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GUAYANILLA-TALLABOA BAYS PLANKTON SURVEY

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[ABSTRACT]

A survey of the plankton population in Guayanilla-Tallaboa Bays was conducted to determine the composition, abundance and distribution of the zooplankton in the bays. Sampling was conducted at 14 stations over a period of one and a half years. The zooplankton population is dominated by copepods and of these, Acantia tonsa is the most abundant. Acantia occurs in highest densities in the stations closer to land and in lower numbers in the stations farthest from shore. The thermal cover area zooplankton population is characterized by A. tonsa and barnacle larvae. The central bay population is characterized by diversified copepod fauna, as well as by larvae of bivalves, ascidians, shrimps, brachyurans, and gastropods. The western bay zooplankton population is mainly composed of A. tonsa and larvae of crustaceans and echinoderms.

INTRODUCTION

A survey of the zooplankton in Guayanilla Bay was conducted to make an inventory of the zooplankton population. The inventory takes into consideration the composition, abundance, and distribution of the zooplankton in the bays. Sampling was conducted at 14 stations in Guayanilla-Tallaboa Bays over a one and a half year period. Zooplankton were collected with a 1/2 meter diameter cone-shaped net with a mesh aperture of 202 microns. Surface samples were obtained. The volume of the water filtered by the net was estimated with a flowmeter. Fig. 1 shows the stations sampled in the Guayanilla-Tallaboa Bays.

COMPOSITION OF ZOOPLANKTON

This zooplankton population is composed of three groups. These are divided into the following: (1) Hotoptankton

Copepods, pteropods, chaetognaths, siphonophores, larvaceans, ctenophores, salps, and doliolids, ostracods, cladocerans, brachiopods, protozoans.

(2) Meroplankton: cirriped larvae, echinoderm larvae, shrimp-like larvae, annelid larvae, brachyuran

larvae, ascidian larvae, decapod larvae, amphipods, gastropod veligers, ectoproct larvae, bivalve larvae, polychaete annelid larvae, stomatopod larvae.

(3) Ichthyoplankton: Fish eggs and larvae.

Of these groups, the copepods, which are the dominant group, were identified to species. They are listed as follows: Acartia tonsa, Acartia spinata, Acartia tilljeborgi, Undinula vulgaris, Calocalanus pavo, Paracalanus parvus, Pseudocalanus elongatus, Clausocalanus furcatus, Temora stylifera, Temora turbinata, Pseudodiaptomus colei, Calanopia americana, Labidocera aestiva, Metis holothuria, Euterpina acutifrons, Oithona nana, Oithona plumifera, Oncaea spp., Corycaeus spp., Farranula gracilis, Microsetella rosea, Eucalanus spp., Centropages furcatus.

In Fig. 2, the abundance of the total zooplankton population is represented. The zooplankton density averaged from 2,000 to 3,000 per hour in the most easterly station of Tallaboa Bay and in the central part of Guayanilla Bay, where oceanic currents prevail. In the Western Bay, at the Rio Yauco watershed, the zooplankton averaged over 3,500 plankters per hour. The average zooplankton abundance was less than 1,500 plankters per hour at four stations of those sampled, being lowest at the station between Punta Guayanilla and Cayo Palomas.

Guayanilla Bay supports a holoplankton population dominated by copepods. In Fig. 3, the densities in numbers per cubic meter of the copepod species are shown for Guayanilla Bay. The densities of copepods are highest in the western bay. Copepods comprise over 90% of the zooplankton population in this area of the bay (Figs. 2 and 3).

As a general rule, the number of species of copepods in neritic waters such as bays and estuaries is much lower than in oceanic and offshore waters.

In Fig. 4, the distribution of the total number of copepod species found at each station or area in Guayanilla Bay is shown. The central bay is characterized as having a species assemblage composed of 20 to 25 different species. The central bay's zooplankton population is similar to that reported from open water sites off Puerto Rico. The western bay, a nearshore estuarine area, has the least number of copepod species, 7-14. The intake area, enclosed by land and near the shore, has comparable numbers of species to those found in the stations of the central bay. An oceanic underwater current was found entering the intake area. This current transports oceanic plankton into this area, thus providing a high number of copepod species in an enclosed coastal area (Goldman, 1978). Acartia tonsa abundance, Acartia tonsa, a copepod found in estuaries and coastal waters in the tropical and sub-tropical regions of the earth, dominates the zooplankton population in Guayanilla Bay (Conover, 1956: Youngbluth, 1974, 1976). The distribution and abundance of A. tonsa is shown in Fig. 5, making up from 30-100% in the western bay, in the beach area, and in the thermal cove area. The abundance decreases towards the oceanic waters, sometimes being only 1%. The abundance of Acartia is in constant flux from month to month. This flux in abundance appears to respond to the fast generation turnover of the copepods as well as response to environmental changes such as seasonal wind, rainfall, and food supply (Reeve, 1964,1970; Youngbluth, 1976). Youngbluth (1974) looked for a relationship between Guayanilla Bay zooplankton abundance and parameters such as salinity, temperature, and season; he found little relationship. This lack of seasonal periodicity seems typical of plankton in tropical waters (Nutt and Wheeler, submitted; Sander and Steven, 1973), and contrasts with the seasonality reported for sub-tropical Bermuda waters (Sutcliffe, 1969: Menzel and Ryther, 1961; Herrman and Sears, 1969; Deevey, 1971) and for Biscayne Bay, Florida.

(Woosransee, 1958; Reeve, 1964). This implies that Caribbean zooplankton, although similar in species composition to that of sub-tropical latitudes, is distinct in that it exhibits no discernible seasonal pattern. Therefore, applications of results from temperate and sub-tropical studies to tropical situations must be made with extreme caution. It appears that A. tonea is not restricted by ambient temperature or salinity, although it is found most abundant at the season when the water is less saline (Reeve, 1970; Youngbluth, 1976). The abundance of Aoartia in the bay was found to peak during December-January and in August (Youngbluth, 1974; Rojas, 1978). The abundance and distribution of zooplankton such as A. tonea is influenced by variations in the large scale circulation of Guayanilla Bay, as well as by smaller scale phenomena, such as temperature and salinity changes at a given locality (Cohen, 1978; Youngbluth, 1976).

The studies in this area have centered around the copepod Aoartia tonea as it makes up from 60% to 100% of the zooplankton population in the bay (Fig.5). The average abundance in number of animals per m^3 of A. tonsa at the stations is shown in Table 1. This abundance in turn represents an inshore population of copepods largely dominated by A. tonsa (Figs 3 and 5). A. tonsa were 5 times as numerous per m^3 inshore as in the entrance to the bay. Inshore they ranged from 248 to 10,355/m^3. Decreasing in abundance towards the oceanic waters of the entrance to the bay, they ranged from 25 to 2000/m^3.

THERMAL TOLERANCE

Since the copepod, A. tonea, is the most abundant organism of the zooplankton population in the inshore areas of Guayanilla-Tallaboa and since it apparently lives near its upper temperature tolerance, it was chosen as an indicator species in a series of studies of thermal tolerance and in a comparison of the intake and thermal cove areas (Tables 1 and 2). Studies in temperate and sub-tropical areas suggest that tropical zooplankton lives close to its upper thermal range.

(Gonzalez, 1974; Reeve and Cosper, 1972). The temperature tolerance of E. tonsa has been studied using specimens from temperate, semi-tropical and tropical zones (Heinle, 1969; Gonzalez, 1974; Reeve and Cosper, 1972). This copepod is found living in a wide range of temperature (1 to 33°C) (Gonzalez, 1974). In the temperate zones, Heinle (1969) found the Upper Thermal Tolerance Limit (UTTL) for A. tonsa to be between 30° and 35°C when the copepods were acclimated to temperatures of 20° or 25°, and the UTTL between 25° and 30°C when the acclimation temperatures were 5° or 10°C. Both sets of experiments were conducted at a seawater salinity of 12°/oo. In independent studies at salinities found in the tropical and semi-tropical areas, Gonzalez (1974) and Reeve and Cosper (1972) found that A. tonsa tolerated up to 37°C for four hours in the laboratory. The range of temperatures tolerated by copepods in laboratory bioassays increases with an increase in acclimation temperature and with an increase in the salinity of the acclimating media (Bradley, 1975; Gonzalez, 1974). This, in part, could explain the differing upper temperature tolerance limits observed for A. tonsa and the distribution of this copepod worldwide. Although the upper temperature tolerance limit for A. tonsa was 37°C, this copepod was found apparently thriving in a semi-enclosed cove where heated water from an electrical power generating plant is pumped into Guayanilla Bay (Youngbluth, 1976). This interesting fact prompted us to conduct a series of thermal tolerance experiments in the laboratory and in the field using A. tonsa.

Experiments were carried out to observe the survival of Acartia species exposed to varying temperatures and duration periods.

Animals were collected from the thermal cove in Guayanilla Bay using a 202-micron mesh net at approximately two knots. The duration of the tow was from 30 seconds to one minute. The animals were brought into the laboratory immediately after collection. In the laboratory, they were

Netted out of the collecting jars, the animals were placed in filtered seawater in glass beakers. They were left overnight in the beakers. The following day, a few copepods were transferred into test tubes containing approximately 10ml of filtered seawater. Experiments were conducted approximately one hour after the copepods were put in the test tubes. One to four test tubes were used at each experimental temperature for the given time period. There were four incubation periods: 0, 10, 60, and 120 minutes. After the experimental time had elapsed, the test tubes were placed in a water bath at room temperature for three minutes. Neutral Red Dye was then added to each tube in order to assess survival (Dressel, 1972). Copepods were observed to note species and survival after at least 15 minutes had elapsed. Acantia seems to be able to survive when shocked to 40°C, but cannot tolerate more than 10 minutes of exposure at that temperature. It cannot survive when exposed to 43°C seawater. At temperature shocks of 40°C and over, the mortality rate increases, but a few copepods were able to withstand exposure to 42°C. This work suggests that there is considerable variability among individuals in their response to temperature and that when one is exposed to high temperatures, it tends to acclimate. This acclimation appears to increase its upper thermal tolerance; therefore, being able to withstand 18°C temperature changes (Rojas and Suarez, 1978). Experiments were carried out for two-hour periods in the intake zone of the thermal cove of Guayani. They were done on copepods collected at these places in order to measure the survival of Acantia sp. in the field. Copepods collected from the intake, placed in filtered intake waters, and incubated at the intake, showed survival of Acantia to be from 93 to 100%. Copepods collected from the thermal cove placed in filtered thermal cove water and incubated in the thermal cove, showed survival of Acartia to be from 98 to 100% (water temperature - 37°C). Copepods from the intake incubated in the

The thermal cove with a water temperature of 37°C demonstrated survival rates from Oto Ane. The Acartia species present in the thermal cove when the water temperature is 37°C have survived after passing through the power plant cooling system. The Acartia population present in the thermal cove is acclimated to high temperatures and, therefore, withstands contact with water up to 37°C. Those from the intake, however, were not able to acclimate to the temperature found in the thermal cove and therefore had a lower survival rate.

In the Guayanilla studies, the thermal cove and intake in the power plant area has been of interest because of the thermal discharge into an enclosed cove (fig. 6). The power plant draws from three shoreline intakes 140,000 liters of seawater per hour for its cooling water system. This water is discharged at the same rate into the thermal cove but at 10°C above ambient. The cove has a volume of 490,000 m3. It is, therefore, flushed every 4 hours.

Studies at power plants in temperate and sub-tropical areas report zooplankton mortalities between five and 100 percent. (Heinle, 1969: Gonzalez, 1973; Carpenter, Peck and Anderson, 1974; Davies and Jensen, 1974). In 1971, Shearls (1974) observed that 95 and 98 percent of the copepods were dead in 40°C discharge waters of the Guayanilla Bay power plant. On another occasion, the same authors saw that when the discharge waters were 31°C, virtually all the organisms were alive. Youngbluth (1974) measured mortality of zooplankton within the Guayanilla Bay discharge canal and found almost complete mortality at 36°C, but in the main body of water in the cove, they were found alive.

The modern world has an ever-increasing need for electrical power. Since there is a shortage of the available fresh water supply, seawater is used as a coolant in the production of this power. The plankton, being a part of this seawater, gets transported across this cooling system. As a consequence, it is trapped, heated, and exposed to strong conditions.

Turbulence disrupts the passage through this system. Due to the significant role of plankton as the resources of the sea, the impact of this disruption is of great consequence. Various authors have tried to tackle this problem. Carpenter (1974) found that about 70% of the copepods entering the cooling system of a nuclear power plant were not returned to the effluent pipe area. This, in part, corroborates the results obtained by Youngbluth. Power plant operations affect the zooplankton community within the thermal cove, providing conditions for the existence of A. tonsa. A. tonsa has been observed living at temperatures up to 37°C in the thermal cove in Guayanilla Bay, but when water temperature reached 38°C, the copepods were found dead. This upper lethal temperature for Acartia is often exceeded in the thermal cove. The mean number of Acartia per m^2 in the thermal cove is 496. Apparently, 40% of the Acartia are lost in the cooling water system of the power plant, resulting in a count of 786 in the passage through the cove.

Ichthyoplankton, a zooplankton component of major commercial importance, were identified only as eggs and larvae. None of the larvae were identified further. The abundance of the fish eggs sampled was greater than the fish larvae, which is due to the ability of the larvae to avoid the net used. Their density ranges from 1 to 194 per m^3 and they are most abundant in the central bay stations (4-8) and in the intake (12) (Figs 1 and 7). The fish egg densities peaked in the months of January, March and September. The fish larvae were most abundant also at the central bay stations (4,6,7, and 8) with densities ranging from 1 to 25 per m^3. The fish larvae densities peaked during the months of December-January and March-April.

The peaks of abundance for the fish eggs and larvae are inferred to coincide with the fish population studies conducted in Guayanilla Bay (Kimmel, 1976). The studies conducted revealed that the yellowfin mojarra ("eteo efnerue") spawned in the months of March and September.

The striped mojarra (Eugerres plumieri) had two spawning peaks which occurred in May through June and in September through December. The low densities of fish eggs and larvae could be due to the fact that Guayanilla Bay is not considered to be a significant spawning area except for those small fishes considered to be strict residents (Blenniids, Gobiids). The commercially important species which occur here use the bay as a nursery and as a feeding ground (Kimmel, 1976). Meroplankton are larvae of the major invertebrate groups which, in coastal zones such as Guayanilla, eventually make up the benthic fauna. Of the meroplankton, the dominant species was the cirripede nauplii (Youngbluth, 1974; Rojas and Suarez, 1978). The stations in the eastern cove have a density of barnacle larvae that separates them from all other stations (Fig. 8, Tukey Test). Their densities range from 20. The barnacle larvae densities peak in the months of April and September. Adult barnacles have been found in the bottom samples in the distribution and abundance of other meroplankton species was as their presence, though not high in densities, eventually contributes to the productivity of the bay. The meroplankton was found to be most abundant from January to March and from August to September. In Fig. 9, the patterns of dominance of the meroplankton in the bay are represented. The shrimp-like larvae which were most abundant at stations 6 and 7 in the central bay and 12 and 13 in the northeastern had densities ranging throughout the sampling period from 1 to 131 per m^3, being most abundant in the period from August to September. The brachyuran larvae which includes the zoea and megalops of many crabs were most abundant at stations 6 and 10 (Figs. 1 and 9). They ranged in abundance in the bay from 1 to 584 per m^3. Their density was greater in the months of January, March, and August, with a smaller peak in September. The gastropod veligers were most abundant at stations 1, 4, 5, and 13 (Figs. 1 and 9). Their abundance was higher in the...

"Months of January, March, April, and August, their density ranged from 1 to 279 per m3. The bivalve larvae density was always lower than 45 per m3. They were most abundant at stations 6, 7, 9, and 4. The highest abundance occurred from January to February. The echinoderm larvae density ranged from 1 to 68 per m3, being most abundant at station 11. The annelid larvae occurred in small numbers at all stations but were most abundant at stations 7 and 12. The ascidian larvae were most abundant at station 9.

SUMMARY

The composition, abundance, and distribution of zooplankton in Guayanilla Bay have been studied. This in turn will aid in the evaluation of the environmental contamination of the bay. The fluctuations of zooplankton density and diversity are related to seasonal rainfall patterns, circulation processes, and pollution loads (Yourgbluth, 1974). In the intake area, the high diversity indicates the entrance of oceanic waters into enclosed coastal areas (Goldman, 1979). The lower diversity and low densities at the thermal cove (station 18) and at station 3 indicate that a few species are affected by the pollution levels found in these areas. The higher diversity and high densities at the entrance to the bay indicate a mixing of coastal and oceanic populations. The low diversity and high densities in the western bay indicate an enrichment of the area by the Rio Yauco and by nutrients transported across the bay. The seasonality of the zooplankton, with higher abundances in the fall, winter and spring months, indicates a relation between the heavy rainfall months of the year, and for the spring months, a nutrient input from resuspended sediments due to strong winds.

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