10. EXPERIMENTAL BEAM TRAWLS FOR SAMPLING JUVENILE PRAWNS

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10.1 Introduction

Small fine-meshed beam trawls have been used for conventional sampling of juvenile penaeids in seagrass areas (Coles and Lee Long 1985). As juvenile penaeids are nocturnally active, beam trawl sampling for them occurs at night for a set time or on a trawl track generally marked by lighted buoys. Many factors can affect the efficiency of beam trawls such as water depth, lunar intensity and the type of substrate or sediment being trawled over.

Sediments associated with seagrass nursery habitat sampled by Coles and Lee Long (1985) in the Gulf of Carpentaria were usually fine and silty. Sediments of Torres Strait nursery areas (Section 4) are coralline and punctuated by pieces of dead corals weighing several kilograms. This rough substrate interferes with the efficiency of a conventional beam trawl. Low tides at night on the reef-platform nursery areas of Torres Strait made daytime time sampling of juvenile penaeids in this region necessary (Section 4). Alternative sampling gear was designed for daylight sampling, which incorporated a higher clearance from the bottom to minimise the effect of rough terrain on the trawl gear.

A variety of gear has been used to sample prawns. Allen and Hudson (1970) described a sled-mounted suction device which they employed to quantitatively sample young pink shrimp, *Penaeus duorarum duorarum*. They found that samples from their suction device compared favourably with those from a more conventional, hand-pulled frame trawl.

Penn and Stalker (1975) described and tested an "active" beam trawl which operated by pumping jets of water into the substrate. This action washed inactive buried prawns into the path of the net. Their design allowed quantitative daylight samples of nocturnally active juvenile prawns. Their beam trawl used a large collecting bottle on the cod end of their net which proved ineffective in substrates with a high volume of organic material such as dead seagrass.

Electricity has been used to improve catches of fish (McRae and French, 1965), prawns (Pease and Seidel, 1967), and lobsters (Saila and Williams, 1972). It is used routinely in the mariculture harvest of prawns such as *Penaeus japonicus* in Japan (Lewis and Carrick, 1987). It also can be used for daytime harvest of nocturnally active animals. Electric sampling gear has an added advantage. It can be designed to limit the retention of vegetation and sediment in the collecting bag by relying on the involuntary movement of prawns influenced by pulsed current rather than through the mechanical disturbance of the bottom.

In the present study three alterative beam trawls were tested to compare their efficiency. A conventional beam trawl designed for nighttime use was compared with a water jet beam trawl, and an electric beam trawl both designed for daytime use.

10.2 Materials and Methods

10.2.1 Frame and net

The same frame and net were used for the three beam trawl types. The frame was constructed of aluminium and its design is shown in Figure 1. The net had a mesh size of 2 mm and was of a similar design to that used by Coles and Lee Long (1985). Netting was added to the front of the net to cover the top and sides of the frame. The net mouth measured 0.5 m high and 1.4 m wide. A 100 mm high rubber flap beneath the net mouth allowed the trawl to pass over lumps of coral, and prevented undue loss of suspended material under the net. The trawl was towed at approximately ^{2}5 m min^{-1}, 20 m behind a 4.44 m aluminium dinghy powered by an outboard motor.

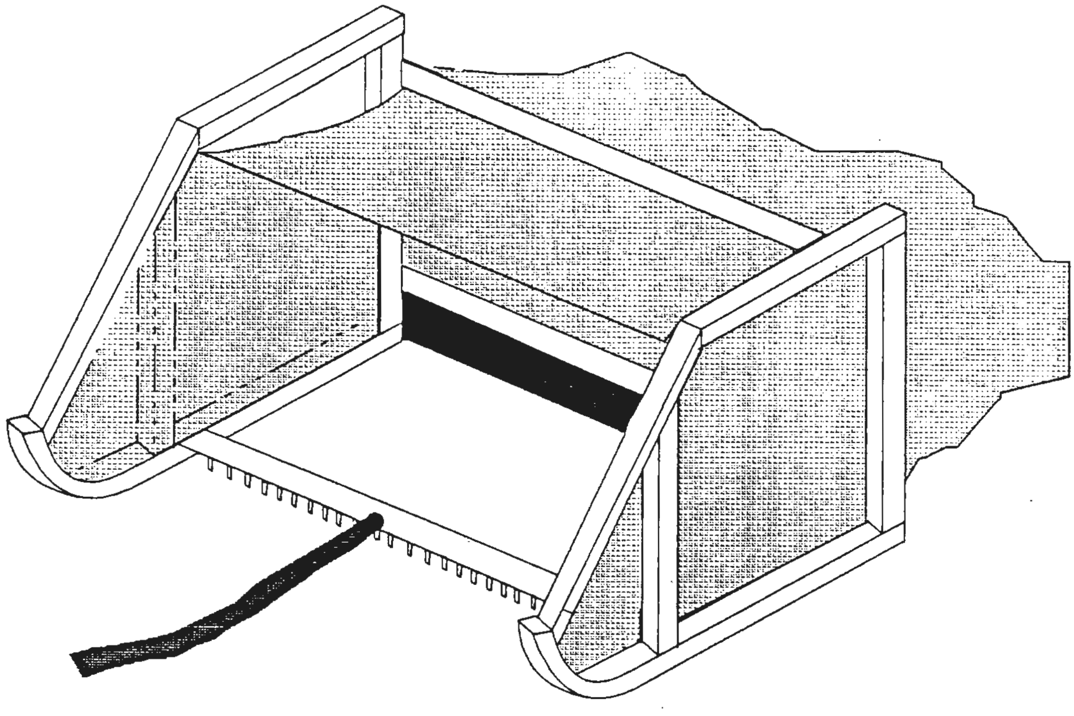

Figure 1. Design of beam trawl frame, net and water jet beam.

10.2.2 Trawl gear types

Conventional beam trawl. This beam trawl samples passively, that is prawns are not stimulated by an active tickler chain, water jets or electric current. A light tickler chain was used by Coles and Lee Long (1985). This was not used with our trawl, as it caught on lumps of coral. Only active prawns, those swimming in the water column or positioned up high on seagrass blades, could be caught by this design.

Water jet beam trawl. To operate the gear as a water jet beam trawl, a centrifugal pump (500 l/min) was used to force jets of sea water into the seagrass ahead of the net. A pump in the dinghy supplied water to the beam trawl through a 20 m length of 25 mm diameter reinforced plastic tubing. The water jet nozzles were incorporated on a beam constructed of 38 mm galvanized water pipe (Figure 1), placed 700 mm in front of the net. The water jet nozzles consisted of 20 x 5 mm diameter plastic tail pieces screwed into the pipe at 60 mm intervals. The ends of the water jet nozzles were 100 mm above the substrate.

The water jets were aimed to disturb the substrate, lifting loose material into suspension ahead of the net. The spacing between the water jet beam and the net, in combination with the speed of the trawl, allowed most of the disturbed sand to settle out in front of net, allowing fine silt, seagrass fragments, and prawns to pass into the net.

Electric beam trawl. To operate the gear as an electric beam trawl, an electrode array was positioned beneath the water jet beam and dragged across the bottom by the trawl. Rapid, direct 20 volt current pulses of a 2 milli-second duration, were supplied to the electrode array, from two, 12 volt batteries. The electrode array consisted of parallel positively charged plates (500 mm long and 50 mm high), with a 200 mm separation. Negatively charged rods, 500 mm long were positioned parallel to and midway between the lower edges of the plates so that they were in contact with the substrate.

10.2.3 Preliminary experiment

During March 1987, a preliminary experiment was conducted using the three beam trawl types at station 101 (Section 4 - Figure 2). The water jet and conventional beam trawls were tested during the daytime and nighttime. Due to the short duration of daytime tides the electric trawl was tested only at night. To test if the electrode array was acting as a tickler, the electric trawl was tested a second time during the nighttime with the current turned off. The short duration of the high tide permitted only one shot with each trawl type.

10.2.4 Experiment 1

During September 1987, sample replicates from beam trawl trials were collected at high tide from adjacent 100 m transects at station 101 on Warrior Reef. Four replicates were made with each beam trawl type at each sampling time. There were two sampling periods for the water jet and the electric beam trawls and one for the conventional beam trawl. On the first day of the experiment, the water jet day trawl tests were quickly followed by those of the electric beam trawl, and the conventional beam trawl was used that evening. On the second day, the order was reversed and the electric beam trawl was used first, to ensure that the order of the trials was not affecting the results. Time did not permit us to retest the conventional beam trawl the second evening.

Analysis of variance was used for the different beam trawls using the numbers of: *Penaeus esculentus,* the brown tiger prawn, *Metapenaeus endeavouri,* the endeavour prawn and all other decapods (mostly carids) as the response variables.

10.2.5 Experiment 2

During March 1988, beam trawl tests were conducted at two stations (101 and 107) on Warrior Reef (Section 4). These stations were approximately 500 m apart. Three replicates were made at each station using the nighttime conventional beam trawl, daytime water jet beam trawl and daytime electric beam trawl. The experiment was completed within a 24-hour period. At station 107 the daytime water jet beam trawl was tested before the daytime electric beam trawl. The order was reversed at station 101.

Counts and carapace length measurements were taken of all penaeid prawns caught in shots in this experiment. Carid prawns were numerous but were not retained.

Analysis of variance was used for the different beam trawl types using as the response variables, the numbers of: *P. esculentus, M. endeavouri,* and *M. bennettae,* a non-commercial species.

Individual gear types were compared by partitioning the total sum of squares into two orthogonal components. A Kolmogorov-Smirnov two-sample test was used to check for differences in the size frequency distributions of the catches (Sokal and Rohlf 1969).

10.2.6 Effect of altering height of water jet nozzles above the substrate

During February 1988, trials were conducted at a regular sampling site (n 112) on the reef surrounding the Yorke Islands in Torres Strait (Section 4), to determine the effect of lowering the height of the water jet nozzles on the daytime water jet trawl. Three replicate 100 m trawls were made. The lower (40 mm) noeight was used first, followed by our standard (100 mm) nozzle height.

Counts and carapace measurements were made of all penaeid prawns taken from trials in this experiment.

The difference in mean catch rates with the jets at normal height (100 mm) and lowered height (40 mm) was analyzed by a Student t-Test.

10.3 Results and Discussion

10.3.1 Preliminary experiment

The conventional and water jet beam trawls conducted at night had the highest catch of *P. esculentus* (Table 1). Beam trawl catches from these gear types taken during the night were approximately twice that of the catches from the daytime water jet beam trawl. Generally, daytime catch rates for all species (*P. esculentus, M. endeavouri* and *M. bennettae*) were very low when the conventional beam trawl was used (Table 1). This is probably due to the nocturnal behaviour of these species (Penn 1984). Catch rates of water jet and electric beam trawls conducted at night were two to four times greater than the nighttime conventional and daytime water jet beam trawls for both *M. endeavouri* and *M. bennettae* (Table 1).

Table 1. Catch rates of *P. esculentus, M. endeavouri,* and *M. bennettae* from the preliminary beam trawl gear experiment. The electric beam trawl was not tested during the day.

Species	Time	Beam trawl type			
		Conventional	Water jet	Electric on	Electric off
P. esculentus	Day	7	59	-	-
	Night	104	84	92	61
M. endeavouri	Day	10	133	-	-
	Night	144	450	495	163
M. bennettae	Day	1	191	-	-
	Night	158	246	360	179

Differences in catch rates between day and night trawls for *P. esculentus* for all gear types were small compared to the large differences between day and night catches with "active" gear for *M. endeavouri* and *M. bennettae* (Table 1). Stimulation (by water\s or electric pulses) at night caused an increase in the number of *M. endeavouri* and *M. bennettae* caught, but appeared to slightly reduce catches of *P. esculentus.* This species is nocturnal and continuously active at night. They are buried during the day with a tendency to occasionally emerge (Penn 1984). Stimulation would be expected to have no effect or a negative effect on the catchability of *P. esculentus.* The dramatic increase in catchability of *M. endeavouri* and *M. bennettae* through stimulation at night suggests that they are strongly nocturnal but often inactive or buried at night. These differences in catchability between species indicates species-specific behaviour in response to the different beam trawl types.

Nighttime water jet beam trawl catches of all three species *(P. esculentus, M. endeavouri* and *M. bennettae)* were higher than daytime water jet beam trawl catches (Table 1). There are two possible explanations, either prawns move into the area at night, or they are deeply buried and/or harder to stimulate during the daytime than at night.

The nighttime electric beam trawl even with the current turned off, increased nighttime catch rates because of a tickler chain effect. While numbers of *M. endeavouri* and *M. bennettae* were greater with the inactive array attached, catches of *P. esculentus* were smaller than the catches taken by the nighttime conventional beam trawl (Table 1). The electrode array of the inactivated electric beam trawl appears to act as a mechanical tickler disturbing the substrate ahead of the net increasing catches of *M. endeavouri and M. bennettae* but decreasing in catches of *P. esculentus.* The disturbance caused by the electrode array may allow sufficient warning for the very active *P. esculentus* to escape the trawl.

10.3.2 Experiment 1

Counts and carapace length measurements were made of all Penaeidae (including carids) taken from trials in this experiment (Table 2). There were no significant differences between replicate shots for each trawl type or between days in the experiment.

Table 2. Mean catch rates from beam trawl Experiment 1. Significance levels from ANOVA are listed and indicated by * p<.05 or ** p<.01. Standard errors are indicated in parenthesis.

	Beam Trawl Type			
	Nighttime Conventional	Daytime Water Jet	Daytime Electric	Significance level
P. esculentus	3.8 (3.1)	13.1 (2.2)	5.8 (2.5)	0.0407 *
M. endeavouri	9.2 (4.4)	35.6 (3.1)	3.0 (3.6)	0.0000 **
Non-commercial	185.5 (27.9)	148.5 (19.7)	38.8 (22.8)	0.0016 **

For all Penaeidae species considered, there were significant differences in catch rates between all beam trawl types (Table 2 and Figure 2). The daytime electric and conventional nighttime beam trawl catch rates were not different and were approximately one third those of the water jet daytime beam trawl for *P. esculentus* and *M. endeavouri* (Figure 2). The catch rates of non-commercial species, mainly carids, in the daytime water jet and nighttime conventional beam trawls were similar and four times greater than those for the daytime electric trawl (Figure 2).

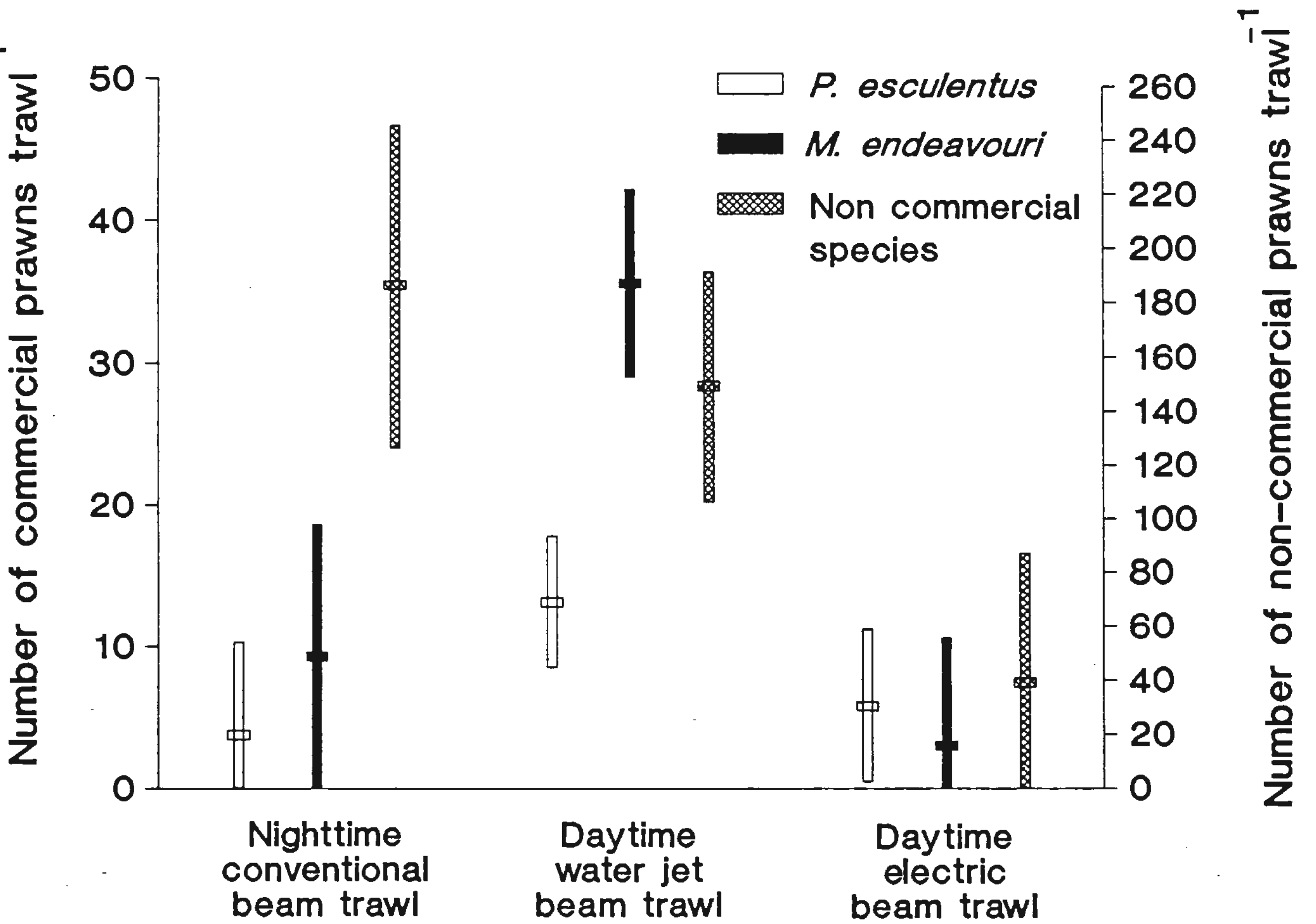

Figure 2. Comparison of catches of *P. esculentus, M. endeavouri* and *M. bennettae* for Experiment 1 from the nighttime conventional beam trawl, daytime water jet beam trawl and daytime electric beam trawl.

The difference in catch rates between commercial and non-commercial species, indicates different behaviour and responses to the different trawl types. The low catch rates of the daytime electric beam trawl for non-commercial species may have been a result of their small size relative to the commercial species. A smaller body width results in a decreased electric potential difference (generated by the electric field between the electrodes) across the animal's body and less stimulus to jump. The jumping height of the small non-commercial prawns may be less, and insufficient to place them in the path of the net.

10.3.3 Experiment 2

There were significant differences between the catch rates in the different beam trawl types for *P. esculentus, M. endeavouri* and *M. bennettae* (Figure 3 and Table 3). The catch rates for *P. esculentus* in the nighttime conventional beam trawl were significantly greater than the daytime water jet beam trawl, which in turn was significantly greater than the daytime electric beam trawl (Figure 3 and Table 3). *M. endeavouri* and *M. bennettae* catches taken by the nighttime conventional beam trawl were much greater than the catches from the other beam trawl types (Figure 3 and Table 3). Catches in the "active" gear types did not differ significantly (Figure 3 and Table 3).

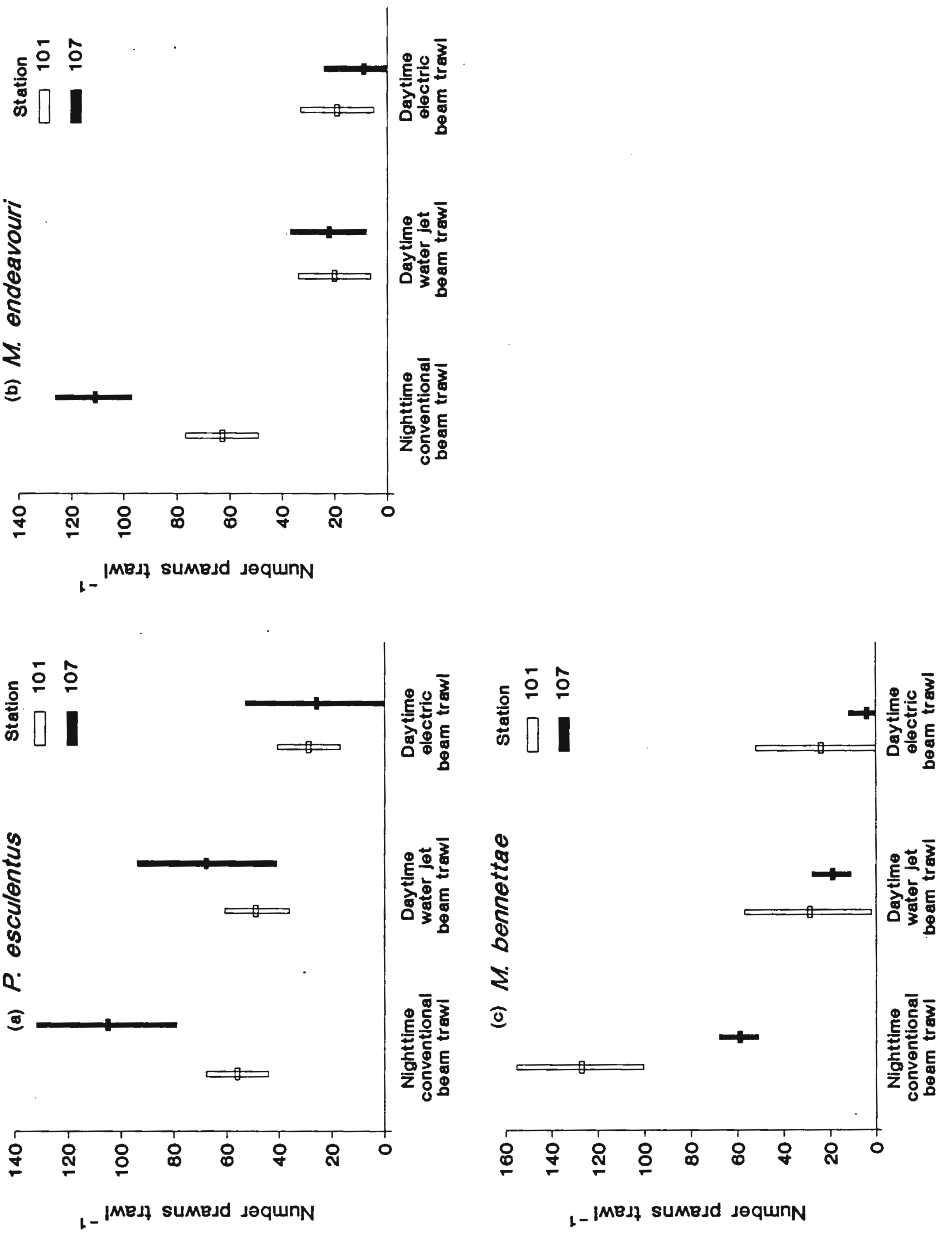

Figure 3. Comparison of catches of (a) *P. esculentus*, (b) *M. endeavouri* and (c) *M. bennettae* for Experiment 2 from the nighttime conventional beam trawl, daytime water jet beam trawl and daytime electric beam trawl.

Table 3. Mean catch rates (no. of prawns trawl^{-1}) from beam trawl Experiment 2. Significance levels from ANOVA indicated by * p<.05 or ** p<.01. Standard errors are indicated in parenthesis. For the orthogonal components analysis the 5% significance level (*) is indicated by an F > 5.99 and the 1% level (**) by F > 13.74 .

Species	Site	Nighttime Conventional	day/night F =	Daytime Water Jet	day/day F =	Daytime Electric	ANOVA P =
P. esculentus	101	56.0 (5.0)	7.65 *	48.7	7.45 *	29.3	0.02 *
	107	105.7 (10.9)	19.25 **	67.7	7.17 *	26.3	0.0063 **
M. endeavouri	101	62.7 (5.7)	38.76 **	20.0	0.03	18.7	0.0024 **
	107	111.3 (6.0)	171.24 **	22.3	2.3	9.0	0.0000 **
M. bennettae	101	127.0 (11.3)	82 **	29.0	0.95	24.3	0.010 **
	107	59.3 (3.4)	22.131 **	19.3	1.71	4.0	0.0001 **

Site differences were apparent between stations 101 and 107 for all species (Figure 3) caught by the nighttime conventional beam trawl. Catch rates of *P. esculentus* and *M. endeavouri* were greater at station 107. Catch rates of *M. bennettae* were greater at station 101 than at station 107. No significant differences were found between the numbers of any species at the two stations using the catches of the water jet and electric beam trawls. Catchability in the nighttime conventional trawl varied between the two stations. The abundance of prawns at these two the stations may have changed due to different phases of the tide. These results indicate that the conventional nighttime trawl is less consistent over a range of sites than the alternative beam trawl types.

Though the order in which the water jet and electric beam trawls were tested had no significant effect on catch rates, there was some evidence that catch rates increased as trials progressed. The beam trawl may disturb and stimulate prawns remaining uncaught in the substrate, increasing their response and catchability in subsequent tests on the same ground.

10.3.4 Comparing results of experiments 1 and 2

The results of Experiment 2 (Table 3) contradicted the results of Experiment 1 (Table 2). In experiment 2 the catches of all species caught by the nighttime conventional beam trawl were greater than the catches made by the daytime water jet beam trawl. *P. esculentus* and *M. endeavouri* catches for Experiment 1 were highest for the daytime water jet beam trawl (Table 2). We believe that large tides and poor weather conditions during Experiment 1 adversely affected the performance of the nightime conventional beam trawl, whereas Experiment 2 was conducted during a period of fine weather with small nighttime tides (only just enough water over the reef-top to operate the dinghy and beam trawl). This experiment also coincided with the time when juvenile prawn abundances are high (Section 4). The differences in the results of the two experiments suggests that the nighttime conventional beam trawl is more susceptible to adverse environmental conditions than the other beam trawl types.

Strong currents tend to make the beam trawl lose contact with the bottom and at night this is much more difficult to observe and control than during the day. Prawns may also withdraw into the seagrass cover to prevent being swept away by the strong currents. This would explain the reduced catch rate from the nighttime conventional beam trawl when tides are large, and currents strong.

Although the daytime water jet and daytime electric beam trawls have lower catch rates, the between shot variability in numbers caught was low. This could be due to catching inactive prawns which have been forced to jump by water jets or electric pulses. The nighttime conventional beam trawl relies on the prawns being already active and emerged from the sediment allowing more scope for behaviourial variation in response to the trawl. The results of the preliminary experiment suggests that at night a high percentage of *M. endeavouri* and *M. bennettae* may still be sitting on the substrate inactive or during the day they move out of the area. As *P. esculentus* are active at nighttime, they have a better chance of escaping from the trawl if some method of stimulation is used. Laboratory behaviourial studies of different species and their escape response to the three different beam trawl types would be required to answer these questions.

10.3.5 Size frequency distribution

There was a significant difference ($p < 0.05$ $D = .2059 > D.05 = .1833$)(Kolmgorov-Smironov two-sample test) in the size frequency distribution of *P. esculentus* at station 101, between catches from the daytime water jet and daytime electric beam trawls. There were less prawns in the smaller carapace length class sizes (4-8 mm) for catches of the electric beam trawl than the catches from the water jet beam trawl. At station 107, the size frequency distributions of *P. esculentus* from catches of the water jet and electric beam trawls were not significantly different ($p > 0.05$ $D_{.05} = .1221 < D = .0771$)(Kolmgorov-Smirnov two-sample test), though the trend of less prawns in the smaller size classes was also apparent at this site. All other combinations of trawl types at each station, for each species, were not significantly different.

10.3.6 Effect of lowering jets

There was no significant increase in catch rates of *P. esculentus, M. endeavouri* or *P. longistylus* caused by lowering the height of the water jet nozzles (Table 4). It appears that variations in the height of the water jet nozzles above the substrate has little impact on the catch rate as long as the nozzles are low enough to effectively disturb the substrate. Direct observation of the water jet beam trawl suggested 100 mm is the greatest effective jet height. Any further elevation reduced the water jets penetration of the bottom.

Table 4. Catches of *P. esculentus* , *M. endeavouri* and *P. longistylus* from tests of different jet heights on the daytime water jet beam trawl. $t_0.05 = 2.78$ and $t_0.01 = 4.60$

Species	jet height	mean number per trawl	'T' value
P. esculentus	normal	46.3	0.5658
	lowered	36.3	
M. endeavouri	normal	18.3	0.0063
	lowered	20.3	
P. longistylus	normal	13.3	0.0158
	lowered	24.3	

10.4 Conclusions

Catch rates for all species examined were highest in the nighttime conventional beam trawl when tides and weather conditions allowed the trawl to operate at maximum efficiency. When strong tides, currents, and winds prevail then the catch rates of the nighttime conventional beam trawl are significantly more variable than the catch rates of the daytime water jet and daytime electric beam trawls.

The daytime water jet beam trawl provided a reliable alternative to the nighttime conventional beam trawl when problems with navigation or tidal range made trawling difficult at night. Although daytime water jet beam trawl catches were generally lower than catches made by the nighttime conventional beam trawl, daytime water jet beam trawls were more reliable over a wider range of tidal and weather conditions. If species specific correction factors are applied to the data to make comparisons with nighttime conventional beam trawl data, then the catch rates of the daytime water jet beam trawl compared to the nighttime conventional beam trawl would be approximately 75% for *P. esculentus,* and 25% for *M. endeavouri* and *M. bennettae.*

The daytime electric beam trawl was not an effective alternative to a nighttime conventional beam trawl because catch rates of all species were lower than the catches for the daytime water jet beam trawl, and the electrode array readily caught on small humps of coral protruding from the substrate.

10.5 Acknowledgements

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