Northeast Consortium Annual Report Dec. 1, 2006

Project Title: Modifying the Nordmore Grid to Reduce Fish Discards and Small Shrimps in the Gulf of Maine Shrimp Fishery

Project Number: 111A21

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Tim Eddy, F/V "Persistence", Portland, ME

Major Accomplishment:

- Completed sea trials as planned involving two commercial fishing vessels
- Tested four designs of size and species separation devices
- Improved shrimp size by 17 to 20 counts per pound

Next Steps:

- Analyze and produce a final report
- Prepare manuscript for publication
- Plan to manufacture two sets of shrimp size grid for fishermen to use
- Continue outreach
- Seek funding to optimize the design and to disseminate information to the fishing industry

Impacts::

Presentations:

He, P. 2006. Reducing Finfish and Small Shrimps in the Gulf of Maine Pink Shrimp Fishery through cooperative research with fishermen. Presented at National Sea Grant Fisheries Enhancement Meeting, Jacksonville, FL. Oct. 15-18, 2006.

He, P. and V. Balzano (2006). Reducing small shrimps in the Gulf of Maine pink shrimp fishery with a new size-sorting grid system. Submitted to ICES Journal of Marine Science. Presented at the ICES Symposium on “Fishing Technology in the 21st Century”, Boston, MA. Oct. 30-Nov. 3, 2006.

Manuscript:

He, P. and V. Balzano (2006). Reducing small shrimps in the Gulf of Maine pink shrimp fishery with a new size-sorting grid system. Submitted to ICES Journal of Marine Science

Signature: ______________________ Date Nov. 30, 2006

Principal Investigator

Reducing small shrimps in the Gulf of Maine pink shrimp fishery with a new size-sorting grid system

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ABSTRACT

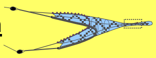
Since the implementation of the Nordmore Grid in the Gulf of Maine pink shrimp trawl fishery in the early 1990s, fish bycatch has been drastically reduced. However, the Nordmore Grid does not improve shrimp size selection and a large amount of small shrimps is still landed. This paper reports two designs of size-sorting grid system. In the new designs, the size-sorting grid was installed in front of the main Nordmore grid. The design was tested at the flume tank and at sea in the pink shrimp (*Pandalus borealis*) fishery in the Gulf of Maine. Both parallel tows involving two vessels and alternating tows using one vessel were made to compare the size-sorting grid system with a conventional Nordmore grid. Both size sorting designs significantly reduced small shrimps in the catch. This was indicated by a reduction of count (number per kg) by 38 and 45 respectively. There was a reduction of shrimp catch rates, presumably due largely to the release of small shrimps. There were no significant differences in the number or amount of major bycatch species between the commercial grid and the two experimental grid designs. The designs were practical to operate and easy to install. Their application may have wider implications in reducing small shrimps in the pink shrimp fishery in the Gulf of Maine and in other areas.

INTRODUCTION

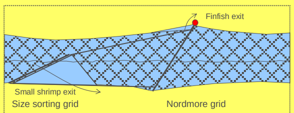
Pink shrimps (*Pandalus borealis*) are widely distributed in the northern Pacific, Atlantic and Arctic oceans. Because small mesh codends are used for harvesting the species, bycatch was considerable before the Nordmore grid became mandatory in 1992 in Gulf of Maine (Howell and Langan, 1992). However, a Nordmore grid cannot reduce small shrimps which pass through the 25 mm (1") grid spacing. Landing of small undersize shrimps represent resource wastes as well as a reduction in landed value. Various projects have been carried out to reduce small shrimps. Square mesh codends were tested in a number of fisheries. Though there was some reduction in small shrimps, mesh brokerage and loss of market size shrimps were reported (Hickey et al., 1993). Valdemarsen (1989) proposed a funnel-shape design, called Radial Escape Section (RES), installed in the rear section of the belly to force small shrimps out of the trawl. The device was shown to reduce small shrimps but blocking of the funnel by debris and complicated rigging prevented wide use of the design. A dual-grid system was tested in Newfoundland and in the Gulf of Maine (DFO, 1998; Schick et al., 1999). In both tests, the size sorting grid was installed behind the Nordmore grid. They had limited success due probably to lowered flow rates at the second grid (FTU, 1996). We here report two size sorting grid designs with the size grid in front of the main Nordmore grid.

MATERIALS AND METHODS

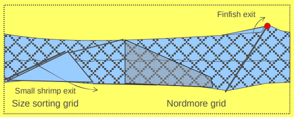
Gear Design

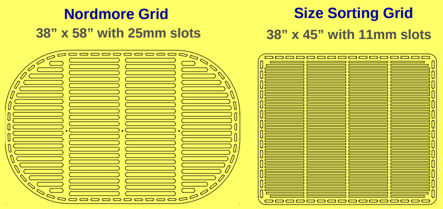


- Size-species grid No funnel (SSNF)



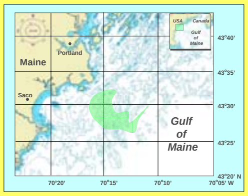
- Size-species grid With funnel (SSWF)



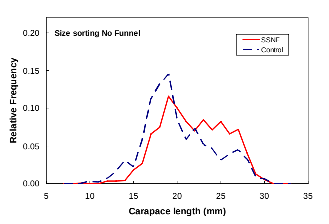


SSI SELECTOR SYSTEMS INC.
Specializing in selectivity devices for the fishing industry

Fishing Vessels: F/V "North Star", F/V "Persistence"
Fishing Grounds: Gulf of Maine, off Portland, Maine
Fishing Depth: 37-49 m
Fishing Season: March – June 2006
Tow Duration: one hour



RESULTS



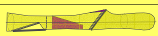
Size-species grid No Funnel (SSNF)

Size Grid 136 shrimp/kg
Control 174 shrimp/kg
Reduce by 38 shrimp/kg
Shrimp catch reduction 16%

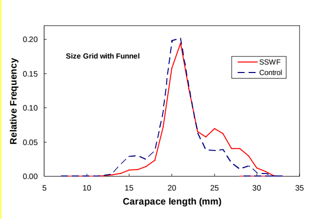
The SSNF Grid

The SSNF grid caught much larger shrimp than the control. Mean counts (number per kg) were 135.5 (SE 6.75) for the experimental tows and 173.6 (SE 7.11) for control tows, which were significantly different (p-value <0.01). This represents a reduction in count of 38.1 shrimp/kg (17.3/lb). Carapace length frequency distribution indicates that the lengths where shrimps appear to be lost from the size-sorting grid was from 20 mm CL or below with the largest amount of shrimp belonging to the 19 mm size class. The K-S test indicated that the size distribution was significantly different (p-value <0.01, z statistic 5.68).

The SSWF Grid



The SSWF grid caught much larger shrimp than the control using the regular Nordmore grid. Mean counts (number per kg) were 147.2 (SE 7.52) for the experimental tows and 192.3 (SE 7.23) for control tows, which were significantly different (p-value <0.01). The difference was 45.2 count/kg (20.5 count/lb). Carapace length frequency distribution indicates that the lengths where shrimp appear to be lost from the size-sorting grid is from 22 mm CL or below with the largest amount of shrimp belonging to the 20 mm size class. The K-S test indicates that the size distribution were significantly different (p-value <0.01, z statistic 5.02).



Size-species grid With Funnel (SSWF)

Size Grid 147 shrimp/kg
Control 192 shrimp/kg
Reduce by 45 shrimp/kg
Shrimp catch reduction 43%

DISCUSSIONS

The new size sorting grid was installed in front of the main Nordmore grid, and was found effective in improving size selectivity of the shrimp. The increase in size is indicated by large reductions in counts. The SGNF grid (Size-Species Grid No Funnel) worked very well with a count reduction of 38 shrimp/kg with an acceptable reduction in shrimp catch (16%). Small shrimps of < 20 mm CL may have counted for the majority of the reduction in the catch. The size grid seemed not to influence the function of the main Nordmore grid as indicated by the low amount of finfish bycatch in the codend.

While the SGWF grid (Size-species Grid With Funnel) is equally effective in reducing small shrimps with a reduction of counts by 45 shrimps per kg, there was also a big reduction of 43% in shrimp catch. It should be noted that during this series of comparative experiments, two different vessels were used and the experimental and control gear were not switched. Though their trawls were very similar, subtle differences between them could account for some of the differences in catch rates. Further work is required with more controlled experiments on this design.

CONCLUSIONS

The new size-sorting grid which was installed in front of the Nordmore grid showed great potential of reducing small shrimps in the pink shrimp fishery in Gulf of Maine. The technology may also be used in other pink shrimp fisheries with suitable adjustment to the grid spacing to match available shrimp size in the area and desirable sizes in the catch. Application to other shrimp and prawn fisheries may also be possible with additional experimentation.

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Reducing small shrimps in the Gulf of Maine pink shrimp fishery with a new size-sorting grid system

Pingguo He and Vincent Balzano

[Submitted to ICES Journal of Marine Science]

Since the implementation of the Nordmore Grid in the Gulf of Maine pink shrimp trawl fishery in the early 1990s, fish bycatch has been drastically reduced. However, the Nordmore Grid does not improve shrimp size selection and a large amount of small shrimps was landed when present on the fishing grounds. This paper reports two designs of a new size-sorting grid system, one with a funnel and one without a funnel. The main feature of the system was that the size-sorting grid was installed in front of the main Nordmore grid. The design was tested at the flume tank and at sea to evaluate its potential of reducing juvenile shrimps in the pink shrimp (*Pandalus borealis*) fishery in the Gulf of Maine. Both parallel tows involving two vessels and alternating tows using one vessel were made to compare the size-sorting grid system with a trawl fitted with a conventional Nordmore grid. Both size sorting designs significantly reduced small shrimps in the catch. This was indicated by a reduction of count (number per kg) by 38 and 45 respectively. There was a reduction of shrimp catch rates, presumably due to the release of small shrimps. There were no significant differences in the number or amount of major bycatch species between the commercial grid and the two experimental grid designs. The designs were practical to operate and easy to install. Their application may have wider implications in reducing small shrimps in the pink shrimp fishery in the Gulf of Maine and other areas.

Keywords: shrimp trawl, pink shrimp Pandalus borealis, size selectivity

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Introduction

Pink shrimps (*Pandalus borealis*) are widely distributed in the northern oceans in the Pacific, Atlantic and Arctic (Shumway et al., 1985). Because small mesh codends were used for harvesting the species, bycatch was considerable (Howell and Langan, 1992). The use of the Nordmore grid became mandatory in 1992 in the pink shrimp fishery in the Gulf of Maine and has proven to reduce finfish bycatch tremendously (Clark et al., 2000; Kenny et al., 1992). However, Nordmore grid cannot reduce small fish and small shrimps which pass through the 25 mm (1") spacing between the grid bars (Clark et al., 2000). Landing of small undersize shrimps represent resource wastes as well as a reduction in landed value. Various projects have been therefore carried out to reduce small shrimps. Increasing mesh size seemed not to increase size selectivity in Norway (Waldemarsen, 1989) and in Canada (Tait and Tait, 1993). Square mesh codends were tested in a number of fisheries. Though there was some reduction in small shrimps in some tests, mesh brokerage and loss of market size shrimp were reported (Hickey et al., 1993). In a test comparing 45 mm diamond and square mesh, Lehmann et al., (1993) did not found differences in size selectivity of the pink shrimp. Valdemarsen (1989) argued that shrimps are passively carried by the flow relative to the net. With bulbous shape of the codend full of catch, flow inside the codend may be reduced to as little as 5%

of the towing speed. Together with the flow outside of the codend, there would not much active flow to take small shrimps out of the codend (Valdamarsen, 1989). He therefore proposed a funnel-shape design, called Radial Escape Section (RES), installed in the rear section of the belly to force small shrimps out of the trawl. The device showed to reduce small shrimps but blocking of the funnel by debris and complicated rigging prevented wide use of the design. A dual-grid system was tested in Newfoundland and in the Gulf of Maine (DFO, 1995; 1998; Schick et al., 1999). In these systems, the size sorting grid was installed behind the Nordmore grid. They had limited success due probably mainly to lowered flow rates at the second grid (FTU, 1996). This paper reports designs which include a size-sorting grid in front of the main Nordmore grid to avoid flow reduction problem.

Materials and Methods

The original design of the grid section included 11 mm bar-spacing size-sorting grid and an upside down Nordmore grid without a funnel. The size-sorting grid acted as a ramp to guide the shrimp to the top of the Nordmore grid. Flume tank tests were carried out at the Center for Sustainable Aquatic Resource of the Memorial University of Newfoundland in St. John's, Canada. A full scale grid section with a codend was tested at the towing speed of 2.4 knots. The tested section was shipped to Portland Maine where the sea trials were based. However, after a few tows, it was concluded that the inverted Nordmore grid caught more flounder bycatch than the control grid. The design was then modified to a regular top-opening grid (Fig. 1). During the second phase of the test, a funnel was added. These two designs are called Size-species Grid No Funnel (SGNF) and Size-species Grid With Funnel (SGWF). Both the size grid and the Nordmore grid were made of high-density polyethylene (HDPE). The size grid was of rectangular shape of 0.97 x 1.27 m external dimension and with bar spacing of 11 mm and bar width of 10 mm. The Nordmore grid was of oval shape of 0.97 x 1.47 m external dimension and with 25 mm bar spacing and 12 mm bar width. The size grid was installed at a 35° angle and the Nordmore grid was around 50°.

For SGNF trials, F/V "North Star", a 13.7 m inshore shrimp trawler, was used with alternating tows through an ECCE and CEEC pattern, where E represents experiment gear and C represents control gear. The control gear uses a regular Nordmore grid with a funnel. The trawl itself and the codend for both experimental and control were identical.

For SGWF trials, F/V "North Star" and F/V "Persistence" (12.6 m length) was paired to conduct parallel tows. F/V "North Star" fished the experimental grid system and F/V "Persistence" fished a trawl with a regular Nordmore grid. Two vessels were within 0.5 nm apart and deployed and retrieved their gears almost simultaneously. The vessels used similar trawls with an identical Nordmore grid and codend. The gears were not switched between the vessels.

For both testing sessions, the codend was made of 50 mm mesh size nylon material. The Nordmore grid used in the size-species grid and the standalone Nordmore grid (control) were also identical. Experimental fishing was carried out between late March and mid June 2006 on shrimp fishing grounds off the coast of Maine. The tow duration was one hour and the towing speed was 2.4 knots.

The catch of shrimp and the bycatch of finfish species were sorted and measured from each tow. The pink shrimp catch was weighed to the nearest kg. Controlled groundfish bycatch species (including cod, haddock, American plaice, winter flounder, witch flounder, and yellowtail flounder), other groundfish (silver hake, red hake, redfish, and butterfish) and pelagic species (mainly blueback herring and alewife), were individually measured to the nearest centimeter, and the total amount for each species was weighed to the nearest 0.05 kg. Sub-samples of about 1 kg were taken when a large amount of bycatch was caught. Other bycatch species were weighed and counted. Three 1 kg shrimp samples from each tow were kept for size count and carapace length (CL) measurement at the laboratory. Carapace lengths were measured to the nearest mm.

The Kolmogorov-Smirnov test was used to test differences in distributions. Mean carapace length was compared using t-test. A Linear Mixed Model was used to look at the difference between replicate counts in the experimental and control tows as variances were not homogenous and the three samples were nested within each tow.

Results

Handling and operation

There were no problems in handling the dual-grid size and species sorting system onboard F/V “North Star” with the usual deck machinery and crew. The grids were durable and maintained shape and integrity during the course of the experiment. During the single-vessel alternating tows, change over from the experimental grid system to the control grid, or vice versa, took about half an hour.

Size-species Grid No Funnel (SGNF)

The new dual-grid system caught much larger shrimp than the control using the regular Nordmore grid (Fig. 2). The experimental size grid caught larger shrimps 10 out of the 11 paired tows. Mean counts (number per kg) were 135.5 (SE 6.75) for the experimental tows and 173.6 (SE 7.11) for control tows, which were significantly different (p-value <0.01). This represents a reduction in count of 38.1 shrimp per kg or 17.3 shrimp per pound. Carapace length frequency distribution indicates that the lengths where shrimp appear to be lost from the size-sorting grid is from 20 mm CL or below with the largest amount of shrimp belonging to the 19 mm size class (Fig. 3). The Kolmogorov-Smirnov test indicated that the size distribution was significantly different (p-value <0.01, z statistic 5.68). Mean size of shrimp was 21.8 mm CL (SE 0.11) for the experimental tows and 21.2 mm CL (SE 0.09) for the control tows, which were also significantly different (independent samples t-test: p-value <0.01).

The mean catch rate of shrimp was 127.5 kg/hr (SE 11.79) for the experimental tows and 151.3 kg/hr (SE 12.4), an average reduction of 16%. Paired t-tests were used to look at the difference between experimental and control catch. Mean catch rates were not significantly different (p-value 0.102), most likely due to the large amount of variation between tows.

Mean numbers of the five main bycatch species (Fig. 4) show little difference between those caught in the control tows and those in the experimental tows with large variability in some species (e.g. witch flounder and whiting). Paired t-test indicates that there were no significant differences between the experimental and control tows for any of the six species (p-value >0.05), indicating that the use of the new size grid would not have an effect on bycatch in the fishery.

Size-species Grid With Funnel (SGWF).

The new SGWF dual-grid system caught much larger shrimp than the control using the regular Nordmore grid (Fig. 5). Overall, the size of shrimp was small during this segment of the experiment than the one described above. The experimental size grid caught larger shrimps 13 out of the 14 paired tows. Mean counts (number per kg) were 147.2 (SE 7.52) for the experimental tows and 192.3 (SE 7.23) for control tows, which were significantly different (p-value <0.01). The difference was 45.2 count/kg or 20.5 count/lb. Carapace length frequency distribution indicates that the lengths where shrimp appear to be lost from the size-sorting grid is from 22 mm CL or below with the largest amount of shrimp belonging to the 20 mm size class (Fig. 6). The Kolmogorov-Smirnov test indicates that the size distribution were significantly different (p-value <0.01, z statistic 5.02). Mean size of shrimp was 21.4 mm CL (SE 0.07) for the experimental tows and 20.0 mm CL (SE 0.06) for the control tows, which were also significantly different (independent samples t-test: p-value <0.01).

Catch rates ranged from 56 to 183 kg/hr for the experimental grid, and from 130 to 383 kg/hr for the control gear. The mean catch rate of shrimp was 128.1 kg/hr (SE 9.81) for the experimental tows and 225.5 kg/hr (SE 20.99), an average reduction of 43%. The mean catch rates were significantly different (p-value <0.01).

Mean numbers of the main five bycatch species caught are shown in Fig. 7. With the exception of witch flounder, there are no statistical differences between those caught in the control tows and those in the experimental tows (p-value >0.05). The new size grid caught a small number of witch flounder compared to the control with a regular Nordmore grid (p-value <0.01).

Discussions

Catch of small shrimps represents a waste of the resource, and in quota-controlled fisheries it can represent an economic loss to the vessel because small shrimps usually have very little or no value but they may be counted as a part of the landing quota (Brothers and Boulos, 1995). Previous efforts on size sorting to reduce small shrimps concentrated on increasing mesh sizes and mesh shapes – square mesh (Lehman et al., 1993; Tait and Tait, 1993; Hickey et al., 1993) and on the installation of the size grid behind the Nordmore grid (DFO, 1995; 1998; Brothers and Boulos, 1996; FTU, 1996; Schick et al., 1999). Valdemarsen (1989) predicted that merely changing mesh size and shape would not reduce small shrimps based on behavior and escape capability of the specie. The rear-installed size grid with small mesh guiding panels reduced the flow rate at the size grid to as little as 40% of that ahead of the grid system (FTU, 1996). Reduced flow rate can reduce sorting effectiveness.

The current designs have the size sorting grid in front of the main Nordmore grid, and were found effective in improving size selectivity of the shrimp. The increase in size is indicated by large reductions in counts. The SGNF grid (Size-Species Grid No Funnel) worked very well with a count reduction of 38 shrimp per kg and an acceptable reduction in shrimp catch (15%). Small shrimps of < 20 mm CL may have counted for the majority of the reduction in the catch. The size grid seemed not to influence the function of the main Nordmore grid as indicated by the low amount of fish bycatch in the codend.

While the SGWF grid (Size-species Grid With Funnel) is equally effective in reducing small shrimps with a reduction of counts by 45 shrimps per kg, there was also a big reduction of 43% in shrimp catch. It should be noted that during this series of comparative experiments, two different vessels were used and the experimental and control gear were not switched. Though their trawls were very similar, subtle differences between them could count for some of the differences in catch rates. Further work is required with more controlled experiments on this design.

In conclusion, the new size-sorting grid which was installed in front of the Nordmore grid showed great potential of reducing small shrimps in the pink shrimp fishery in Gulf of Maine. The technology may also be used in other pink shrimp fisheries with suitable adjustment to the grid spacing to match available shrimp size in the area and desirable sizes in the catch. Application to other shrimp and prawn fisheries may also be possible with additional experimentation.

Acknowledgment

This project was funded by the Northeast Consortium. Benjamin Foster, Tracey Smith and Sean Maxwell were involved in at-sea data collection, sample measurements, and data analysis. Sea trials were assisted by the crew of F/V “North Star” and F/V “Persistence”.

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Figure Captions

Fig. 1. Two size-sorting grid system tested in the sea. Top, Size-species grid No Funnel (SGNF). Bottom, Size-species Grid With Funnel (SGWF).

Fig. 2. Shrimp sizes indicated by counts (number/kg) during 11 paired tows. SGNF - Size-species Grid No Funnel, the experimental gear, Control – regular Nordmore grid.

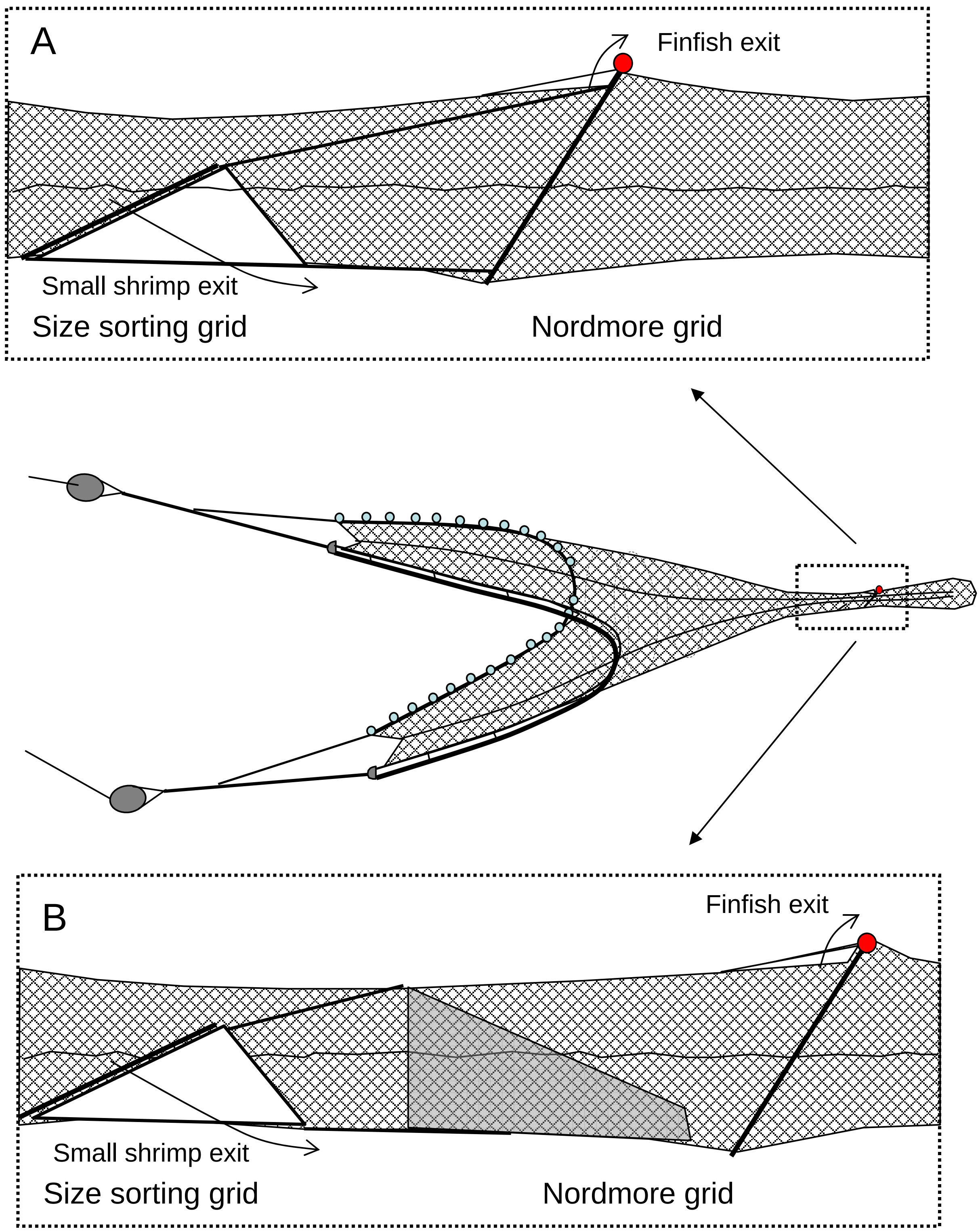
Fig. 3. Shrimp carapace length distribution. SGNF - Size-species Grid No Funnel, the experimental gear, Control – regular Nordmore grid.

Fig. 4. Number of bycatch species caught during 11 paired tows. SGNF - Size-species Grid No Funnel, the experimental gear, Control – regular Nordmore grid. Species are: Whiting (*Merluccius bilinearis),* American plaice (*Hippoglossoides platessoides*), witch flounder (*Glyptocephalus cynoglossus*), redfish (*Sebastes spp*.), and red hake (*Urophycis chuss*).

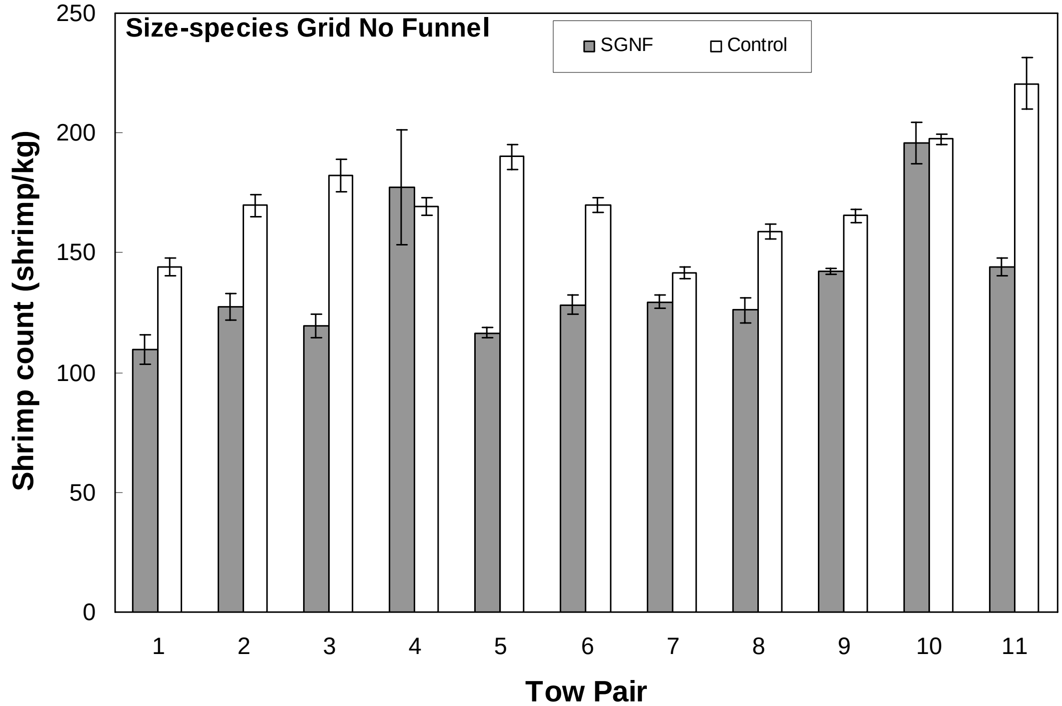
Fig. 5. Shrimp sizes indicated by counts (number/kg) during 11 paired tows. SGWF - Size-species Grid With Funnel, the experimental gear, Control – regular Nordmore grid.

Fig. 6. Shrimp carapace length distribution. SGWF - Size-species grid With Funnel, the experimental gear, Control – regular Nordmore grid.

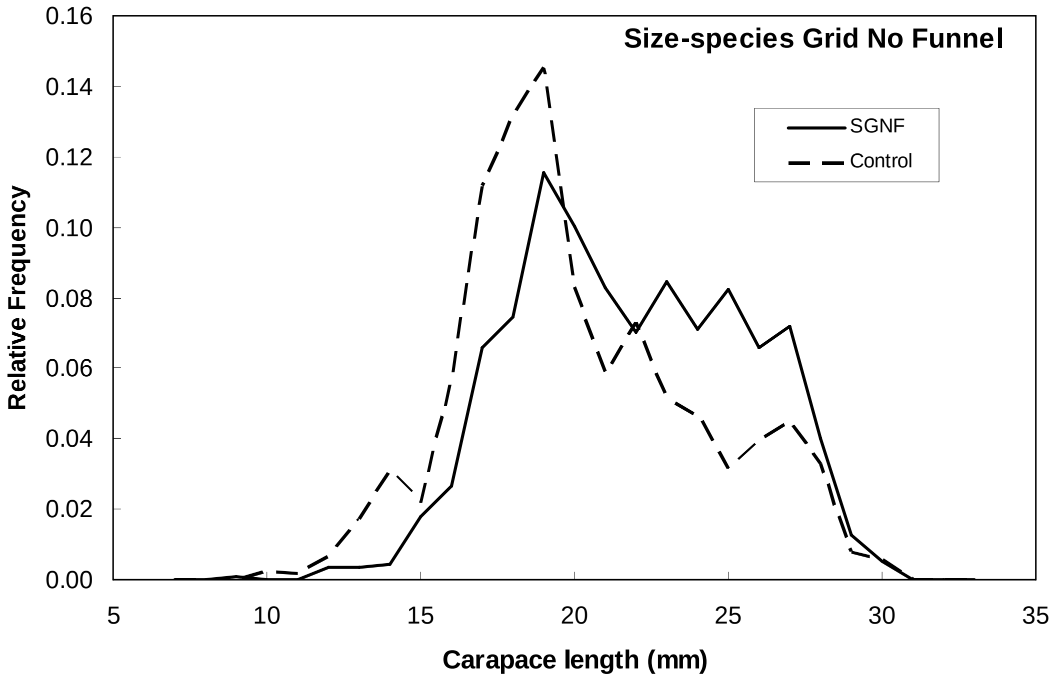
Fig. 7. Number of bycatch species caught during 14 paired tows. SGWF - Size-species Grid With Funnel, the experimental gear, Control – regular Nordmore grid. Species names, see Fig. 5.



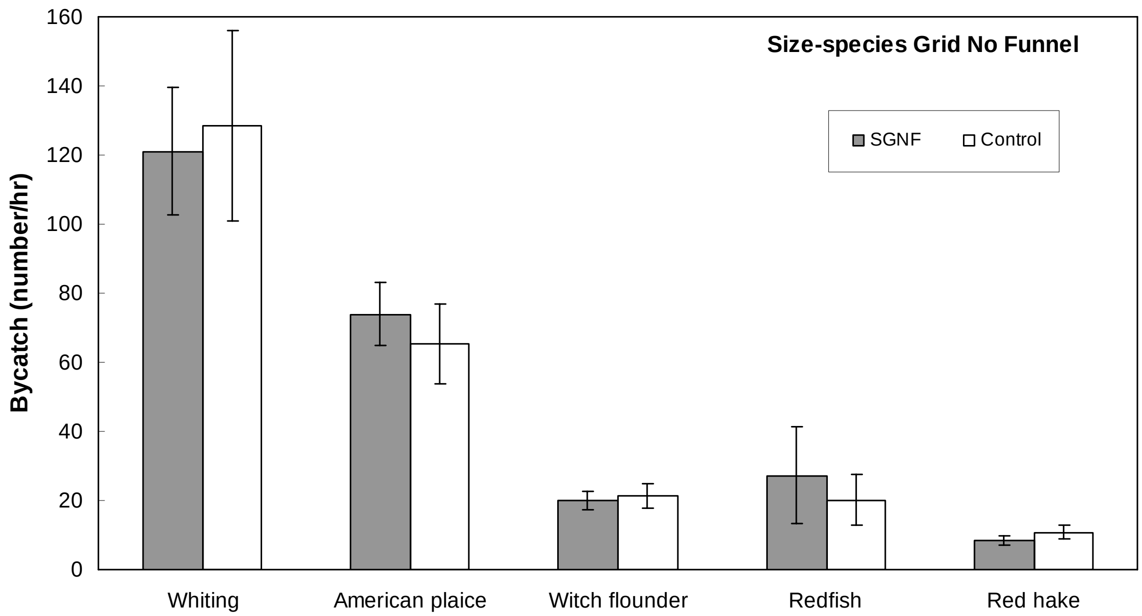
He & Balzano, Fig. 1



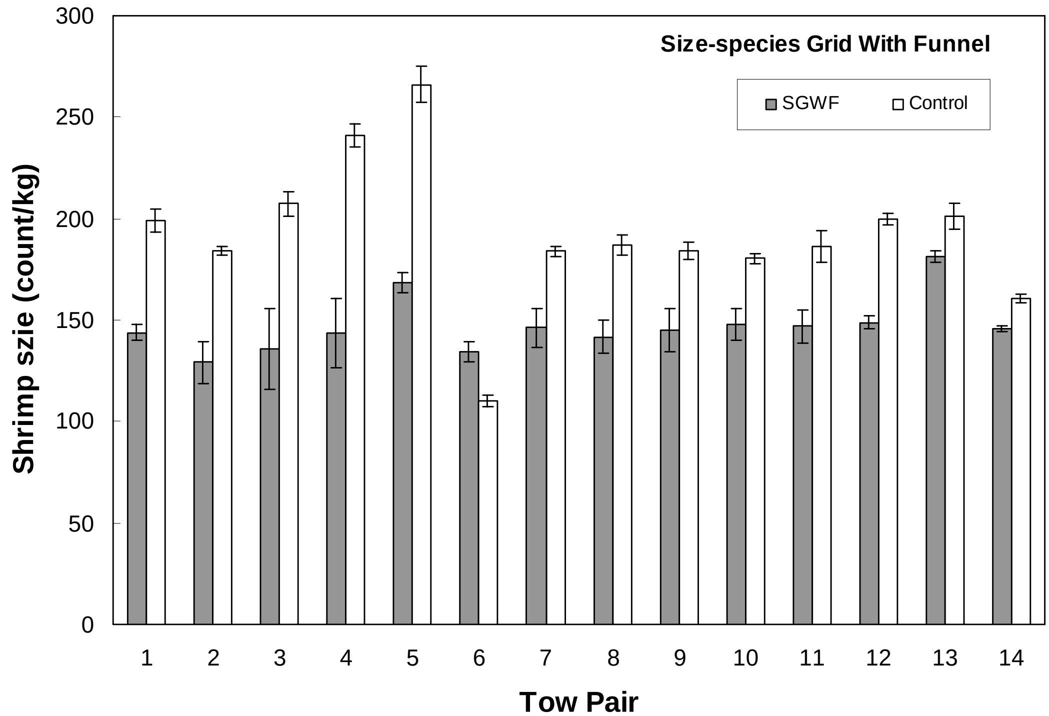
He & Balzano, Fig. 2



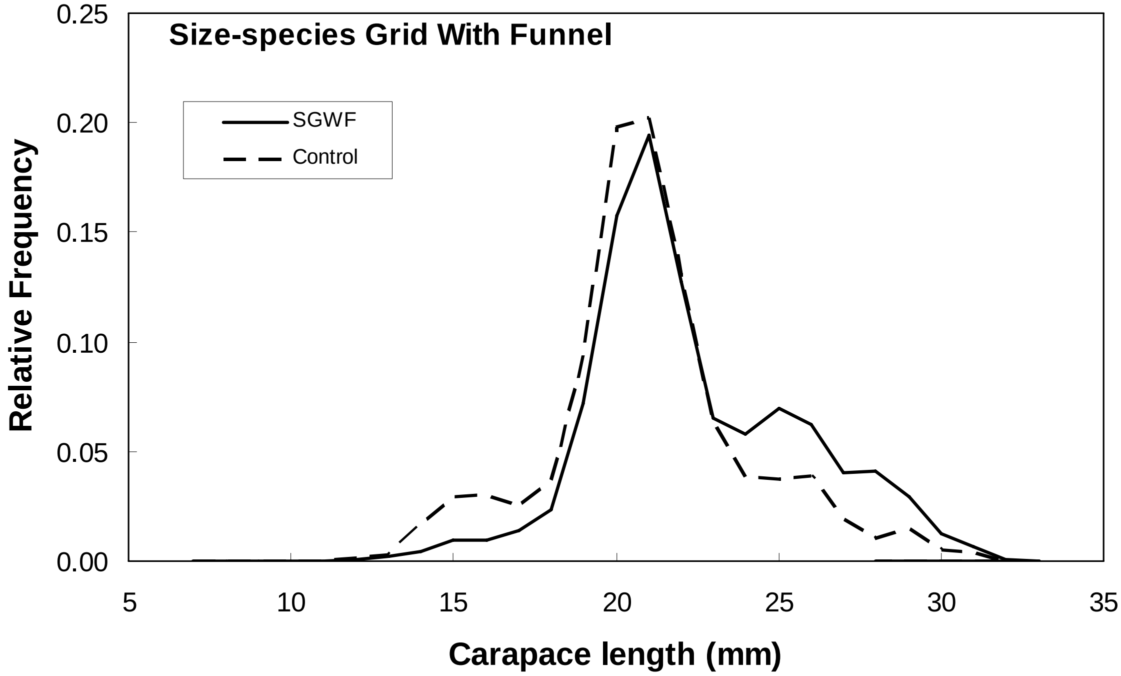
He & Balzano, Fig. 3



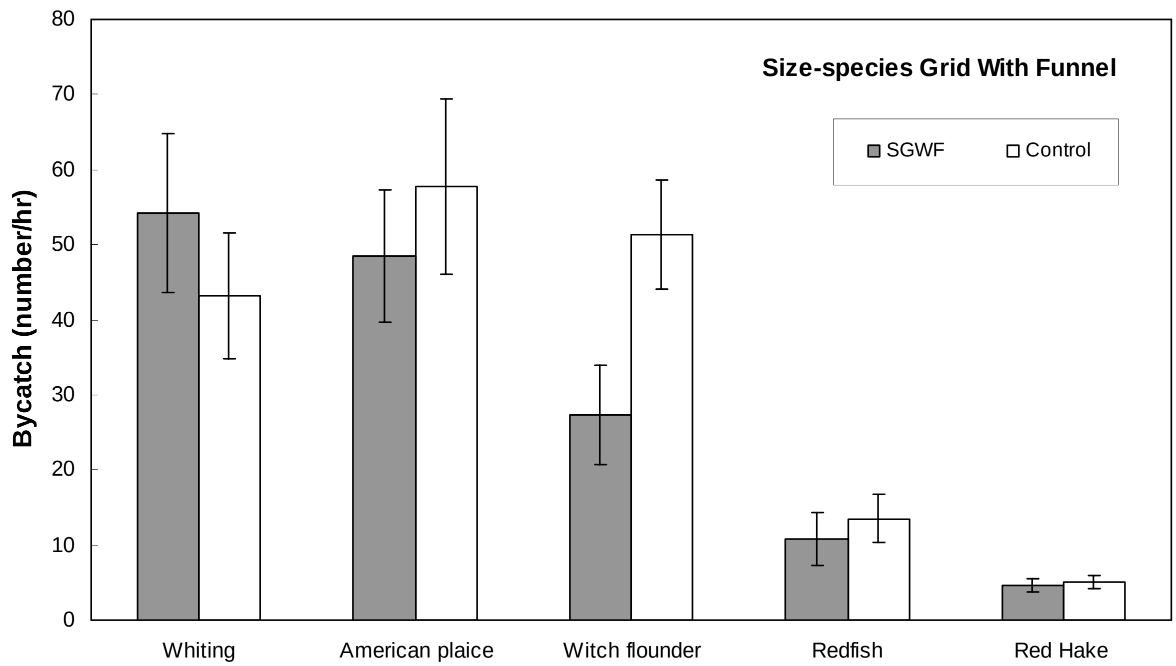
He & Balzano, Fig. 4



He & Balzano, Fig. 5



He & Balzano, Fig. 6



He & Balzano, Fig. 7