DISTRIBUTION OF MACROBRACHIUM ROSENBERGII IN AN CIRCULATED VS UNCIRCULATED POND SYSTEM

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INTRODUCTION

The distribution of Macrobrachium rosenbergii in a circulated vs uncirculated pond will be determined. In one pond, a circulating device is used to mix the water and prevent stratification (thermal and oxygen) while in another pond, no mechanical circulator is used, and the condition of stratification is observed. Temperature and oxygen stratification may have an effect on prawn distribution within a pond culture system. A study conducted by Dr. Arlo W. Fast indicates that prawns tend to occupy shallow shoreline areas in an uncirculated pond, while in a circulated pond, the prawns were found in deep waters away from shorelines. In this project, the prawns were tagged by placing a stainless steel wire clip through their rostrum and a small painted cork was attached to the other end of the wire. Although this system provide a measure of the distribution differences between a circulated and uncirculated pond, this marking system was without fault since the wire and cork easily tangled in the weeds. In my project, modified minnow traps and sonar tags will be used to determine the distribution and movement of prawns in a circulated vs uncirculated pond.

MATERIALS AND METHODS

The experiment will be conducted at the Aquatic Farms Ltd. in two 1/2 acre earthen ponds. One pond will be mechanically mixed with a low energy circulator while the other pond will be left uncirculated. The circulated device operates by a 1/4 horse power motor which powers a fan blade (Figure 1). The water flows through the circulator at a rate of 1500 gallons per minute.

In the first part of the project, 48 modified minnow traps will be used in prawn capture. Net floaters will be tied to a 1 meter nylon rope and fastened to the trap. Plastic bait containers will be placed inside of the trap and filled with an inexpensive fish (Figure 2).

A preliminary study will be conducted to determine which modified minnow trap is most effective in capturing Macrobrachium rosenbergii. There will be 3 groups of traps used in this test. Each group will be comprised of 4 different traps: 1) galvanized wire minnow trap, 2) galvanized wire minnow trap with a black polyethylene plastic, 3) plastic minnow trap and 4) plastic minnow trap with a black polyethylene covering. The openings of each trap will be enlarged to allow the larger prawns to enter. The traps will be set on one side of the uncirculated pond in an alternating pattern (Figure 3). The test will be conducted for 8 hours and the captured prawns will be counted, measured, and released away from each trap site. Temperature and oxygen readings will be taken at each trap site using a conventional meter (YSI). The modified trap which is most effective in prawn capture will be used in the actual study.

In the actual study, there will be 2 different fresh water systems used (circulated vs uncirculated). The field test will be conducted for 4 days and run for 24 hours. The 24 hour test will be used to determine if there is a distribution difference during the day and night. There will be 24 traps set in each pond and checked every 3 hours. Two long ropes will be placed diagonally across each pond, and floaters will be used to mark each trap site. Each trap site will be determined on the depth of the pond. A total of 4 traps will be set at 6 difference depths (Figure 4a & 4b). The captured prawns will be counted, measured, sexed, and released a few feet away from the trap site. The prawns will be measured from the back of the eyes to the tip of the telson (Figure 5). The sex of the prawn will be determined by observing the 5th pereiopod. In males, the primary sexual characteristic are the gonopore flaps which can easily be observed on coxae of the 5th pereiopod. In females, the gonopore flaps are absent on the 5th pereiopod (Figure 6). Temperature and oxygen values will be taken at different depths at the deepest section of the pond.

In the second part of the project, the movement of the prawns in a circulated and uncirculated pond will be monitored with the use of sonic tags. The test will be conducted for 2 to 3 days and run for 24 hours. The location of each prawn will be monitored every 3 hours. An acoustic transmitter which measures about 2 1/2 inches will be glued on each prawn using a wet suit material and crazy glue (Figure 7). A total of 3 large prawns will be tagged and released in each pond (circulated and uncirculated pond). Each tagged prawn will have a transmitter that is pulsed at a different rate. An underwater hydrophone will be used to receive the transmitters pulse. A 6 meter grid of sampling stations will be established

on all four sides of the pond from which the prawns location will be determined by triangulation (Figure 8).

RESULTS

Preliminary Study

The preliminary test resulted in the galvanized wire traps with an without the polyethylene covers captured the most prawns (Table 1). Although the galvanized wire traps captured the most amount of prawns, the galvanized traps with the polyethylene covers captured prawns of larger average sizes. The dark traps may be preferred by the larger prawns but the polyethylene plastic covers were quite troublesome. After 2 testing days, the polyethylene covers on some traps slipped off and had to be replaced. The decision was made to use the galvanized wire traps without the black polyethylene covers during the actual study.

Temperature and oxygen values were recorded during the 4 day testing period to accustom myself with a conventional YSI meter (Table 2).

Testing Conditions

The 4 testing days were conducted in the month of July to the beginning of August (7/11, 7/18, 7/25, 8/1). The 4 testing days were characteristic of 50% cloud cover with light trade winds. In the last week of June, a dinoflagellate (Gymnodinium) bloom occurred in pond 4. The pond was a dark brownish color instead of the dark green color. The Aquatic Farms Ltd. flushed the water out and moved the low energy circulator into pond 4 to oxygenate the water. Although the dinoflagellate bloom did not change for about 4 weeks, the study was still conducted.

In pond 4 (circulated) which the dinoflagellate bloom occurred, the total prawn capture for 2 testing days were only 25. In pond 5 (uncirculated) the total prawn capture was about 650. With this great difference in the total prawn capture, there could have been a "kill" in pond 4 due to the dinoflagellate's toxins or oxygen depletion. The toxicity of the dinoflagellates were tested by force feeding a few prawns but the toxins had no effect. There seemed to be no "kills" by oxygen depletion because of the fact that prawn carcasses would have been seen floating at the surface of the pond.

Since the prawn capture in pond 4 was extremely low for the 2 testing days, only pond 5 was used in the study. On the first 2 testing days, pond 5 was left uncirculated and the last 2 testing days, it was circulated. The data obtained from pond 4 during the first 2 testing days were not valuable and not used in the evaluation of the distribution of prawns.

Temperature and Oxygen

In the circulated and uncirculated ponds, the highest temperature and oxygen values occurred during the late afternoon (1630 hours), and the lowest values occurred in the early morning (0430 hours). In the uncirculated pond, the temperature and oxygen values decreased with an increase in depth. In the circulated pond, there was minimal reduction of temperature and oxygen values with an increase in depth (Table 2a - 2h). On the first 2 testing days (7/11, 7/18), the temperature and oxygen difference between the surface and bottom during the day (0730 hours - 1630 hours) were

1.8°c and 6.0 mg/L respectively in the uncirculated pond. During the night (1930 hours - 0430 hour), the temperature and oxygen difference between the surface and bottom were 0.4°c and 1.6 mg/L (Table 3a). In the circulated pond (7/18, 8/1), the temperature and oxygen difference between the surface and bottom during the day were 0.5°c and 1.3 mg/L respectively. During the night, the temperature and oxygen difference between the surface and bottom were 0.1°c and 0.3 mg/L (Table 3b). During the 4 testing days, extreme thermal stratification did not occur in the uncirculated pond but there seemed to be oxygen stratification in the late afternoon. This oxygen stratification may affect the distribution of prawns within the pond. In the circulated pond there was no thermal or oxygen stratification.

Distribution of Prawns in a Circulated vs Uncirculated Pond

Percent Capture of the Total Catch:

In the uncirculated pond at 0730 hours, the greatest percent of prawns were captured in the deepest section of the pond (80 to 85cm) and the least percent were captured at a depth of 40 to 45cm. At 1030 hours, the greatest percent of prawns were captured at a depth of 50 to 55cm and the least percent captured at 90 to 95cm. At 1330 hours, the greatest percent of prawns were captured at the depths of 60 to 65cm and 80 to 85cm, and the least percent captured in the middle of the pond at a depth of 70 to 75cm. At 1630 hours, the greatest percent was captured in the middle at a depth of 60 to 65cm and the least captured in the deepest section of 90 to 95cm in depth. During the night at 1930 hours, the greatest percent of prawns were captured along the banks at 40 to 45cm and the least captured at the

the deepest section of 90 to 95cm in depth. At 2230 hours, the greatest percent was captured along the banks at 40 to 45cm in depth and the least captured at 80 to 85cm. At 0130 hours, the greatest percent was captured at the depth of 50 to 55cm and least captured at 90 to 95cm in depth. At 0430 hours, the greatest percent was captured at 50 to 55cm in depth and the least captured at a depth of 70 to 75cm (Table 4a) (Figure 9a - 9b).

In the circulated pond at 0730 hours, the greatest percent of prawns were captured along the banks at a depth of 40 to 45cm and the least percent captured at a depth of 80 to 85cm. At 1030 hours, the greatest percent of prawns were captured at a depth of 80 to 85cm and the least percent captured at 90 to 95cm. At 1330 hours, the greatest percent of prawns were captured at a depth of 60 to 65cm and the least percent captured at 70 to 75cm in depth. At 1630 hours, the greatest percent of prawns were captured at a depth of 50 to 55cm and the least percent captured at a depth of 70 to 75cm. During the night at 1930 hours, the greatest percent of prawns were captured at a depth of 50 to 55cm and the least percent captured at 90 to 95cm in depth. At 2230 hours, the greatest percent was captured at a depth of 40 to 45cm. At 0130 hours, the greatest percent was captured at a depth of 40 to 45cm and the least captured at a depth of 80 to 85cm. At 0430 hours, the greatest percent was captured at a depth of 40 to 45cm and the least captured at a depth of 80 to 85cm (Table 4b) (Figure 9a - 9b).

In the circulated and uncirculated pond, the greatest percent of prawns were captured along the banks, and the least percent captured in the deepest section of the pond (Table 5a - 5b) (Figure 10).

Average Size of Captured Prawns:

In the uncirculated pond during the day hours (0730 to 1630 hours), the largest average size prawn was captured at depth of 60 to 65cm and the smallest average size was captured at a depth of 40 to 45cm. On the 2nd testing day (7/18), the largest average size was captured at a depth of 90 to 95cm and the smallest captured at a depth of 40 to 45cm. In the circulated pond (7/25), the largest average size prawn was captured at a depth of 90 to 95cm and the smallest average size captured at 40 to 45cm. On the 4th testing day (8/1), the largest average size was captured at a depth of 60 to 65cm and the smallest average size was captured at a depth of 50 to 55cm (Table 6a - 6b) (Figure 11a).

In the uncirculated pond during the night hours (1930 to 0430, 7/11), the largest average size prawn was captured at a depth of 80 to 85cm and the smallest average size was captured at a depth of 50 to 55cm. On the 2nd testing day (7/18), the largest average size was captured at a depth of 90 to 95cm and the smallest average size was captured at a depth of 40 to 45cm. In the circulated pond (7/25), the largest average size was captured at a depth of 90 to 95cm and the smallest average size prawn were captured at depths of 40 to 45cm and 50 to 55cm. On the 4th testing day (8/1), the largest average size was captured at a depth of 80 to 85cm and the smallest average size was captured at a depth of 40 to 45cm (Table 6a - 6b) (Figure 11b).

In the circulated and uncirculated ponds, the larger prawns were captured in the deeper section of the pond, and the smaller prawns were captured in shallow waters along the banks of the pond.

Sexes of the Captured Prawns:

During the 4 testing days, a total of only 90 prawns were sexed. The majority of the captured prawns were difficult to sex because of the small sizes. Prawns with total lengths greater than 8cm were sexed. Less than 1% of the total prawn capture for the 4 testing days were large enough to be sexed.

Determining the Movement of Prawns with the Use of Sonic Tags

In this part of the project, the movement of prawns could not be determined because the tags came off of the prawns. On 2 testing days (7/25, 8/1), there was no movement of prawns in both the circulated and uncirculated ponds. The signals for one tagged prawn was lost in the uncirculated pond (7/25). On 8/2/83, the Aquatic Farms Ltd. harvested the circulated and uncirculated pond, but did not recover any prawns with tags.

DISCUSSION

The pond in which the dinoflagellate (Gymnodinium) bloom occurred was not used in determining the distribution of prawns due to the low prawn capture. Since there was a low prawn capture, the Aquatic Farms Ltd. sampled this pond with a throw net and found prawns of various sizes. This suggest that the dinoflagellates could have affected the prawn chemoreceptors in some way which prevented it from homing in on the scent of bait. Another possibility could have been that the larger prawns may have established a territory around the trap site and thus preventing the smaller prawns from entering the traps. The larger prawns may not have been able to enter the trap because of the small opening.

During the testing period, extreme thermal stratification was not observed in the uncirculated pond due to the light tradewinds. The tradewinds overturned the waters in the uncirculated pond and prevented thermal stratification. Although there was no thermal stratification, oxygen stratification was observed in the afternoons. High turbidity will limit photosynthetic oxygen to the surface and often result in lower concentration on the pond bottom. In the uncirculated pond, temperature and oxygen levels decreased with an increase in depth. In the circulated pond, no extreme thermal or oxygen stratification was observed. The circulator mixed the whole water column effectively and prevented stratification.

When comparing the circulated vs uncirculated ponds, there was no significant difference in the distribution of prawns. During the day and night hours, the greatest amount of prawns were distributed along the banks at a depth of 40 to 45cm, and the least amount of prawns were found at

depths of 80 to 95cm. The circulator did not have any effect on the distribution of prawns. There was no significant difference in the distribution of prawns in a circulated vs uncirculated pond due to several possibilities: 1) The tradewinds mixed the uncirculated pond and prevented stratification. It could be possible that I was not actually comparing a circulated vs uncirculated pond, but really 2 circulated ponds. 2) The greatest amount of prawns were distributed along the banks of both circulated and uncirculated ponds because it may have provided more food than the deep waters. The prawns may congregate along the banks because of insects, insect lavae and vegetation which may serve as a food source. 3) The banks also may provide a form of shelter and habitat. The prawns may seek shelter from other prawns due to aggressive behaviors.

When comparing the distribution of prawns in the circulated vs uncirculated pond according to average sizes, there was no significant difference. With an increase in depth there was an increase in average prawn size. In the uncirculated pond during the day, I expected the larger prawns to congregate along the banks where the water is warmer and the oxygen levels are higher, but this did not occur. The larger average size prawns were found in the deeper waters and the smaller average size prawns were found in shallow waters along the banks of the pond. The larger prawns may prefer the deep waters during the day because there may be less light penetration due to high algal density. Prawns prefer a habitat which is not in the direct sunlight. The smaller prawns were found along the banks of the ponds because the vegetation may have provided sufficient cover against the sunlight. During the night, there was again an increase in average prawn size with an increase in depth in the uncirculated pond. The prawns may have establish territories

therefore they do not move around in the pond tremendously. In the circulated pond, this same condition was observed. The circulator did not have any effect on the distribution of prawns according to size.

The movement of prawns in a circulated vs uncirculated pond could not be determined because the sonic transmitters came off of the prawns. The prawn somehow managed to pick at the transmitter with its large chela or the tag simply fell off. The sonic tag must be glued to the prawns carapace securely and smaller sonic tags must be used in the test. The sonic tags were difficult to track because of the similar pulse rates.

CONCLUSION

There was no difference in the distribution of prawns in a circulated vs uncirculated pond. The test must be conducted on calm, sunny days in order to test the real effects of the circulator. During the 4 testing days, there was light tradewinds which prevented extreme stratification in the uncirculated pond. The circulator may be ineffective in an area which is windy. The effectiveness of the circulator could be tested by observing production rather than the distribution.

Table 1: Total prawn capture of each modified trap for 4 testing days.

Modified Trap	Total Prawn Capture	*Average Size (cm)
Galvanized Wire Trap	27	5.5
Galvanized Wire Trap with Black Polyethylene Cover	21	7.6
Plastic Trap	15	7.8
Plastic Trap with Black Polyethylene cover	9	5.3

*Total length measure: Back of the eyes to the tip of the telson.

Table 2: Average temperature and average oxygen levels at 35 cm depth in the uncirculated pond for 4 testing days.

Time	Average Temperature (°C)	Average Oxygen (PPM)
10:00 am	26.0	7.6
12:00 pm	26.8	9.9
2:00 pm	27.9	12.4
4:00 pm	27.2	11.8

Table 2a: Temperature and Oxygen Values for the Uncirculated Pond (7/11/83)

TEMPERATURE °c

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	-	-	-	-	-	-	-	-
20	25.5	26.0	27.0	28.5	28.0	26.4	26.0	25.6
30	25.4	25.9	26.0	28.0	27.0	26.4	26.0	25.5
40	25.4	25.8	26.0	27.0	27.0	26.4	26.0	25.6
50	25.4	25.7	25.8	26.5	26.5	26.4	25.9	25.6
60	25.3	25.6	25.3	26.0	26.5	26.4	25.9	25.7
70	25.3	25.4	25.3	26.0	26.0	26.3	25.9	25.6

OXYGEN mg/L

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	-	-	-	-	-	-	-	-
20	5.6	9.9	9.0	8.8	16.8	11.6	8.2	6.6
30	5.3	9.4	8.0	8.5	16.2	11.6	8.2	6.6
40	5.1	8.8	7.4	8.2	15.0	11.6	8.2	6.6
50	5.1	8.1	6.0	8.1	13.0	11.5	8.2	6.6
60	5.0	7.2	4.1	7.6	10.2	11.4	8.2	6.6
70	4.9	5.9	3.8	7.2	8.6	11.4	8.2	6.6

Table 2b: Temperature and Oxygen Values for the Circulated Pond (7/11/83)

TEMPERATURE ^{o}c

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	-	-	-	-	-	-	-	-
20	27.0	26.0	26.8	27.2	27.0	26.4	26.3	25.9
30	27.0	26.0	26.8	27.2	27.0	26.4	26.2	25.8
40	27.0	25.9	26.7	27.2	27.0	26.4	26.2	25.8
50	27.0	25.8	26.6	27.2	27.0	26.4	26.2	25.8
60	27.0	25.8	26.5	27.2	27.0	26.4	26.2	25.8
70	27.0	25.8	26.4	27.2	27.0	26.4	26.2	25.8

OXYGEN mg/L

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	-	-	-	-	-	-	-	-
20	4.9	9.5	12.0	8.4	17.4	9.6	7.5	5.5
30	4.8	9.3	11.8	8.2	17.4	9.5	7.4	5.5
40	4.9	9.1	11.6	8.2	17.4	9.5	7.4	5.5
50	4.8	8.8	11.7	8.2	17.4	9.5	7.5	5.6
60	4.8	8.5	11.6	8.2	17.2	9.5	7.5	5.5
70	4.7	8.2	11.5	8.2	17.0	9.4	7.5	5.5

Table 2c: Temperature and Oxygen Values for the Uncirculated Pond (7/18/83)

TEMPERATURE °c

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	26.0	27.6	27.9	29.3	28.9	27.0	26.8	26.1
20	26.0	27.4	27.8	28.2	27.9	27.0	26.8	26.1
30	26.0	27.4	27.8	28.2	27.8	27.0	26.8	26.0
40	26.0	27.3	27.7	28.1	27.8	27.0	26.8	26.1
50	26.0	27.2	27.7	28.1	27.8	27.0	26.8	26.0
60	26.0	27.1	27.7	28.0	27.8	27.0	26.8	26.0
70	26.0	27.0	27.7	28.0	27.8	27.0	26.8	26.0

OXYGEN mg/L

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	8.4	12.9	10.3	14.4	11.5	7.8	7.4	4.8
20	8.4	11.2	10.0	13.3	11.5	7.9	7.4	4.6
30	8.4	10.8	10.0	13.1	11.5	7.9	7.3	4.6
40	8.2	8.6	9.9	12.8	11.4	7.9	7.3	4.5
50	8.2	8.4	9.7	12.6	11.4	7.9	7.4	4.5
60	8.2	8.3	9.6	12.1	11.4	7.9	7.4	4.5
70	8.2	8.0	9.1	11.9	11.3	7.8	7.3	4.5

Table 2d: Temperature and Oxygen Values for the Circulated Pond (7/18/83)

TEMPERATURE °c

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	26.0	26.8	27.3	27.8	27.6	27.1	26.5	26.2
20	26.0	26.8	27.2	27.9	27.5	27.0	26.5	26.0
30	26.0	26.7	27.2	27.8	27.5	27.0	26.5	26.2
40	26.0	26.7	27.3	27.7	27.5	27.0	26.6	26.2
50	26.0	26.7	27.2	27.7	27.5	27.0	26.8	26.2
60	26.0	26.7	27.2	27.7	27.5	27.0	26.8	26.2
70	26.0	26.7	27.3	27.7	27.4	27.0	26.8	26.2

OXYGEN mg/L

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	5.4	9.0	10.2	13.6	10.9	8.5	7.0	5.7
20	5.2	9.0	10.1	13.6	11.0	8.4	7.0	5.7
30	5.3	8.9	10.1	13.4	10.9	8.4	7.0	5.7
40	5.4	8.8	10.1	13.0	10.8	8.2	7.0	5.7
50	5.3	8.6	10.1	12.6	10.8	7.9	7.0	5.6
60	5.2	8.5	10.0	12.2	10.7	7.9	7.0	5.6
70	5.3	8.4	10.0	12.0	10.7	7.9	7.0	5.6

Table 2e: Temperature and Oxygen Values for the Uncirculated Pond (7/25/83)

TEMPERATURE °c

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	26.0	27.8	29.0	29.0	27.9	27.5	27.0	26.5
20	26.0	27.4	29.0	29.0	27.9	27.5	27.0	26.2
30	26.0	26.9	28.7	28.7	27.9	27.5	27.0	26.2
40	26.0	26.7	28.5	28.4	27.9	27.5	27.0	26.1
50	26.0	26.6	28.3	28.0	27.9	27.5	27.0	26.2
60	26.0	26.6	28.0	27.6	27.9	27.3	27.0	26.1
70	26.0	26.6	27.1	27.1	27.9	27.3	27.0	26.0

OXYGEN mg/L

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	5.0	10.4	13.6	14.9	12.4	11.6	8.6	6.9
20	5.0	10.3	13.2	16.3	12.2	10.4	8.2	6.6
30	4.9	9.8	13.4	15.8	12.2	10.2	8.0	6.4
40	4.9	9.4	13.6	15.2	10.3	9.6	7.9	6.2
50	4.8	9.3	13.3	13.4	9.7	9.6	7.9	6.2
60	4.8	9.2	11.8	12.0	7.9	9.2	7.9	6.2
70	4.7	8.9	9.6	7.7	5.8	9.0	7.8	6.0

Table 2f: Temperature and Oxygen Values for the Circulated Pond (7/25/83)

TEMPERATURE °c

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	26.3	28.5	28.7	29.0	28.4	28.0	27.5	26.9
20	26.3	27.7	28.6	29.1	28.4	28.0	27.2	26.8
30	26.3	27.4	28.4	29.0	28.4	28.0	27.3	26.8
40	26.2	27.3	28.4	29.1	28.3	28.0	27.3	26.8
50	26.2	27.2	28.3	29.1	28.3	28.0	27.2	26.5
60	26.2	27.2	28.3	29.1	28.3	28.0	27.2	26.5
70	26.2	27.2	28.3	29.1	28.3	28.0	27.2	26.5

OXYGEN mg/L

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	6.5	12.7	15.1	16.9	14.4	12.0	10.0	7.4
20	6.4	12.0	14.9	16.7	14.4	11.6	10.0	7.4
30	6.1	11.6	14.8	16.7	14.3	11.4	9.9	7.4
40	6.1	11.2	14.6	16.6	14.3	11.2	9.8	7.4
50	6.1	10.8	14.4	16.4	14.3	11.0	9.8	7.4
60	6.1	10.1	14.4	16.2	14.3	11.0	9.8	7.2
70	6.1	9.8	14.4	16.1	14.3	11.0	9.7	7.2

Table 2g: Temperature and Oxygen Value for the Uncirculated Pond (8/1/83)

TEMPERATURE ^{o}c

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	27.0	27.8	30.2	30.9	28.7	27.9	27.1	26.5
20	27.0	27.7	29.5	30.9	28.7	27.9	27.1	26.5
30	27.0	27.2	27.9	30.7	28.7	27.9	27.0	26.5
40	27.0	26.9	27.2	29.0	28.7	27.9	27.0	26.5
50	27.0	26.8	27.0	28.5	28.7	27.9	27.0	26.5
60	27.0	26.7	26.8	27.8	28.7	27.9	27.0	26.5
70	27.0	26.3	26.5	27.2	28.5	27.8	27.0	26.5

OXYGEN mg/L

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	4.0	10.7	15.9	20.0	13.0	7.5	5.0	3.3
20	4.0	9.9	13.4	20.0	12.9	7.5	5.0	3.3
30	3.9	7.0	9.9	20.0	12.9	7.5	5.0	3.3
40	3.9	5.7	8.6	14.5	12.8	7.5	5.0	3.3
50	3.9	4.6	6.5	12.4	12.7	7.5	5.0	3.3
60	3.9	4.1	4.8	8.4	12.1	7.4	5.0	3.3
70	3.9	3.1	3.0	4.9	9.7	7.4	5.0	3.3

Table 2h: Temperature and Oxygen Values for the Circulated Pond (8/1/83)

TEMPERATURE °c

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	27.0	28.7	31.2	30.6	30.0	29.0	28.2	27.5
20	27.0	28.6	29.9	30.6	30.1	29.0	28.2	27.5
30	27.0	28.5	29.6	30.5	30.0	29.0	28.2	27.5
40	27.0	28.4	29.1	30.5	30.0	29.0	28.2	27.5
50	27.0	28.3	29.0	30.5	30.0	29.0	28.2	27.5
60	27.0	28.3	28.9	30.5	30.0	29.0	28.2	27.5
70	27.0	28.3	28.8	30.5	30.0	29.0	28.2	27.5

OXYGEN mg/L

Depth (cm)	Time: 0730	1030	1330	1630	1930	2230	0130	0430
Surface	3.95	10.8	16.6	18.0	14.7	9.7	6.5	4.5
20	3.90	9.8	15.8	18.2	14.6	9.7	6.5	4.5
30	3.90	9.4	15.0	18.2	14.6	9.7	6.5	4.5
40	3.90	9.4	14.0	17.9	14.5	9.7	6.5	4.5
50	3.90	9.4	12.6	17.9	14.4	9.6	6.5	4.5
60	3.90	8.9	12.4	17.8	14.4	9.6	6.5	4.5
70	3.90	8.8	12.2	17.7	14.3	9.6	6.5	4.5

Table 3a: Average Temperature and Oxygen Values taken in the Uncirculated Pond for 2 Testing Days (7/11, 7/18)

A) Values taken during the daytime (0730 - 1630 hours)

B) Values taken during the night (1930 - 0430 hours)

	-A-		-B-	
Depth of Pond (cm)	Temperature (°c)	Oxygen (mg/L)	Temperature (°c)	Oxygen (mg/L)
Surface	28.4	11.6	27.4	8.5
20	28.1	11.3	27.3	8.2
30	27.6	10.4	27.2	8.2
40	27.3	9.3	27.2	7.8
50	27.1	8.4	27.2	7.7
60	26.8	7.3	27.1	7.5
70	26.6	5.6	27.0	6.9

Table 3b: Average Temperature and Oxygen Values taken in the Uncirculated Pond for 2 Testing Days (7/25, 8/1)

A) Values taken during the daytime (0730 - 1630 hours)

B) Values taken during the night (1930 - 0430 hours)

	-A-		-B-	
Depth of Pond (cm)	Temperature (°c)	Oxygen (mg/L)	Temperature (°c)	Oxygen (mg/L)
Surface	28.7	12.4	28.2	9.9
20	28.5	12.2	28.2	9.8
30	28.5	12.0	28.2	9.8
40	28.3	11.6	28.1	9.7
50	28.2	11.4	28.1	9.7
60	28.2	11.2	28.1	9.6
70	28.2	11.1	28.1	9.6

Table 4a: Average Percent of Total Prawn Capture in the Uncirculated Pond for 2 Testing Days (7/11, 7/18)

Group	Depth (cm)
I	40-45
II	50-55
III	60-65
IV	70-75
V	80-85
VI	90-95

Time	Group: I	II	III	IV	V	VI
0730 Average %	10	15	13	19	23.5	19
1030 Average %	16.5	24	16.5	15	16.5	7.5
1330 Average %	16.5	15	20	13	20.5	15
1630 Average %	15.5	19	20.5	16.5	18.5	10
1930 Average %	29	23	13	13.5	13.5	8
2330 Average %	29	15.5	16.5	16.5	9	19
0130 Average %	16	24.5	16.5	12.5	14	12
0430 Average %	19	24.5	19	5.5	13	18.5

Table 4b: Average Percent of Total Prawn Capture in the Circulated Pond for 2 Testing Days (7/25, 8/1)

Group	Depth (cm)
I	40-45
II	50-55
III	60-65
IV	70-75
V	80-85
VI	90-95

Time	Group:	I	II	III	IV	V	VI
0730 Average %		25	15.5	17	19	11	13.5
1030 Average %		15	16.5	12.5	14	18.5	8
1330 Average %		17	12.5	20.5	10	17.5	16
1630 Average %		12.5	22.5	18.5	10	12.5	20
1930 Average %		20	23.5	15	17.5	13.5	10
2230 Average %		22.5	20	21.5	10.5	11	14
0130 Average %		25	18.5	15	17	9.5	15
0430 Average %		24.5	22	20	17	4	13

Table 5a: Total Prawn Capture at 6 Different Depths, the Percent of the Total Catch and the Average Prawn Size

A) Day capture in the uncirculated pond 5 (0730 - 1630 hours) 7/11, 7/18

B) Night capture in the uncirculated pond 5 (1930 - 0430 hours) 7/11, 7/18

Group	Traps in Each Group	Depth (cm)	Total Capture	Percent of Total Capture	Average Size (cm)	
I	1,11,12,13	40-45	76	22%	4.5	
II	2,10,14,24	50-55	62	17%	5.0	A
III	8,9,15,23	60-65	50	15%	5.1	
IV	3,6,7,22	70-75	53	15%	5.5	
V	4,5,20,21	80-85	64	19%	5.0	
VI	16,17,18,19	90-95	42	12%	5.7	

Group	Traps in Each Group	Depth (cm)	Total Capture	Percent of Total Capture	Average Size (cm)	
I	1,11,12,13	40-45	81	27%	4.7	
II	2,10,14,24	50-55	52	17%	5.4	B
III	8,9,15,23	60-65	54	18%	5.1	
IV	3,6,7,22	70-75	39	13%	5.1	
V	4,5,20,21	80-85	39	13%	5.6	
VI	16,17,18,19	90-95	39	13%	6.0	

Table 5b: Total Prawn Capture at 6 Different Depths, the Percent of the Total Catch and the Average Prawn Size

A) Day capture in the circulated pond 5 (0730 - 1630 hours) 7/25, 8/1

B) Night capture in the circulated pond 5 (0730 - 1630 hours) 7/25, 8/1

Group	Traps in Each Group	Depth (cm)	Total Capture	Percent of Total Capture	Average Size (cm)	
I	1,11,12,13	40-45	83	23%	5.5	
II	2,10,14,24	50-55	47	13%	5.5	A
III	8,9,15,23	60-65	65	18%	5.7	
IV	3,6,7,22	70-75	48	13%	5.9	
V	4,5,20,21	80-85	60	17%	5.6	
VI	16,17,18,19	90-95	56	16%	5.8	

Group	Traps in Each Group	Depth (cm)	Total Capture	Percent of Total Capture	Average Size (cm)	
I	1,11,12,13	40-45	77	23%	5.1	
II	2,10,14,24	50-55	67	20%	5.4	B
III	8,9,15,23	60-65	58	16%	5.8	
IV	3,6,7,22	70-75	61	18%	6.0	
V	4,5,20,21	80-85	33	10%	6.1	
VI	16,17,18,19	90-95	43	13%	5.9	

Table 6a: The Total Prawn Capture, The Average Size of Prawns, The 95% Confidence and The Size Range at Different Depths in the Uncirculated Pond.

Group	Depth
I	40-45
II	50-55
III	60-65
IV	70-75
V	80-85
VI	90-95

A) Day (7/11, 0730 to 1630 hours)
B) Night (7/11, 1930 to 0430 hours)
C) Day (7/18, 0730 to 1630 hours)
D) Night (7/18, 1930 to 0430 hours)

A & B

Group:	I	II	III	IV	V	VI
Total Capture	20	21	18	21	23	12
$\bar{x}$	4.5	4.9	6.3	5.0	5.0	6
95% Confidence	4.5 ± .26	4.9 ± .55	6.3 ± 1.1	5.0 ± .59	5.0 ± .52	6 ± 1.1
RANGE (cm)						
Smallest Largest	3.5 8.8	3.5 8.6	3.5 12.0	3.8 8.3	3.4 8.5	4.3 12.0
Total Capture	39	27	22	12	10	19
$\bar{x}$	5.1	5.0	5.9	5.7	6.1	5.7
95% Confidence	5.1 ± .39	5.0 ± .47	5.9 ± .49	5.7 ± .52	6.1 ± .61	5.7 ± .68
RANGE (cm)						
Smallest Largest	3.2 10.6	3.5 9.1	3.4 9.0	4.3 10.7	4.3 8.0	3.4 9.4

C & D

Group:	I	II	III	IV	V	VI
Total Capture	34	45	41	30	39	32
$\bar{x}$	4.6	4.8	5.2	4.8	5.0	5.4
95% Confidence	4.6 ± .45	4.8 ± .34	5.2 ± .42	4.8 ± .33	5.0 ± .41	5.4 ± .50
RANGE (cm)						
Smallest Largest	3.5 7.8	3.0 8.5	3.5 10.0	3.5 11.1	3.6 7.5	4.1 11.5
Total Capture	35	34	24	25	28	19
$\bar{x}$	4.5	4.8	5.1	5.8	5.9	6.2
95% Confidence	4.5 ± .29	4.8 ± .24	5.1 ± .39	5.8 ± .70	5.9 ± .62	6.2 ± .74
RANGE (cm)						
Smallest Largest	3.6 6.0	3.2 7.6	3.3 7.6	3.8 11.5	4.0 9.0	3.2 12.5

Table 6b: The total Prawn Capture, The Average Size of Prawns, The 95% Confidence and The Size Range at Different Depths in the Circulated Pond.

A) Day (7/25, 0730 to 1630 hours)
B) Night (7/25, 1930 to 0430 hours)
C) Day (8/1, 0730 to 1630 hours)
D) Night (8/1, 1930 to 0430 hours)

Group	Depth
I	40-45
II	50-55
III	60-65
IV	70-75
V	80-85
VI	90-95

A & B

Group:	I	II	III	IV	V	VI
Total Capture	32	30	38	31	39	29
$\bar{x}$	5.3	5.7	5.8	5.6	5.5	5.8
95% Confidence	5.3 ± .70	5.7 ± .57	5.8 ± .49	5.6 ± .59	5.5 ± .52	5.8 ± .66
RANGE (cm)						
Smallest Largest	3.4 11.5	3.4 9.0	3.4 10.5	3.8 11.5	3.8 11.5	3.8 10.5
Total Capture	34	30	26	23	14	23
$\bar{x}$	5.2	5.2	5.5	5.4	5.4	6.0
95% Confidence	5.2 ± .33	5.2 ± .45	5.5 ± .39	5.4 ± .46	5.4 ± .41	6.0 ± .84
RANGE (cm)						
Smallest Largest	4.1 7.5	3.5 7.5	4.1 8.5	3.5 7.5	4.2 8.7	3.9 12.3

C & D

Group:	I	II	III	IV	V	VI
Total Capture	34	33	26	16	22	27
$\bar{x}$	5.5	5.3	6.5	5.9	6.3	6.1
95% Confidence	5.5 ± .59	5.3 ± .36	6.5 ± .82	5.9 ± 1.2	6.3 ± .57	6.1 ± .56
RANGE (cm)						
Smallest Largest	3.4 12.0	3.3 7.4	4.0 11.5	3.6 10.5	3.8 10.8	3.5 9.3
Total Capture	39	40	34	28	19	19
$\bar{x}$	5.1	5.2	5.7	5.6	6.1	5.8
95% Confidence	5.1 ± .37	5.2 ± .41	5.7 ± .47	5.6 ± .63	6.1 ± 1.2	5.8 ± .82
RANGE (cm)						
Smallest Largest	3.5 9.0	3.5 8.8	3.9 9.1	3.8 10.2	4.1 12.6	3.9 10.2

Figure 1 Low Energy Circulator powered by a ½ horse power motor which circulates about 1500 gallons per minute.

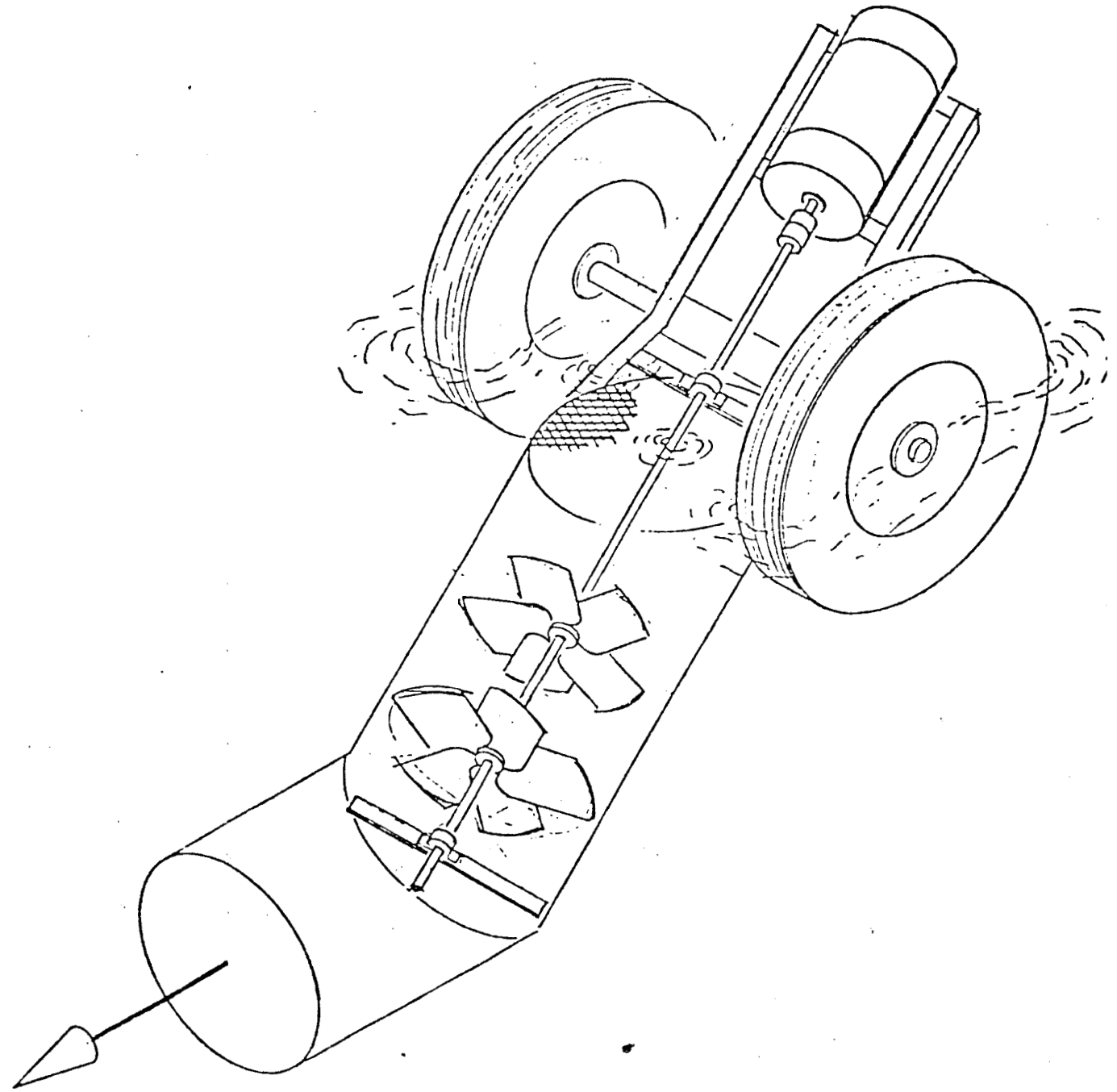


Figure 2: Modified Minnow Trap

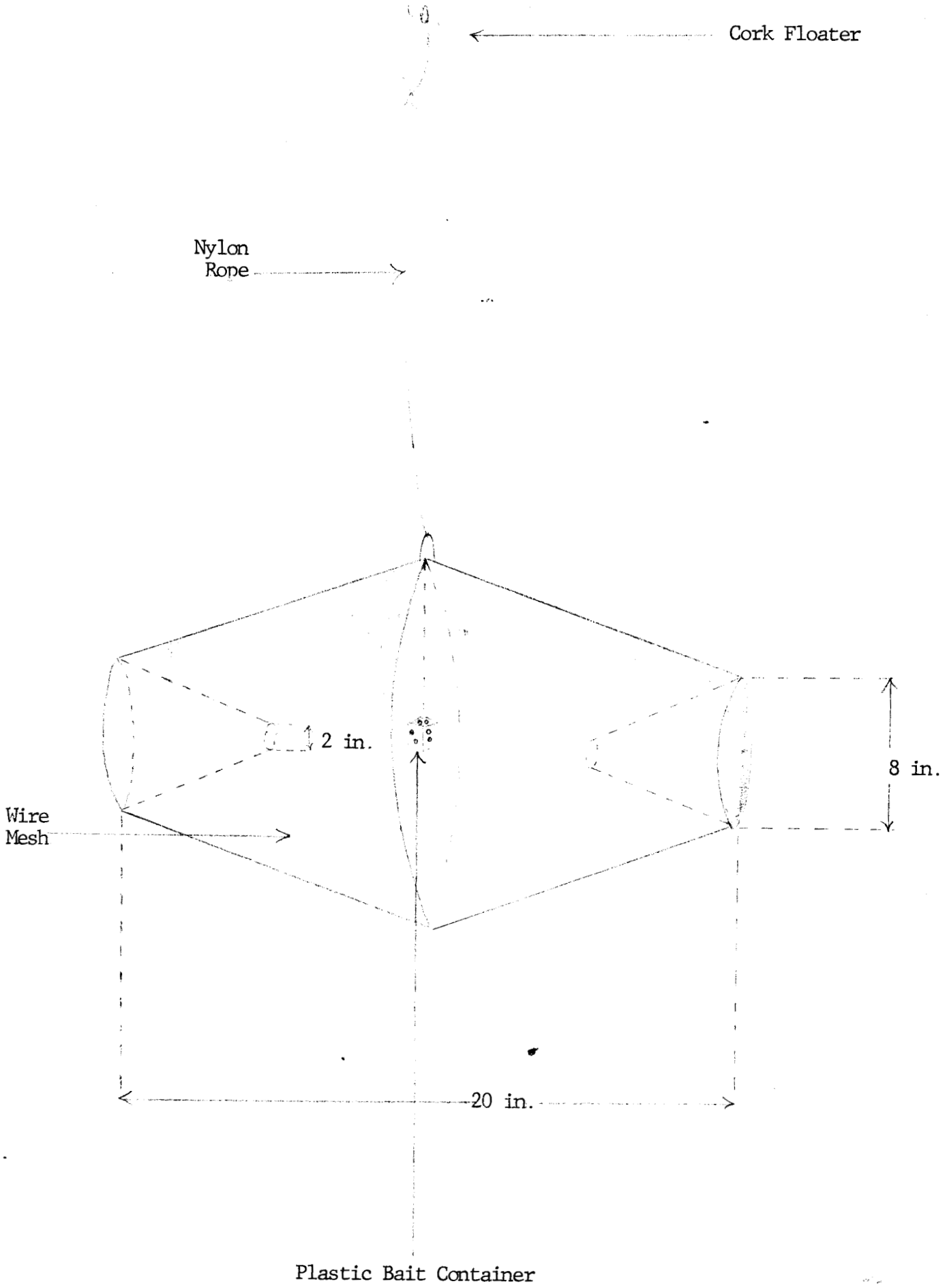


Figure 3: The modified traps set at approximately 35 cm depths in an alternating pattern.

1 - Galvanized Wire Trap
2 - Galvanized Wire Trap with Black Polyethylene cover
3 - Plastic Trap
4 - Plastic Trap with Black Polyethylene cover

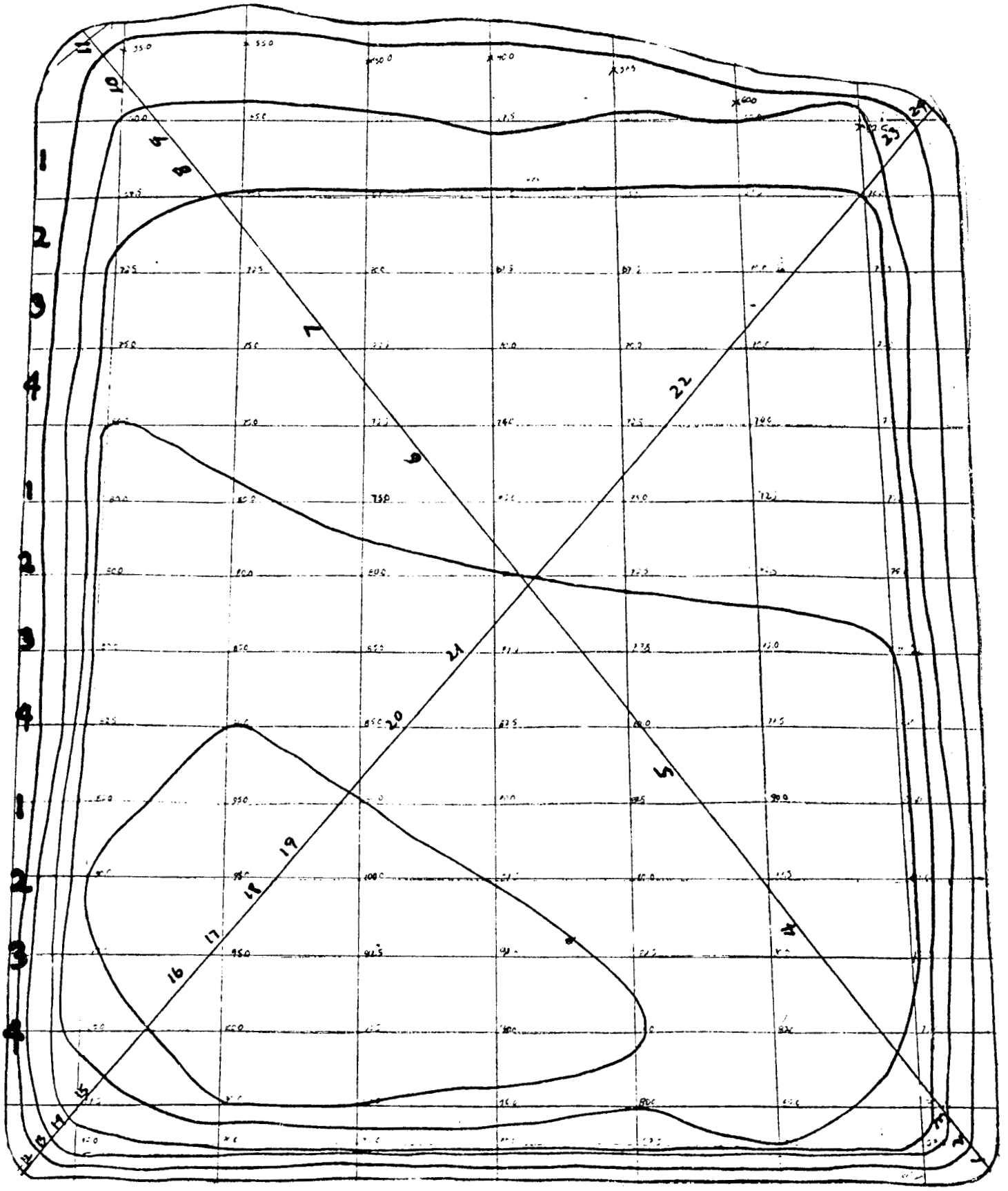


Figure 4a: A total of 4 traps set at different depths in the circulated pond.

I. 1, 11, 12, 24	Traps: 40 - 45 cm	IV. 6, 7, 15, 22	Traps: 70 - 75 cm
II. 2, 10, 13, 23	Traps: 50 - 55 cm	V. 4, 5, 20, 21	Traps: 80 - 85 cm
III. 3, 8, 9, 14	Traps: 60 - 65 cm	VI. 16, 17, 18, 19	Traps: 90 - 95 cm

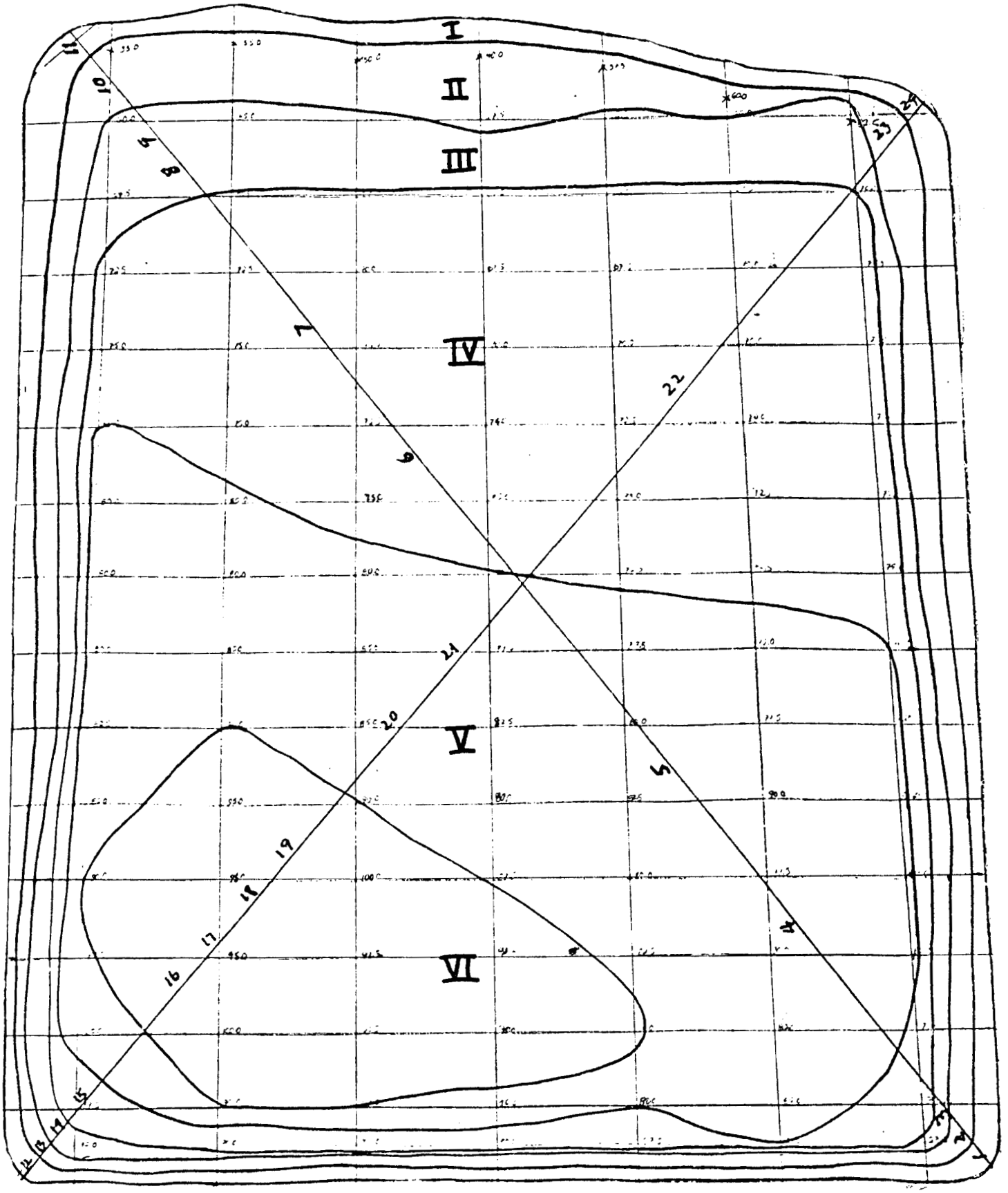


Figure 4b: A total of 4 traps set at different depths in the uncirculated pond.

I. 1, 11, 12, 13 Traps: 40 - 45 cm
II. 2, 10, 14, 24 Traps: 50 - 55 cm
III. 8, 9, 15, 23 Traps: 60 - 65 cm
IV. 3, 6, 7, 22 Traps: 70 - 75 cm
V. 4, 5, 20, 21 Traps: 80 - 85 cm
VI. 16, 17, 18, 19 Traps: 90 - 95 cm

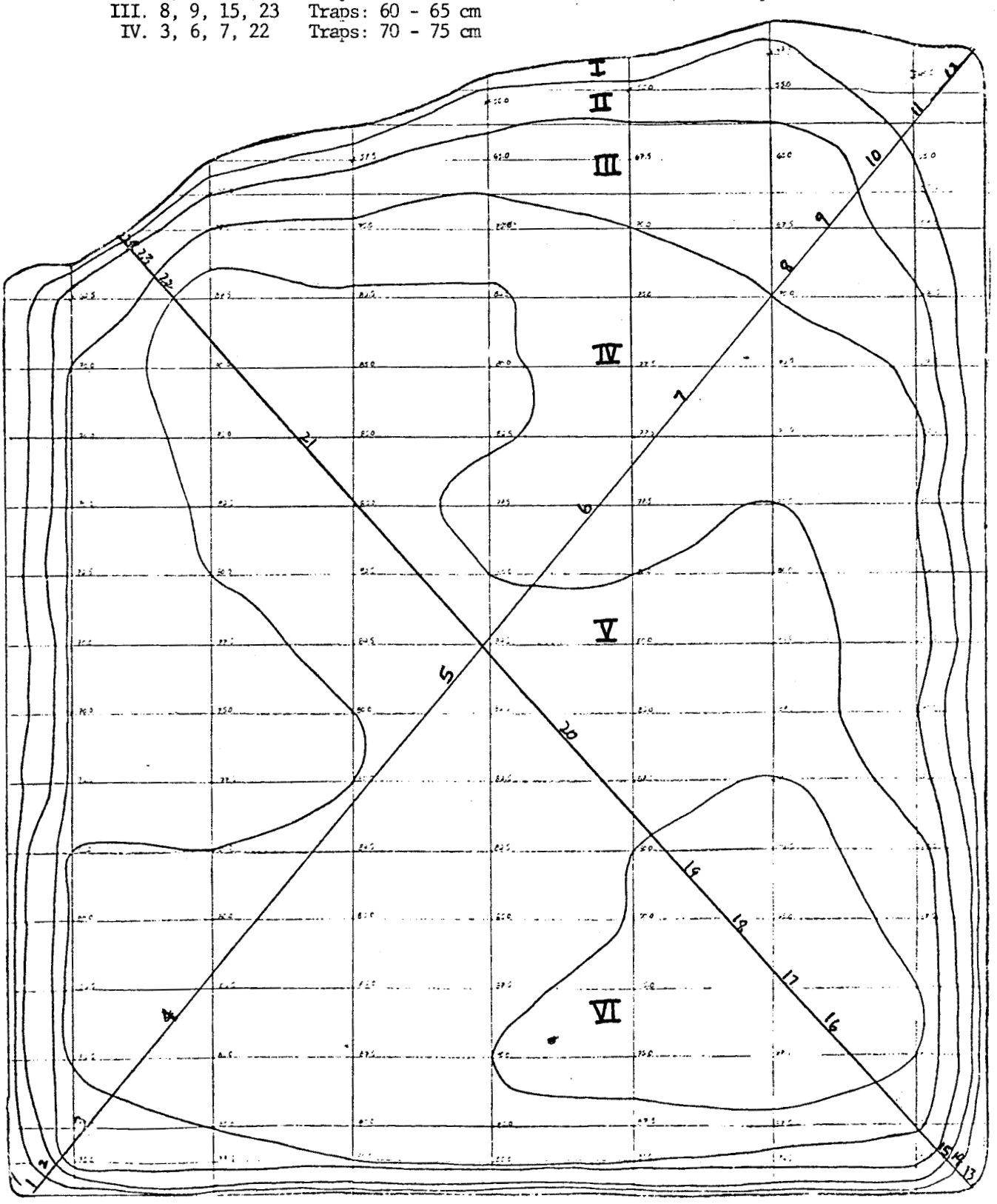


Figure 5: The total length of the prawn were measured from the back of the eyes to the tip of the telson.

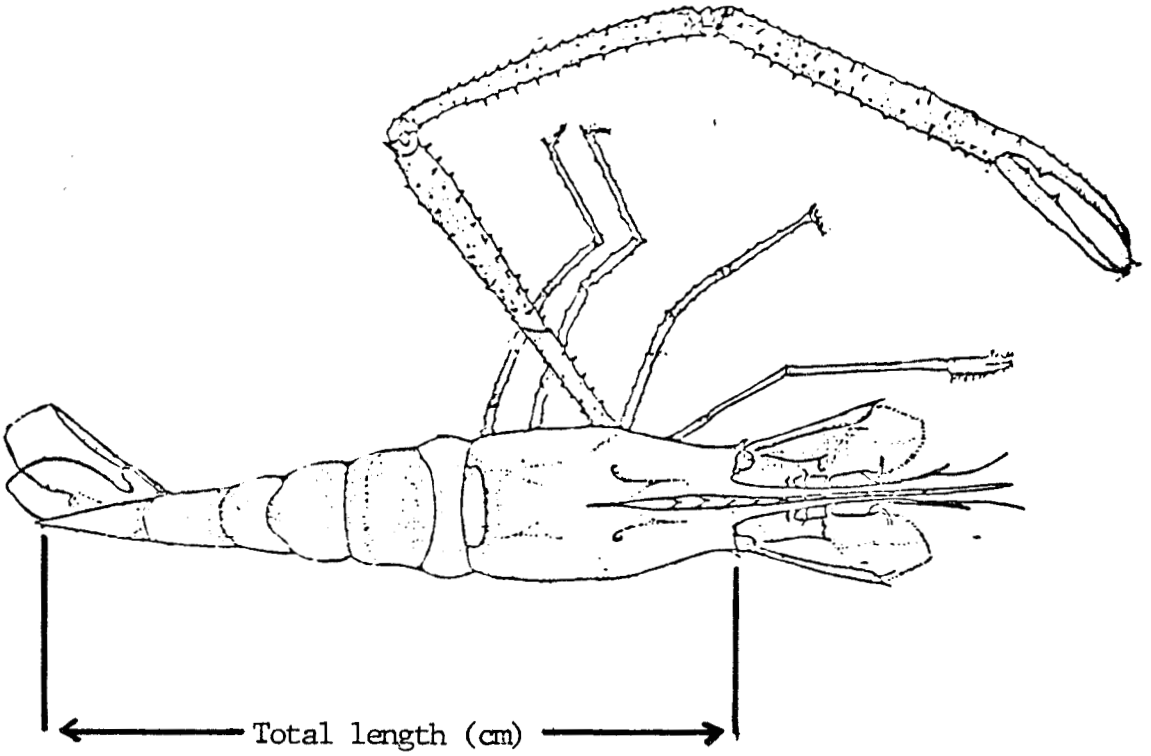
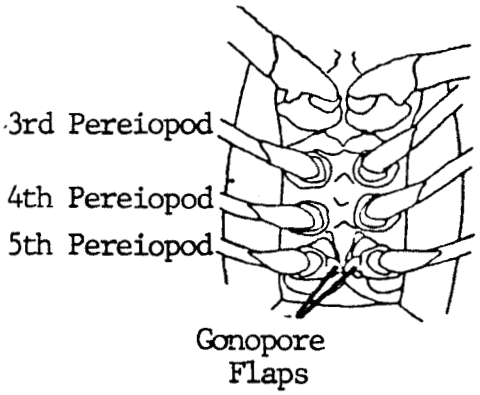
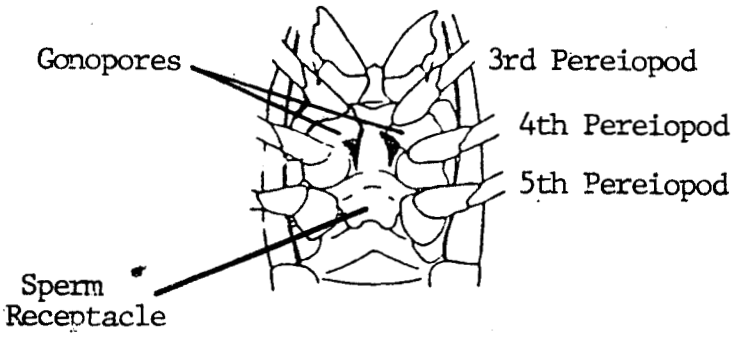


Figure 6: A) Ventral view of cephalothorax of a male prawn showing position of male gonopore flaps, on coxae of the 5th pereiopod.

B) Ventral view of cephalothorax of a female prawn, with no gonopore flaps on the 5th pereiopod. The female gonopores exist at the coxae of the 3rd pereiopod.



A



B

Figure 7: Sonic Tag Glued to the Carapace of the Prawn.

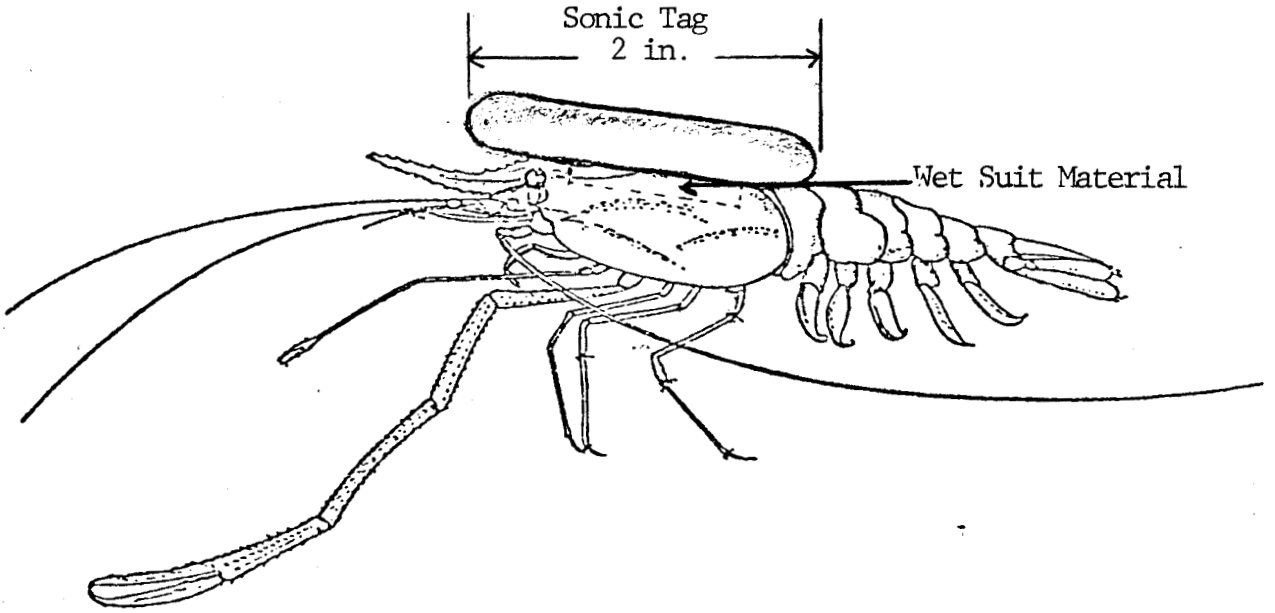


Figure 8: A Grid System and Triangulation was used to Track the Movements of Prawns.

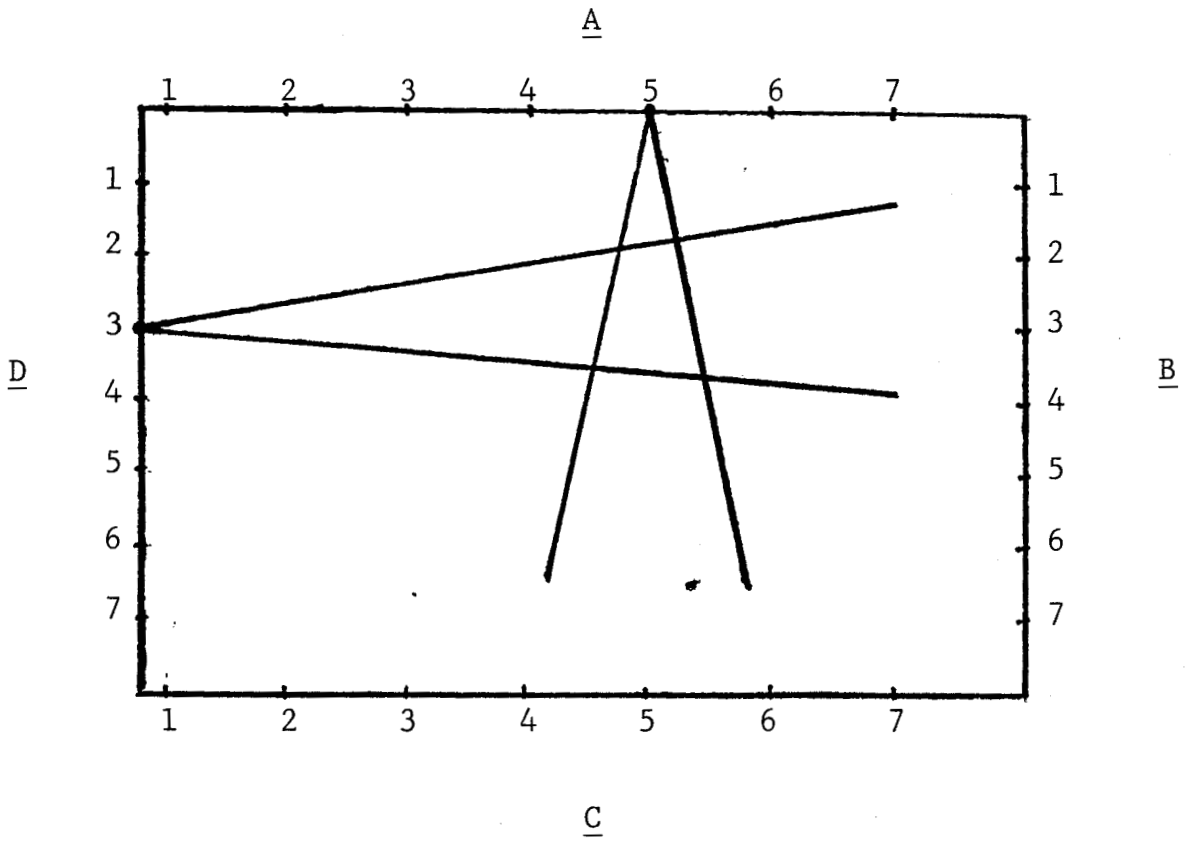


Figure 9a: Percent of Total Capture at Different Depths

A) Uncirculated Pond (7/11, 7/18 - 0730 to 1630) Dark Bars

B) Circulated Pond (7/25, 8/1 - 0730 to 1630) Clear Bars

Group	Depth
I	40-45cm
II	50-55cm
III	60-65cm
IV	70-75cm
V	80-85cm
VI	90-95cm

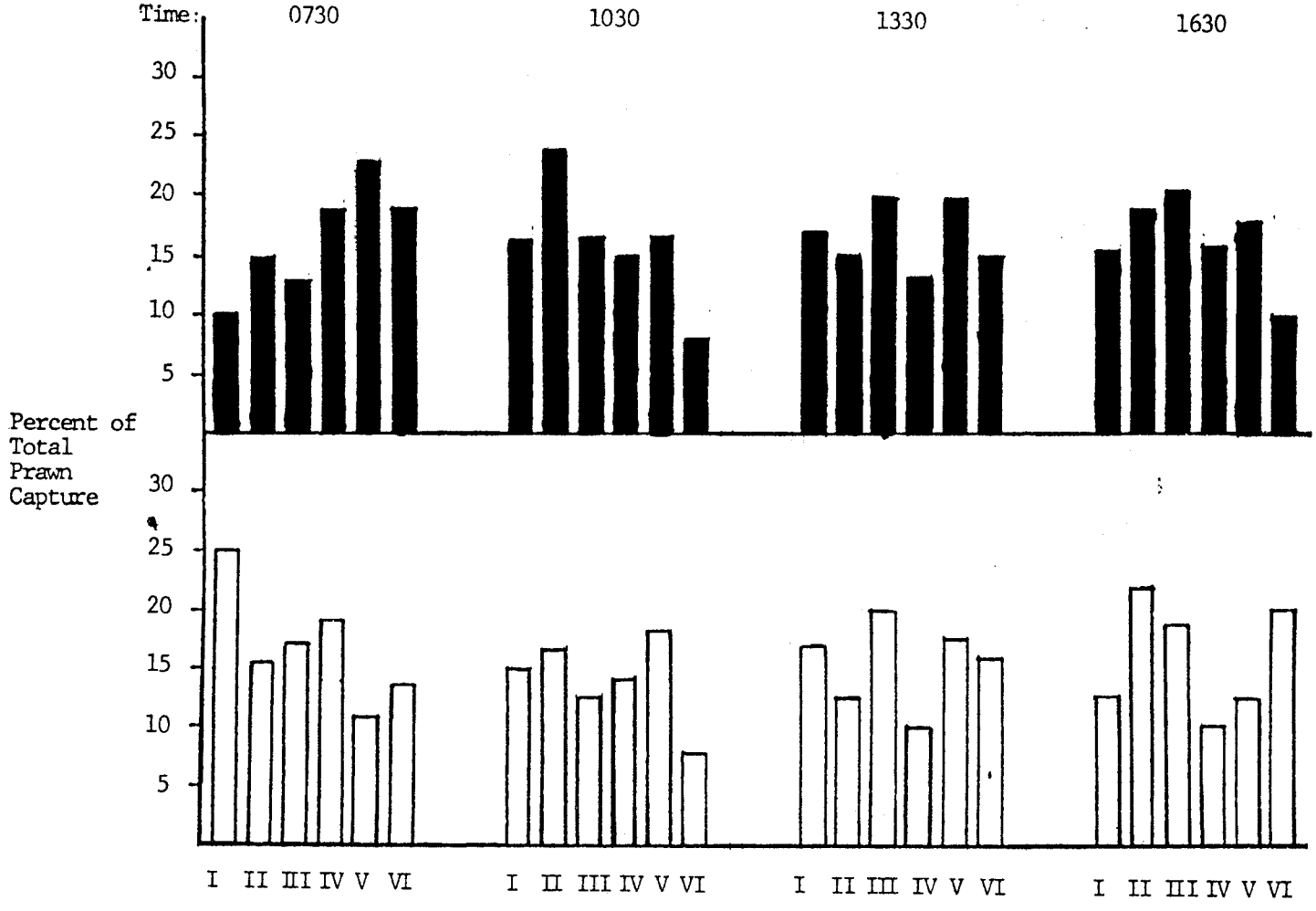


Figure 9b: Percent of Total Capture at Different Depths

A) Uncirculated Pond (7/11, 7/18 - 1930 to 0430) Dark Bars

B) Circulated Pond (7/25, 8/1 - 1930 to 0430) Clear Bars

Groups	Depth
I	40-45cm
II	50-55cm
III	60-65cm
IV	70-75cm
V	80-85cm
VI	90-95cm

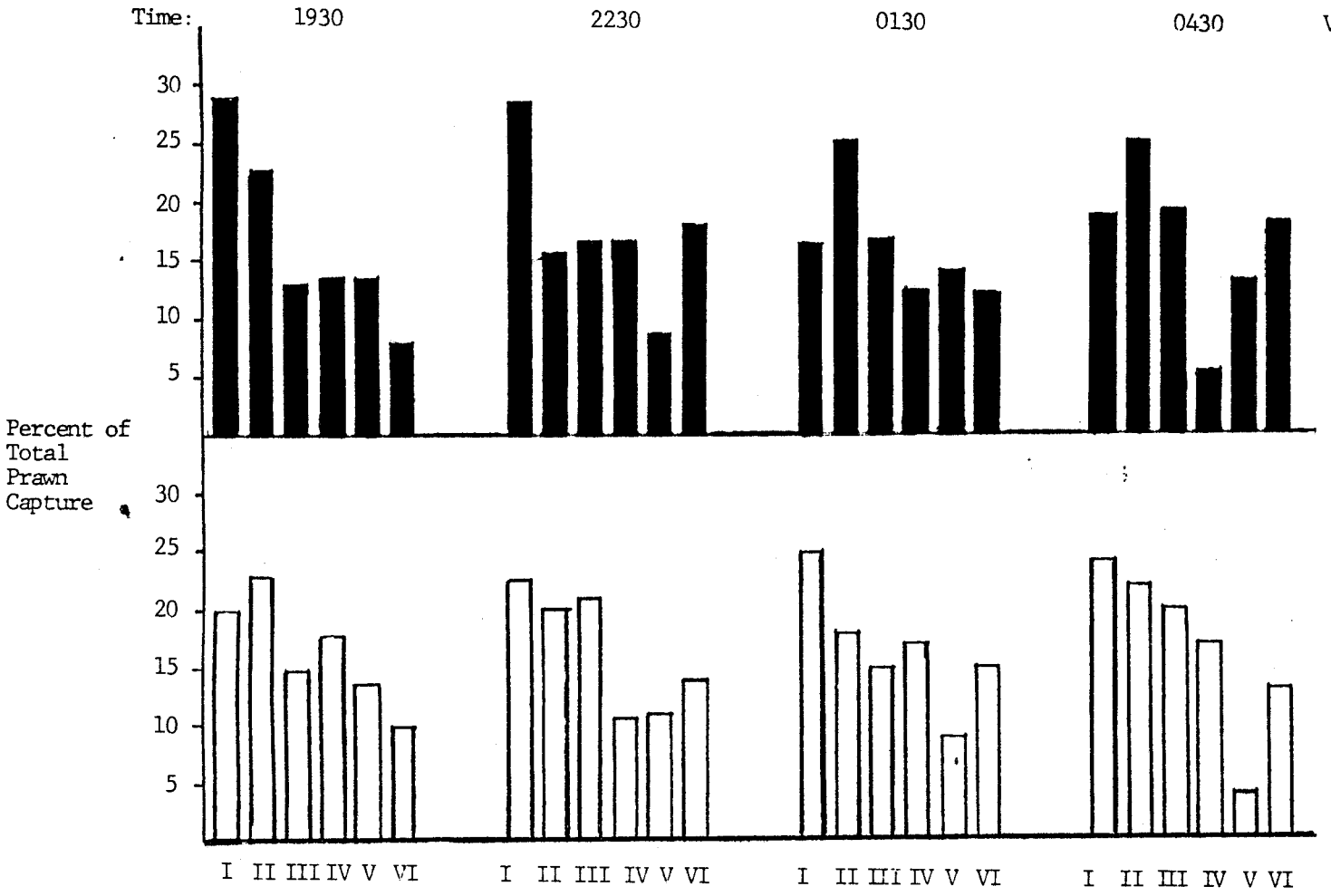


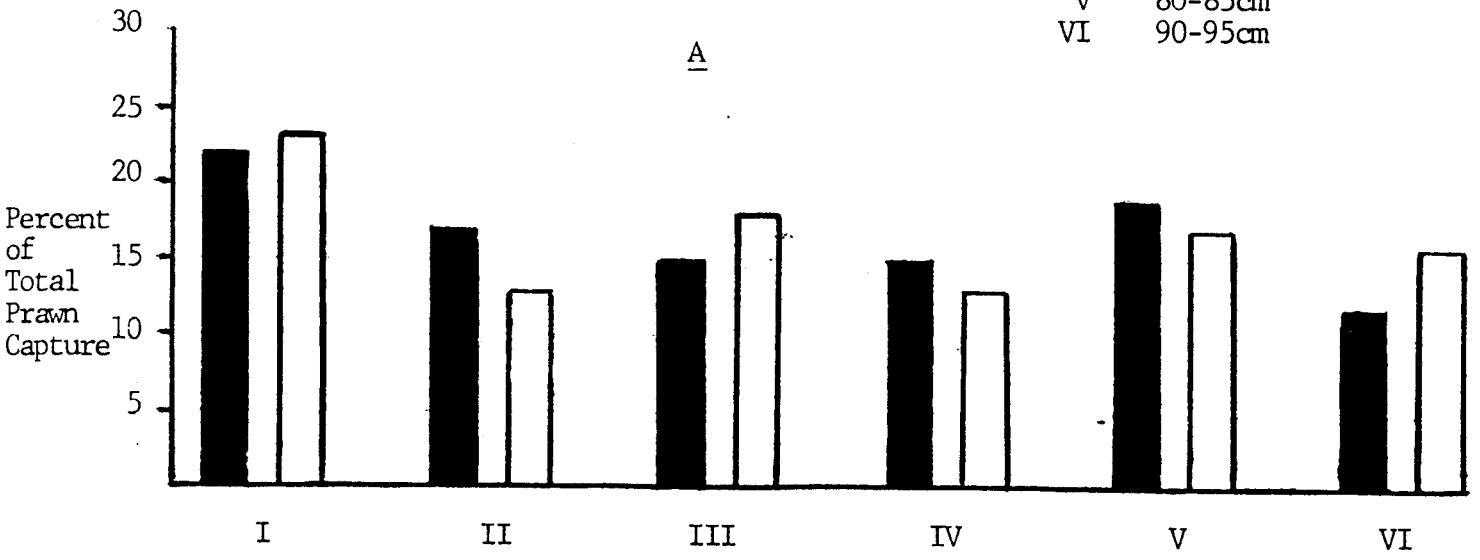
Figure 10: Average Percent Capture of Prawn at Different Depth

A) Day (0730 to 1630)

B) Night (1930 to 0430)

Dark Bars (7/11, 7/18)
Clear Bars (7/25, 8/1)

Group	Depths
I	40-45cm
II	50-55cm
III	60-65cm
IV	70-75cm
V	80-85cm
VI	90-95cm



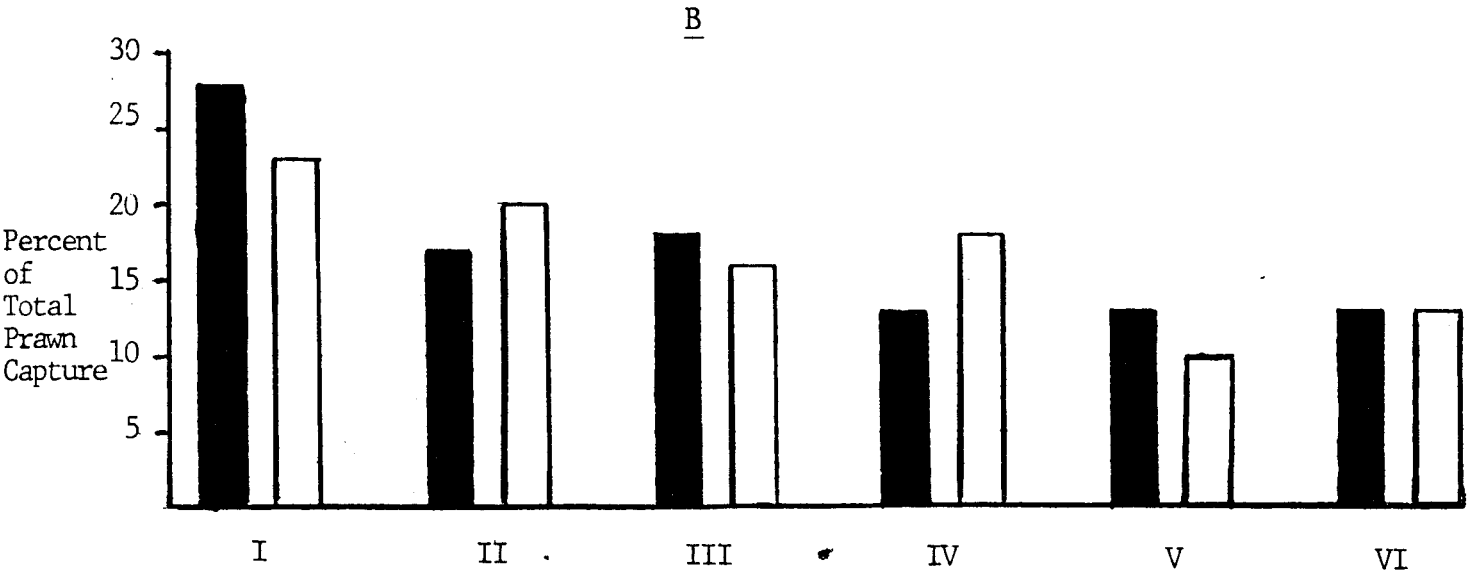


Figure 11a: Range of Prawn Sizes (Largest, Smallest), the 95% Confidence Interval and the Average Size Prawn Capture at Different Depths During the Day (0730 - 1630 hours)

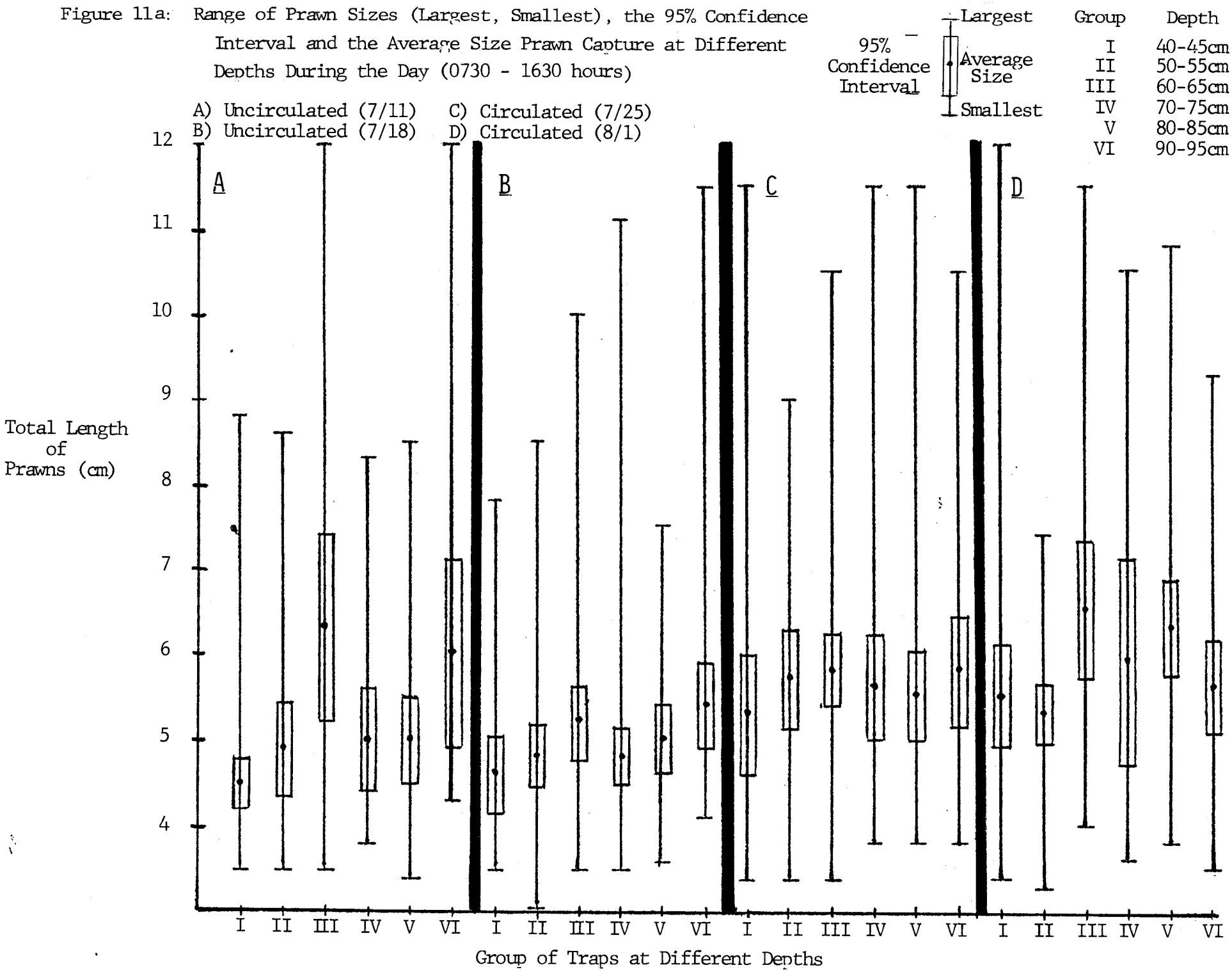
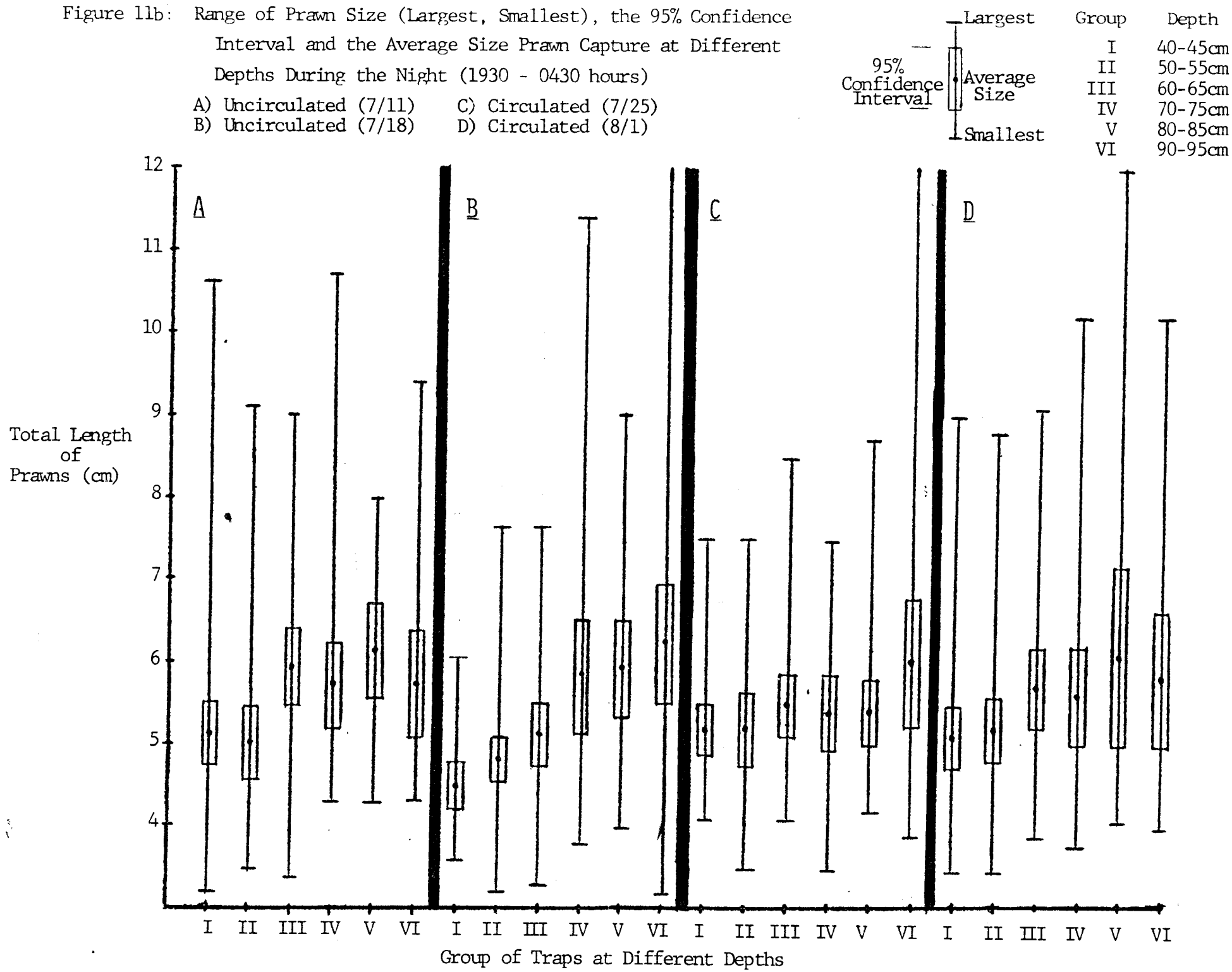


Figure 11b: Range of Prawn Size (Largest, Smallest), the 95% Confidence Interval and the Average Size Prawn Capture at Different Depths During the Night (1930 - 0430 hours)

A) Uncirculated (7/11)
B) Uncirculated (7/18)
C) Circulated (7/25)
D) Circulated (8/1)



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