Distribution of bivalve species along an altitudinal gradient in a sandy beach ecosystem in the tropical Pacific; Playa Azul, Tárcoles, Gulf of Nicoya, Costa Rica

Colby Davis, Mike Swart, Tanner Scholten

1. Introduction

The community of Tárcoles, Costa Rica is one of artisanal anglers who use traditional techniques rather than modern commercial methods, such as trawling, to harvest fish for subsistence and sale. The Gulf of Nicoya, within which Tárcoles is located, is the estuary of the Tempisque River on the Pacific coast of the country and is a popular location for commercial fishing, due to its historically strong fish populations. In the 1980’s, the community struggled with declining fish populations, which were impacted by unchecked local fishing practices and overharvesting by commercial shrimp boats in the area. In order to combat these threats, a cooperative, La Cooperativa de Pescadores de Tárcoles R.L. (Coope Tárcoles), was formed in 1986, unifying the area anglers. Since the formation of the cooperative, the local people have kept detailed catch records, formed a code of ethics to which they agree to adhere in order to protect the environment and their community, created an alternative source of income in the form of ecotourism, and successfully established the Marine Area of Responsible Artisanal Fishing of Tárcoles (MARAFT). Costa Rican law officially recognized the MARAFT in 2009, and within this area, fishing techniques are restricted in order to protect fish populations and allow the people of Tárcoles to harvest using their lower-impact techniques (David Rojas, personal communication, January 13, 2014 and United Nations Development Programme 2012).

While much progress has been made, there are yet many unknowns related to the success and efficacy of the MARAFT. In order to evaluate its long-term impact, it is necessary to collect time-series data pertaining to individual species in the area. Anecdotal reports from residents of Tárcoles indicate that various bivalve mollusk populations are growing—some locals claim that
species that have not been found for over 30 years are now present on area beaches (David Rojas, personal communication, January 13, 2014)—which could be evidence that the impact of commercial fishing extends to the intertidal zone.

Understanding species distribution and relative abundance is a critical step in evaluating population trends to create valuable time-series data. The objectives of this study are (1) to describe the current distribution and relative abundances of two species along an altitudinal gradient, and (2) to produce a data point for use in future time-series analyses of bivalve demography within the Gulf of Nicoya.

2. Methods

The study was performed on a sandy beach known as Playa Azul (9.764,-84.629) approximately 1.6 km north of the town of Tárcoles. This beach is one of the few area sites frequented by locals harvesting clams, as it is reputed to have the largest, most predictable population of these bivalves. The surrounding terrain is relatively flat, with the area above the high-water mark being dominated by grasses, giving way to tropical deciduous trees. The mouth of the Tárcoles River is approximately 3 km north of Playa Azul, and both are within the southwest-oriented Gulf of Nicoya.

The bivalve population at Playa Azul was measured on 16 and 17 January 2014, beginning 30 to 60 minutes prior to the morning low tide each day. A pilot survey determined that there were two species of bivalve on the beach, one of which tended to be located nearer to the low tide mark and buried more than several centimeters in the sand, and the other of which tended to be higher up the beach and buried one to two centimeters in the sand. Within a reach of the beach found by the pilot study to have clams, a starting point was designated just above the swash line. This point was the beginning of the northernmost of seven 100 m transects perpendicular to the waterline spaced 10 m apart (Brazeiro et al. 2000, Degraer et al. 1999).
Along the south side of each transect, a clam gun (15 cm diameter) was used to collect cylinders of sand approximately 40 cm long at 1 m intervals (Brazeiro et al. 2000; Sibaja-Cordero & Vargas-Zamora 2011). Each cylinder was sorted through by hand in order to collect any bivalves contained therein (Hughes 1970), and for each collected bivalve, the species (assigned arbitrary identifiers during a pilot study; e.g. Species A and Species B), color, and
maximum valve length (measured using Vernier calipers) were recorded, as well as the distance from the swash line. If four consecutive cylinders yielded none of a given species, it was assumed that the last location where an individual was found was the end of that species range for that transect. On the north side of each transect, a similar process was repeated, beginning at the high tide mark and creating a belt survey that extended 1 m north of the transect (Figure 1, above). Within this belt, telltale holes were searched for, and spoons or knives were used to dig up individual bivalves. The same data were collected as for the clam gun bivalves, and again, four consecutive meters of transect with no bivalves of that species was considered the end of that species’ range.

3. Results

A demographic map was developed of the habitat locations of three species of bivalves in the sandy beach ecosystem. Individuals of Species A (Figure 2) were encountered from zero to 48 meters above the swash line. Species A is a larger clam reaching nearly 7 cm in maximum valve length, with a pink shell. Specimens observed had an average maximum valve length of 4.87 cm.

![Figure 2 Various specimens of Species A—one of two primary species—collected at a research site at Playa Azul in a study of bivalve distribution on the Pacific coast of Costa Rica in January 2014.](image)

Species B (Figure 3) was generally smaller than Species A and was found 19 to 73 meters above the swash line. Species B showed some variation in color, including black, yellow and
white varieties. The longest individual of Species B had a maximum valve length of 3.8 cm and the species average was 2.61 cm. On all but one transect there existed a region approximately 20 m in length that was devoid of clams, and was therefore referred to as the “dead zone.”

Figure 3 Examples of Species B—one of two primary species—collected at a research site at Playa Azul in a study of bivalve distribution on the Pacific coast of Costa Rica in January 2014. Note the range of colors.

Species C was discovered much less frequently than either Species A or Species B, only appearing 3 times in all the samples taken on the beach. The three Species C clams were all collected between 42 and 44 meters above the swash line and had an average maximum valve length of 3.87 cm and a maximum of 4.7 cm. Appendix A shows the frequencies of clams found at varying distances above the low tide mark.

Table 1 Valve length of the three different species of bivalves found at a site in the Gulf of Nicoya just north of Tárcoles, Costa Rica.

<table>
<thead>
<tr>
<th>Species</th>
<th>Transect</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>5.1</td>
<td>5.2</td>
<td>4.7</td>
<td>4</td>
<td>4.6</td>
<td>5.4</td>
<td>5.1</td>
<td>4.871</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>2.6</td>
<td>2.2</td>
<td>2.6</td>
<td>2.6</td>
<td>2.8</td>
<td>2.6</td>
<td>2.9</td>
<td>2.614</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>4.7</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>3.3</td>
<td>N/A</td>
<td>3.6</td>
<td>3.867</td>
</tr>
</tbody>
</table>
Table 2 Number of bivalves found at a site in the Gulf of Nicoya just north of Tárcoles, Costa Rica.

<table>
<thead>
<tr>
<th>Species</th>
<th>Transect</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td>2</td>
</tr>
<tr>
<td>A</td>
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<td>38</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Figure 4 Habitat distributions of the two major species collected along seven transects in a survey of bivalve distribution on a sandy beach, Playa Azul, in the Gulf of Nicoya on the Pacific coast of Costa Rica, near Tárcoles.
4. Discussion:

The two primary species had distinct ranges. Species A ranged from the low tide mark to the saturation line while Species B ranged from 18 to 75 meters above the low tide mark. There could be several reasons for this distribution. It could be that Species A is not able to live in a dry environment. This is supported by the observation that the visually observable region of saturated sand varied in distance from the swash line in a manner similar to that of the presence of Species A. Along the transect on which Species A was found as high as 48 m, the saturation line was also higher up the beach. No individuals of Species A were found above the area of saturated sand. Samples collected above the saturation line the sand contained substantial amounts of organic material, which may play a role in the absence of clams in that area. It is possible that this organic layer makes the area uninhabitable by either species.

This study found that of the bivalves present on Playa Azul, Species A was the most abundant, and individuals of Species A were generally larger and could be found living as deep
as 40 cm in the sand. The presence of these clams was indicated by a ripple or wavy texture on the surface of the sand with a visible hole above each individual. This texture in the sand was present only within the area of saturated sand. Species B was generally smaller and found near the surface of dry sand.

The results of this study could be influenced by bias introduced by the data collection methods. The collection of Species B was dependent on researchers being able to accurately identify where the clams were located within the belt transect, and the accuracy of the collection of Species A is dependent on the consistency with which researchers were able to pull up the entire contents of the clam gun.

The local anglers of Coope Tárcoles stated that Species C had not been seen in over 30 years on the beach. The recent sightings of Species C could be an indication that the establishment of the MARAFT allowed for population growth of this species. This research was designed to provide the first data point in a time-series evaluation that allows Coope Tárcoles to monitor clam populations, as well as to evaluate the efficacy of the MARAFT. This data collection method could be applied to different beaches in the area, for example, future researchers could sample beaches along the length of the MARAFT region in order to create a more complete understanding of local ecology. Doing this would allow a study of how the biodiversity and abundance of bivalves on sandy beach ecosystems changes over space and time within the MARAFT zone. Repeated measurements on Playa Azul would enable the evaluation of a time series of bivalve abundance and biodiversity, allowing the assessment of the degree to which trends vary over the year and from year to year. These data may be useful in assessing the degree of success of the MARAFT in preserving species biodiversity in the study area.
Works Cited


Appendix I: Transect Data

Below are specific data collected at each of the seven transects on Playa Azul near Tárcoles, Costa Rica in January 2014 as part of a study to evaluate bivalve distribution within the sandy beach ecosystem.

![Frequency at Site 1](image)

*Figure 5 shows the frequency of all clams found at site 1*
Figure 6 shows the frequency of all clams found at site 2

Figure 7 shows the frequency of all clams found at site 3
Figure 8 shows the frequency of all clams found at site 4

Figure 9 shows the frequency of all clams found at site 5
Figure 10 shows the frequency of all clams found at site 6.

Figure 11 shows the frequency of all clams found at site 7.