DIEL FLUCTUATIONS IN CATCH OF POSTLARVAL WHITE SHRIMP, *PENAEUS SETIFERUS* (LINNAEUS), WITH THE RENFRO BEAM TRAWL

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ABSTRACT

From August 30 through September 3, 1964, duplicate (clockwise and counterclockwise) semicircular tows of 100-ft radius were made with the Renfro beam trawl every 2 hours over a 98-hour period. The sampling site was a tidal flat adjacent to the shoreline at Cheniere la Croix, Louisiana, bordering the Gulf of Mexico. A total of 9,462 postlarval white shrimp, *Peneaus setiferus* (Linnaeus), were captured. Because the standard deviation of catches (numbers of postlarvae) taken in duplicate tows was proportional to the arithmetic mean of duplicate catches, the geometric mean catch per tow was used as a measure of relative abundance of postlarvae. Peak catches of postlarvae per tow occurred at night. 2-4 hours after high water and at the lowest water temperature, during each of the four 24-hour periods. Minor peak catches occurred each afternoon near the low-water stage and at the highest water temperature during each 24-hour period.

INTRODUCTION

A small beam trawl designed by Renfro (1963) has been used to measure relative abundance of postlarval shrimp (*Penaeus* spp.) in the shallow waters near the shoreline of estuaries bordering the Gulf of Mexico (Baxter, 1963; Baxter & Renfro, 1966; Christmas, Gunter & Musgrave, 1966). Several factors have been shown to influence the catch of postlarvae with the beam trawl, which is usually towed in a semicircle of constant radius adjacent to the shoreline. Disturbance of the substrate by both the person towing the net and the metal pipe beam that drags in front of the mouth of the net presumably causes postlarvae on the bottom to rise into the path of the net's mouth. Caillouet, Dugas & Fontenot (1968) showed that tows of 50-ft radius were no less efficient than tows of 100- and 150-ft radius in capturing postlarvae. Baxter (1964) reported diel variation in catch of postlarvae with the beam trawl. Using different gear, other investigators have also demonstrated diel fluctuations in catch

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1 Contribution No. 962 from the Institute of Marine Sciences, University of Miami.

The purpose of this investigation was to measure diel fluctuations in catch of postlarval white shrimp, *Peneaus setiferus* (Linnaeus), with the Renfro beam trawl.

**METHODS**

From August 30 through September 3, 1964, duplicate (clockwise and counterclockwise) semicircular tows of 100-ft radius were made with the Renfro beam trawl every 2 hours over a 98-hour period. The sampling site was a tidal flat adjacent to the shoreline at Cheniere la Croix (T 17 S, R 4 E, Section 24) on the south side of Marsh Island, Louisiana, bordering the Gulf of Mexico. The substrate was finely ground shell and firm, heavy mud. The first of each pair of tows was made in a counterclockwise direction and the second in a clockwise direction. Water temperature and tidal elevation were recorded each time duplicate tows were made.

Samples were fixed in a solution of 10-15 per cent formalin and 5 per cent glycerin, buffered with sodium tetraborate decahydrate. Postlarvae were later removed and counted. Subsamples of not more than 25 postlarvae from every sample were identified to species according to Pearson (1939) and Williams (1959). The sampling was conducted in the fall to decrease the likelihood of capturing *Peneaus* spp. other than white shrimp.

**RESULTS**

Of the 9,462 postlarvae captured during the study, 1,959 identified to species were all white shrimp. The standard deviation of catches (numbers of postlarvae) taken in duplicate tows was proportional to the arithmetic mean of duplicate catches (Fig. 1), i.e., the coefficient of variation of duplicate catches was relatively constant. Therefore, the geometric mean catch per tow (square root of the product of catches in duplicate tows) was used as a measure of relative abundance of postlarvae (Fig. 2) and a logarithmic transformation of catches was performed to assure additivity and homogeneity of variance prior to analysis of variance. Since no postlarvae were taken in some tows, 1 was added to each catch before it was transformed to a common logarithm. The following analysis of variance of the transformed data detected significant (P < 0.05) differences
in catch per tow among the four days (from hours 1200 to 1000) of sampling and among hours of the day:

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling periods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days</td>
<td>(3)</td>
<td>7.3260</td>
<td>2.4420</td>
<td>35.14*</td>
</tr>
<tr>
<td>Hours</td>
<td>(11)</td>
<td>17.5061</td>
<td>1.5915</td>
<td>22.90*</td>
</tr>
<tr>
<td>Interaction</td>
<td>(33)</td>
<td>5.8610</td>
<td>0.1776</td>
<td>2.56*</td>
</tr>
<tr>
<td>Duplicate tows</td>
<td>48</td>
<td>3.3357</td>
<td>0.0695</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>34.0288</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at P < 0.05.

There was also a significant interaction between days and hours, but the contribution of this interaction to the variation in catch of postlarvae was not as great as that of either days or hours alone.

Peak catches of postlarvae were taken at night (between and including the hours of 2000 and 0400) 2-4 hours after the high-water tidal stage in each of the four tidal cycles (Fig. 2). Minor peak catches occurred each afternoon near the low-water stage. The peaks in catch at night occurred when the water temperature was lowest, but the minor peaks that were observed during the day occurred when the water temperature was highest. On such a tidal flat, water temperature can be expected to increase when low water occurs during the day and results in exposure of shallow areas to the heat of the sun, and it can be expected to decrease at night with incoming tidal currents. There was a relatively strong negative correlation (r = -0.67) between tide and water temperature.

**DISCUSSION**

Peak catches of postlarval white shrimp occurred at night, 2-4 hours after high water, and at the lowest water temperature during each of the tidal cycles in this study. Tabb, Dubrow & Jones (1962), using a plankton net operated from a stationary position in a tidal canal, reported that catches of postlarval pink shrimp, *Penaeus duorarum*, were greater at night than during the day and were greater during flood tide than during ebb tide. Catches of postlarval shrimp (probably brown shrimp, *Penaeus aztecs*) were observed by Baxter (1964) to be higher at night (from 2000 to 0600 hours) than during the day. St. Amant, Broom & Ford (1966) showed that catches of postlarval shrimp (probably both white and brown shrimp) were greatest in periods of incoming tide, but they detected no relationship between catch and time of day. Though results of these studies are similar, they are not all directly comparable because of differences in gear and method of operation of gear. Both our study and that of Baxter (1964) employed the Renfro beam trawl, an active gear. The passive gears used by Tabb, Dubrow & Jones (1962) and St. Amant, Broom & Ford (1966) depended upon water movement for their operation; nevertheless, movement of postlarvae was shown to occur unidirectionally with the flood tide or incoming tidal currents.

Hughes (in press) concluded that tide-associated movements of postlarval pink shrimp were related to the changes in salinity that normally occur in the tidal cycle, but these movements seemed to be conditioned by rhythmic control. The postlarvae rose from the substrate and were more active at the higher salinities associated with periods of incoming tidal currents. They settled to the bottom and became inactive at the lower salinities that usually accompany outgoing tidal currents. Since the postlarvae were not capable of swimming against strong currents, they were passively displaced when off the substrate and active in the water of higher salinity associated with incoming tidal currents.

It was possible that catch of postlarval white shrimp with the Renfro beam trawl was influenced in part by changes in volume of water strained through the net. At least two conditions associated with the tidal cycle could have contributed to these changes: (1) changes in direction and velocity of currents near the shoreline, and (2) changes in configuration of the gear. When current direction deviates from a direction perpendicular to the shoreline, more water should be strained through the net when towed in one direction (into the current) than in the opposite direction (with the current). It is reasonable to expect such deviation in current direction with flood and ebb tides. Changes in velocity of tidal currents are also associated with flood and ebb tides. At low water, the gear was towed in water not more than about 1 ft deep. Both the metal beam and the entire lead-weighted footline chafed the bottom, and the whole footline was at the surface, giving the mouth of the net a flattened oval shape. At high water, the gear was buoyed to a greater extent, there was not as much chafing of the bottom, and the mouth of the net was held wide open by footline and leadline. Apparently, more water was strained through the net during flood and ebb tides when current velocity was greatest, yet peak catches were not made at these times but occurred 2-4 hours after high water when current velocity was low. Minor peak catches also occurred with low current velocity accompanying low water.

It appears that the postlarval white shrimp were carried seaward at night by the incoming tidal currents and reached peak abundance 2-4 hours after high water. The rapid decline in abundance thereafter could have resulted from emigration of postlarvae from the sampling area, or decreased vulnerability of postlarvae to the gear, or both. It seems likely that the postlarvae would be more vulnerable to the gear when actively swimming than when settled on the bottom. If the postlarvae were on the bottom...
and not active during the day, disturbance of the bottom by the propeller and towing the gear in shallow water and by the gear itself might have contributed to minor peak catches that occurred each afternoon at low water. The relatively high water temperature at that time may have induced the postlarvae to become more active as well. However, these minor peak catch may have been produced by immigration of postlarvae into the sampling area with the outgoing tidal currents.

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SUMARIO

FLUCTUACIONES DIARIAS EN LA CAPTURA DE POSTLARVAS DEL CAMARÓN BLANCO, Peneaus setiferus (LINNAEUS), CON LA RED DE VIGA DE RENFRO

De agosto 30 a septiembre 3 de 1964, redadas semicirculares de 100 pies de radio, dobles—o favor y en contra del movimiento de las manecillas del reloj—fueron hechas con la red de viga de Renfro, cada 2 horas, por un período de más de 98 horas. El lugar de muestreo fue un bajo expuesto por la marea, próximo a la línea de la costa en Cheniere de la Croix, Louisiana, bordeando el Golfo de México. Se capturó un total de 9,462 postlarvas del camarón blanco, Peneaus setiferus (Linnaeus). Debido a que la desviación regular de las capturas (número de postlarvas), tomadas en redadas dobles, fue proporcional a la media aritmética de las capturas dobles, la media geométrica de captura por redada fue usada como una medida de la relativa abundancia de postlarvas. Los puntos de máxima en la captura de postlarvas por redada tuvieron lugar en la noche, de 24 horas después de la marea alta, y a la más baja temperatura del agua durante cada uno de los cuatro periodos de 24 horas. Los puntos de mínima tuvieron lugar cada tarde, cerca de la marea baja y a la más alta temperatura del agua durante cada periodo de 24 horas.

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