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GUAYANILLA-TALLABOA BAYS

PLANKTON St

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GUAYANILLA-TALLABOA BAYS PLANKTON SURVEY

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[ABSTRACT

[A survey of the plankton population in Guayani!a-Tal laboa Bays was conducted in order to determine the composition, abundance and the dis~ tribution of the zooplankton in the bays. Sampling was conducted at 1h stetions for a period of one and one-half years. The zooplankton popula Is dominates by copepods and of these Aoantia tonea Is most abundant. doartia occurs in highest densities in the stations closer to land and In low nurbers in the stations farthest from shore. The thermal cove area zooplankton population Is characterized by 4. tonea and barnacle larvae. The centen! 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 4, toned and larvae of crustaceans and echinoderms.

nTRoDUCTION

A survey of the zooplankton In Guayani lla Bay was conducted in order to make an inventory of the zooplankton population. The inventory takes into consideration the composition, abundance and distribution of the zooplankton in the bays.

Sompling was conducted at 14 stations in Guayani}Ia-Tallaboa Says for

?2 one and one-half year period. Zooplankton were collected with a 1/2

eter diameter cone-shaped net with a mesh aperture of 202 microns. Surface Samples were obtained. The volune of the water filtered by the net was estimated with a flowmeter. In fig. 1 the stations sampled in the Guayani lla: Tal laboa Bays are shown.

COMPOSITION OF ZOOPLANKTON

This zooplankton population Is composed of three groups. These are led into the following:

(1) Hotoptankton

copepods pedusze

chaetognaths STphonophores

larvaceans ctenophores

pteropods salps and dolof lids

ostrocods cladocerans

brachiopods portezoans

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(2) Meroptankton

cirriped larvae ?echinoderm larvae

shrimp-Itke larvae annelid larvae

brachyuran larvae ascldian larvae

decapod larvae amphipods

gastropod veligers _ectoproct larvae

bivalve larvae pocel lanid larvae

stomatopod larvae

(3) AchthyopLankton

Fish eggs and larvae

OF these groups the copepods which are the dominant group, were satified to species. They are listed as follow

foartia tonsa hoartia apinata

hoartia Tilljeborgtt Undinula vulgarie

Calocatanus pavo Paracalanue auleatus

Panacalenue onaseivoatrt Pamcalane quaeimodo

Clausoslams furcatue Tenona atylifera

Tenora turbinata Peeudodiaptomus cokert

Calanopta anerioaa tabidooera of

Metis holothuaia Eutonpina aoutt frone

Ofthona nana

Oithona plrifera

Onoaea ep.

Conyoreue ep.

Farnamuta gracilie

Méorogetatta rosea

Eusalanus ep. Contropages? furcatue

Abundance

Zooptankton

lin fig. 2 the abundance of the total zooplankton population is

Fepresented. The zooplankton density averaged From 2,000 to 3,000 per H

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 43. The average Zooplankton abundance wos less than 1,500 plankters per 43 at four stations of those sampled, being lowest at the station between Punta Guayanilla and Cayo Palomas.

Copepods

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 densitles 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).

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As a general rule, the nunber of species of copepods in neritic waters such as bays and estuaries is much lover than in oceanic and of f-shore waters. In fig. 4 the distribution of the total nunber of copepod species found at each? station or area in Guayanitla Bay is. shown. The central bay can be characterized as having a species assenblage conposed

Of 20 to 25 different species. The central bay's zooplankton population Js Similar to that reported from open water sites off Puerto Rico.

The western bay, s nearshore estuarine area, has the least nunber of conepod species, 7-14. The intake area enclosed by land and being near Shore has conparable 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 2 high number of copepod species in an enclosed coastal area (Goldman, 1978).

Aoartia tonea

Abundance

A

srtia tonea, a copepod found in estuaries and coastal waters In the tropical and sub-tropical regions of the earth, dominates. the zooplankton population in Guayani tla Bay (Conover, 1956: Youngbluth, 1974, 1976). The distribution and abundance of 4, toned Is shown In fig. 5, making up from 30-1003 in the western bay, In the beach area and in the thermal cove area. The abundance decreases towards the oceanic waters, being at tines only Iz The abundance of sazrtia 1s in constant Flux from month to months This flux in abunéance appears to respond to the fast generation turnover oF the copepos as wel! as response to environmental changes such as seasonal wind and rainfall and food supply (Reeve, 1964,1970; Youngbluth, 1976).

Youncbtuth (1974) looked for a relationship between Guayani lla Bay Zooplankton abundance and parameters such as salinity, temperature, and season; he found little relationshio. This lack of seasonal perfodielty 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, 19615,

Herman ond Seers, 1969; Deevey, 1971) and for Biscayne Bay, Florida (Woosransee, 1958; Reeve, 1964}. This infers 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 of tropical situations must be ade 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 {5 less saline (Reeve, 1970; Youngbluth, 1976). The abundance of Aoartia in the bay was found to peak during Decenber= January and in August (Youngbluth, 1974; Rojas, 1978) .

The abundance and distribution of zooplankton such as A. tonea is Influences by variations in the large scale circulation of Guayanilla Bay, 25 well 95 by smaller scale phenonena, such as temperature and salinity changes at a given locality (Cohen, 1378; Youngbluth, 1976)

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?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 nunber of animals per m> of A. tonsa at Th stations is shonin Table 1, This abundance in turn represents an inshore population of copepods largely dominated by A. tonca (Figs 3 and 5). A. tonsa were 5 tines as numerous per m3 inghore as in the entrance to the bay, Inshore they ranged Fron 248*10,355/ns. Decreasing In abundance towards the oceanic waters of the entrance to the bay, they ranged from

25° to 2000/m8,

THERMAL TOLERANCE

Since the cosepod, A. tonea, Ts the most abundant organism of the Zooplankton population in? the inshore areas of Guayani!a-Tal laboa ?and since it apparently lives near its upoer temperature tolerance, it was ?chosen as 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 terperate and sub-tropical areas suggest that tropical Zooplankton lives close to its upper thermal range (GonzSlez, 1974; Reeve ?and Cosper, 1972).

?The temperate tolerance of £. tonsa has been studied using specimens of temperate, seni-trosica) and tropical zones (Heinle, 1969; Gonzélez, 197%; Reeve and Cosper, 1972). This copepod is found living in a wide range of temperature (=1 to 33°C) (Gonzélez, 1974)

In the temperate zones Heinle (1969) found the upper thermal tolerance limit (UTTL) for A. tonaa 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 §° or 10°C. Both sets of experiments Were conducted at a seawater salinity of 12°/ze. In Independent studies

at salinities found in the tropical and semi=tropical areas, Gonzélez (1974) ?and Reeve and Cosper (1972) found that A. tonea tolerated up to 37°C for Four hours in the laboratory.

The range of temperatures tolerated by copepods in laboratory bio~

assays Increases with increase in acclination temperature and with increase in salinity of the acclimating media (Bradley, 19/5; GonzSlez, 1974). This in part could explain the differing upper tenperature tolerance linits observed for A. tonaa and the distribution of this copepod world-wide.

Although the upper temperature tolerance limit for A. tonoa was 37°C, this copepod was found apparently thriving in a seni-enclosed cove where heated water fron an electrical power generating plant is punped into Guayani tia Bay (Youngbluth, 1976). This interesting fact prompted us to conduct a series of thermal tolerance experiments in the laboratory and Tn the fielé using 4. tonea.

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

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Animals were collected from the thermal cove in Guayani Ita Bay using

2 202 micron mesh net at approximately two knots. The duration of the

tow was from 30 seconds to one minute. The aninals were brought into the laboratory immediately after collection. In the laboratory they were netted out of the collecting jars and placed in filtered seawater in glass beakers. The animals wore left overnight in the beakers. The following day, a feu conenods were transferred Into test tubes containing approximately Ion! of Filtered seawater. Experiments were conducted approximately one hour after the copenods were out 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 experi= mental Cine had elapsed, the test tubes were placed In a water bath at

room tenperature for three minutes. Neutral Red Dye was then added to

?each tube 'n order to assess survival (Oressel, 1972), Copepods were ob- served to note species and survival after at least 15 minutes had elapsed, Acantia seems to be able to survive uhen shocked to WI°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 with= stand exaosu-es to 4272, This work suggests that considerable variability arora individuals in their rassonse to temperature and that when @ 1s exposed to hioh temperatures it tends to acclimate. This ac climat?on angears to Increase its upper theenal tolerance; therefore, Deing ab'e to withstand 18"C temperature changes (Rojas and Suarez, 1978).

of>4 experiments were carried out for two hour periods in the intake jane the therma! cove of Guayani ila Say on copepods collected at these places in order to measure the survival of Jincnsin sp. In the field. Coperods collected Fron 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 Aoartza to be from 98

Yo 1002 (water temperature - 37°C). Copepods from the intake incubated in the thermal cove with water temperature of 37°C had survival rates from

Oto Ane.

The Acartia sps. present in the thermal cove when the water tenperature

is 37°C have survived passing through the power plant cooling system.

?The Acartia population present In the thermal cove is acclimated to

high tenperatures and therefore withstands contact with water up to 37%

Those from the intake, however, were not able to acclimate to the tenperature

found in the thermal Cove and therefore had a lower survival rate.

?Thermal Cove and Intake

In the Guayani!la studies 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

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has a volune of 490,000 m3. It Is, therefore, flushed every + 4 hours

Sy hyo entering through i (fia. 65.

Studies at power plants in temperate and sub-tropical areas report zooplankton mortalities between Five and 100 percent. (Heinle, 1969: Gonzdlez, 1973; Carpenter, Peck and Anderson, 1974; Davies and Jensen, 1974). jn 1971 Shear!s (i974) observed that 95 and 98 percent of the cope-pods 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 ail the organisns were alive. Youngbluth. (1974) Ineasured mortality of zooplankton within the Guayanilla Bay éiacharge canal and found almost conplete 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 95 2 coolant in the production of this power. The plankton ~-~ being 2 part of ths seawater == gets transported acrass this cool ing system. Asa consequence, it fs trapped, heated, and exposed to strong turbulence 'p the passage through this system. Because of the important role of the plankton ?= Se resourees of the sea, the effect of this Impingement 13

Of great consecuence. Various authors have attacked this aroblem.

Carsenter (1974) found that adovt 70% of the copepods entering a

ng systen of a nuc'ear power p'art were not returned to the effluent

vine area, This, in sart, corroborates the results obtained by Youngbluth

) roar the power plane operat ions *'np!ify the zooplankton community

sof the thermal cove, providing then for the existence

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 dead. This upper lethal temperature for Asartia Is often

exceeded in the thermal cove.

The mean number of Acartia per m? in the int:

thermal cove is 496. Apparent ly 40% of the dourt:

passage through the coo

ce Is 786 and in the

tonsa are lost In the

ig water system of the power plant.

Ichthyop tankton

The ichthyoplankton, the zooplankton component of major commercial importance, were identified as to eggs and larvae only. None of the larvae were keyed out. The abundance of the Fish eggs sampled was greater than the fish larvae, this being due to the ability of the larvae to avotd

the net used, Their density ranges from 1 to 194 per m3 and they are most abundant in the central bay stations (4-8) and in the intake (12) (Figs 1 and 7). The fish eggs! densities peaked in the months of January, March ?and September, The Fish larvae were found most abundant also at the central bay stations (4,6,7, and 8) with densities ranging fron 1 to 25 per m3. The fish larval densities peaked during the months of Decenber-January and March-April

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The peaks of abundance for the Fish eggs and Tarvae are inferred to coincide with the Fish populations studies conducted in Guayani la

Bay (Kinmel, 1976). The studies conducted revealed that the yellowfin aojarra (?eteo efnerue) spawned in the moaths of March and Septenber.

The striped mojarra (Mapterue plurter!) had two spawning peaks which occurred in May through June and in Septenber through Decenber. The low densities of Fish eggs and larvae could be due to the Fact that Guayani lla Bay is rot considered to be 3 significant spaning area except for those smal] fishes considered to be strict residents (Blennids, gobiids). The commercial ly important species which occur here use the bay as a nursery for as 2 Feeding ground (kimmel, 1976)

Merop lanicton

The rerop'ankton are larvae of the major invertebrate groups which, in coasta? zones such a5 Guayani lia, eventually make up the benthic fauna. OF the meroslankton the doninant species was the cirripede nauplii (Youngbtuth, 1974; Rojas and Suarez, 1378). The stations in the eastern

cove have 2 density of barnacle larvae tha: separates them fram all other stat vaniV"a [fig, 8, Tukey Test). Thetr densities range from

2t0 The barnacie larvae dens'ties peak in the months of Apri]

ane Sea) Adeit Sarnac?es Save been found in the botcon samples in the

disteaurTon ane abundance of other meroplankton species was

2s their sresance, thous not h'gh in densities, eventual ly

Touter to the sroduetivity of the bay. The meroplankton was found

to be most abundans ?rom January to varen and fron August to Septenber.

tn Tig, 9 the patterns of dominance of the meroplankton in the bay

are represented. The shrimps like larvae which were most abundant at

stations 6 and 7 in the central bay and 12 and 13 in the northeastern

hhad densities ranging throughout the sampling period from! to 131 per

being most abundant in the period From August to Septenber.

The brachyuran larvae which includes the 2o¢a ond megalops of many

crabs were most abundant at stations 6 and 10 (figs. 1 and 9). They ranged in abundance in the bay from} to 584 perm}. Their density was greater in the months of January, March and August, with 9 smaller peak in Septenber.

The gastropod eligers were most abundant at stations 1, 4, 5 and 13 (Figs. 1 and 9)." Thetr abundance was higher in the months Of January y March, April and In August. Their density ranged from 1 to 279 per m3.

The bivalve larvae density was always lower than 45 per m3. The stations where they were most abundant were stations 6, 7, 9 and 4. The highest abundance occurred from January to February.

The echinoderm larvae density ranged from 1 to 68 per #3 being most abundant at station 11,

The annelid larvae occurred in sma) numbers at all statfons but were most abundant at stations 7 and 12. The ascidian larvae were most abundant at station 9

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SUMMARY

The composition, abundance, and distribution of zooplankton ia Guayanil'a Bay have been studied. This in turn will eld in the evaluation Of the environnenta) contamination of the bay.

The Fluctuations of zooolankton density and diversity are related to seasonal rainfall patterns, circulation processes and pollution loads (Yourgbluth, 1974)

Im the Intake area the high diversity indicates the entrance of oceanic waters into enclosed coastal areas (Goldnan, 1979). The lower diversity

and tow densities at the thermal cove (station 18) and at station 3 indicate that a few soecies are affected by the pollution levels Found in these areas.

The higher diversity ond high densities in the entrance to the bay indicate 2 mixing of coastal and oceanic populations. The low diversity land high densizies In the western bay indicate an enrichment of the area by the Ho Yauco and by nutrients transnortee aeross the Say

The seasona'ty of the zooplankton, with higher abundances in the Fall, winter anc sortng months, Indicates 2 revacion between the heavy rainfall hnonths of the ?yi! ane winter, and For the spring mantis s nutrient. input From resucended secinents cue to strong winds.

LITERATURE CITED

Bradley, 8.P. 1975. Adaptation of copepod populations to thermal stress. Tech. Rep. No. 3H Water Resources Research Center, U. of Md. 16 p.

Carpenter, £.J., 8.8. Peck and S.J. Anderson. 1974. Survival of copepods passing through a nuclear power station on Northeastern Long sland

Sound. Marine Biology 24: 9-55.

Cohen, ?.8. 1976. An overview of the plankton communities of the Gulf
Of Maine. International Conmission for the Northwest Atlantic Fisheries,
Selected Papers No. 1.

Conover, &. 1956. Oceanography of Long Island Sound 1952-1954. VI. Biology
of 'dointia Glayet and Aaartta toned. Bulletin of the Bingham
Oceanographic Collection, 15: 156-233.

Davies, RM. and L.0. Jensen. 1974. Effects of entrainment of zooplankton
at three Mid-Atlantic power plants. Electric Power Research Institute,
Rept. No. 10 (ERP! Publ. No. 7é-0U9-00-1). 76 p.

Deevey, 6.8. 1971. The annual cycle in quantity and composition of the
Zooplankton of the Sargasso Sea off Bermuda. I. The Upper 500m.
Limology and Oceanography 16:219-240.

---Page Break---

Dressel, D.M., S.R, Heinle and M.C. Grote, 1972. Vital stai

?dead and? Vive copepods. Chesapeake Science. 13:156-159.

ng to sort

Goldman, 6.C. 1879. A case of Frequent uowelling in a nearby enclosed

tropical sub-bay. Submitted For publication to Estuarine and

Coastal Marine Science.

Gonzaiez, J.6. 197K. Critical thermal maxima ond upper

for the calanoid copepods Zearcia tonea and &. elauat

27:219-223,

hal temperature

Marine Biology.

Heinte, 0.

16 (

169. Temperature and zooplankton. Chesapeake Science.

186-209.

Herman, $.3. and J.R. Seers. 1969. The ecology of inshore populations in

Bermuda. Part 11. Seasonal abundance and conpos ition of zooplankton.

Bulletin of Marine Science. 19:493-503,

kinmel, J. 1977. CER Fish Studi

Unpublished report.

sin Guayani 19 Bay 1976-1977,

Menzel, 0.1%, and JM, Ryther. 1961. Zooplankton in the Sargasso Sea off

Seeruca ard ite" relation to organic production. J. Cons. Perm. Int.

Mer. 26:250-258

- Studies on the seasona? variation of the zooplankton

sub-tropical inshore environment, Bulletin of Marine

Science.

1970. Seasonal changes in the zooplankton of South Biscayne

Tay a7 sone problems of assessing the effects on the zooplankton

of natural and artificial thermal and other Fluctuations. Bulletin

of Marine Science. Vol. 20, No. lh. pp. 894-921.

Reeve, M.R. and E. Cosper. 1972. Acute effects of heated effluents on

the copepod Jicartia tonea From a sub-tropical bay and some problems

Of assessment. In: Marine Pollution and Sea Life, pp. 250-252.

(Ruivo, M.(ed.), Fishing News (Books) Led. London?

Rojas, H.M. and J.A. SuSrez-Caabro. 1978, Guayanilla-Tal laboa Bays Zooplankton Survey, Unpbl. report.

Sander, R, and 0.6. Steven. 1973. Organic productivity of inshore and offshore waters of Barbados: A study of the island mass effect. Bulletin of Marine Science. 23:771-792.

Shearls, E.A. and J.A, SuSrez-Caabro. 1974. Zooplankton 1971-1972. Jn! Guayani Ita Bay Envi ronmental Report 1971-1974, PRNC Rept. No. 179.

wteliffe, WH. Jr. 1960. On the diversity of the copepod population in the Sargasso Sea off Bermuda. Ecology &1:585-587.

---Page Break---

Woodnansee, 8.8. 1958. The seasonal distribution of the zooplankton off

Chicken Key in Biscayne Bay, Florida, Ecology, 39 (2):247-262

Youngbtuth, ¥.

Report

1974, Zooptankton=1971-1974, Guayanilla Bay Environmental

Bic179, Puerto Rico Nuclear Center.

1976. Zooolankton populations in a polluted tropical

Estuarine ang Coasts! Marine Science. :kB1-496,

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2, . oe 7

---Page Break---

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