)
1/21/2004	1	start	40.1	50.2	42	1.75	700	56.50	3	150	300
		end	37.4	45.5	43						243
	2	start	37.7	45.5	42	1	725	57.00	3	150	
		end	38.4	41.8	42						
	3	start	39.0	51.0	41	2	750	56.00	3	70	
		end	37.5	46.2	42						
1/22/2004	4	start	38.9	60.0	42	1	150	60.57	1	60	
		end	38.0	47.5	44						
	5	start	39.1	47.7	39	1	130	65.93	1	50	
		end	39.6	50.0	38						
	6	start	39.2	50.8	41	1.5	350	56.36	4	60	
		end	36.0	52.5	47						
1/27/2004	7	start	38.5	51.5	40	1	340	52.04	3	25	
		end	36.0	53.0	40						
	8	start	37.2	53.0	42	1	250	43.29	3	25	200
		end	38.9	51.1	40						
	9	start	39.0	51.1	43	1	650	54.84	3	8	
		end	36.5	52.4	46						
	10	start	36.5	52.3	45	1	800	51.33	3	8	
		end	38.5	51.4	42						
	11	start	38.2	51.5	43	1.5	900	50.70	15	38	
		end	38.0	52.1	43						
2/2/2004	12	start	37.1	52.0	44	1.25	350	52.00	6	25	
		end	37.5	52.8	42						
	13	start	37.4	51.3	44	1	220	56.67	3	15	
		end	37.0	52.9	44						
	14	start	36.2	53.0	43	1	220	56.67	8	20	
		end	37.2	51.4	43						
	15	start	36.7	51.6	44	1.5	350	59.33	15	25	
		end	37.4	52.3	44						
2/3/2004	16	start	37.8	48.1	45	0.5	90	61.00	2	8	
		end	36.6	46.9	46						
	17	start	36.6	46.9	48	1	300	51.67	10	25	
		end	35.5	46.7	51						
	18	start	35.5	46.7	49	1.25	1100	0.00	20	80	
		end	33.4	49.9	61						
	19	start	33.4	49.9	61	1.5	800	54.00	15	150	100
		end	32.9	50.4	61						
2/6/2004	20	start	38.8	49.5	42	1	115	68.00	1	40	
		end	37.7	47.9	44						
	21	start	36.7	47.8	50	1	300	55.33	15	60	
		end	35.2	47.3	53						
	22	start	35.2	47.3	54	1	750	50.00	7	60	
		end	35.3	50.1	53						
2/10/2004	23	start	35.7	50.2	52	1	175	42.33	3	30	
		end	35.3	48.1	53						
	24	start	35.4	48.4	53	1	225	50.33	3	20	
		end	35.7	50.6	52						
	25	start	35.7	50.6	52	1	200	46.67	4	50	
		end	35.9	48.6	52						
	26	No Tow 26 for Janice Marie									100
2/11/2004	27	start	38.5	51.4	41	1	210	46.00	4	45	100
		end	36.7	53.1	41						
	28	start	36.9	52.7	42	1	190	52.67	3	40	
		end	38.6	51.3	42						
	29	start	38.6	52.7	42	1	190	50.67	4	45	
		end	36.3	52.8	45						
2/12/2004	30	start	38.1	51.8	41	1	120	50.33	2	20	160
		end	36.9	52.8	41						
	31	start	36.9	52.8	42	1	180	58.67	2	20	120
		end	38.1	51.8	41						
	32	start	37.7	50.9	44	1	110	53.33	2	20	
		end	36.9	49.5	48						
	33	start	36.8	49.5	48	0.75	65	50.00	4	30	175
		end	38.9	51.4	44						
2/17/2004	34	start	39.7	48.3	38	1	150	45.67	2	20	133
		end	39.7	47.1	38						
	35	start	40.6	46.4	31	1	0	0.00	35	100	
		end	40.5	48.2	31						
	36	start	40.2	48.5	33	1	0	0.00	4	40	
		end	40.1	46.2	31						

Appendix III

Oral and Poster Presentations

ICES/FAO Fishing Technology and Fish Behavior Working Group, Gdynia, Poland, April 2004

Reducing Seabed Impact of Fishing Operations
SEMI-PELAGIC SHRIMP TRAWLING



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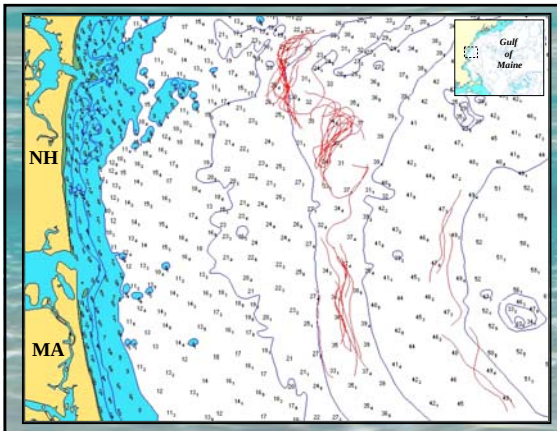
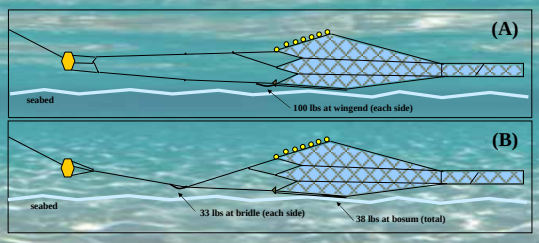
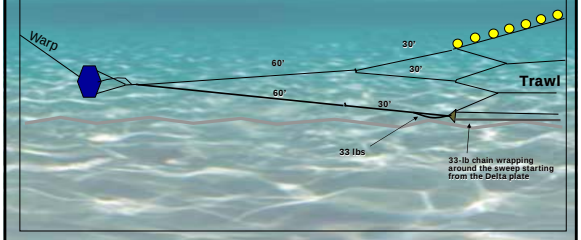
SEMI-PELAGIC SHRIMP TRAWL
Flume Tank Tests

Fishing Areas





BRIDLE RIGGING
90 ft total bridle length



Trawl Doors

Poly-Ice El Cazador

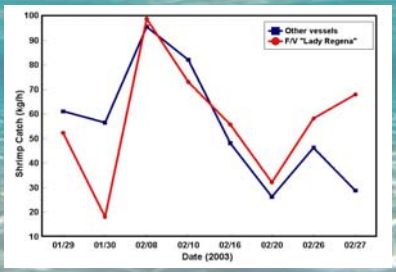
Fishing Vessels

F/V Atlantic Challenger

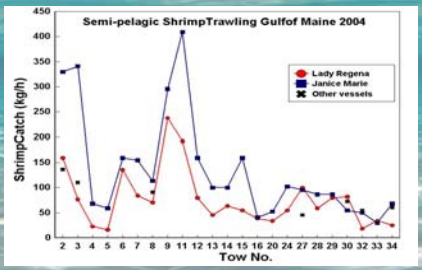
Target Species

Pink Shrimp
(Pandulus borealis)

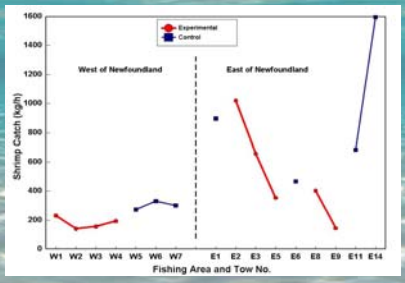
Catch Rates
2003 Gulf of Maine



Catch Rates
2004 Gulf of Maine



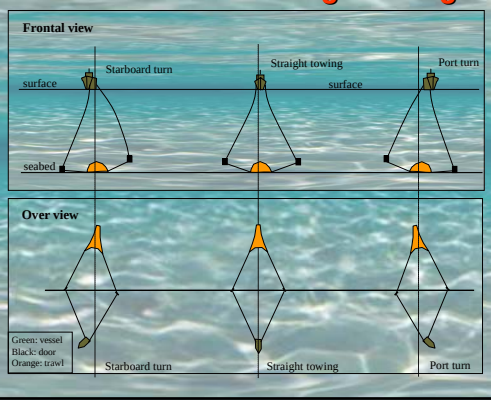
Catch Rates
2003 Newfoundland



Door Shoe

After 38 tows in 2003

Door Behaviour during Turning

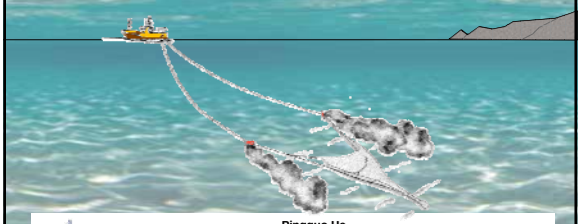


Summary and the Next Steps

- Catch rates comparable if the gear is properly rigging and warp/depth ratio suitable
- Sensitive to depth change
- Monitoring and control equipment needed
- Longer bridles beneficial
- Phase I of Gulf of Maine experiments completed
- Newfoundland experiment continuing

Maine Fishermen's Forum March 2006

Mitigation Measures against Seabed Impact of Mobile Fishing Gears



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Technical Measures

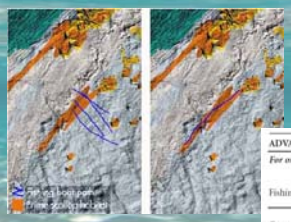
- Mapping, efficiency and effort
- Alternative gears
- Gear modifications
- Alternative stimuli
- Novel techniques

Mapping and Efficiency

- Efficient gears can reduce seabed effect in strictly-enforced output-controlled fisheries
- Examples: Scallop dredging in US & Canada

Mapping

High resolution multibeam sonar mapping on Browns Bank off Nova Scotia



(Bedford Institute of Oceanography, DFO)

ADVANTAGE OF MULTIBEAM MAPPING IMAGERY

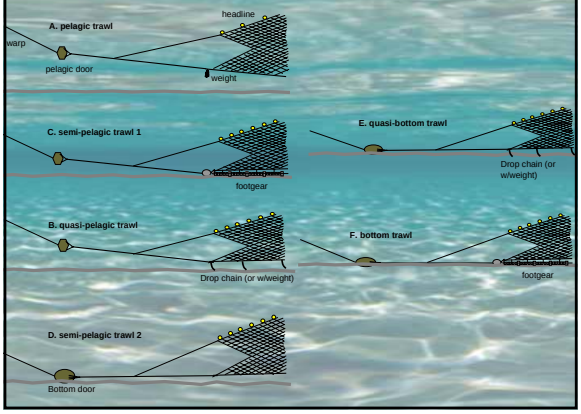
For one tonne of scallop meat:

	Without imagery	With imagery	Reduction
Fishing effort	6.37 hours	2.41 hours	62%

For a scallop quota of 13,640 kilos:

	Before imagery	With imagery	Reduction
Time gear on bottom	162 hours	43 hours	73%
Area of bottom towed	1,176 km²	311 km²	74%
Fuel usage	27,697 liters	17,545 liters	36%

Gears Use and Modifications

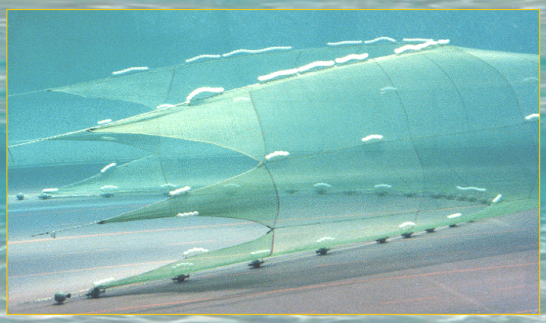


Alternative Gears

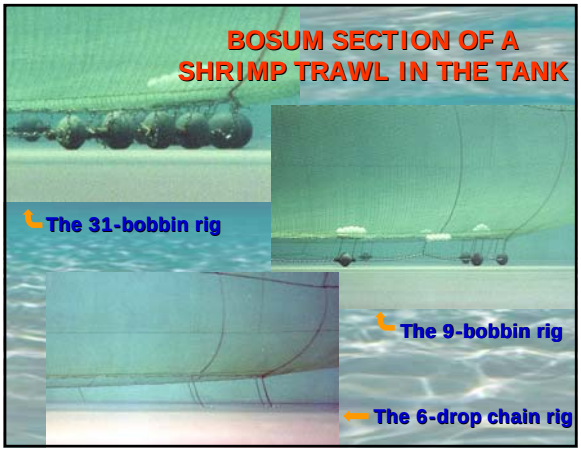
- Alaska Pollack Trawl Fishery:
  - Pelagic fishing to reduce bycatch of crabs and halibut
  - Use the number of crab catch as performance measure
  - More resource allocated to “pelagic” operations

Gear Modifications

- Lighter footgears
- Semi-pelagic shrimp trawling
- Sweepless trawls
- High aspect doors
- Wheels, wheels, ...

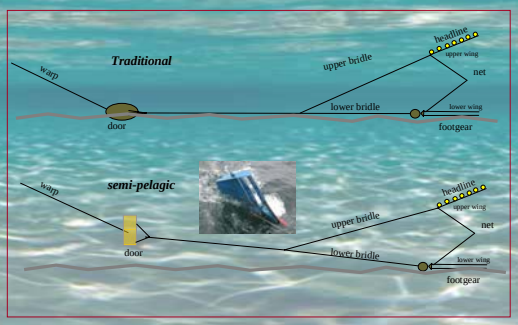


BOSUM SECTION OF A SHRIMP TRAWL IN THE TANK

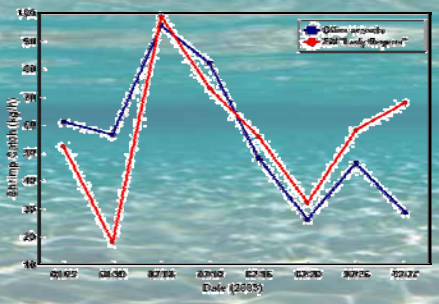


SEMI-PELAGIC SHRIMP TRAWL

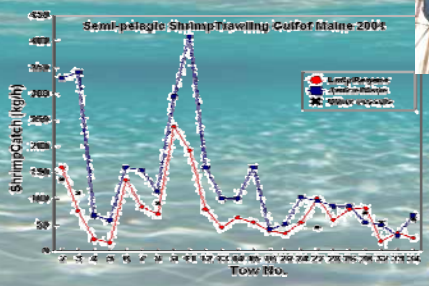
Gulf of Maine and Newfoundland



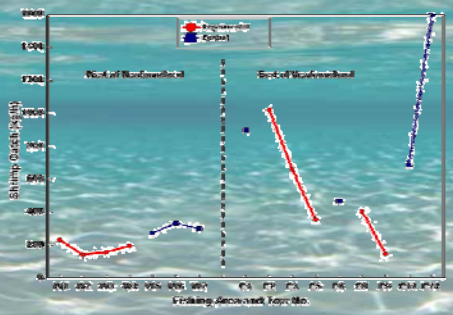
Shrimp Catch 2003



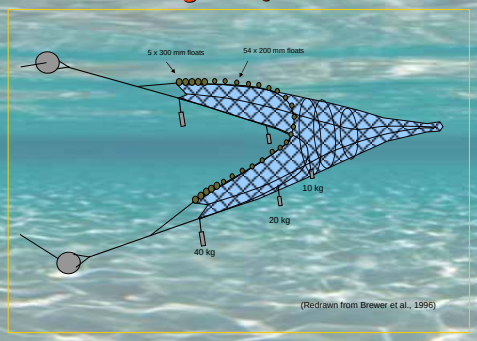
Shrimp Catch 2004



Shrimp Catch 2004 - Newfoundland

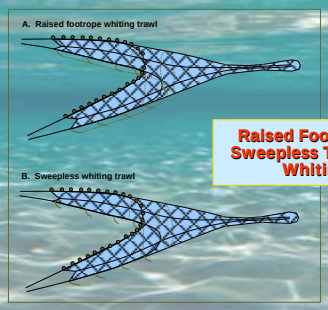


Australian design – "Quasi-bottom"



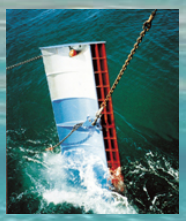
(Redrawn from Brewer et al., 1996)

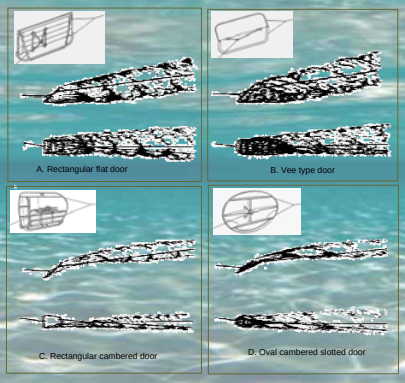
MA DMF design – "Quasi-bottom"



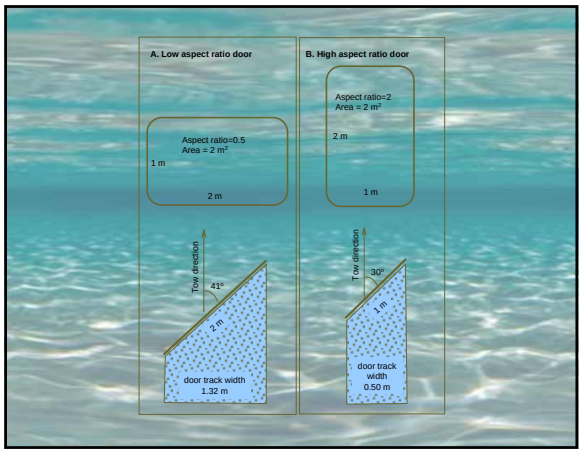
Raised Footrope & Sweepless Trawl for Whiting

(Redrawn from Pol & Carr, 2000; Pol et al, 2003)



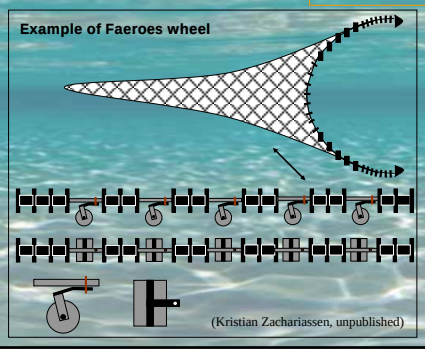


(From Main & Sangster, 1981)

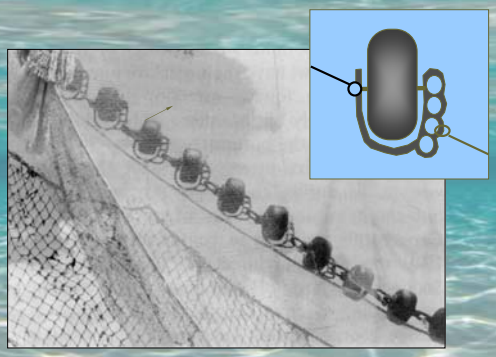


Wheels, wheels … and reinventing …wheels for trawls

- Ireland wheels
- Faeroes wheels
- Norwegian wheels

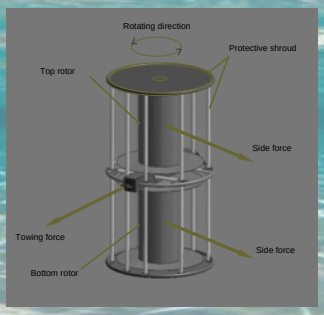


(Kristian Zachariassen, unpublished)



Modified from Gabriel et al., 2005

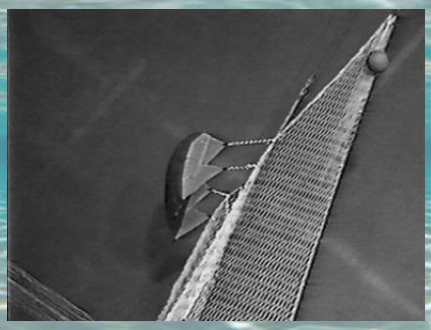
Other Developments …..



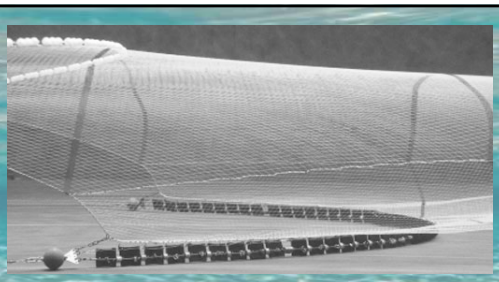
Active Trawl System – Variable Thrust Vector Device (VTVD)

(After Shenker, 2005)

"Soft Door"



(From Goudey, 1999)



Self Spreading Groundgear "Plate Gear"

(U. Hanson, SINTEF)

"Street Sweeper" Footgear

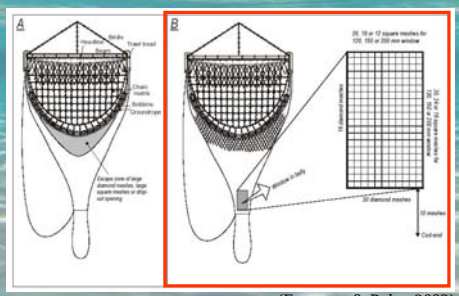
Banned here, testing elsewhere

Alternative Stimuli

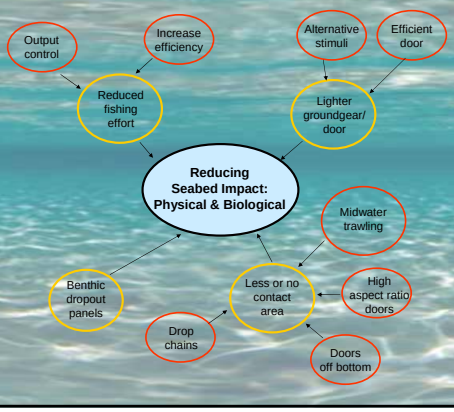
- Electrical Beam Trawls: flatfish & Shrimp
- Work in progress: Scallop dredge

Dropout Panels in Beam Trawls

Aft-belly dropout panel



(Fonteyne & Polet, 2002)



Symposium on "Effect of Fishing Activities on Benthic Habitat: Linking Geology, Biology, Socioeconomics, and Management". Nov. 12-14, 2002. Tampa, FL. USA

REDUCING SEABED CONTACTS OF BOTTOM TRAWLS

Flume Tank Tests and Full-scale Sea Trials

PINGGUO HE, UNIVERSITY OF NEW HAMPSHIRE, DURHAM, NH 03824, PINGGUO.HE@UNH.EDU

ABSTRACT

- Typical bottom trawls leave tracks when they are towed over the seabed.
- Reducing contacting points of doors and/or bobbins can reduce tracks left by trawls and alleviating impact of trawling on the benthic system.
- A Canadian offshore shrimp trawl and a Gulf of Maine inshore shrimp trawl were tested to reduce bottom contact while trawling.
- The number of bobbins was reduced from the traditional 31 to nine in the Canadian offshore shrimp trawl during flume tank tests and sea trials.
- Less number of bobbins on its footgear may result in the footgear intermittently being lifted off bottom, but this may not necessarily result in reduction in catch of shrimps.
- A semi-pelagic shrimp trawl has been designed through flume tank tests, and is ready for sea trials in Gulf of Maine in the upcoming winter shrimp season.

INTRODUCTION

The pink shrimp (*Pandulus borealis*) is the major shrimp species in Atlantic Canada and Northeastern United States. The shrimp is primary harvested by otter trawls, with a small trap fishery in the Gulf of Maine. Shrimp trawls are towed on the seabed with otter boards (or called doors) and ground sweeps contacting the seabed, resulting in potential alteration of seabed substrates and disturbance to benthic organisms.

Here we report two projects aimed to reduce bottom contacts of shrimp trawls in Canada and in the US.

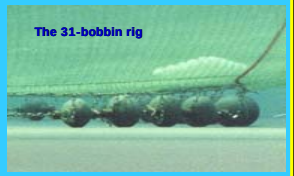
EXPERIMENTS TO REDUCE BOTTOM CONTACT OF SHRIMP TRAWLING

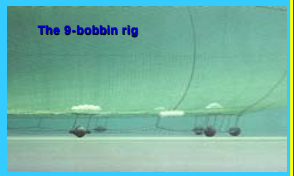
Canadian offshore shrimp trawls use large steel bobbins to roll over irregular grounds in Labrador Sea. As many as 40 bobbins of 21" to 24" diameter are used. We examined whether the number of bobbins can be reduced without affecting trawl performance and catch efficiency.

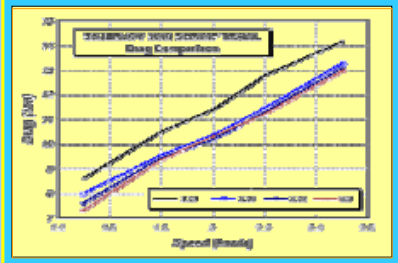
Inshore shrimp trawls in the Gulf of Maine use rubber discs to hover over smooth bottom. Steel trawl doors are used to spread the net horizontally. Here we are testing if the doors can be towed off the seabed while maintaining bottom contact of the trawl net.

CANADIAN OFFSHORE SHRIMP TRAWL FLUME TANK TESTS

BOSUM SECTION OF A SHRIMP TRAWL IN THE TANK







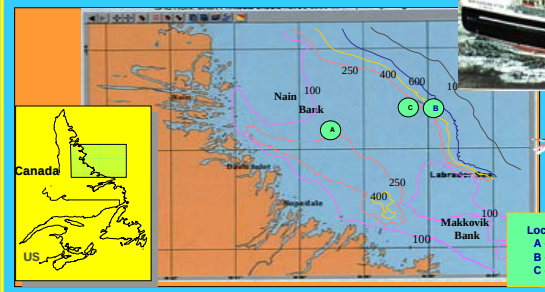
Substantial reduction (12%) in drag for 17,- 15-, and 9- bobbin rigs compared with the traditional 31-bobbin rig.

FLUME TANK TESTS - SUMMARY

- Stable gear with less number of bobbins
- Unstable with drop-chains, further tests required
- Contacting with seabed reduced by 70% when the number of bobbin reduced from 31 to 9
- Trawl system drag reduced by 12%

CANADIAN OFFSHORE SHRIMP TRAWL SEA TRIALS

Fishing Grounds and Fishing Vessel



Location:
- A – Smooth grounds
- B – Rough grounds
- C - Intermediate

Sea Trials - Results

Location, catch and gear conditions at retrieval

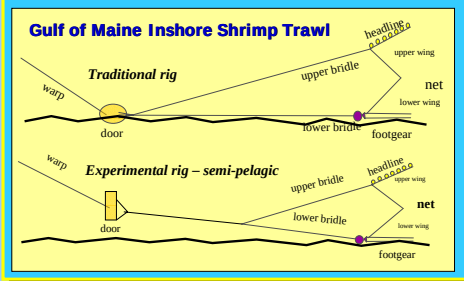
Tow #	Loc**	Gear**	Bobbins	Tow (km)	Catch** (kg)*	Size** (No/kg)	By-c (kg)**	By-c rate (kg/km)	CPUE (kg/km)	Gear condition at retrieval
1	A	Exp	9	3.04	2805	170	2	0.1%	654	No damage
2	A	Exp	9	2.08	213	110	6	2.8%	71	No damage
3	A	Con	31	3.09	181	120	1	0.6%	60	No damage
4	A	Exp	9	1.23	68	110	3	1.3%	136	No damage
5	B	Con	31	2.60	4014	119	14	0.3%	2007	No damage
6	B	Exp	9	3.04	2121	122	10	0.5%	707	Hooked, minor damage
7	B	Exp	13	1.08	1418	118	26	0.8%	2814	Twisted, slight
8	B	Con	31	1.58	3169	130	9	0.2%	2496	No damage
9	B	Exp	13	1.58	5402	115	11	0.2%	3481	Major damage
10	B	Con	31	2.35	2805	126	10	0.3%	540	No damage
11	B	Exp	15	1.48	2346	127	13	0.4%	1537	Hooked, no damage
12	C	Exp	19	2.08	3169	126	13	0.4%	1760	Belly torn
13	C	Exp	19	1.45	3492	136	7	0.1%	3138	No damage
14	C	Con	31	1.45	4962	142	12	0.2%	2833	No damage
15	C	Exp	19	1.45	4968	136	12	0.2%	2833	No damage
16	C	Exp	19	3.04	4757	140	17	0.4%	1586	No damage
17	C	Exp	19	2.12	4147	136	13	0.3%	1296	No damage

** Loc: location - see chart, ** - gear type: Exp - experimental, Con - Control, ** catch - noted weight (kg)
** damage size - expressed by counts, number of chainings per kg, ** by-catch weight - included redfish, turbot, and American plaice.

Sea Trials - Summary

- The major problems involving trawl with reduced bobbins in footgear are:
  - Chain cutting into the substrate
  - Footgear lifting off bottom
- Number of bobbins in shrimp trawls can be reduced when operating in smooth grounds and weak current such as Location A and southern grounds
- There were no noticeable differences in catch rates and bycatch amount between the original trawl and the trawl with less bobbins

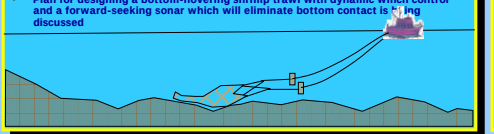
GULF OF MAINE INSHORE SHRIMP TRAWLING - SEMI-PELAGIC TRAWL



Semi-pelagic shrimp trawl as seen in the flume tank at Memorial University of St. John's, Newfoundland, Canada. The trawl doors are off the bottom and the trawl is on the bottom. A full scale trawl based on flume tank tests is being built and sea trials are scheduled for the up coming winter shrimp season in Gulf of Maine.

SUMMARY AND FURTHER WORKS

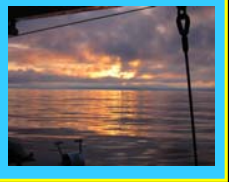
- Canadian offshore shrimp trawls can be operated with reduced number of bobbin when operated on smooth fishing grounds, with savings on fuel and reduced disturbance to the bottom habitat
- Testing of a semi-pelagic shrimp trawl in the tank showed promise of its use in the Gulf of Maine inshore shrimp fishery
- Sea trials on semi-pelagic shrimp trawl for the Gulf of Maine have been planned for the coming winter
- Design and testing of semi-pelagic shrimp trawl for the Newfoundland shrimp fleet will be carried out cooperatively with Memorial University of Newfoundland
- Plan for designing a bottom-hovering shrimp trawl with dynamic winch control and a forward-seeking sonar which will eliminate bottom contact is being discussed



ACKNOWLEDGEMENTS

Work on the Canadian offshore shrimp trawl was carried out while the author was with the Fisheries and Marine Institute of Memorial University of Newfoundland, Canada. Project team included Mr. David Foster of Fishery Product International Ltd. and staff at the Centre for Sustainable Aquatic Resources of MUN. Financial support was provided by the Canadian Center for Fisheries Innovation.

Work on semi-pelagic shrimp trawling in the Gulf of Maine was carried out cooperatively with Capt. George A. Littlefield of F/V "Lady Regena", Seabrook, NH and Mr. Harold DeLoache of MUN. Financial support for the project was provided by the Northeast Consortium.



The Fourth World Fisheries Congress, May 2-6, 2004, Vancouver, BC, Canada

REDUCING SEABED CONTACT OF TRAWLING
A Semi-pelagic Trawl for Pink Shrimps

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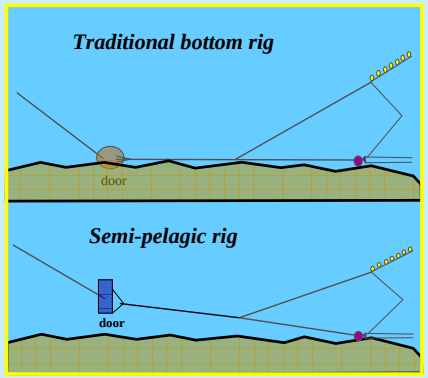
INTRODUCTION

The pink shrimp (*Pandulus borealis*) is the major shrimp species in Atlantic Canada and Northeastern United States. The species is primary harvested by otter trawls. Shrimp trawls are towed on the seabed with doors and bridles in contact with the seabed, resulting in potential alteration of seabed substrates and disturbance of benthic organisms. Here we report two projects aimed at reducing bottom contacts of shrimp trawls.



SEMI-PELAGIC SHRIMP TRAWLING

Shrimp otter trawls were developed from groundfish otter trawls. Groundfish trawls require the doors on the seabed so that the doors, sand clouds stirred up by the doors, and bridles which skim on or near the seabed can herd the fish toward the mouth of the trawl. Herding contribute as much as 2/3 of the fish entering the mouth of the trawl. Shrimps, on the other hand, can not be herded due to poor swimming capacity and reaction capabilities. Therefore, off-bottom trawl doors without trailing sand cloud would not reduce catching efficiency of the trawl. Trawling system with doors off bottom and trawl on bottom is called Semi-pelagic trawl.

On the right is a semi-pelagic shrimp trawl model in the flume tank at the Fisheries and Marine Institute in St. John's, Newfoundland, Canada.

Two parallel full scale sea trials were carried out by the co-authors and their industry partners. One was conducted in Gulf of Maine in the northeastern USA and the other was in Newfoundland, Canada.

In both experiments, high aspect PolyIce "El Cazador" trawl doors were used. The doors provide a high left-to-drag ratio, and can be operated on or off the bottom. Shorter warps were used to lift the doors off the seabed.

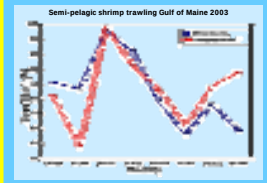
FISHING AREA

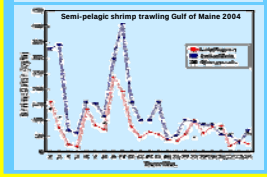
GULF OF MAINE EXPERIMENT

The Gulf of Maine experimental fishing was carried out off New Hampshire during winters of 2003 and 2004. A 55' inshore trawler, F/V "Lady Regena", was used along with an experimental trawl fitted with a typical Nordmore Grid bycatch reduction device. Fishing was conducted at depths between 28 and 51 fm. Trawl geometry and the position of the door in relation to the seabed were measured using NetMinder acoustic monitoring equipment.

Catch rates were compared with the average of the fleet fishing on the same ground in 2003. In 2004, tow-by-tow comparisons were made with another commercial trawler fishing side by side with F/V "Lady Regena".

GULF OF MAINE EXPERIMENT



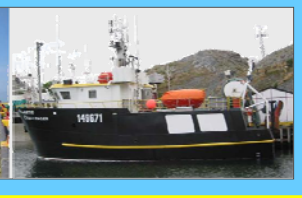


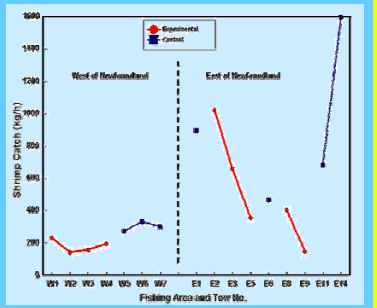
Catch was variable day to day and tow to tow. Catch rates were low in the beginning of the experiment when the rigging was being tuned. Catch rates were comparable towards the end of the experiment.

The doors were kept off bottom for the most of time during the tow as indicated by the NetMinder sensors. If they were on bottom during turning and depth change, bottom contacts would be very light and intermittent. After 38 tows, only about 1/3 of the area on the door shoe was polished. Doors operating on bottom would be fully polished in one tow.

NEWFOUNDLAND EXPERIMENT

The Newfoundland experiments were carried out on board F/V "Straits Foam" on the west coast, and F/V "Atlantic Challenger" on the east coast. Both are 65' shrimp trawlers. Fishing was conducted at depth 118 to 155 fm on the west coast and between 175 to 182 fm on the east coast. Shrimp catch rates (kg/hr) are shown below. The results are very preliminary, and further work is planned for this coming shrimp season.





SUMMARY

- Testing of a semi-pelagic shrimp trawl showed promise in the Gulf of Maine and Newfoundland shrimp fisheries.
- Catch rates of shrimp were comparable to those of commercial operations if the warp length was properly adjusted for the water depth.
- Trawl system is sensitive to depth change and turning. Longer bridles seemed beneficial.
- Further work is needed to better monitor and control the position of the doors and the trawl.

ACKNOWLEDGEMENTS

The Gulf of Maine experiment was carried out cooperatively with Capt. George Littlefield of F/V "Lady Regena". Financial support for the project was provided by the Northeast Consortium.

The Newfoundland experiment was carried out with assistance from George Legge and industry partners Capt Marcel O'Brien and Capt. Jason Petten. Financial support was provided by the Canadian Center for Fisheries Innovation.

The authors would like to thank Dr. Troy Hartley of UNH for constructive comments and suggestion.

Appendix IV

Related Media Articles

Gear Review: A Semi-Pelagic Trawl System

As the shrimp season in the Gulf of Maine approaches, the time is ripe to review developments in fishing gear designed to maximize catch rates while minimizing sea bottom impact.

Recently, the preliminary results from tests of a semi-pelagic shrimp trawling system were posted on the Northeast Consortium's website (www.northeastconsortium.org) and, according to the report, the innovative gear exhibited catch rates equal to or better than traditional gear fishing the same grounds.

"I'm very excited about this system," said New Hampshire fisherman George Littlefield, captain of the 55-foot wooden trawler, Lady Regena, which was used to test the trawl. "Whenever you can keep iron off the bottom it's a good thing, and when you can do it without sacrificing the effectiveness of the gear it's a win-win situation. We proved that this off-bottom system is capable of fishing as well or better than normal gear."

Reducing Bottom Damage

Since the Sustainable Fishing Act of 1996 called for government managers to pay more attention to the health of "essential fish habitat," fishermen and scientists have searched for ways to reduce the impact trawling gear has on the sea floor, which is considered important to the spawning and feeding habits of fishes throughout the Gulf of Maine.

In the northwest Atlantic (and around the world) the otter trawl is the most common gear used for harvesting shrimp. The trawl uses heavy iron doors, dragged along the sea bottom, to keep the mouth of the net open. And while the impact of trawl doors on the ocean floor is not well understood, it is generally agreed that minimizing the time doors spend on the bottom would improve habitat for a variety of species.

I'm very excited about this system. Whenever you can keep iron off the bottom it's a good thing, and when you can do it without sacrificing the effectiveness of the gear it's a win-win situation. We proved that this off-bottom system fished as well or better than normal gear.
-George Littlefield

This $88,004 study, funded by the Consortium, was developed by Littlefield and Pingguo He, a fishing gear specialist at the University of New Hampshire "To eliminate seabed contact of trawl doors by using a pair of pelagic doors operating off the bottom, while keeping the ground gear on the bottom in order to maintain catch efficiency," said Pingguo He.

The hope is that by reducing the impact shrimp gear has on bottom habitat, managers might be willing to extend the length of the shrimp season a few days to allow fishermen to land more shrimp without causing more damage to the environment. In other words, both the ocean habitat and fishermen would benefit.

The Gear

The trawl is based on a four-panel configuration designed by gear specialist Harold DeLouche, with modifications suggested by the project's participants. Further refinements were added after tests in a flume tank.

The back of the trawl, including a Nordmore Grate, is similar to other shrimp nets used in Gulf of Maine; the front was designed to keep the trawl mouth on the bottom while keeping the doors off the bottom.

A pair of 1.9 meter squared Poly-Ice® El Cazador doors from Iceland were selected (see photo below) for their ability to stay off the bottom as well to withstand inevitable contact with rocks, boulders,

Image courtesy Pingguo He: The trawl door.

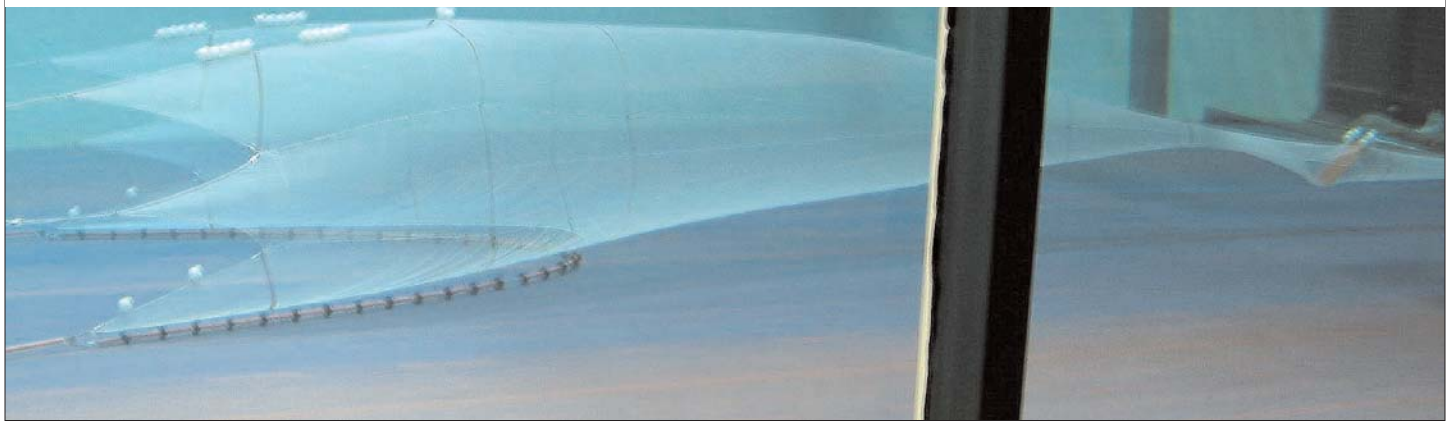


Image courtesy Pingguo He: The system was tested inside the flume tank in Newfoundland before sea trial began last year.

and other sea floor features.

They measure 1.660 meters high and 1.245 meters wide, weighing 518 pounds in air. The rigging includes two bridles splitting to three at the wingends. Upper and lower bridles were attached to the doors with two five-meter backstraps. An idler chain connects bridles per specification of the manufacturer. Backstraps and idler chains were later replaced with combination wires for ease of operation.

The bridles measure 180 feet from wingend to door minus the backstrap length. Upper bridles were made of 3/8-inch wire; the lower bridles 5/8-inch wire. Wingend weight began at 118 pounds, but was reduced as the experiment progressed.

Sea Trials

Trials were conducted in January and February 2003 off the coast of New Hampshire. The fishing was limited to eight days because of the regulated season and poor weather, but more tests are scheduled this coming season.

During each tow, an effort was made to match depths so that warp length would not have to be changed. Depth strata ranged from 30-31 fathoms, 35-36 fathoms, 38-39 fathoms, and 49-50 fathoms. However, the majority of fishing was carried out between 30-31 and 35-36 fathoms.

Towing speeds hovered around 2.4 knots, though slight deviations may have occurred due to tides and currents. Tow durations were one hour with one 30-minute tow. A NetMind® acoustic trawl monitoring system was used to ensure consistency in tows.

Samples of shrimp and bycatch from each tow were measured and weighed to the nearest pound. The average number of shrimp per pound was approximately 42.

Results

Catches ranged from zero when the net was off the bottom at the start of the experiment to as much as 347 pounds per hour. A total of 4,822 pounds of shrimp were caught in 38 one-hour tows, with an average catch rate of 127 pounds per hour.

The effectiveness of the experimental gear was then determined by comparing its catch rate to that of other vessels fishing the same area (landings data was supplied by the Yankee Fishermen's Coop in Seabrook, N.H.)

The study indicates that the experimental gear displayed catch rates very close to the vessels it was compared to and, after some fine tuning, actually exceeded that of other vessels fishing the same grounds.

Pingguo cautions that exact comparisons to the landings data cannot be made because their operations were not controlled, but said "In this phase of the experiment we wanted to determine whether or not the gear could perform with the doors off the bottom, and it did." More rigorous comparative trials with traditional gear, fishing alongside the experimental gear, is scheduled for January and February 2004

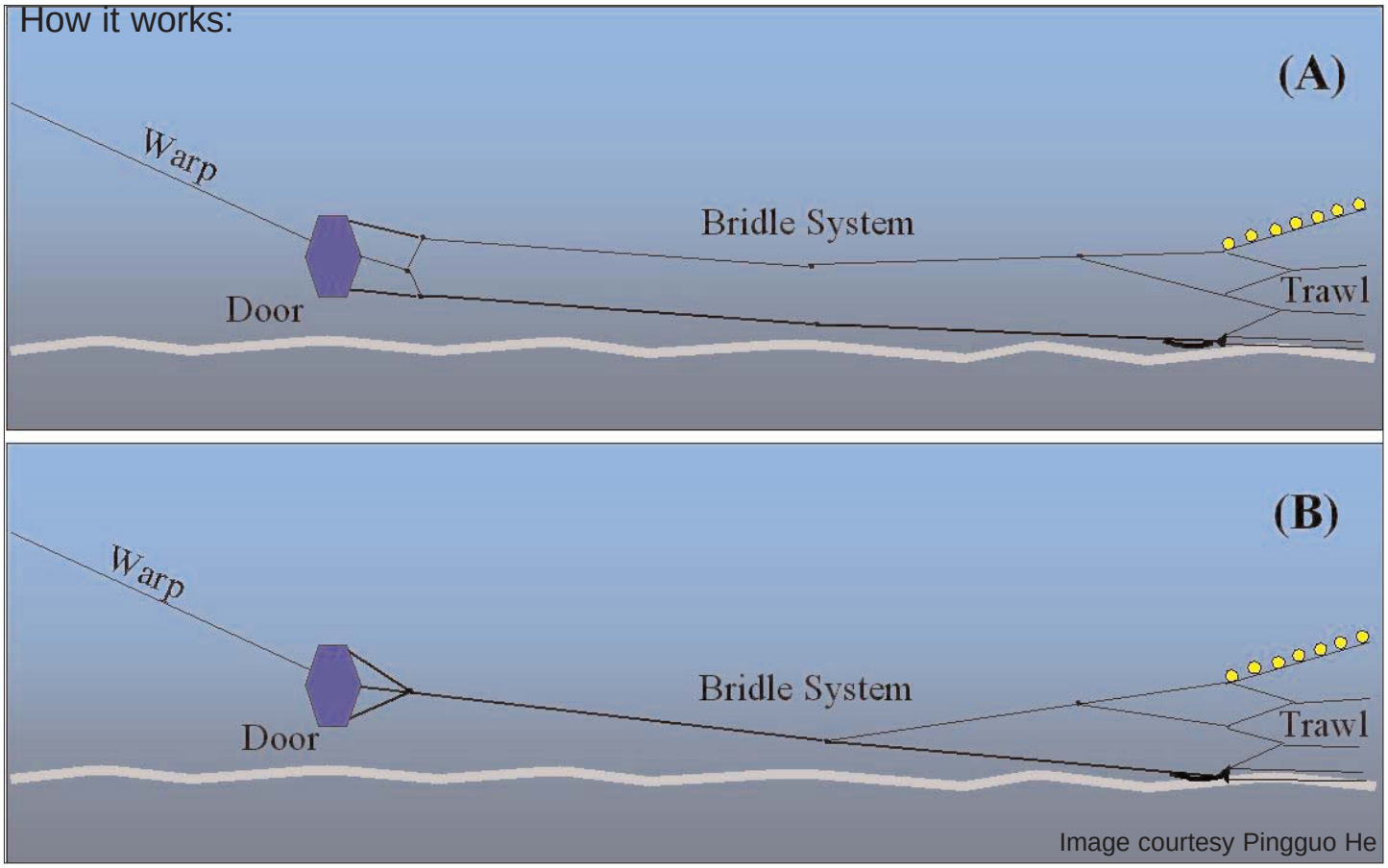


Image courtesy Pingguo He

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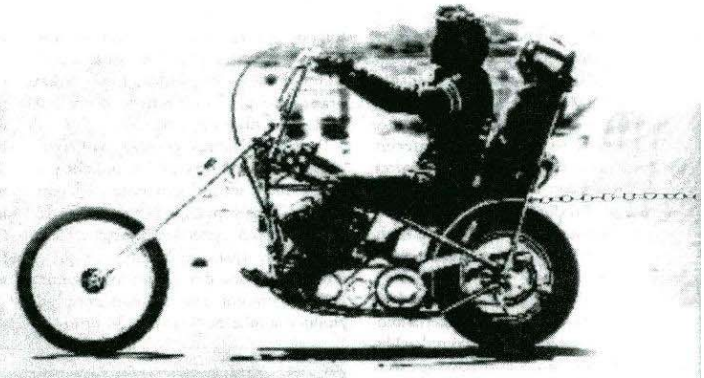


easy RIDERS

Trawl components, such as doors, are being designed for less habitat impact

By Michael Crowley

Fishermen who think they don't have to pay attention to conservation issues are kidding themselves. That's doubly true for mobile-gear fishermen, especially those whose gear hugs the seafloor.

Closed areas, fewer days at sea and bycatch limits that shut down a fishery are just a few of the reasons fishermen who use groundfish trawls spend more days at the dock than they spend at sea. Some see these regulations as the only way to increase fish stocks, preserve bottom habitat and ensure the survival of fishermen and the communities that depend on them.

Others see the measures as slow strangulation, designed ultimately to end with the demise of the fisherman who tows his nets along the bottom.

The most strident critics have a very short time frame for accomplishing this. The Web site for the Deep Sea Conservation Coalition quotes the report of the U.N. Task Force on Environmental Sustainability: "Global fisheries authorities must agree to eliminate bottom trawling on the high seas by 2006.... and to eliminate bottom trawling globally by 2010."

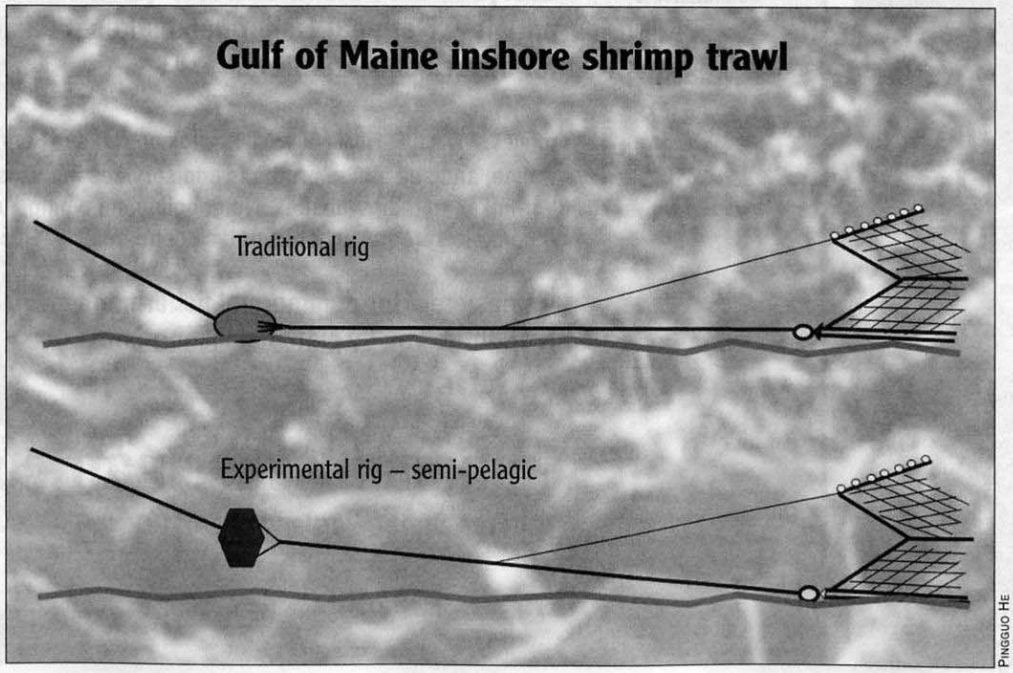
This is not the first attempt to suppress bottom trawling.

In 1583, trawling for shrimp was prohibited in the estuaries of Holland. A year later, the trawl was outlawed in France, and England banned it in 1631. The penalty for using a trawl was harshest in France — capital punishment. How many fishermen met that ignominious fate is unknown.

Back then, the criticism of the trawl wasn't that different from today: It caught too many small fish and tore up the bottom. But the attack on trawl fishermen went beyond fishing gear to the character of the fishermen themselves. They were "besotting themselves with pipe and pot in a beastly manner, sucking smoak, and drinking healths, until death stares many in the face" (see "The History of Trawling," *The Fish Trades Gazette & Poultry, Game & Rabbet Trades Chronicle*, March 19, 1921, p. 31).

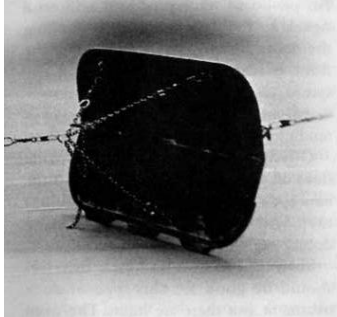
And in 17th-century England, critics of trawling labeled it an "idle kind of fishing" and "less laborious than others," meaning the harder you worked, the more credible you were. Evidently, trawlers were the slackers of the fishing communities.

The trawl survived because it was very effective at catching bottom fish, and people had to eat. Plus, there were a lot of fishermen, and taking their nets created problems for the government. In 1405, when English authorities took away 16 nets from fishermen on the Thames, 2,000 people from Kent and Essex gathered and "horribly by sound raised of the bells of the churches upon the shores... and in guise of insurrection... arrayed to make war with bows, arrows and swords, bucklers, clubs and doors and windows in place of shields." The fishermen got their nets back and



PINGGUO HE

Flying shrimp doors off the bottom in Gulf of Maine trials did not affect the amount of shrimp that was caught.



were pardoned for their actions that day (see "The History of Trawling," p. 25).

Six-hundred years later, fishermen and scientists are betting the future not on insurrection but on designing trawls that ride easier or hardly at all on the bottom, are selective about the fish they retain, and instead of warring with environmentalists and conservationists, they are sharing ideas with them.

"The idea is to work with them and understand they have valid points. The quicker the fisheries can address the points, the better off everyone will be," says Dan Schick, with the Maine Department of Marine Resources in Boothbay.

An example is a small-boat sweepless trawl that was developed for Maine's whiting fishery. The sweepless trawl is the "only reason we have a whiting fishery at all," Schick says. A primary design consideration was to reduce the bycatch of flounders and lobsters, which it did. But it turns out the trawl avoids what some say is a more important consideration than bycatch, and that is habitat damage.

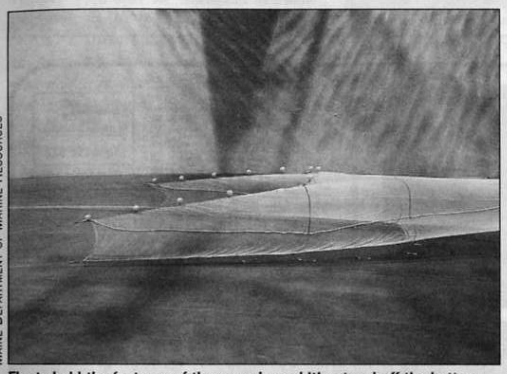
Schick says that compared with almost any other type of trawl, "it has almost zero contact with the bottom." There's no roller gear or chain sweep, and the footrope is held off the bottom by a series of floats on the headrope that have enough flotation to pick up the footrope.

The only things touching the bottom are the shoes of the doors and tips of chains that are placed every 8 feet along the footrope.

Trawl doors dragging along the seafloor have a lot of conservationists, fishermen and scientists concerned. This summer, Maine's Department of Marine Resources will experiment with an Icelandic trawl designed to reduce the impact of trawl doors on the bottom.

Instead of roller gear, the trawl features flat rubber panels strung together along the footrope with a wire running through the middle of each panel. As the net is pulled, the panels are designed to ride so "their bottom edge may or may not be touching, but there's no hard force down. Water pressure holds the panels vertical," Schick says.

The panels push water ahead of them, providing some spreading force to the net and, thus, the door size can be reduced. The panels and smaller doors should have less impact on the bottom. And a reduction in door size should mean less money spent on fuel.



Maine Department of Marine Resources

Floats hold the footrope of the sweepless whiting trawl off the bottom. The only things touching the sea bottom are the tips of the chain.

Getting trawl doors completely off the bottom is an idea more people are working with. It was the focus of shrimp trawl experiments run in the Gulf of Maine by Pingguo He with New Hampshire Sea Grant and a research associate with the University of New Hampshire's Institute for the Study of Earth, Oceans and Space.

He found that shortening the warps kept the doors off the bottom, and when fishermen were able to tow through constant depths, the same amount of shrimp was caught as when doors were on the bottom.

Tables show the relationship between depths and how far the doors should be off the bottom, based on things such as the door's weight and towing speed.

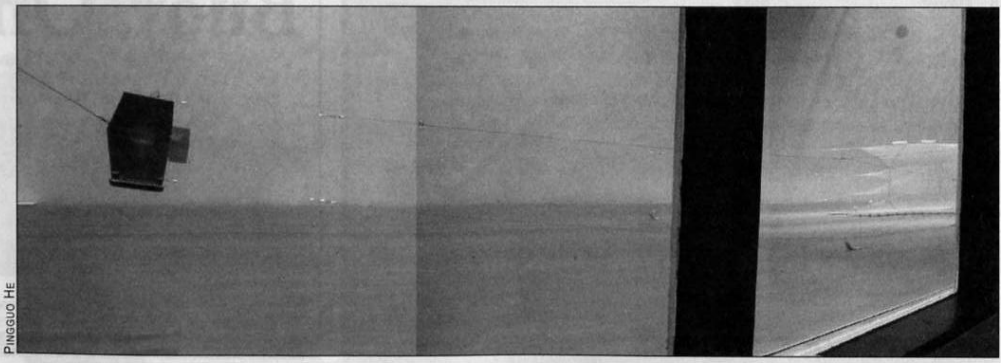
In the end, this was an idea that didn't work for Maine and New Hampshire small-boat fishermen for two reasons: There aren't large expanses of seabed at a constant depth, and because most small-boat shrimpers can't operate their winches independently of the engines, the warp length can't be adjusted to meet changing depths. However, He says, in areas like Newfoundland, where depths don't change over vast areas, the idea should be viable.

Cliff Goudy, director of the Center for Fisheries Engineering Research at the Massachusetts Institute of Technology also is trying to develop a way to keep trawl doors off the bottom.

"The trawl door, most people believe, is the most significant impactor on the bottom. As long as that is on the bottom, the motivation to reduce the impact of other components is less important," Goudy says.

This spring, Goudy is scheduled to head up a project that keeps doors off the seabed with an acoustic height-control mechanism.

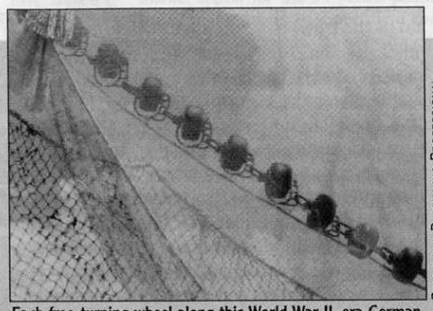
An acoustic sensor that can be preset to whatever height off the bottom is



Pingguo He

The feasibility of towing groundfish doors off the bottom was tested at Newfoundland's Memorial University flume tank.

Modernizing with 1940s German engineering



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Each free-turning wheel along this World War II–era German trawl's footrope ran parallel to the towing direction.

You might think the Germany of the 1940s, preoccupied with conquest — and later with survival — would have put the benthic effects of trawling on the back burner. Nonetheless, the Germans did invest in fishing, and some of that investment could help 21st-century trawlers reduce the effect of bottom gear on the seabed.

At least that is the thinking of Pingguo He, who participated in a discussion on reducing trawl impacts at the Maine Fishermen's Forum in March.

He, a research associate with the University of New Hampshire's Institute for the Safety of Earth, Oceans and Space and affiliated with New Hampshire Sea Grant, showed German-designed wheels to be used on sweeps.

He believes they wanted to reduce drag and thus save fuel.

The wheels were designed to run parallel to the direction the trawl was being towed. "It's not like our roller gear, where only the middle ones roll," He says. "They had some sort of mechanism where they were able to have the axis parallel to the towing direction."

A modern but similar idea He cited is a caster-like affair being tested in Europe. "It replaces bobbins and rockhoppers. It would be on a swivel and roll, and may leave less of a footprint," He says. **— M.C.**