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CULTURE OF ESTUARINE BENTHIC AND NECTONIC FIRST TROPHIC LEVEL FEEDERS

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SYNOPSIS

The paper deals with some base trophic factors in relation to two herbivores, namely oysters and mullets, which derive their energy directly from the first trophic level of an estuarine ecosystem. The analysis of the gut contents of both organisms has shown that they feed mostly on micro-organisms, especially planktonic and benthic diatoms, and a significant percentage of detritus materials, including inorganic particles, is always present. Their dietary components are very much related to seasonal abundance of food production of the estuary. Current yields of oysters and mullets are far too low and food source is not a limiting factor for their production on large scale. Tidal flows, particularly in relation to salinity, have profound effect on culture grounds. Mortality is largely due to predation.

Introduction

In a series of detailed study of Paraiba river estuary, the ecology, energy flow, composition and distribution of plankton, potential resources and other related factors were investigated during the years 1976 – 1978. Much of the information presented here relates to two economically most important groups such as the benthic filter-feeding shellfish, especially oysters, and the highly sucessful nectonic fishes, particularly of Mugilidae. These organisms largely derive their energy from the primary producers and, partly for this reason, that they can be successfully cultured in the tropical estuarine conditions where the food chain is constantly replinished.

The paper attempts to relate some of the trophic factors and the relatively simple methods of culturing these living resources on a commercial level.

Materials and methods

Much of the detailed account on the simple and rather inexpensive culture sites has recently been reported (Singarajah, 1978). Since the basic designs of culture ponds and methods employed here are essentially same, these will not be described, but is should be emphasised that the first trophic level feeders utilize the natural ecosystem of the estuary where the imput of energy is well absorbed by the primary producers.

The physico-chemical parameters were determined fortnightly. Plankton samples, together with fish sample, were collected monthly. The gut contents of both fishes and oysters were examined regularly in fresh conditions as well as in preserved specimens. Most of the planktonic species were identified, as far as possible, up to species under a stereoscopic microscope, but the florescence microscope greately facilitated the identification of life specimens. Much of the data on length-weight relationship were obtained during harvesting, which takes place usually once in two years, when abundant fishes are available for statistical treatment. The species of fishes that are of commercial potential and commonly grown in culture ponds are listed in Table I. A part of the gut contents was used for determination of dry weight and organic detritus materials, while the rest, after suitable dilution, was used for estimation of percentage composition.

Results

TIDAL EFFECTS – A general description of the hydrographic conditions of the estuary is given by Singarajah (in press). Because of the close proximity of Paraiba river estuary to the Atlantic Ocean, the culture sites are very much influenced by the tidal flow, particularly in relation to salinity, temperature, pH, concentrations of nutrients and dissolved oxygen and other factors. Salinities much above 24.6 ‰ were rarely if ever present and salinity stratification was never detected on culture sites. On the other hand, in the main segment of the estuary proximal to the river mouth which forms the Cabedelo Port, where the depth varies from 6 – 10 m. there is a very distinct salinity stratification. A salinity difference of 2 – 10 ‰ between the surface and bottom layers was measurable. Surface, mid and bottom water samples taken about 1.5 km outside the port at 10 m depth have clearly demonstrated absence of any salinity stratification. It is, therefore, concluded that this vertical salinity stratification commences at or just outside the river mouth and continues beyond the "Resting Island" and then gradually thins out and eventually dissapears landward in waters less than 2 – 3 m deep.

Similarly a horizontal salinity gradient is also evident (Singarajah, in press), with a high salinity of 35 ‰ in the sea which rapidly falls landward reaching at times 2.5 ‰ or less, depending much on the weather conditions.

Temperature is though constant increases only slightly landward while pH increases seaward. Nutrients are always abundant because of the river effluents, and concentration of oxygen increases seaward, despite much plankton productivity in the estuary.

ESTIMATES OF CURRENT PRODUCTION – Currently, despite utilizing the natural ecosystem of the estuary, only oysters and Mugilidae fishes are popularly cultured. Rough estimates have indicated that the current yield of oysters is far too low, amounting to 5 – 8 tons per Ha per a period of two years, in terms of meat weight, and the maximum yield of fishes is slightly in excess of 2000 Kg per Ha for a similar period. The culture ponds are provided with a variety of materials, including wooden poles, which,

FEEDING BEHAVIOUR – The oysters are sedentary filter feeders which remain on the muddy bottom permanently attached to substrates. Laboratory experiments have demonstrated that during feeding the upper or right valve opens only partially, the maximum gap being 4 – 6 mm between the valves along the broadest ventral margin. The ciliary current, to which the gills contribute quite substantially, draws the water, together with a variety of micro-organisms and suspended materials. The gills filter the water and collect the food particles. These are often entangled in small mucus lumps and passed on between the labial pulps by a complex system of ciliary current and then conveyed to the mouth cavity. When the oysters feed they filter the water continuously for several hours at a time.

In contrast, the mullets are powerful swimmers, with their upper lip forming a well define snout. The mouth is terminal and transverse with a shallow cleft and is slightly protrudable and the anterior margin of the mandible is fairly sharp. Perhaps, these are some of their special adaptations to suit the first trophic level feeding. When feeding, they slightly extend their mouth and suck thick concentrations of algal materials from the surface or muddy bottom or they often dart at the surfaces of any submerged leaves or other similar objects.

ANALYSIS OF GUT CONTENTS – The results of gut analysis and the specimens identified in both oysters and mullets are shown in Table III. The percentage composition of food items found in their alimentary tracts is categorised in Figs 2 – 3. In both cases, a greater proportion of the diet included a variety of planktonic and benthic diatoms, some dinoflagellates, and organic detritus. In mullets, particularly, relatively high percentage of the gut contents included solid inorganic particles and quartz. A limited variety of other micro-organisms seen in the alimentary tract of the oyster consisted, especially, flagellates, ciliates, tintinnids, rotifers, and nauplii larvae of cirripede and copepods. In general, the gut contents of the adult mullets consisted relatively little or no zooplanktonic organism, except rotifers and copepodites. The only exceptions were the mullet larvae and juvenile forms whose stomach contents frequently consisted freshly ingested intact and undigested or fragmented and partially digested crustacean larvae, mysids and other smaller fish larvae.

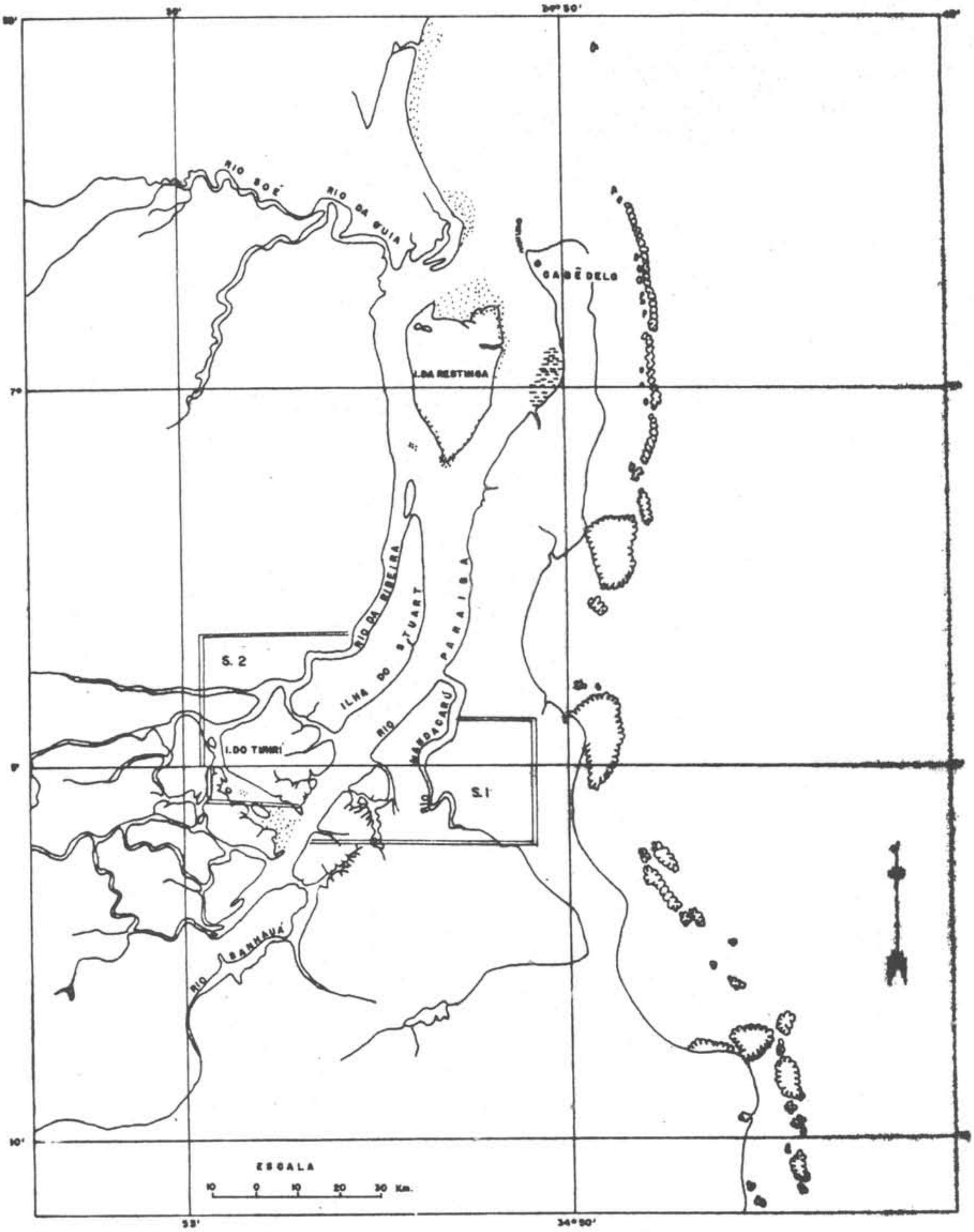

Fig. 1. Estuário do Rio Paraíba do Norte

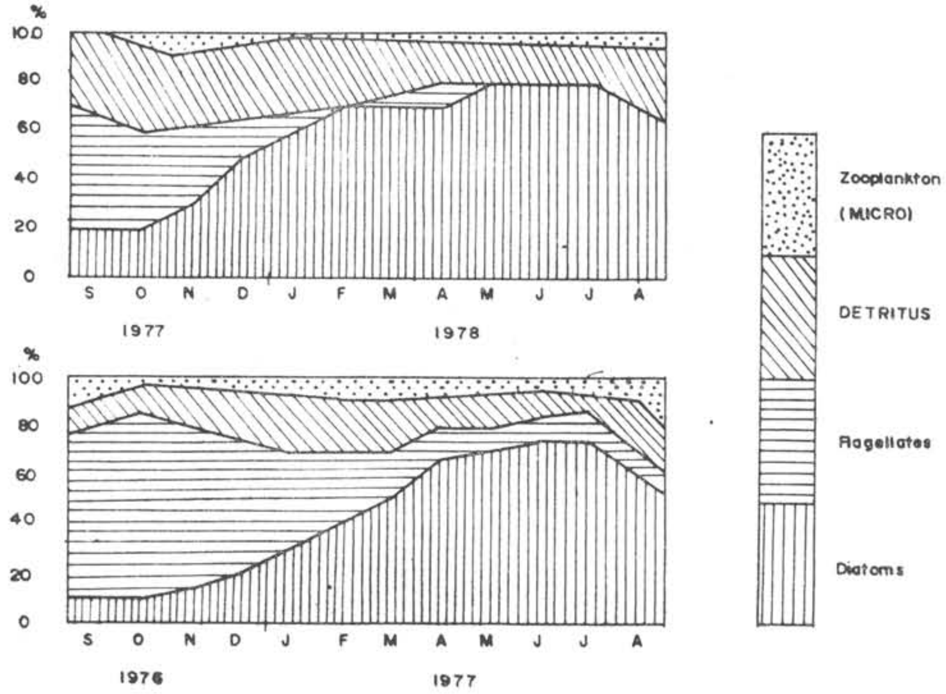

Fig. 2. Food composition in oyster alimentary tract

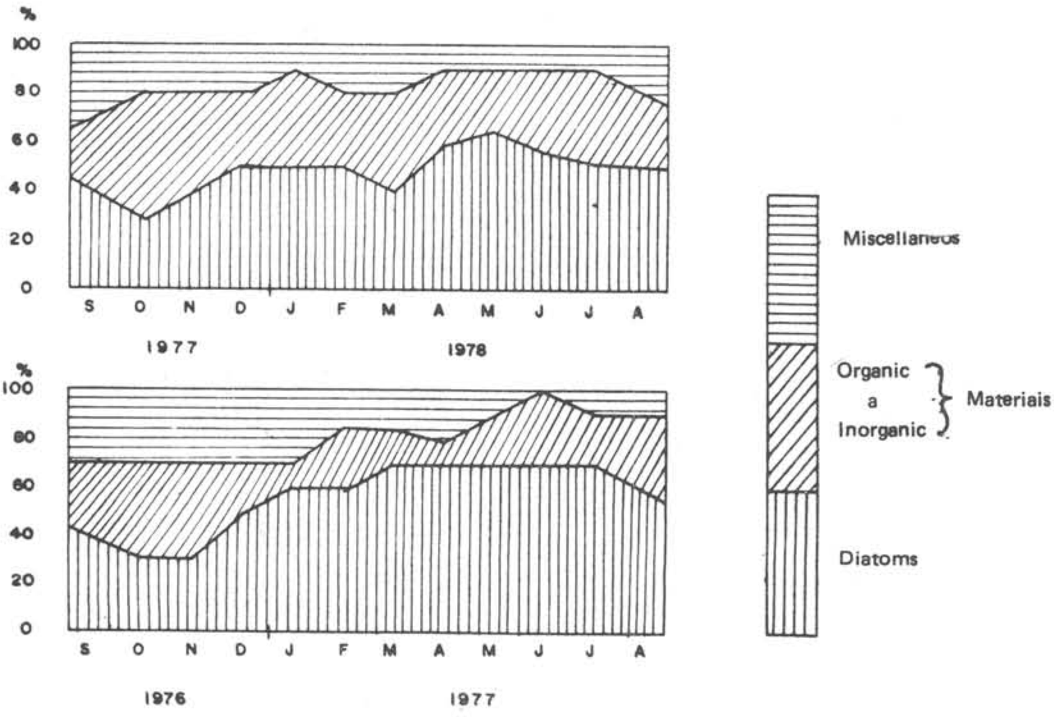

Fig. 3. Mullet gut contents

besides providing substrates for the settlement of oyster spat, increased the surface areas for the growth of benthic diatoms, an important source of food for the mullets. Odum (1970) suggested that maximum yields of mullets could be obtained by creating artificial grass beds and by increasing the bottom of the culture ponds with inorganic and plant detritus.

Comparatively, oyster production was greater at culture site 1 than at 2, and the reverse was true for the Mugilidae fishes though both sites had similar designs of water circulation and culture techniques. Physico-chemical parameters (see Table II) over the past two years though differed to some extent at the two sites of the same estuary, these are less likely to reflect the difference in the rate of production. The exact relationship between abundance and relative paucity of these species at the two sites is difficult to interpret and more data would be useful to test the apparent correlation.

MORTALITY AND FOULING PROBLEMS – In both culture sites mortality factors were inherent in the culture system and equally affect both oysters and mullets. The mortality rate has largely been due to predation, though prolonged rain might cause some damage, particularly to oysters. Fouling organisms compete with oyster spat for both food and space.

Discussion

The estuarine ecosystem is a dynamic and complex abiotic system in which the living organisms constantly interact. One of the advantages of utilizing such natural ecosystem for culturing the benthic oysters and the nectonic mullets is that the food web and energy flow are constantly renewed (Fig. 4) and food circulation is not a limiting factor. The results of the gut contents analysis have shown that both oysters and the adult mullets are somewhat selective in their feeding. The gut contents indicate fairly accurately the actual food intake by these trophic level feeders, and the significant difference displays their diet preference. In specimens taken from the two culture sites, the predominant food items were found to be diatoms, 10 – 80% in oysters and 15 – 65% in mullets. There was always a significant percent, 10 – 45% of detritus, particularly in mullets. Most of the diatoms found in oysters were alive and these results confirm the observations made by Blegvad (1914) and Loosanoff & Engle (1947) who were able to culture diatoms which they recovered from the faeces of the oysters. By contrast, the larval and juvenile stages of mullets are less selective and their food items consisted a mixture of diatoms and zooplanktonic organisms. Diatoms are known to conserve oils as reserve food which have a high caloric value (Odum, 1970). Furthermore, the dietary components were much related to seasonal abundance of plankton of the estuary (Singarajah, in press).

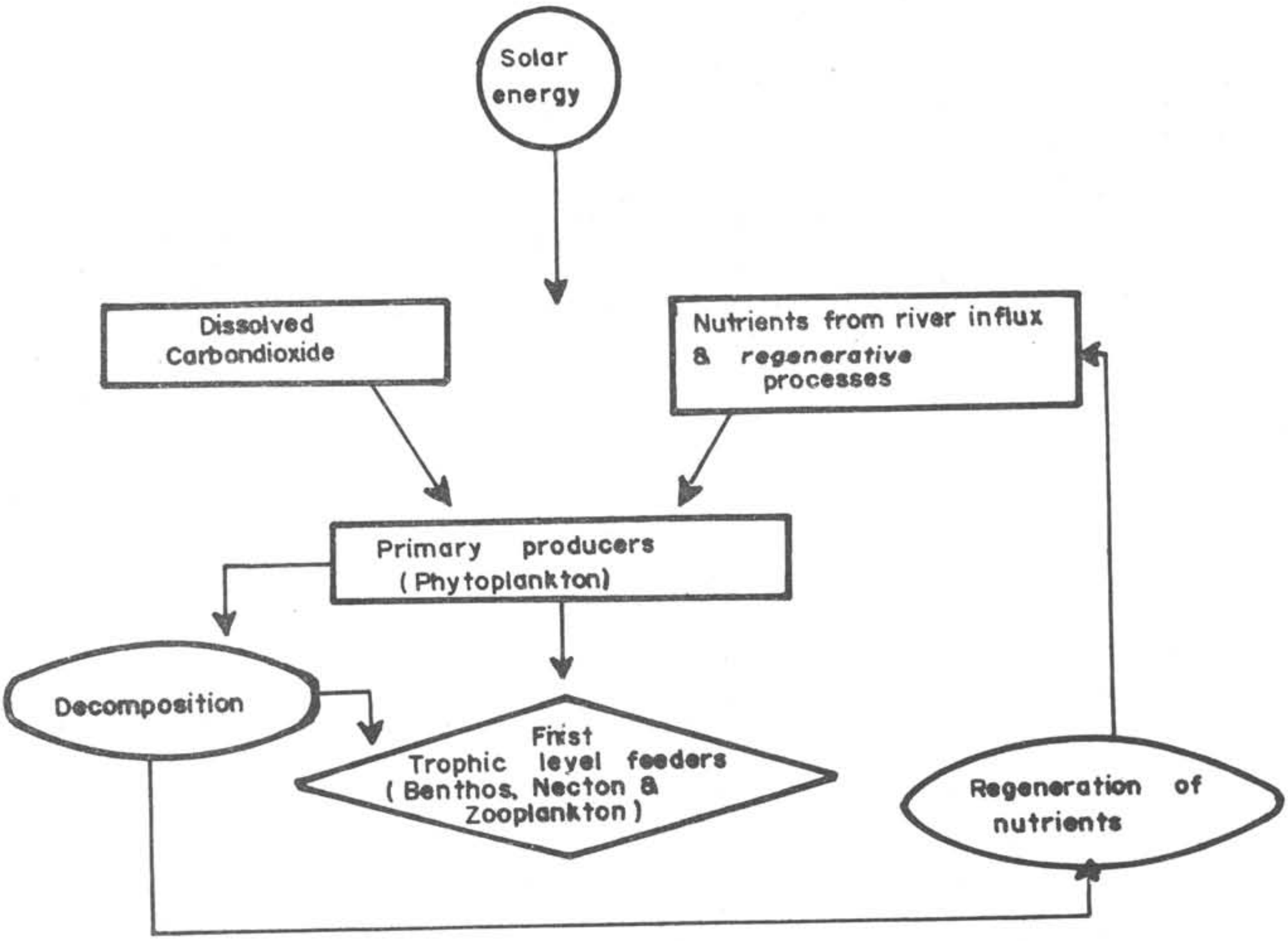

Fig. 4. Schematic representation of the energy flow of a river estuary ecosystem.

Under unusual circumstances of spawning, the mullets in particular, showed tendency to starve and the guts were found to be almost empty. Mullets are also migratory and they often escape from the culture ponds during winter. During their migratory behaviour, the mullets are able to tolerate a greater salinity range than the oysters. The latter have been observed to tolerate salinity variations from 2.5 ‰ to 24.6 ‰ in their natural environment. On the other hand, the mullets are hardy and euryhaline and they were seen in shoals at regions where the sea water mixes with estuarine waters and the salinity often exceeds 34‰. Distribution of mullets have been reported in waters with salinity range from 0 to 137 ‰ (Zenkevich, 1963; McFarland, 1965).

TABLE I. The highly steemend and commonly found fishes in culture ponds.

Fish Species	Invertebrate Species
Mugil cephalus	*Penaeus brasiliensis*
Mugil brasiliensis	*Penaeus aztecus*
Mugil doubula	*Penaeus duorarum*
Diapterus rhombeus	*Crangon sp*
Sphyraena sp	*Carcinus paguras*
Centropomus undecimalis	*Carcinus moenas*
Cynoscion striatus	*Callinectes sapidus*
Anguilla bostoniensis	*Crassostrea paraibanensis*
Elops saurus	*Crassostrea (brasiliana) rhizophorae*

TABLE II. Abiotic and biotic parameters of the culture sites.

	Site 1 (Range)	Site 2 (Range)
Salinity (‰)	5.80 – 24.60	2.50 – 22.40
Temperature (°C)	25.00 – 29.80	25.20 – 30.00
Transparency (m)	00.32 – 00.70	00.31 – 00.30
pH	6.40 – 7.80	6.20 – 7.00
Oxygen (ml/L)	3.21 – 6.25	3.12 – 5.08
Detritus materials (ml/L)	20.00 – 118.20	25.20 – 109.28
Organic (%)	49.05 – 7.69	36.11 – 8.32
Inorganic (%)	50.05 – 92.31	63.89 – 91.68
Plankton count No / L	680,00 – 7.000,000	480,000 – 5,000,000

TABLE III. Analysis of gut contents and food items identified.

	Oyster	Mullet
Flagellates		
Diatomacea	+	+
Coscinodiscus centralis	+	+
Coscinodiscus sp	+	+
Chaetoceros affinis	+	+
Campylodiscus sp	+	+
Ditylum brightwellii	+	+
Gyrosigma sp	+	+
Licomophora juergensii	–	+
Navicula litoricola	+	+
Nitzchia bilobata	+	+
Streptotheca tamesis	+	+
Synedra sp	+	+
Talassiosira subtilis	+	+
Dinoflagellata		
Peridinium depressum	+	+
Oscillatoria erythraea	–	+
Zooplankton		
Ciliates	+	–
Tintinnids	+	–
Rotifers	+	+
Nauplii of cirripede	+	+ (in larvae)
Copepodites	+	+ "
Detritus Materials	+	+

+ = present
– = absent

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