MESH SIZE SELECTIVITY STUDY OF PENAEID SHRIMP TRAWLED FROM GALVESTON BAY, TEXAS MAY 1981

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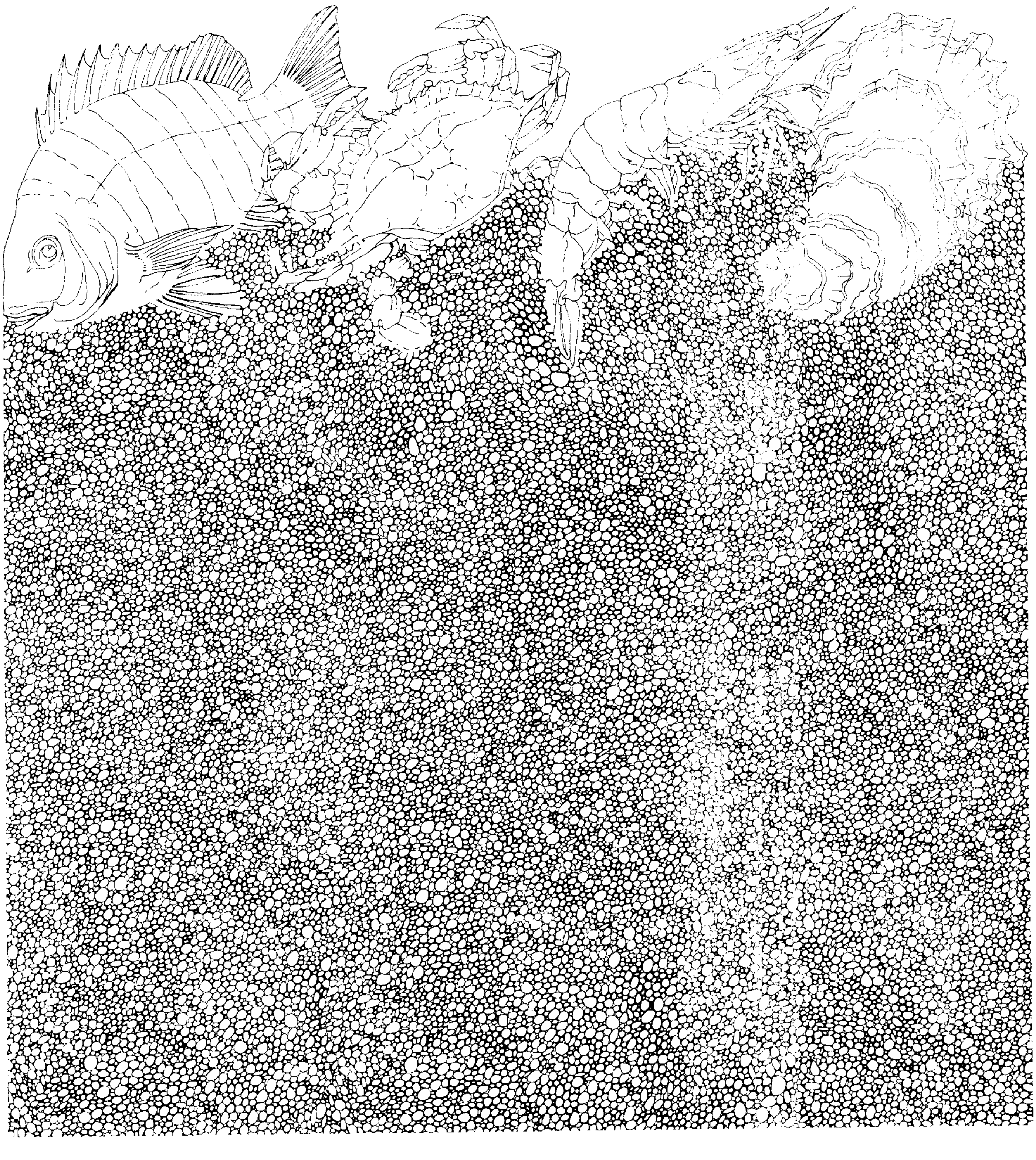

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ABSTRACT

The number and size of penaeid shrimp retained in trawls were found to be dependent upon the mesh size and twine size of the trawl. During the study brown shrimp (*Penaeus aztecus*) were smaller with mean sizes of 81.0-85.5 mm than white shrimp (*P. setiferus*) with mean sizes of 118.8-128.5 mm. There were no significant differences in the total number of white shrimp caught among the different trawl mesh sizes. The larger mesh sizes did result in a significantly larger white shrimp being caught. Trawls with larger mesh sizes caught significantly fewer brown shrimp than did trawls with smaller mesh sizes, however there was no significant differences among the mean sizes of shrimp caught. This suggested that when there was a wide range in the size of shrimp available the larger mesh trawl caught larger shrimp without a decrease in the total number caught (i.e. white shrimp). When the shrimp were fairly uniform in size, trawls with larger meshes resulted in smaller total catches with no differences among the mean sizes of shrimp caught (i.e. brown shrimp). Larger twines may change the effective mesh size (i.e. a trawl made with number 12 twine having a stretched mesh of 47.6 mm may catch the same number and size of shrimp as a trawl made with number 9 twine having a stretched mesh of 44.5 mm). Towing trawls for relatively short periods revealed a linear relationship between the catch (number) and tow time (a 45-min tow resulted in three times the number of shrimp caught as a 15-min tow). Tow times were not found to affect the size of the shrimp caught.

INTRODUCTION

The shrimp fishery of Texas is the most valuable commercial fishery in the state. Total landings for brown shrimp (*Penaeus aztecus*), white shrimp (*P. setiferus*) and pink shrimp (*P. duorarum*) were 24.0 million kg in 1978 and were valued at $141.1 million (U. S. Department of Commerce 1980). Another segment of this fishery is the live and dead bait shrimp fishery. During 1978, 1.06 million kg of bait shrimp were landed in Texas and were valued at $6.8 million (Center for Wetland Research 1978). Estimates of the 1980 harvest are approximately 1.4 million kg (Jim Morgan, NMFS, personal communication). Shrimp management regulations in Texas include size restrictions, closed seasons, closed areas (nursery areas) and regulations controlling trawl mesh sizes. Present shrimping regulations permit bay shrimping with a minimum stretched mesh size of 33.0 mm (1.3 inches) during a spring bay shrimping season and a minimum stretched mesh size of 44.5 mm (1.75 inches) during a fall bay shrimping season.

While it is generally accepted that the mesh size of a trawl is effective in limiting the size and number of shrimp caught, the relationship has not been well defined. A study by Regan et al. (1956) attempted to measure capture efficiency with mesh sizes ranging from 44.5 to 63.5 mm stretched mesh for different size shrimp but their study did not involve shrimp or mesh sizes as small as those found in the Texas bay fishery. Another study by Berry and Hervey (1964) also attempted to relate mesh selectivity to mesh size and time of tow. Their study showed linear relationships between size of shrimp caught and mesh size of trawl and size of shrimp caught and duration of tow. However, very few details were provided regarding the experimental design (i.e. sample sizes, species and number of shrimp caught, etc.) or the reliability of the results.

The objective of this study was to describe the relationships between the mesh size of an otter trawl, the lapsed time of the tow and the number and size of white and brown shrimp retained. This information may be used to enhance management of the Texas shrimp fishery.

MATERIALS AND METHODS

This study was conducted in Clear Lake, an estuary of about 518 ha in the Galveston Bay system. It is 4.0 km long and less than 1.6 km wide (Diener 1975). The estuary averages ~1.2 m in depth (maximum depth: 4.3 m in channel areas). The waters are typically low in salinity. Pullen (1969) reported a salinity range of 0.1-17.1 o/oo. In 1979, the 66th Texas Legislature designated Clear Lake as a shrimp nursery area.

Three 6.1-m long flat otter trawls having stretched mesh sizes of 38.1, 44.5 and 47.6 mm were constructed for use in this study. The 38.1 and 44.5 mm mesh trawls were constructed of 9-thread nylon twine and the 47.6 mm mesh trawl was made with 12-thread nylon twine. The trawls were attached to 50.8 x 121.9 cm plywood otter doors having iron bottom runners measuring 6.4 x 38.1 x 1372.0 mm. The headrope and footrope were secured 25.4 cm from the back of the trawl doors. The towing lines were 3.75 mm in diameter and 31.8 m in length.

Thirty-six trawls were taken from 7 May to 12 May, 1981 in five different areas in Clear Lake. The five sampled areas were established (Figure 1) based on the ability to delineate one area from another by visible landmarks and on the fact that there was sufficient area in which to make a 45-min tow. Data from a recent TPWD study (Benefield and Baker, 1980) indicated that both white and brown shrimp having various lengths could be expected to be present in Clear Lake during the time of this study. Six samples were collected with each of the three mesh sizes and with two tow times (i.e. there were 18-15 min tows; there were 18-45 min tows). A sampling schedule was arranged such that every area was represented in each cell of a two-way analysis of variance. The occurrence of an area more than once in a cell was randomized. Between five and six samples were collected each day. The first sample of a given day was selected at random; subsequent samples were taken sequentially. This design was used because of limited time during which the sampling had to be accomplished and because of the desire to minimize the effect different shrimp densities in the different areas and different catch rates caused by the diel behavior of shrimp might have on the analysis (i.e. a Latin Square design was attempted). A 7.9-m inboard boat was used to tow the trawls at ~1000 rpm (3 mph) in a serpentine manner to avoid the trawl passing over bay bottom that had been disturbed by the propeller wash. Trawling was accomplished so that bay bottom was never trawled twice during any one sample.

Shrimp from each sample were sorted according to species, counted and weighed en masse. At least 60 shrimp of each species were selected at random (when available) from each sample and measured from tip of rostrum to the end of the telson. Mean lengths and variances were calculated for each sample. The by-catch in each sample was ignored.

Differences in mean lengths and mean catches between mesh sizes and different trawl times were determined using a two-way analysis of variance (Sokal and Rohlf 1969). Linearity in the catch rate function was tested with a t-test assuming that a 45-min tow should result in three times the catch (in numbers) of a 15-min tow. The number of shrimp caught per sample was converted to log (number + 1) to attain homogeneity of variances for the analysis of variance.

RESULTS

The 36 trawl samples collected in Clear Lake contained 3351 penaeid shrimp (2016 brown shrimp and 1335 white shrimp). Catches according to trawl mesh size were: 38.1 mm - 1469 brown shrimp, 480 white shrimp; 44.5 mm - 320 brown shrimp, 453 white shrimp; 47.6 mm - 227 brown shrimp, 402 white shrimp. The number of shrimp contained in each sample varied from 7 to 966.

No significant differences were found in the mean length of brown shrimp caught by different mesh sizes ($F_s = 0.862$, df = 2,29) or because of different tow times ($F_s = 1.498$, df = 1,29). The mean length of brown shrimp had a narrow range (81.0±5.4 mm for 15-min tows using 44.5-mm stretched mesh to 85.5±1.5 mm for 45-min tows using 38.1-mm mesh; (Table 1).

The 38.1-mm mesh trawl caught smaller white shrimp than did the 44.5-mm mesh trawl or the 47.6-mm mesh trawl ($F_s = 7.712$, df = 2,30). The differences found for the white shrimp mean lengths by the analysis of variance were most likely due to the small mean lengths obtained for the 38.1-mm mesh trawl (118.8±0.8 mm) because the mean lengths for the other two mesh sizes were much larger and numerically closer together (44.5 mm trawl - 128.5±1.5 mm and 124.8±1.5 mm; 47.6 mm trawl - 121.7±2.9 and 125.0±0.7 mm). The mean length of white shrimp did not vary with the time of the tow ($F_s = 0.92$, df = 1,30).

The mean catch of brown shrimp in each trawl (Table 2) was found to vary with the size of the mesh ($F_s = 12.070$, df = 2,30) and the duration of the tow ($F_s = 27.212$, df = 1,30). Both the 44.5- and 47.6-mm mesh trawls caught fewer brown shrimp than did the 38.1-mm mesh trawls pulled the same length of time. The 44.5-mm mesh trawls caught 80% fewer shrimp than the 38.1-mm trawl and the 47.6-mm mesh trawl caught 82% fewer shrimp than the 38.1-mm trawl. The total number of brown shrimp caught in the 45-min tows was 3.8 to 9.0 times greater than the number caught in the 15-min tows. The mean multiplier (5.8±1.6) was not significantly different from 3.0 indicating that the catch in a 45-min tow was a simple multiple of the catch in a 15-min tow. The differences in the mean catch of brown shrimp caught per sample was apparently due to the large catches in the 38.1-mm trawl. There was essentially no differences in the mean catches between the 44.5-mm trawl and the 47.6-mm trawl.

The mean catch of white shrimp varied with the length of the tow ($F_s = 51.202$, df - 1,30) but not with the mesh size of the trawl ($F_s = 0.729$, df = 2,30). Although the interaction term in the analysis of variance was not significant, the mean catch in the 15-min tows for the 44.5-mm and 47.6-mm trawls was less than the mean catch in the 38.1-mm trawl - 15.3±2.1 and 13.7±6.7 shrimp respectively. Larger sample sizes might show these to be different from the mean catch of 22.7±5.1 shrimp obtained from the 38.1-mesh trawl. The 45-min tows did not show a similar pattern (i.e. the largest mean catch obtained was from the 44.5-mm trawl). The mean difference between the number of shrimp caught in a 15-min tow and a 45-min tow was 3.4±0.5. Again, this difference was not significantly different from 3.0 and the catch in a 45-min tow was considered to be a simple multiple of the catch in a 15-min tow.

DISCUSSION

The data in this study indicated that the regulation of mesh sizes used in trawls can be very effective in controlling the number and size of shrimp retained. Berry and Hervey (1964) reported a linear relationship between the length of shrimp retained in a trawl and the mesh size of the trawl. This study failed to show this relationship for the brown shrimp (mean lengths were the same for all mesh sizes). White shrimp retained in the 38.1-mm trawl were smaller than the shrimp retained in the 44.5- and 47.6-mm trawls but there was no difference in the lengths of shrimp retained by the 44.5- and 47.6-mm trawls. The reason the mean lengths of the brown shrimp were the same for all three mesh sizes was probably due to all the brown shrimp being small and relatively uniform in size during the sampling period. The reason the mean lengths of the white shrimp were the same for the 44.5-mm and 47.6-mm trawls was probably due to the larger twine size in the 47.6-mm trawl decreasing the size of the holes in the trawl and to the fact that the difference between the 38.1-mm stretch mesh and the 44.5-mm stretched mesh was greater than the difference between the 44.5-mm mesh and the 47.6-mm mesh.

Regan et al. (1956) reported increased rates of escapement of pink shrimp as the mesh size was increased form 44.4 to 63.5 mm. This study also found higher rates of escapement (lower mean catch rates) for small brown shrimp in the 44.5- and 47.6-mm mesh trawls than for the 38.1-mm mesh trawl. Again, the failure to detect different catch rates for the 44.5- and 47.6-mm mesh trawls was probably due to the 47.6-mm trawl being made of number 12 twine instead of the number 9 twine used in the 38.1- and 44.5-mm mesh trawls. The clogging of a trawl (the process of the catch progressively filling the holes of the trawl) theoretically could cause the trawl to become more efficient the longer it is towed and the larger the catch. If this were true, catches in trawls towed for 45 min should have catches greater than three times the catches of trawls towed for 15 min. Although the catches in the 45-min tows of this study averaged 3.4 (white shrimp) to 5.9 (brown shrimp) times greater than catches of trawls towed for 15 min, these means were not significantly greater than three times and it was assumed that the relationships between the catch and the time towed was a simple linear function for time periods and trawls involved. The failure to detect a difference in this study may also be due to the small sample size. The relatively large standard errors indicated that the differences would have had to be 2-3 times greater than they were for the sample sizes to have indicated a difference.

Most of the problems associated with the study of mesh selectivity in trawls include not knowing what sizes of organisms are available in areas being trawled, what the density of organisms are in the area and the many different combinations of ways a trawl can be utilized. This study attempted to reduce as many of these variables as possible. An area was selected that historically had two species of shrimp varying greatly in size and having fairly high numbers. Interference in the analysis of comparing mean sizes and mean catches was reduced by designing the sampling schedule so that local differences in shrimp densities and changes in shrimp densities in time were removed or reduced. The conclusions made from the results of this study were based on the assumptions that if significant differences in shrimp densities or sizes occurred between the five sample areas, then the approximated Latin Square design (all areas represented in each cell) removed the effects of these differences from the analyses. The standardized trawling procedure used with this study and the relatively short time period required to complete the study should have also contributed to the reliability of the results. In short, the comparisons involved the variables mesh size, twine size and tow times, not different shrimp densities and sizes between areas or dates.

Similar studies in the future would be enhanced if at least three widely different tow times and three equally spaced but widely different mesh sizes were used. If twine size is to be a variable each size should be represented in each of the mesh sizes and trawl times. The continued use of a Latin Square design and a short sampling season would also be highly desirable.

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Figure 1. Clear Lake showing mesh selectivity sample stations.

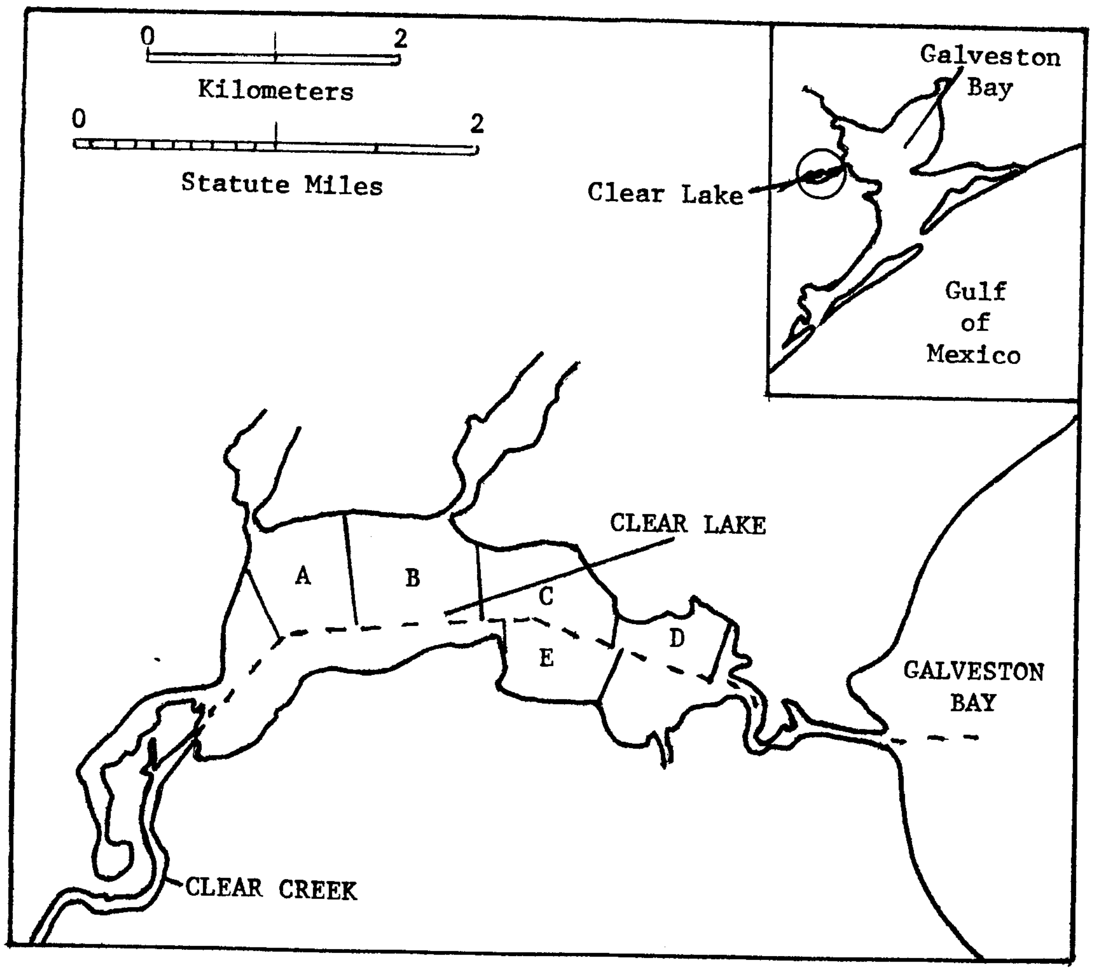

Table 1. Mean lengths (mm) and standard errors for brown shrimp (*Penaeus aztecus*) and white shrimp (*P. setiferus*) by trawl mesh size and tow time.

Tow time	Trawl mesh size (mm)	Brown shrimp Mean length	Brown shrimp Standard error	White shrimp Mean length	White shrimp Standard error
15 min	38.1	84.5	± 1.0	118.8	± 2.2
	44.5	81.0	± 5.4	128.5	± 1.5
	47.6	81.2	± 1.8	121.7	± 2.9
45 min	38.1	85.5	± 1.5	120.5	± 0.8
	44.5	85.2	± 1.3	124.8	± 1.5
	47.6	83.0	± 1.3	125.0	± 0.7

Table 2. Mean catch (number) and standard errors for brown shrimp (*P. aztecus*) and white shrimp (*P. setiferus*) per tow by mesh size and tow time.

		Brown shrimp		White shrimp	
Tow time	Trawl mesh size (mm)	Mean catch	Standard error	Mean catch	Standard error
15 min	38.1	41.3	± 7.6	22.7	± 5.1
	44.5	5.3	± 2.5	15.3	± 2.1
	47.6	7.8	± 4.5	13.7	± 2.1
45 min	38.1	186.8	±131.8	57.4	± 15.1
	44.5	48.0	± 17.6	60.2	± 9.9
	47.6	30.0	± 5.8	53.3	± 6.6

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