An- Najah National University
Faculty-Of Graduate Studies

Short - term Variations in the Abundance of Zooplankton near Coral Reef and Open Water in the Northern Part of Gulf of Aqaba in the Red Sea.

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This Thesis was defended successfully on 13.01.2001

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DEDICATION

To My Parents, My Wife, My Kids, My Brothers And Sisters

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Special thanks to the Palestinian Consultancy Group (PCG) for their funding of my study. I would like to express my deep thanks and gratitude to my acadamic supervisers: Prof. Z. Abdeen, Prof. A. Abu Zuhri and Prof. A. Genin for their kind and unlimited professional support, encouragment and guidance. I am grateful to the Interuniversity Institute (IUI) in Eilat for their support in the field and in their laboratories.

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Glossary

Abyssal zone The benthic zone between a bout 2000 m and 6000 m depth

Abyssopelagic zone The water column between 4000 m and 6000 m depth

Aphotic zone That part of the ocean in which sunlight is absent

Bathyal zone The benthic zone between 200 m and about 2000 m depth

Bathypelagic zone The water column between 1000 m and 4000 m depth

Benthic Pertaining to the seafloor environment

Benthos Plants or animals that inhabit the benthic environment

Bioluminescence The production of light by living organisms

Biomass The number of individual organisms(in some area or volume or region) multiplied by the average weight of the individuals

Continental shelf The zone bordering a continent extending from the line of permanent immersion to the depth (usually 200m) at which there is a marked increase the slope

Continental slope The relatively steep downward slope from the outer edge of the continental shelf to the flat ocean floor.

Copepods A group of small planktonic, benthic or parasitic crustaceans; holoplanktonic species are usually the numerically dominant group of zooplankton captured by nets marine areas

Coral Animal belonging to the phylum cnidaria, class Anthozoa that forms a calcareous exoskeleton

Demersal Pelagic species that live near the seafloor

Detritus organic debris

Diel Referring to events that occure with a 24- hour periodicity

Diurnal Referring to events that occur during time

Downwelling The sinking of water

Grazing The consumption of plants by herbivores

Holoplankton Planktonic organisms that spend their entire lives in the water column; permanent residents of the plankton community

Meroplankton Plankton that spend only part of their life cyde in the water column, usually the eggs and larvae of benthic or nektonic adults

Mesopelagic zone The water column from the bottom of the epopelagic zone (200-300 m) to about 1000 m depth

Nekton Pelagic animals capable of swimming against the current, adult squid, fish and marine mammals

Neritic Referring to inshore waters shallower than 2oom in depth that overlie continental shelves

Oceanic Referring to offshore waters in areas deeper than 2oo m

Patchiness Nonrandom distribtion of organisms referring to the ocean water column and the organisms living therein

Phytoplankton Microscopic planktonic plants

Plankton Plants or animals that live in the water column and are incapable of swimming against current

Predation The act of an animal feeding upon another animal

Turbulence Physical mixing of water

Upwelling A rising of nutrient – rich water toward the sea surface

Primary production The amount of organic material synthesized from inorganic substances per unit volume of water or unit area

Zooplankton Plaktonic aniamls

Zooxanthellae Symbiotic unicellular dinoflagellates found in corals, sea anemones, mollusks and several other types of marine animals

ABSTRACT

The processes taking place when open-oceanic waters bearing pelagic organisms encounter shallow coastal habitats are virtually unknown. Such processes could potentially be a principal trophic path for benthic (coral-reef) and epibenthic (fish) communities, particularly in oligotrophic regions. This proposed to investigate the processes involved in the coupling between the open ocean and coastal habitats in the Gulf of Aqaba. Specifically, we propose to test hypotheses relating high-freguency (minutes, hours, days) fluctuations in zooplankton abundance, ocean currents, animal behavior, and trophic interactions on an ecosystem level.

Zooplankton abundance and grazing in short term variation (minutes to weeks) were measured along the Gulf of Aqaba reef and at a near-by, open water site during October 10 and December 2.1999. Role of currents, behavior and localized predation of zooplankton in the generation of the observed variations were also studied.

In our experiments zooplankton samples were obtained by filtering the pumped water through 100 m mesh net from the reef and open water sites to compare the temporal variations in the abundance of zooplankton and behavior at the tow above sites. Also two current meters equipped with a temperature sensor were deployed at the reef and away sites to record the average speed, direction and temperature of the current.

Our results clearly show that: Zooplankton were less abundant at the reef, compared with the away site because of the zooplankton predation at the reef from the corals and fish. A general increase in zooplankton abundance at the two study sites in the diurnal (during day time)and nocturnal (during night time)samples, from the start of our sampling to its ends coincided with the ennsuing fall mixing and seasonal eutrophication in the northern Gulf of Aqaba. A covariation of zooplankton abundance between the two sites on the scales of both the entire period and on hourly samples within a days. A bundance of zooplankton in a diel cycle was seen at the two sites, with nearly a doubling of zooplankton biomass during night. No correlation was found between the abundance of zooplankton and the component of the currents because of the behavior primarily active swimming of zooplankton in the vertical water column.

This study supports earlier reports on the important of zooplankton advection to the nutrition of coral reefs. Grazing at the reef together with physical advection seems to affect temporal variations of the zooplankton at our study sites.

CHAPTER ONE

INTRODUCTION:

1.1 Scientific Background

1.1.1 Division Of Marine Environments And Marine Organisms

The world's oceans can be subdivided into a number of marine environments. The most basic division separates the pelagic and benthic realms. The **pelagic environment** (Pelagic meaning " Open Sea") is that of the water column, from the surface to the greatest depths. The **benthic environment** (Benthic meaning "bottom") encompasses the seafloor and includes such areas as shores, littoral, or intertidal areas, coral reefs, and the deep seabed. Another basic division separates the vast open ocean, the **oceanic** environment, from the inshore **neritic** zone. This division is based on depth and distance from land, and the separation is conventionally made at the 200 m depth limit which generally marks the edge of the continental shelf (Fig. 1.1). The animals of the pelagic division include the **zooplankton** and **nekton**. Most nektonic animals begin life as members of the zooplankton community. As the zooplankton grow and improve their swimming capabilities, they eventually graduate to the status of nekton (Sumich, 1996).

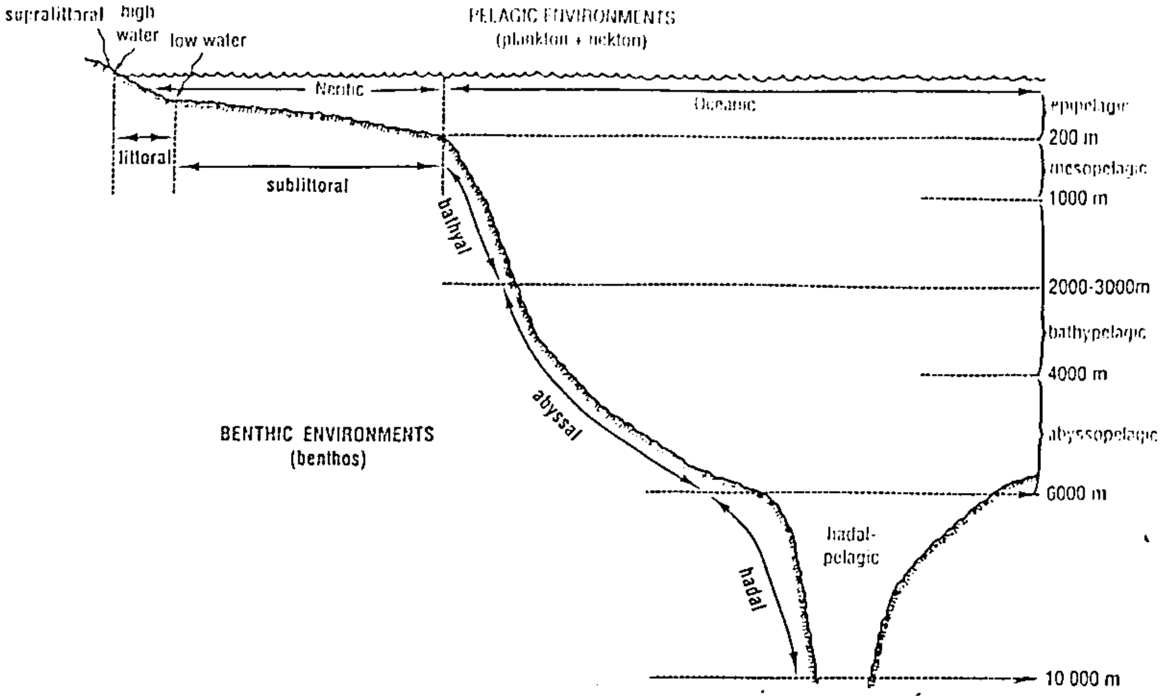

Figure 1.1 ***Division Of The Ocean (Hedgpeth, 1957).***

The animals making up the zooplankton are taxonomically and structurally diverse. They range in size from microscopic, unicellular organisms to jelly fish several meters in diameter. Although all zooplankton are capable of movement, by definition none are capable of making their way against a current. By definition also, all zooplankton – indeed all animals and some micro- Organism- are **heterotrophic**. That is, they require organic substrates as sources of chemical energy in order to synthesize body materials. Unlike plants, which carry out autotrophic production by utilizing solar energy to reduce carbon dioxide, animals obtain carbon and other essential chemicals by ingesting organic materials. Animal species differ in how their energy is obtained: Some species are **herbivores** which consume plants; others are **carnivores** which are capable of eating only other animals; and some species are predominantly **detritivores** which consume dead organic material. Many animals, however, are **omnivore** with mixed diets of plant and animal material. Different types of zooplankton often are placed in categories which describe their diets.

In addition to size categories and positions in food chains, zooplankton can be subdivided into classifications based on habitat (oceanic VS. neritic species) and taxonomy. They also form two categories depending upon the length of residency in the pelagic environment; **holoplankton** (or permanent plankton) spend their entire life cycles in the water column, whereas **meroplankton** are temporary residents of the plankton community (Sumich, 1996).

The meroplankton includes fish eggs and fish larvae (the adults are nektonic), as well as the swimming larval stages of many benthic invertebrates such as clams, snails, barnacles, and starfish. Meroplankton are concentrated in near-shore neritic provinces over continental shelves and near shallow banks, reefs, and estuaries. Their distribution and abundance is related to the seasonal distribution and productivity cycles of local phytoplankton communities (Mullin and Brooks, 1976).

Over 5,000 species of holoplankton have been described, recruited from numerous phyla. Prominent among these are **protozoans, cnidarians, ctenophores, mollusks, chaetognaths, crustacean arthropods, and invertebrate chordates.** The microscopic tintinnids, flagellates, and other protists seldom move far under their own power. Because of their very small cell sizes, they have great difficulty trying to overcome the viscous between water molecules by swimming. As a result, there is almost no glide in this microscopic world. A cell must swim continuously in order to move. When it stops working, it stops swimming. They employ flotation and buoyancy devices similar to those found in phytoplankton. Since most holoplankton are characteristically small, they increase their frictional resistance to the water by having high surface areas to body volumes ratio. A profusion of spines, hairs, wings, and other surface extensions also increases frictional resistance to sinking (Lalli and Parsons, 1993).

The vertical gradients of **temperature, light, primary production, pressure, and salinity** create distinctive environments and different depths in the water column. These vertical zones (epi-, meso-, bathy-, and abyssopelagic) are somewhat arbitrary in nature, but different species of zooplankton generally inhabit discrete depth zones within the ocean. The life styles, morphology, and behavior of organisms living deeper in the water column differ from those exhibited by epipelagic species, and the biomass of zooplankton decrease exponentially with depth.

1.1:2 Bioluminescence Of Zooplankton

Light production is a common feature of marine organisms (Lynch 1981, Young 1983). Swift etal. (1983) have presented evidence that zooplankton in some regions of the ocean can be the dominant source of stimulable bioluminescence observed by bathyphotometers. The biology significance of bioluminescence varies with the species. Some use light displays to attract potential prey, others to deter predators, some may use bioluminescence to attract mates, or to form reproductive swarms.

1.1:3 Vertical Migration Of Zooplankton

Vertical migratory behavior is one of the most prominent, widely studied aspects of behavior. It occurs on time scales from portions of the life span of the organism (Ontogenetic migrations) and seasonal migrations to diel migrations. Each type of migration can vary (e.g in time of onset, range) as a function of environmental conditions. The importance of studies of these aspects of zooplankton behavior has been reviewed by Hamner (1985).

1.1.3.1 Diel Vertical Migration .

One of the most characteristic behavioral features of zooplankton is a vertical migration that occurs with a 24-hour periodicity. This has often been referred to as diurnal vertical migration. However, diurnal refers to events that occure during daytime; it is the opposite of nocturnal. Diel refers to events that occur with a 24-hour rhythm. Diel vertical migration is usually marked by the upward migration of organisms toward the surface at night, and a downward movement to deeper waters in the daytime.

The major stimulus that initiates and controls vertical diel migrations is **light**. Vertical migraters respond negatively to light, moving themselves deeper as the surface light intensity increases. Conversely, they move toward the surface as the surface light intensity decreases. The adaptive significance of diel vertical migration remains unclear, and it may be different for different species. This behavior may allow animals to conserve energy by remaining in colder waters except when feeding; it may reduce mortality from visual predators; or it may pemit animals of limited swimming ability to sample new feeding areas with each ascent.

Diel vertical migration has several important **biological** and **ecological** consequences. It probably enhances genetic exchange by mixing the members of a given population; this result because vertical migration are never precisely synchronized among all the members of a population. Some individuals begin migrations sooner or later than others , with the result that some members will eventually be lost from the original group and new members will be added. Diel vertical migrations increase the speed at which organic materials produced in the euphotic zone are transferred to deeper areas (Lalii and Parsons, 1993).

In high latitudes, extensive vertical migrations may be undertaken on a seasonal basis, and these are generally linked with reproductive cycles and development of larval stages. In such migration, the adults are usually found in deeper waters during the winter when food is scarce; the developing young are present in surface waters during the spring and summer when phytoplankton is plentiful.

By moving vertically in the water column, zooplankton enter currents that are moving in different directions and at different speeds. Thus diel or seasonal vertical migrations that are attuned to particular current regimes can result in the retention of populations within favorable localities. The numbers of species of epipelagic and mesopelagic zooplankton are higher in low latitudes but the numbers of individuals tend to be relatively low. The reverse situation is found in high latitudes, where there are fewer species but with higher abundance.

1.1.4 Patchy Distribution Of Zooplankton

In the ocean, as on land, the distributions of most organisms are characterized by spatial heterogeneity, or **patchiness** (Steel, 1978; Levin etal. 1993). The generation of patchiness in oceanic ecosystems is often attribute to forcing by physical processes (Haury and Pieper, 1988). Well-documented examples include the observations of zooplankton aggregations in eddies and rings (Wiebe etal. 1976. 1992; Roman etal. 1985), and patches generated along oceanic front (Boucher, 1984; Franks, 1992). In many cases, however strong, spatial variability in biological properties has little or no correspondence to variations of physical properties (Omori and Hamner, 1982; Star and Mullin, 1981; Mackas and Boyd, 1979). The processes responsible for such patchy distributions in the ocean have been the subject of much speculation, but remain poorly understood (Hamner, 1988). For example, historical data from net collections have shown that distributions of vertically migrating zooplankton of California exhibit greater patchiness in oceanic areas characterized by shallow irregular topography than in adjacent deep-water areas with a flat bottom (Genin etal. 1988).

Nonrandom distribution may result from responses **to physical, chemical,** or **biological** events. Some of the physical determinants of patchiness are the same for both phytoplankton and zooplankton. Various types of horizontal and turbulent mixing can result in aggregation or despersion of planktonic population. Some types of mixing **(upwelling)** result in elevated surface nutrient concentrations, high primary production, and increased numbers of zooplankton; other forms of mixing **(downwelling)** have the opposite effect on production and aggregation of organisms. Aggregations can result from responses to **temperature** and **salinity** gradients or discontinuities, **water motion, Light intensity**. Patchiness may also result from interaction between **prey** and **predators,** or it may reflect other biological events such as **reproduction.** The size and shape of aggregation and the concentration of individuals in the assemblage differ among localities, species and even among developmental stages of a given species because of individual response to physico-chemical conditions, unique species-specific and age related social behavior and interaction in the aggregation (Omori and Hamner, 1982).

Behavioral information, in particular, is sorely needed. For example, some species form intense aggregations only during certain times of day or year, and this results in hourly, daily, and seasonal variations in population density even if the biomass over a wide area remain relatively uniform. The role of the species and its interactions within the food web will be different between aggregated and dispersed phases.

1.1.5 Zooplankton Abundance And Grazing At The Reef.

Zooplankton are an integral component of coral reef ecosystems, for they are an important food item for corals (Glynn 1973; Muscatine and Porter, 1977) and a number of reef - fish species (Randall, 1967). It has often been assumed that coral reef zooplankton largely came from surrounding oceanic waters. However, coral reefs pocess unique assemblages of zooplankton which live in association with the benthic substrate by day and migrate into the water column at night (Sale etal. 1976; Alldredge and King 1977; Hobson and Chess 1979).

What supports this reef zooplankton? Coral reefs have higher rates of primary production than surrounding waters (Erez, 1990), but most of this production is by benthic primary producers: Zooxanthellae in corals, epibenthic microalgae and macrophytes. Primary production of suspended phytoplankton above coral reef is low. Pelagic primary production is less than benthic primary production (Kinsey, 1972). As is typical of tropical phytoplankton communities, much of the suspended phytoplankton biomass over reef is picoplankton (< 2 m), and may not be readily captured by zooplankton (Gerber and Marshall, 1982). The combined demersal and pelagic zooplankton community were often able to crop 30% of the daily primary production by > 2 m phytoplankton.

Alternative food sources for reef zooplankton include **coral mucus, algal detritus** and **protozoans.** Mucus aggregates produced by corals can be a dominant component of the particulate matter in reef water - column (Ducklow and Mitchell, 1979). Reef copepods ingest and assimilate coral mucus (Gerber and Marshall, 1974; Gottfried and Roman, 1983). Additional input of organic particulate matter to the water column of coral reefs occurs from algal detritus (e.g Gerber and Marshall, 1974). Algal fragments may comprise a major component of particulate matter downstream of reef crests and flats because of fragmentation of turnfforming algae in these zones. Copepods ingest and assimilate algal detritus in laboratory experiments (Roman 1984a). Using in situ incubations, Mullin and Roman, 1986 found that the coral reef mysid ***Anisomysis sp***. ingest detritus derived from the reef algae ***Spyridia filamentosa.*** Another significant source of particulate matter over reefs comes from microbial production. Bacterial production in reef waters can sometimes exceed phytoplankton production (Sorokin, 1973). This bacterial production may be converted to a size range that is available to zooplankton through aggregation and by protozoan food webs. The biomass of protozoa was similar to that of phytoplankton over the Enewetok Atoll (Gerber and Marshall, 1982).

1.1.6 Interrelations Between Planktivorous Reef Fish And Zooplankton

Recent studies indicate a number of potential relations between **reef fish, zooplankton** and **reef**. Supply of zoopankton may influence the growth and patterns of distributon of reef fish (Bray, 1981; Jones 1986). Fish in turn may affect densities and composition of zooplankton passing over reefs (Coates, 1980), as well as the input of nutrients to reefs (Robertson, 1982).

The local distribution of planktivorous fish changed according to the direction of currents. Other investigations have found also highest densities of planktivorous on the incurrent sides of reefs feeding on uncropped zooplankton (Hobson &Chess, 1978). The feeding activity of fish was capable of causing localised reductions in the abundance of zooplankton. Rate of feeding and diet of fish, as well as density and composition of zooplankton changed between times (Kingsford and MacDiarmid, 1988). These findings emphasize the importance of making concurrent measures of these factors if the interrelations between fish and zooplankton are to be interpreted properly.

1.1.7 Coupling processes Between the Open Ocean and Coastal Habitats

The processes taking place when open-oceanic waters bearing pelagic organisms encounter shallow coastal habitats are virtually unknown. Such processes could potentially be a principal trophic path for benthic (coral-reef) and epibenthic (fish) communities, particularly in oligotrophic regions.

Coastal and shallow oceanic regions are in many cases more productive then nearby deep-water regions (Steele, 1978; mackas et al. 1980; Richards, 1981; Yoder et al., 1983). Two different flow patterns can enhance biological production in coastal areas. The first process (**hereafter" Type I Enrichment"**) is the classical coastal upwelling phenomenon, where a wind-driven off-shore current causes an upward motion of nutrient-rich waters. Nutrient enrichment in the upper, illuminated layers of the water column enhances primary production, leading to an overall high biological production at all levels of the local food chain (Steel, 1978; Richards, 1981 and references therein). The second flow-related enrichment **(hereafter "Type II enrichment")**. This enrichment is also driven by cross-shore current, but with a strong on-shore component. The flow in this case transports particulate oceanic food (i.e zooplankton) from the open ocean onto the shallow habitat. This flow pattern enhances food supply to, and thereby the production of, plankivorous predators. Thus community enrichment in this case starts at the trophic level of consumers, rather than primary producers as in the Type I Enrichment. Examples that might be related to Type II processes include the trophic enrichment of fish communities on seamounts (Isaacs and Schwartzlose, 1965; Genin et al., 1988), canyons (Pereyra et al., 1969) and coral reefs (Erez, 1990). This pattern can also indirectly affect benthic primary producers (e.g. corals), utilizing the nutrients excreted by zoopplankton predators (Erez, 1990; Liberman et al, 1994).

Mechanisms concentrating zooplankton over shallow bottom can play an important role in processes of benthic-pelagic coupling in the ocean. For example, when vertically migrating zooplankton move deep to near-surface depths during night and are then advected over areas of shallow topography, they become trapped above the shallow bottom, unable to complete their morning descent. Being trapped in illuminated waters during daytime, these zooplankton become susceptible for predation by visual predators such as planktivorous fish (Genin et al. 1988; see also wiebe et al., 1979).

1.2 Significant of the Study

Our proposed study can significantly contribute to the understanding of the important of zooplankton advection to the nutrition of coral reefs. Grazing at the reef together with physical advection seems to affect temporal variations of the zooplankton at our study sites.

1.3 Research Objectives

Short term variation of zooplankton were examined at the Gulf of Aqaba - Red Sea from October 10 to December 2. 1999. The goal of this research are:

1- To study the patchy distribution between the zooplankton biomass with zooplankton density starting from October 10 to December 2. 1999 in the Gulf of Aqaba in the Red Sea.

2- To know the percentages of zooplankton taxa in the counted samples at the two different sites day and night.

3- To study the abundance of zooplankton in the open water and reef starting from October 10 and December 2. 1999 in the Gulf of Aqaba in the Red Sea sites

4- To study the zooplankton abundance at the reef and open water, both In terms of density and biomass. (To test the hypothesis that zooplankton abundance is lower near the reef than open water).

5- To study the short-term variations of zooplankton biomass with the scale of hourly samples within a day in all 24 hour samples.

6- To study the patchy distribution of zooplankton abundance and patchy distribution of phytoplankton concentration.

7- To evaluate the roles of currents, behavior and localized predation of zooplankton in the generation of the observed variations.

CHAPTER TWO

Materials and Methods :

2.1 Study Site :

This study conducted in October until December 1999, on the Gulf of Aqaba. The Gulf of Aqaba is situated at the northern part of the Red Sea (Fig 2.1). This Gulf is very special in many aspects: Water temperature is relatively constant, without major changes: In summer up to 25/26 degree and in winter not lowest than 21/22 degree. No big storms, mild currents, and the lack of rain do not bring much sediment from land. All of these elements ensure excellent clarity of the water and a very rich variety of coral growth. Gulf Aqaba is considered as one of the richest concentrations of varieties of marine life in all of the tropical seas.

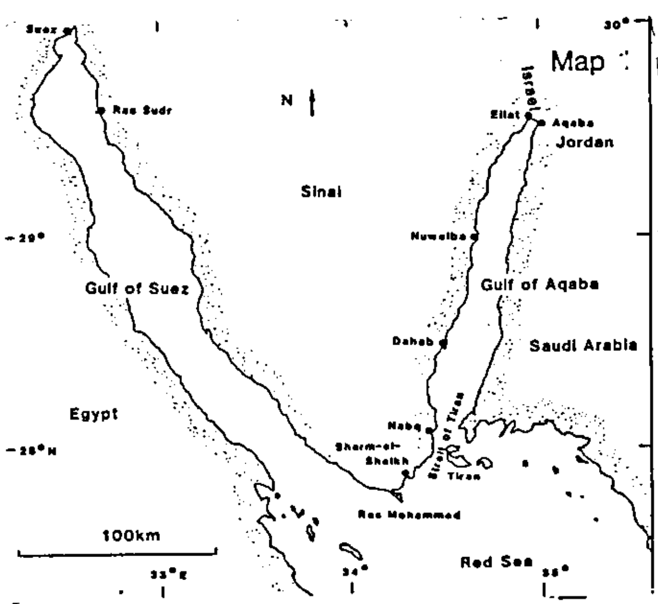

Figure 2.1: Map showing loactions of sampling sites in the Gulf Of Aqaba in the Red Sea.

2.2 Study Schedule

The sampling plan consisted of four different interval-schedules, carried out during a 54 days period (10 October - 2 December 1999; Fig. 2.2). A "sample" in the following two sections indicates a pair of water samples, one from the reef and the other from the away site (open water, 163 meter off shore).

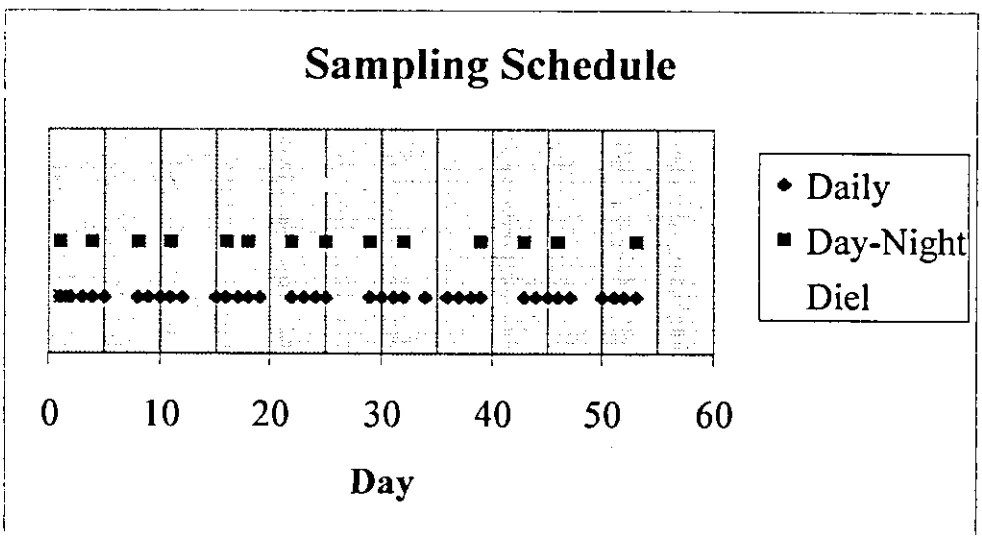

Figure 2.2 ***Sampling Schedule Of Zooplankton at the Northern Part Of Gulf of Aqaba in the Red Sea October 10– 2 December 1999.***

The daily schedule consisted of one sample a day around 10:00 am obtained 5 days a week (Sunday through Thursday). Twice a week (Sunday and Wednesday), a nocturnal (during night) sample (between 19:00 and 20:00 pm) was added, producing a 14 pairs of day-night samples. Once every two weeks, on Wednesday, 16 to 17 samples of zooplankton were taken throughout a 24 h interval (a zooplankton sample every approx. 1.5 h), producing four series of samples of diel cycles (Refer to Appendix 1).

2.3 Physical and Chemical Analysis

Water samples were obtained with two large (132 L/min) submersible pumps, delivering the pumped water to shore via 45 mm diameter PVC pipes. Both pumps were deployed at 8 m depth: one at the reef, 40 m off shore, attached to a tripod with the intake opening suspended 0.75 m above bottom, and the other at the open waters, 163 m off shore, where the pump was attached to a mooring line with its intake positioned 34m above bottom (42 m depth) (hereafter "Reef" and "Away" sites, respectively).

Zooplankton samples were obtained by filtering the pumped water through a 1 m long, 36 cm diameter, 100 μm mesh net, submerge in a large (135 liter) container to avoid drying and damage of the trapped animals. The pumps' impeller design ensured an intact passage of plankton. Visual examination, using fluorescein dye, indicated that the pump created a minimal disturbance to the flow field around it, with no visible effect as far as 20 cm away from its intake. Nevertheless, to assure lateral suction at the intake depth and to avoid a resuspension of bottom particles by the reef pump, a 0.5 m^2 plastic sheet was attached to the tripod legs 20 cm below the pump. Each sample was obtained by filtering water for about 1 h, with an average (±sd) volume filtered of

8.25 m^3 (±0.68). The sample was immediately transferred to the laboratory where it was separated into two parts: one aliquot (10.4% of the sample) was separated using a Stempel Pipette and preserved in 4% buffered formalin for later microscopic counts, while the rest of the sample was processed for organic biomass, as follows. After initial screening through a 1.35 mm mesh net, to remove large (rare) specimens, this sub-sample was filtered through a pre-combusted Whatman GF/A filter type and put for 1 to 3 days in a drying oven (60°C). After weighing the dried animals with the filter, the organic matter trapped on the filter was combusted for 4 h at 450°C and weighed again, producing the ash-free dry weight of the sampled organisms (hereafter "AFDW").

Microscopic counts were made using a dissecting microscope (x40 magnification). Depending on the animal density in the sample, 2 to 9 sub-samples were taken from smaller aliquot using a Stempel pipette, consisting together 4 to 19% of that aliquot (0.4 to 1.98% of the original sample) so that at least 200 specimens were counted. The counted animals were sorted to the following taxa: (a) calanoid and cyclopoid copepods, (b) harpactiocoid copepods, (c) copepod nauplii, (d) molluscs, (e) appendicularia, (f) chaetognaths and (g) polychaets.

All the above samples were processed for AFDW, as described above. Microscopic counts of zooplankton were made only for the daily and day-night series (only one day sample and one night sample in the series of diel cycles) (Fig. 2.2).

Overall, during the 54 days of the field sampling at the two sites, a total of 222 single samples were processed for zooplankton biomass, a total of 102 zooplankton samples were sorted (classify) under the microscope.

Currents and temperature data were measured using two electromagnetic current meters (Model S4, Inter Ocean, San Diego, USA) equipped with a temperature sensor. One current meter was deployed at the Away site, attached to a separate mooring line at 6.5 m depth, while the other instrument was deployed at 8 m depth the reef site. Each current meter was positioned about 10 m away from the pump. The current meters were set to record the average current speed and direction and the temperature of a 1 min interval every 10 min.

2.4 Data Analysis

Statistical program used was SPSS (Version 9).

Type of Analysis

- Coefficient of Variation (CV)
- Pearson Correlation Coefficient
- Pared T-test
- Mean, Average, Range, Standard deviation, Standard Error

CHAPTER THREE

RESULTS

1- Patchy distribution between the zooplankton biomass with zooplankton density starting from October 10 and December 2. 1999 in the Gulf of Aqaba in the Red Sea.

Result 3.1

Over our entire data set (N=222 ,(zooplankton biomass varied from 1.16 to 10.47 gr ash-free dry weight (AFDW) m^3, with an average of 3.68 gr and CV of 41.5% (Refer to the Analysis Data in Appendix 2). The average zooplankton density caught with our 100 µm mesh was 5630 specimens/m^3, with a range of 549 to 11289 specimens/m^3 and CV of 35.7% (N= 102) (Refer to the Analysis Data in Appendix 3). The biomass (gr AFDW) and density (#) of zooplankton were significantly correlated one with another, only less than half of the variance in the biomass values were explained by the numerical density (Fig.3.1.1; (Fig.3.1.2;(Fig.3.1.3).

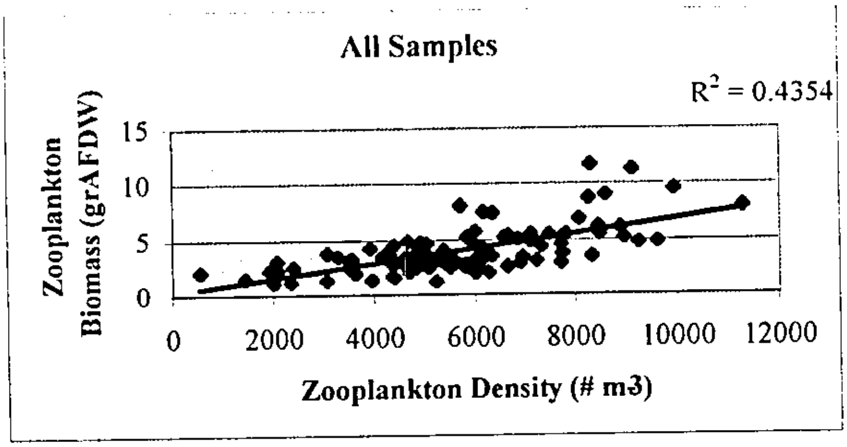

Figure 3.1.1 ***Patchy Distribution of Zooplankton Biomass With Zooplankton Density - October 10 - December 2. 1999 in the Gulf of Aqaba ; All Samples;***

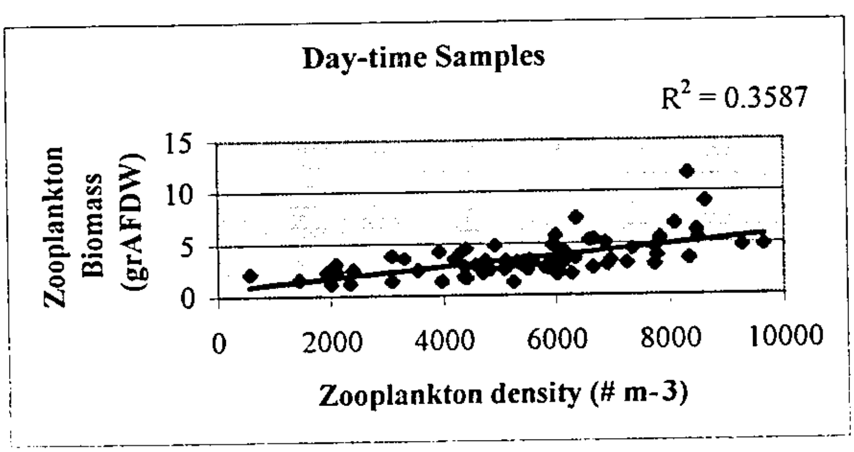

Fig 3.1.2 ***Patchy Distribution of Zooplankton Biomass With Zooplankton Density - October 10 - December 2. 1999 in the Gulf of ; Day-Time Sample ;***

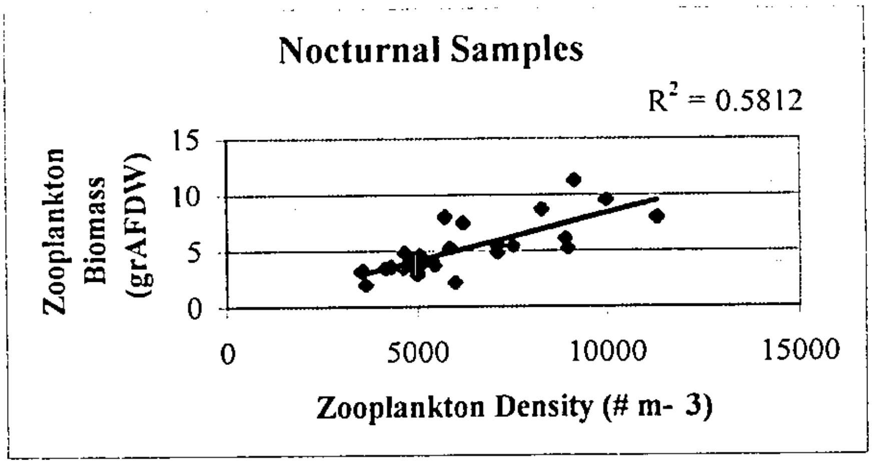

Figure 3.1.3 ***Patchy Distribution of Zooplankton Biomass With Zooplankton Density -October 10 - December 2. 1999 in the Gulf of Aqaba ;Nocturnal Samples.***

2- The percentages of zooplankton taxa in the counted samples at the two different sites day and night starting from October 10 and December 2. 1999 in the Gulf of Aqaba in the Red Sea.

Results 3.2

Adult and nauplii copepods dominated (74%) the sampled zooplankton community (Table 3.2.1), which together with molluscs and appendicularia formed over 92% of the collected specimens.

Table 3.2.1 ***Percentages of zooplankton taxa in the counted samples at the different sites.-October 12 - December 2. 1999 in the Gulf of Aqaba***

Taxon	Overall	Day-Away	Day-Reef	Night-Away	Night-Reef
Calanoids & Cyclopoids	31.8	37	30	32.3	28
Harpacticoid	24.8	26.9	24	25.3	23
Nauplii	17.6	16.6	18	19.7	18.1
Molluscs	11.3	9.7	11.8	10.5	13
Appendicularia	6.8	5.1	7.8	6.5	7.7

The taxonomic composition of the zooplankton community was similar at the two sites (Fig.3.3.1-3.3.8) except for calanoid and cyclopoid copepods (combined) which, in addition to their higher density away from the reef, consisted there a significantly (Paired t-test, $P<0.0001$, $N=51$) higher proportion of the zooplankton community (Fig. 3.4.7).

3- The abundance of zooplankton in the open water and reef site starting from October 10 and December 2. 1999 in the Gulf of Aqaba in the Red Sea.

Result 3.3

The CV of zooplankton biomass during the day (daytime samples throughout our 54-day long series) at the Away and Reef sites were 48.2 and 36.3%, respectively, while the CV values of the nocturnal samples were 37.4 and 38%, respectively (Refer to the Analysis Data in Appendix 4). A general increase in zooplankton density took place at the two study sites, both in the diurnal and nocturnal samples, from the start of our sampling in early October to its end in the beginning of December (Fig. 3.3.1-3.3.8). This increase was more evident in the density (Fig. 3.3.1-3.3.8), particularly in the day-time (Fig.3.3.1), than in the biomass data (Fig. 3.3.9-3.3.10).

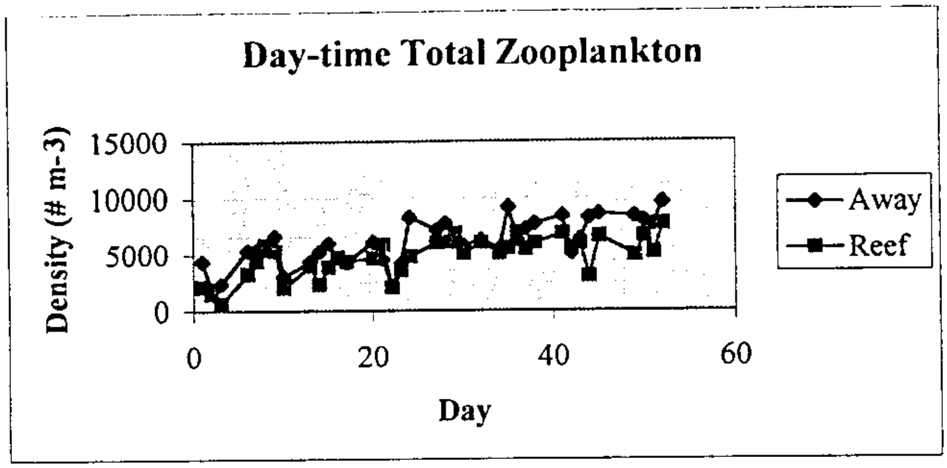

Figure 3.3.1 :*Small –Scale (in Days) Patchy Distribution of Zooplankton Density at the reef and away sites -October 12-December 2. 1999 in the Gulf of Aqaba ; Day – Time Total Zooplankton*

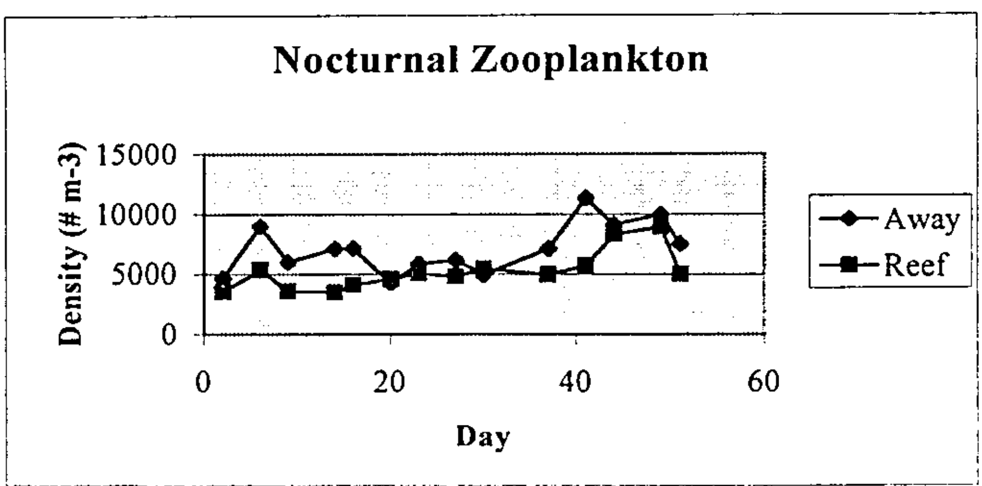

Figure 3.3.2 : *Small –Scale (in Days) Patchy Distribution of Zooplankton Density October 12 - December 2. 1999 in the Gulf of Aqaba at the Reef and Away Sites; Nocturnal Zooplankton;*

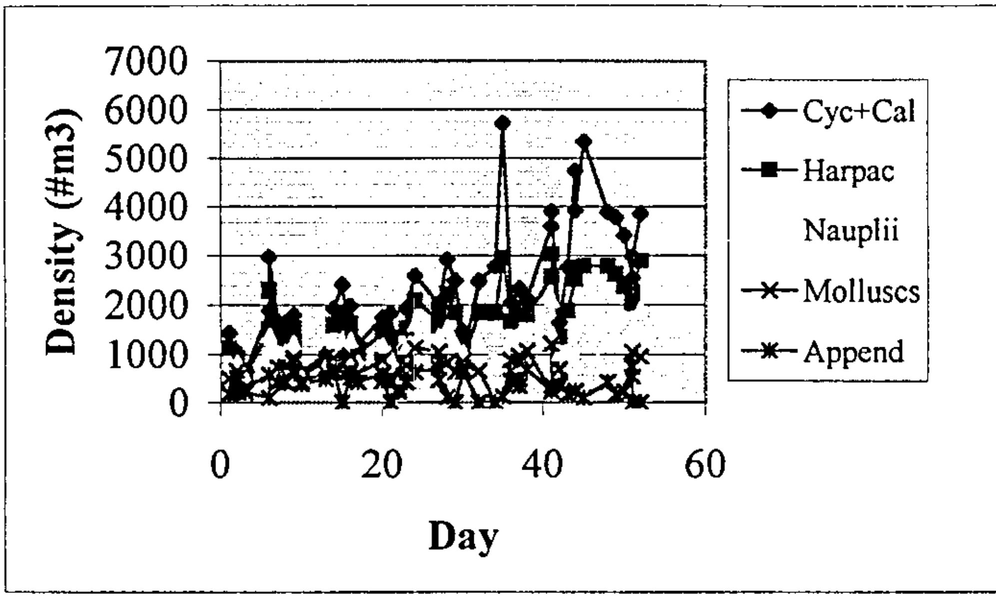

Figure 3.3.3 ***Small – Scale (in Days) Patchy Distribution of Zooplankton Density at the Reef and Away Sites -October 12 - December 2. 1999 in the Gulf of Aqaba ; Cyclpoids & Calanoids, Harpacticoids , Nauplii, Molluscs , Appendicularia .***

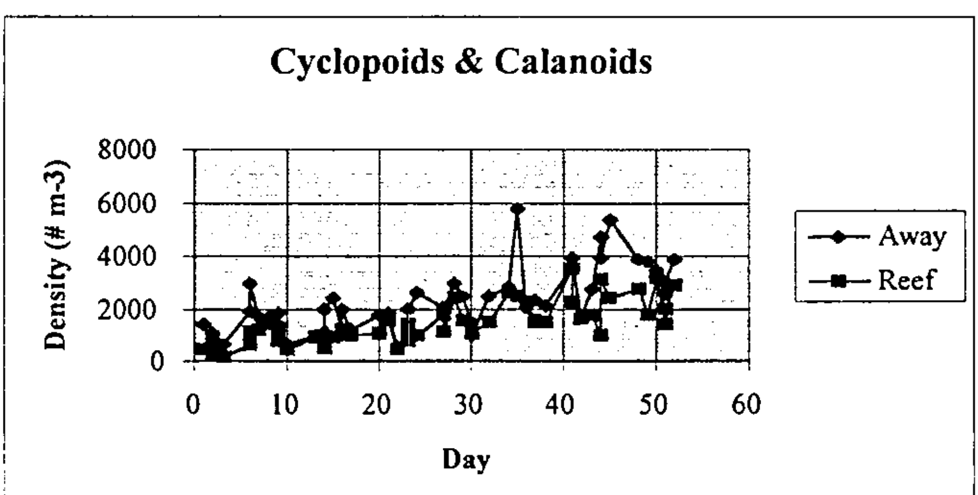

Fig 3.3.4 *:Small –Scale (in Days) Patchy Distribution of Zooplankton Density at the Reef and Away Sites -October 12 - December 2. 1999 in the Gulf of Aqaba; Cyclopoids & Calanoids.*

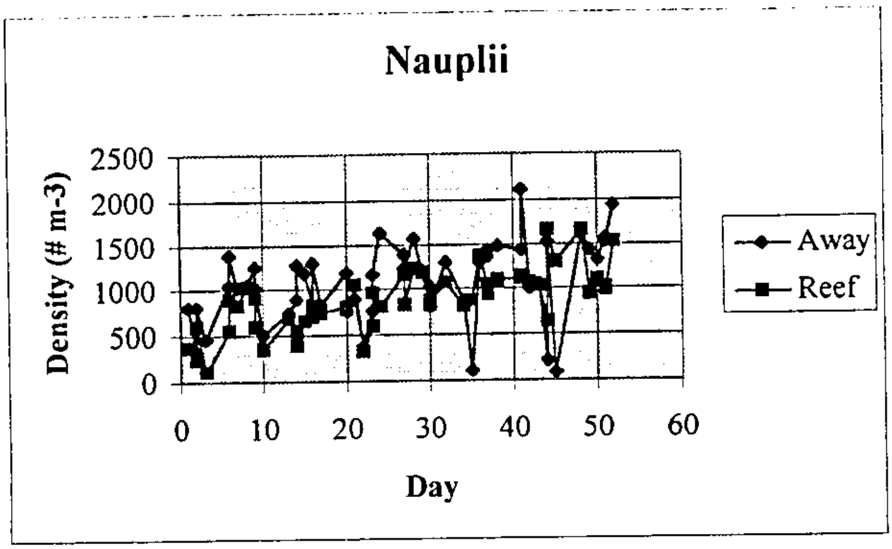

Figure 3.3.5 :*Small –Scale (in Days) Patchy Distribution of Zooplankton Density at the Reef and Away Sites -October 12 -December 2. 1999 in the Gulf of Aqaba ; Nauplii.*

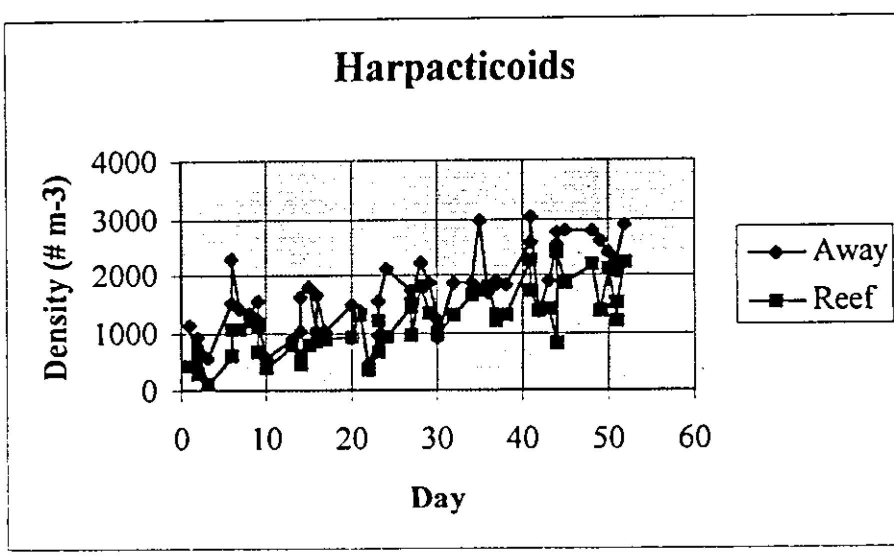

Figure 3.3.6 :*Small –Scale (in Days) Patchy Distribution of Zooplankton Density at the Reef and Away Sites -October 12 - December 2. 1999 in the Gulf of Aqaba ; Harpacticoids.*

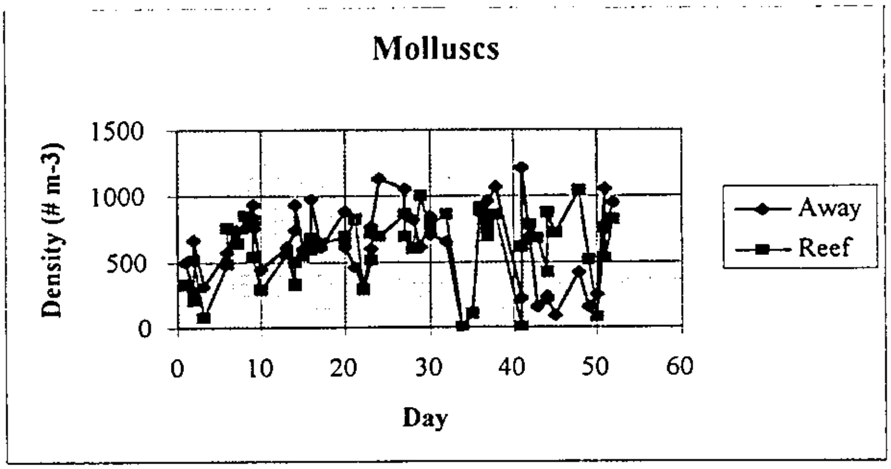

Figure 3.3.7 *:Small – Scale (in Days) Patchy Distribution of Zooplankton Density at the Reef and Away Sites -October 12 - December 2. 1999 in the Gulf of Aqaba ; Molluscs.*

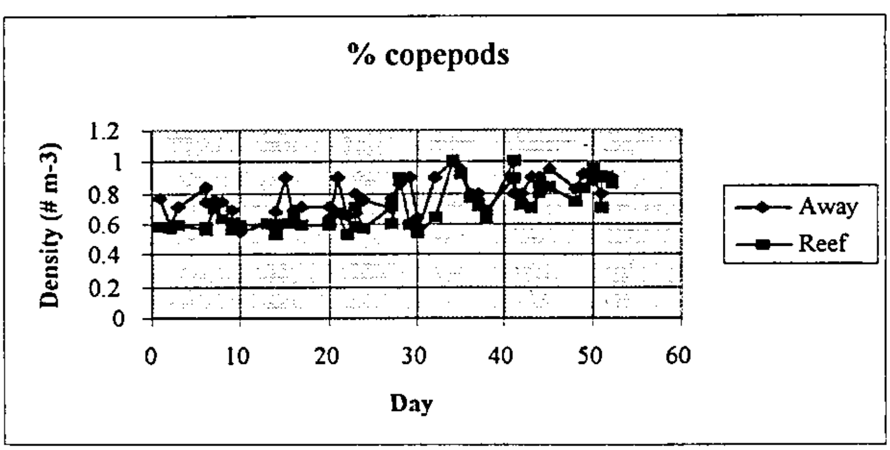

Fig. 3.3.8 *Scale (in Days)Patchy Distribution of Zooplankton Density at the Reef and Away Sites -October 12 – December 2. 1999 in the Gulf of Aqaba; % Copepods.*

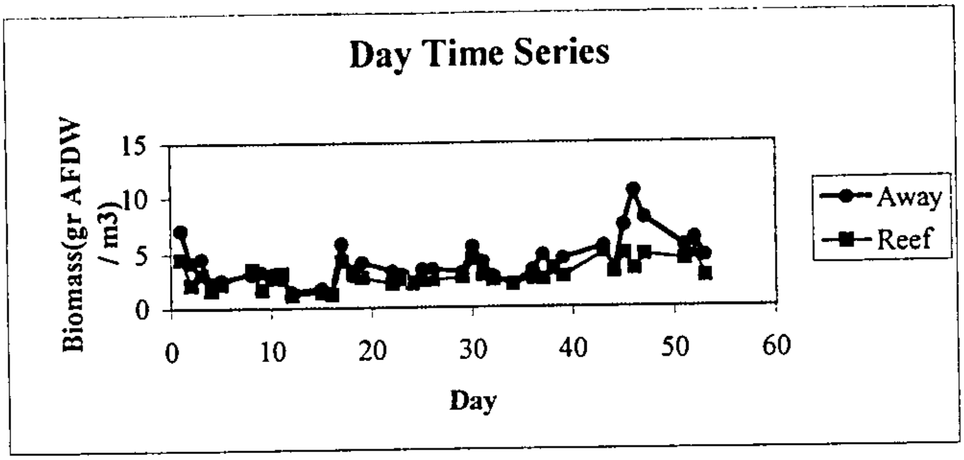

Figure 3.3.9 : ***Relation Between Zooplankton Biomass Within Days at the Two Sites–October10–December 2.1999 in the Gulf of Aqaba Day- Time Series.***

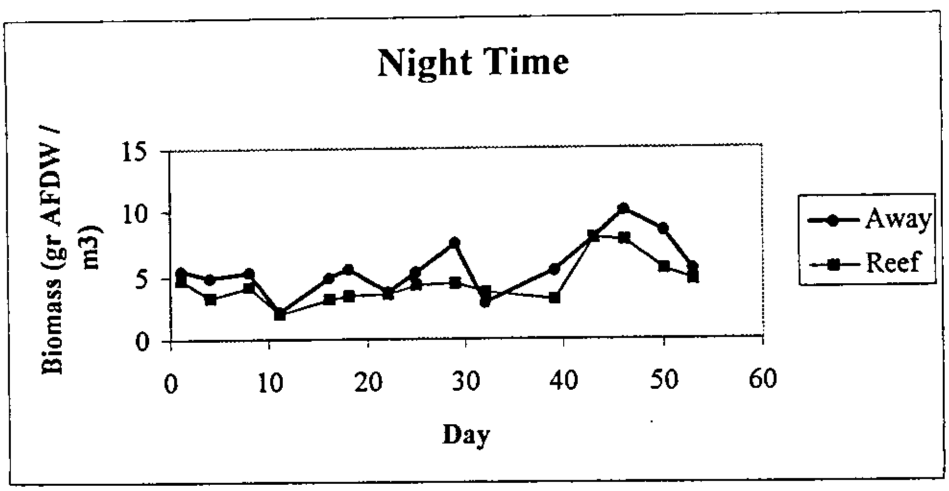

Figure 3.3.10 : ***Relation Between Zooplankton Biomass Within Days at the Two Sites–October10–December 2.1999 in the Gulf of Aqaba ; Night –Time.***

4- The zooplankton abundance at the reef and open water, both in terms of density and biomass. (To test the hypothesis that zooplankton abundance is lower near the reef than open water).

Result 3.4

The zooplankton abundance co-varied at the two sampling sites, both in terms of density (Fig. 3.4.1-3.4.3) and biomass (Fig.3.4.4-3.4.6). A significant ($P<0.001$) correlation between the two sites, with Pearson Correlation Coefficient R 0.7, was found for each of the total zooplankton biomass and density, as well as for each of the densities of copepods (cyclopoids and calanoids combined) and harpacticoids (Fig. 3.4.1-3.4.3).

The zooplankton biomass and the density of the total zooplankton and each of the three dominant taxa (cyclopoids and calanoids copepods [combined], harpacticoid copepods and copepod nauplii) were significantly higher ($P<0.0001$, Paired t-test) at the away site (Fig. 3.4.1-3.4.3). The magnitude by which the zooplankton density was higher at the away than the reef site greatly varied between different samples, being on the average 1500 animals (about 25%) per m^3. The difference between the two sites was on the average greater during the night (1931 ±1654 specimens/m^3 or 1.225 ±0.945 grAFDW/m^3) than in the day (1303 ±1401 specimens/m^3 or 0.836 ±0.826 grAFDW/m^3), however this day-night effect on the inter-site difference was statistically significant only for biomass (t-test, $P<0.03$; $N=66$ and 44 for the day and night samples, respectively).

The covariation of zooplankton abundance between the two sites was evident on the scales of both the entire period(Fig. 3.4.1-3.4.3) and (Fig. 3.4.4-3.4.6) as well as on the scale of hourly samples within days (Fig. 3.5.1). The level of covariation, as indicated by the R^2 values was higher during the day than night (Fig. 3.4.4-3.4.6).

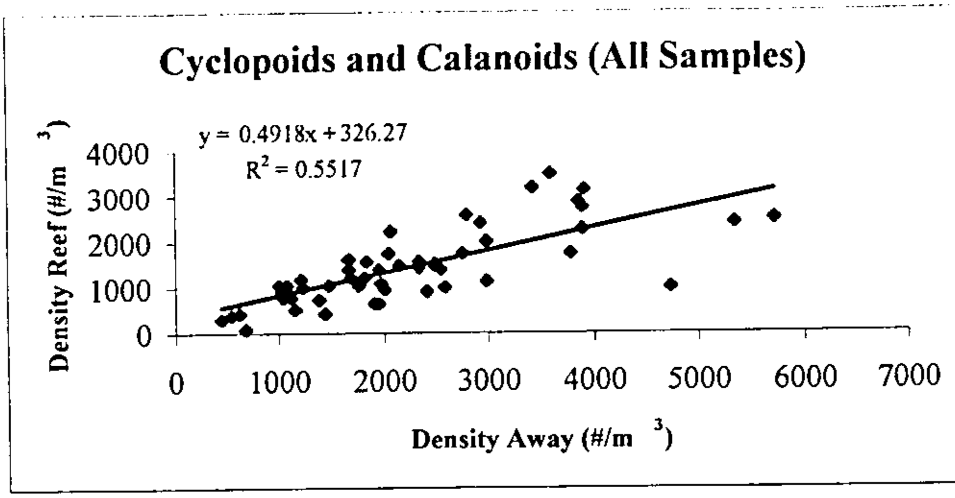

Figure 3.4.1 ***Relation Between Density Reef And Density Away For All Samples-October 12-December 2-1999 in the Gulf of Aqaba ; Cyclopoide and Calanoids.***

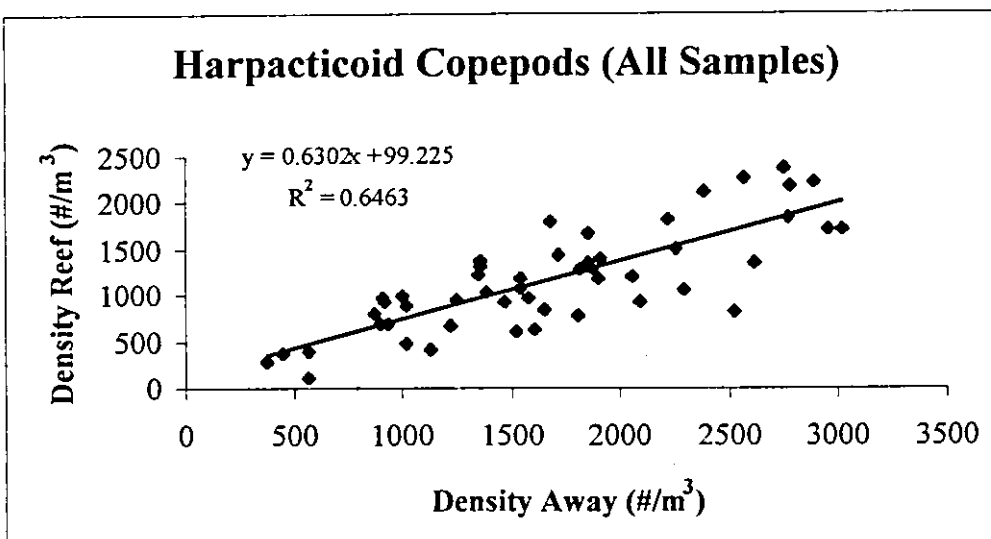

Figure 3.4.2 ***Relation Between Density Reef And Density Away For All Samples-October 12-December 2-1999 in the Gulf of Aqaba ; Harpacticoid Copepods.***

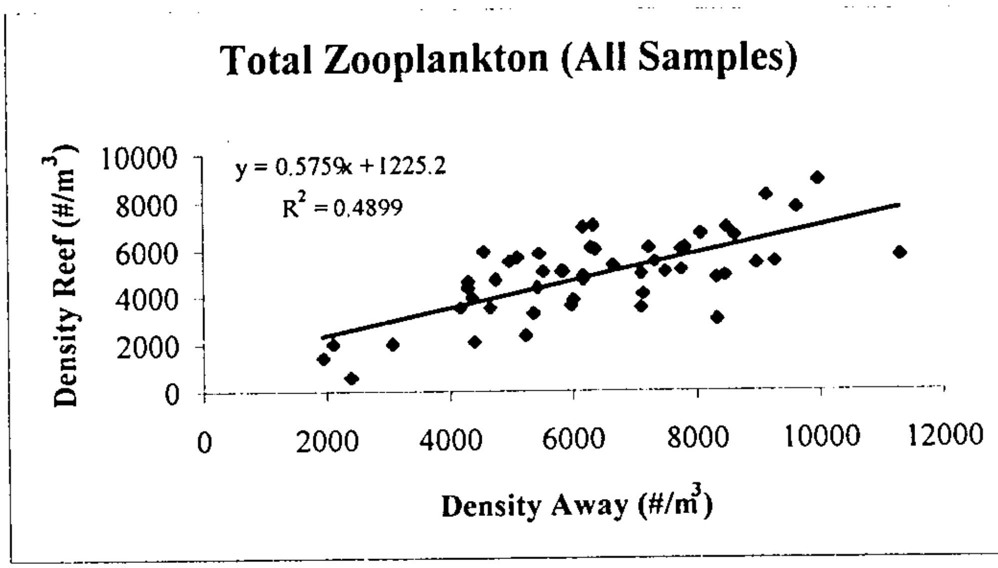

Figure 3.4.3 ***Relation Between Density Reef And Density Away For All Samples-October 12-December 2-1999 in the Gulf of Aqaba ; Total zooplankton.***

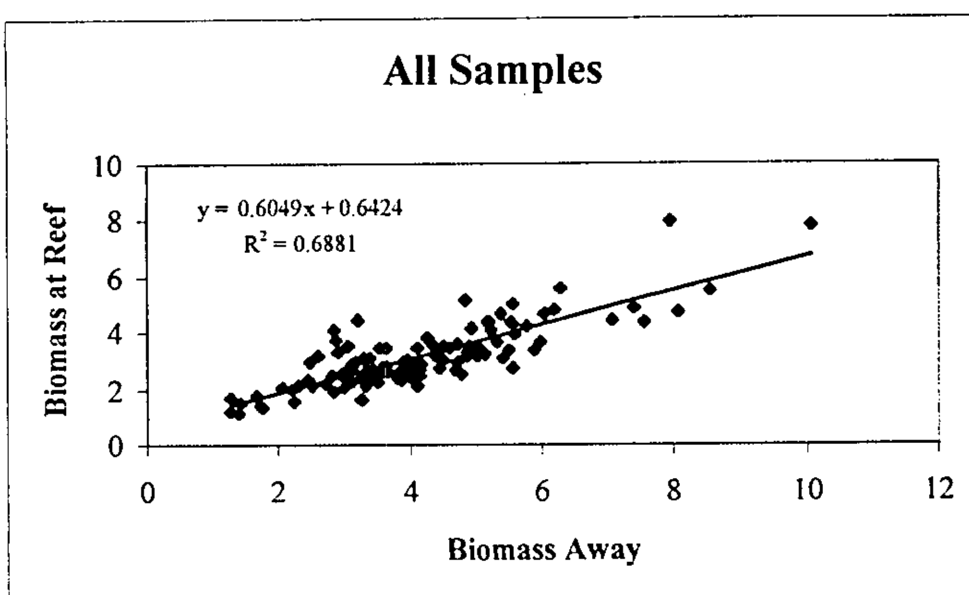

Figure 3.4.4 ***Variation of Zooplankton Biomass at Reef With Biomass Away – October 10-December 2. 1999 in the Gulf of Aqaba ; All Samples***

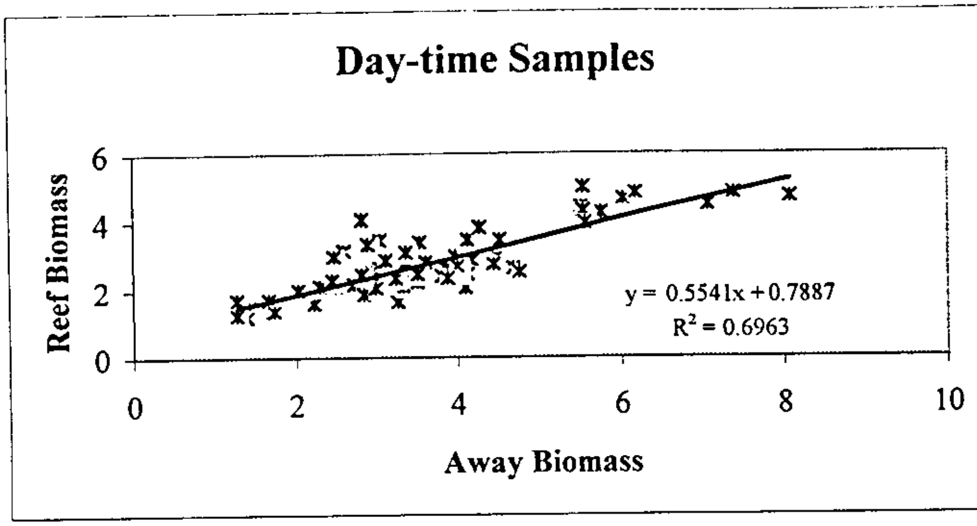

Figure 3.4.5 *Variation of Zooplankton Biomass at Reef With Biomass Away – October 10-December 2. 1999 in the Gulf of Aqaba for Day-time Samples.*

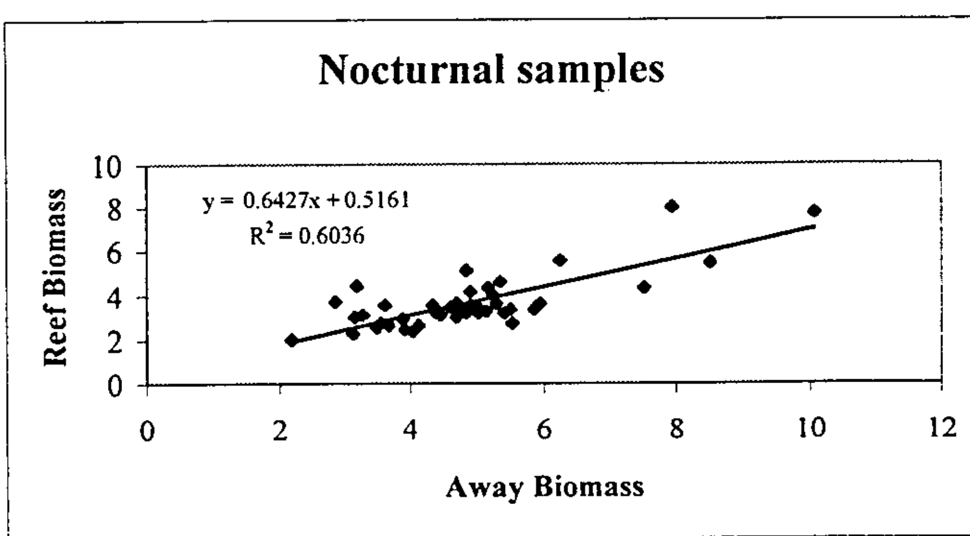

Figure 3.4.6 *Variation of Zooplankton Biomass at Reef With Biomass Away - October 10-December 2. 1999 in the Gulf of Aqaba for ; Nocturnal Samples.*

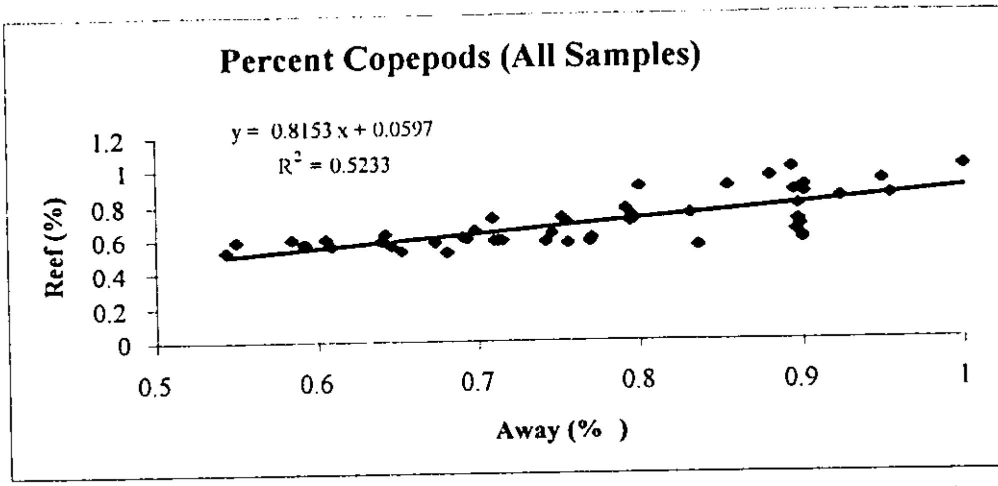

Figure 3.4.7: ***Relative Of Reef Copepods with Away Copepods for All Samples - October 12-December 2. 1999 in the Gulf of Aqaba.***

5- The short-term variations of zooplankton biomass with the scale of hourly samples within a day in all 24 hour samples.

Result 3.5

The variations of biomass during a single day were much smaller, compared to the variation during the 54 day-long series, with the average CV for the single sampling days (N=4 single days, each consists of 16-17 samples) equal to 24.1 and 27.2% for the Away and Reef sites, respectively (Refer to the Analysis Data in Appendix 5). A diel cycle in the abundance of zooplankton was seen at both the Away and Reef sites, with nearly a doubling of the zooplankton biomass during night (Fig. 3.5.2-3.5.3). The zooplankton abundance started to increase around

16:00, remaining high until about 04:00 am, declining to low values which prevail during the morning because of diel vertical migration (or DVM) which is usually marked by the upward migration of organisms towards the surface at night, and adownward movement to deeper waters in the daytime. Diel vertical migrations are tuned to the natural light : dark cycle suggests that changes in ambient light intensity may be of primary importance as stimuli in initiating and timing the migrations. Light intensity changes act as orienting cues for vertically migrating of zooplankton.

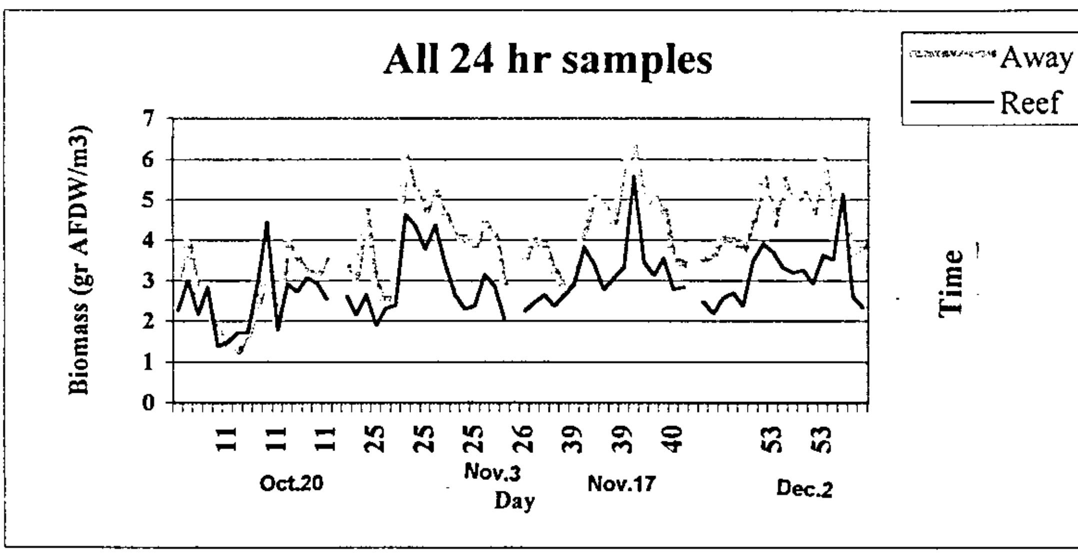

Figure 3.5.1 ***Variation of Zooplankton Biomass With the Scale of Hourly Samples Within Days in All 24 hr Samples (Oct.20, Nov.3, Nov.17, Dec.2) in the Gulf of Aqaba.***

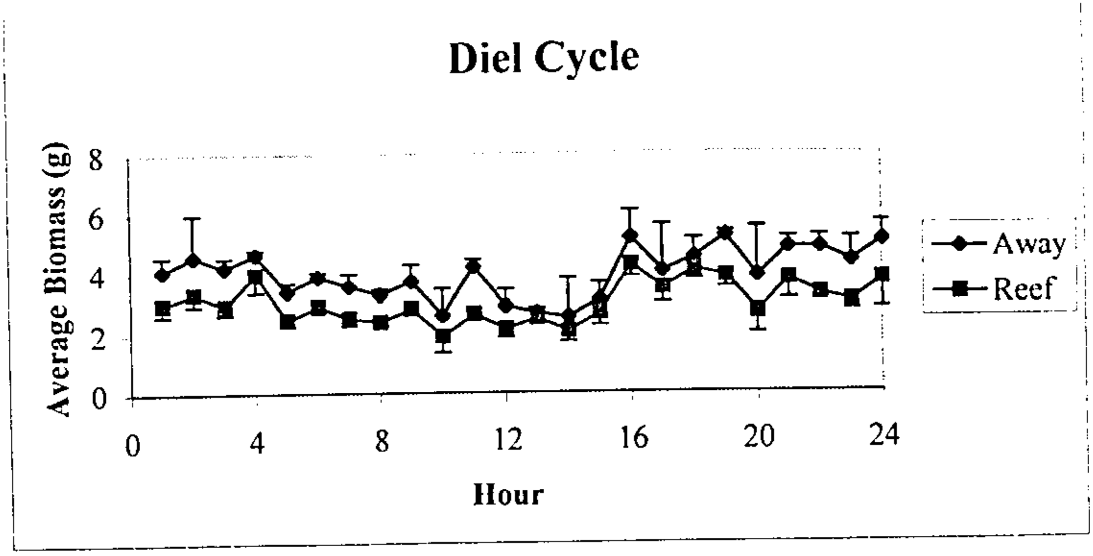

Figure 3.5.2 *Variation of Average Zooplankton Biomass With the Scale of Hourly Samples in All 24 hr Samples (Oct.20, Nov.3, Nov.17, Dec.2) 1999 in the Gulf of Aqaba.*

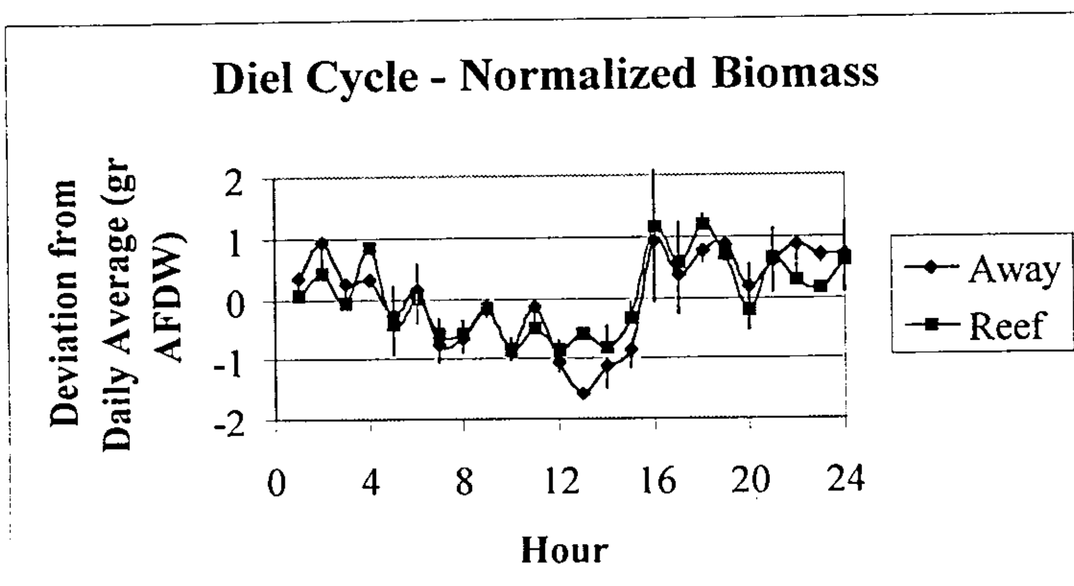

Figure 3.5.3 *Variation of Deviation from Daily Average Zooplankton Biomass With the scale of Hourly Samples in All 24 hr Samples (Oct.20, Nov.3, Nov.17, Dec.2) 1999 in the Gulf of Aqaba.*

6- The patchy distribution of zooplankton abundance and patchy distribution of phytoplankton concentration.

Result 3.6

Over the entire data set, the density of zooplankton (Fig. 3.6.1-3.6.4 and 3.6.5), but not its biomass, co-varied with chlorophyll concentrations (Fig. 3.6.6), although the R^2 value of this regression, even the zooplankton density (R^2=0.23), were relatively small. The apparent reason for the low R^2 values was the much higher variation of the zooplankton on the scale of days (Fig. 3.6.1-3.6.4).

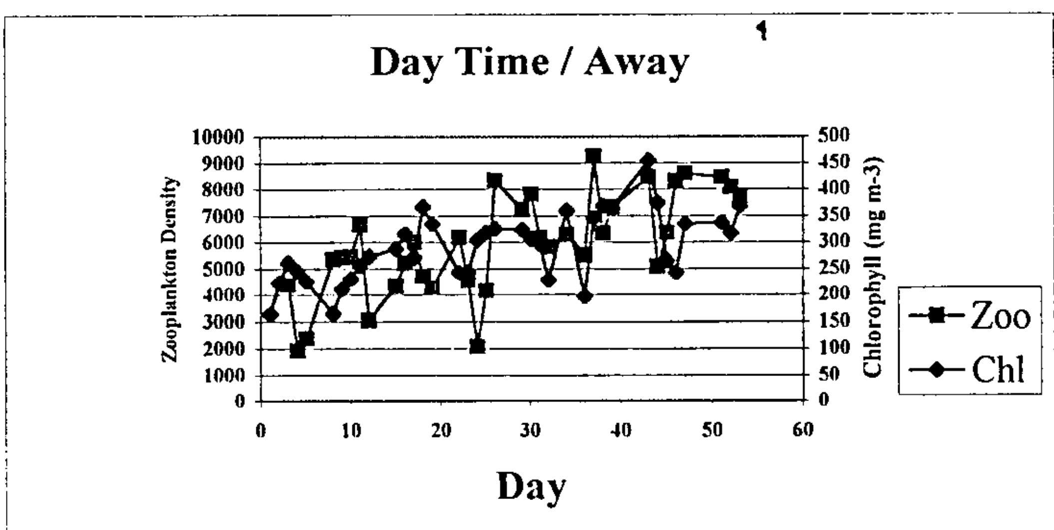

Figure 3.6.1 ***Abundance of Zooplankton Density With Chlorophyll Concentration Within Days in Day- Time in the Away sites- October 12 -December 2. 1999 in the Gulf of Aqaba.***

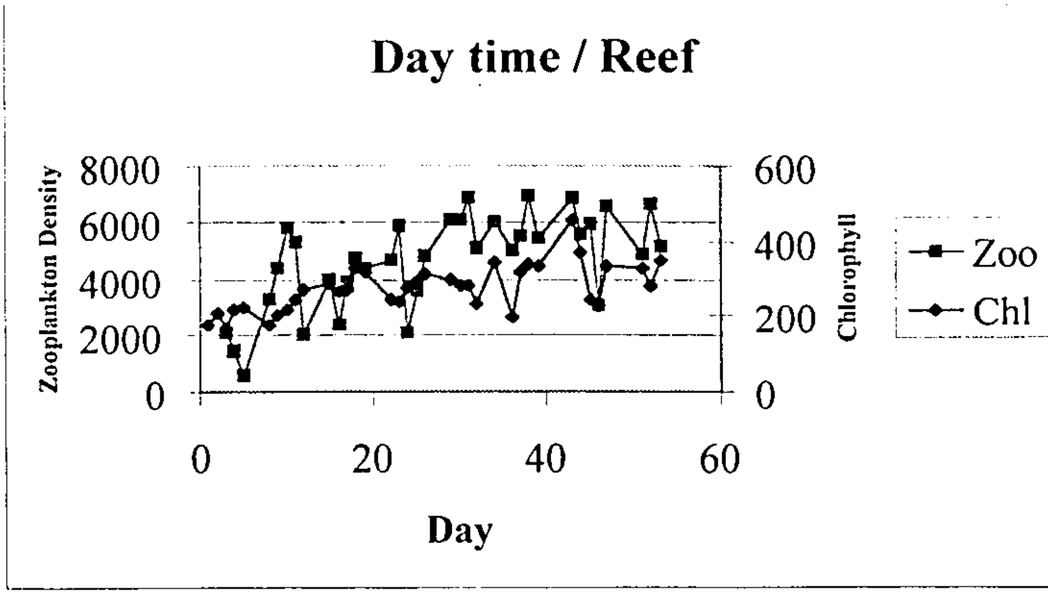

Fig. 3.6.2 *Abundance of Zooplankton Density With Chlorophyll Concentration Within Days in -October 12 - December 2. 1999 in the Gulf of Aqaba.; Day Time Reef.*

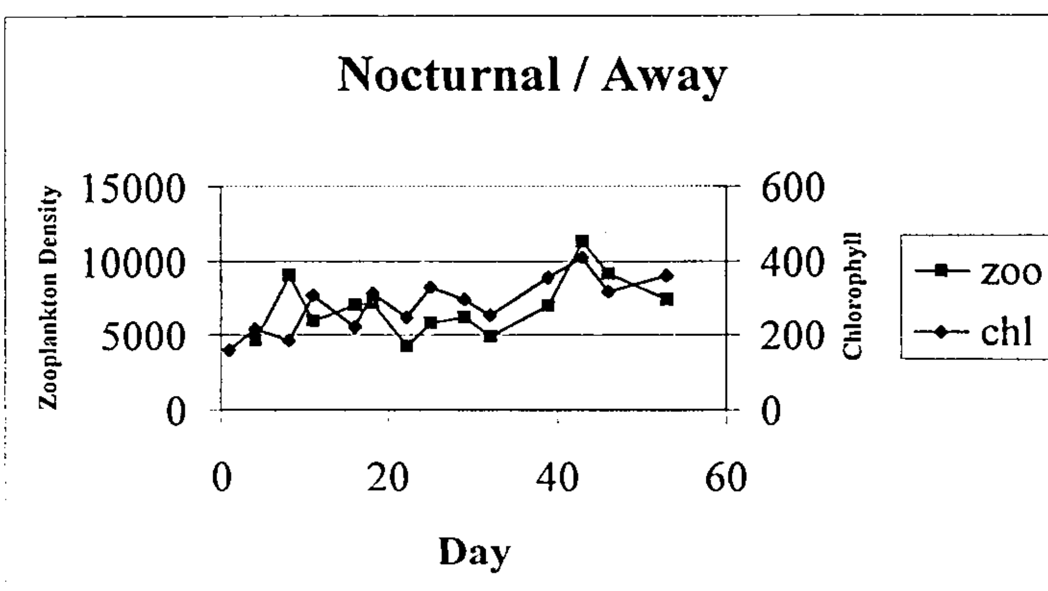

Figure 3.6.3 *:Abundance of Zooplankton Density With Chlorophyll Concentration Within Days in -October 12 - December 2. 1999 in the Gulf of Aqaba.: Nocturnal Away.*

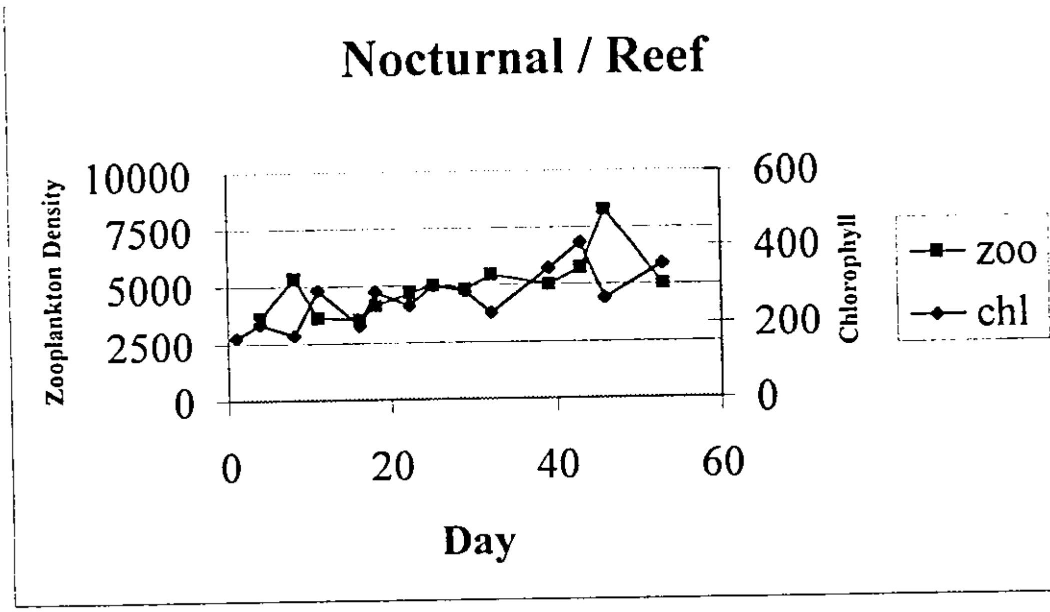

Figure 3.6.4 ***Abundance of Zooplankton Density With Chlorophyll Concentration Within Days -October 12 -December 2. 1999 in the Gulf of Aqaba. in Nocturnal Reef***

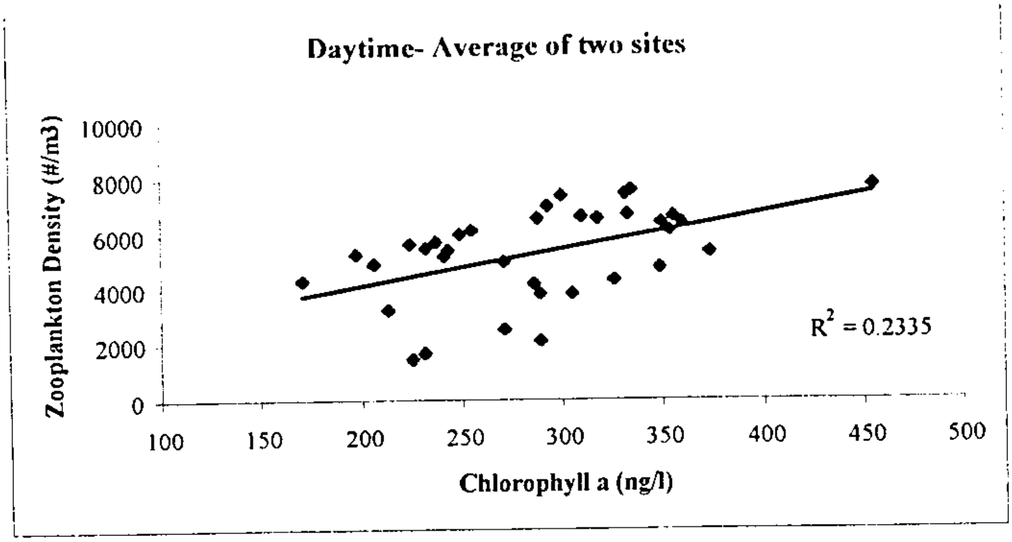

Figure 3.6.5 ***Variation of Zooplankton Density With Chlorophyll Concentration -October 12 -December 2. 1999 in the Gulf of Aqaba Through the Average of the Two Sites.***

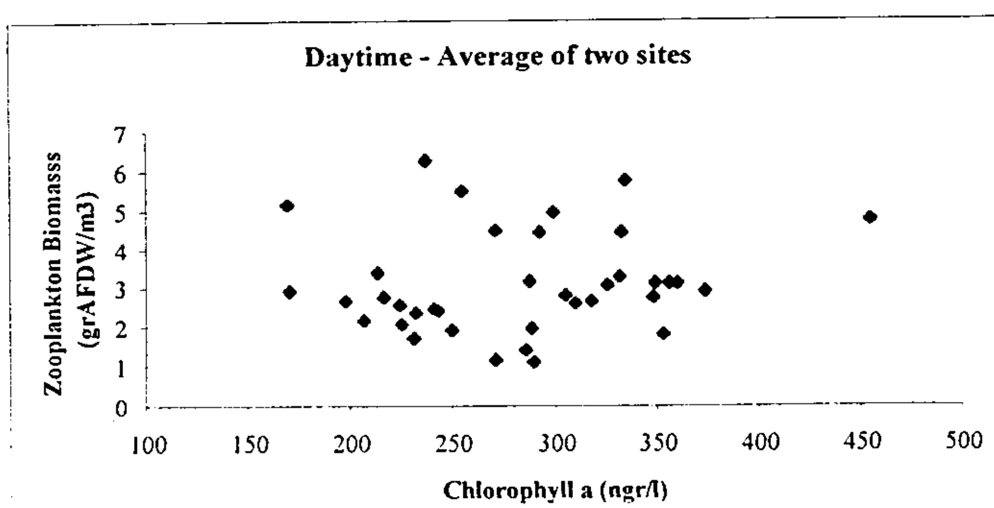

Figure 3.6.6 ***Variation of Zooplankton Biomass With Chlorophyll Concentration -October 10 and December 2. 1999 in the Gulf of Aqaba Through the Average of the Two Sites***

7- The roles of currents, behavior and localized predation of zooplankton in the generation of the observed variations

Result 3.7

The flow regime during our field study consisted of relatively medium-weak currents, with an average flow speed (scalar) of 9.7 and 5.3cm/s at the Away and Reef sites, respectively. Overall, the flow at the height of our pump at the Away site was in general to the north with a weak (0.8 cm/s) component of on-shore flow (Fig. 3.7.1). At the reef, the flow was directed straight off shore, at a net advection speed of about 1.8 cm/s.

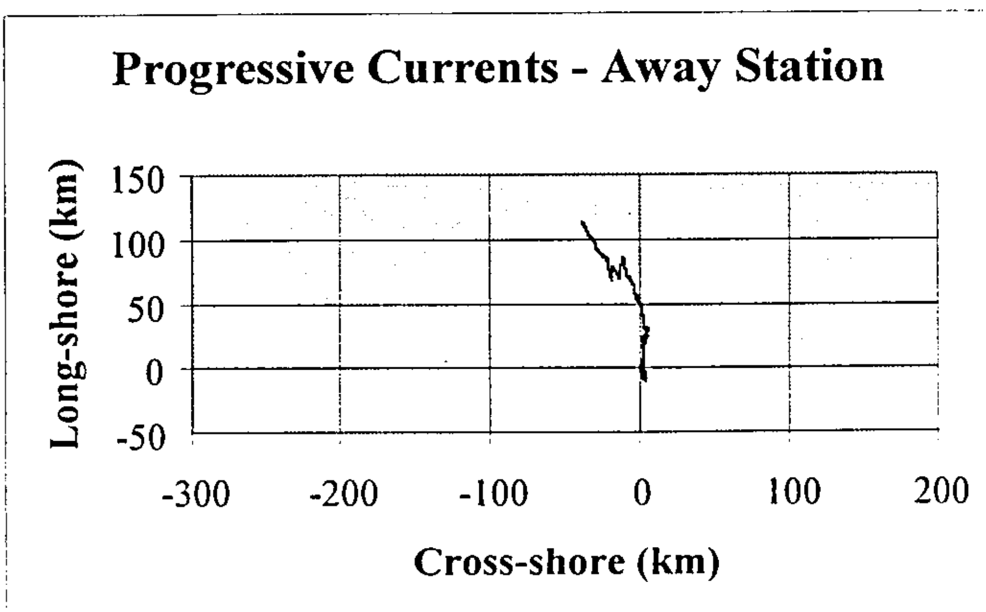

Figure 3.7.1 *Current Directions at 6.5 m Depth and 163 m off Shore at Open Water -10 October – 2 December in the Gulf of Aqaba*

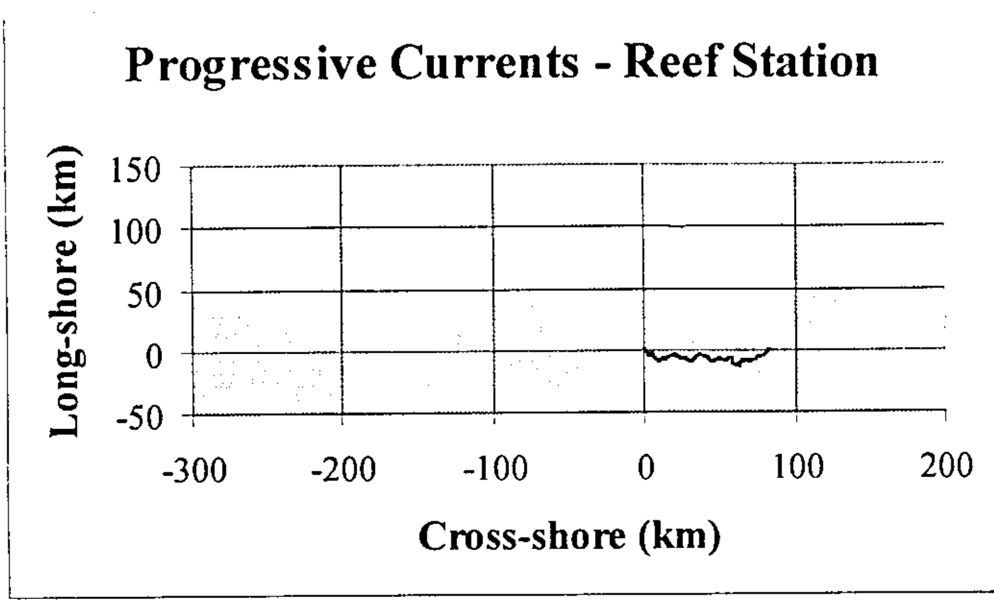

Figure 3.7.2 ***Current Directions at 8 m Depth and 40 m off Shore at Reef Site - 10 October 2-December in the Gulf of Aqaba .***

CHAPTER FOUR

DISCUSSION

1- The patchy distribution between the zooplankton biomass with zooplankton density starting from October 10 and December 2. 1999 in the Gulf of Aqaba in the Red Sea.

Discussion 4.1

As large zooplankters are encountered from time to time, we prefer to base our interpretations of temporal variations on direct counts, rather than the total animal biomass.

2- The percentages of zooplankton taxa in the counted samples at the two different sites day and night.

Discussion 4.2

Crustaceans usually comprise the majority of zooplankton in net collection community (supported by Lalli and Parsons, 1993) because most are too small to avoid capture and because their hard skeletons protect them from damage and distortion in net and preservatives.

3- The abundance of zooplankton in the open water and reef site starting from October 10 and December 2. 1999 in the Gulf of Aqaba in the Red Sea.

Discussion 4.3

Finding (in Fig 3.3.1-3.3.8 and in Fig. 3.3.9-3.3.10), that the abundance of zooplankton are gradually increase in water column and reef site starting from October 10 and December 2. 1999 was supported by Genin et al., 1995 in which this increase was coincided with the ensuing(effect) fall mixing and seasonal eutrophication(nutrients) in the northern Gulf of Aqaba. This seasonal change in overall abundance was due primarily to the increase of adult copepods.

4- The zooplankton abundance at the reef and open water, both in terms of density and biomass. (To test the hypothesis that zooplankton abundance is lower (decrease)near the reef than open water).

Discussion 4.4

The results clearly show that zooplankton were significantly less abundant at the reef, compared with the Away site, located only 130 m seaward. Together with the current-meter data, this inter-site difference of planktonic abundance can be best interpreted in terms of intense phytoplankton grazing and zooplankton predation at the reef. As described by Genin et al. (1998).

5- The short-term variations of zooplankton biomass with the scale of hourly samples within a day in all 24 hour sample

Discussion 4.5

In diel cycles (Fig. 3.5.1 and 3.5.2– 3.5.3), it shows that the biomass added by the emergence of demersal zooplankton to the water column over the reef leads to about twice the night time over the day-time varies with high-temporal and spatial variations, this is supported by Alldredg and King (1977), Roman,et al., (1990).

6- The patchy distribution of zooplankton abundance and patchy distribution of phytoplankton concentration.

Discussion 4.6

There is no correlation (Fig.3.6.6) found between the concentration of phytoplankton and zooplankton biomass which is consisted with Mackas & Boyed (1979), which is due to the spatial variation in grazing stress.

The temporal variations of zooplankton at the coral reef and away from it were much higher than those of phytoplankton, on each temporal scale examined (Supported by Mackas & Boyed 1979). The zooplankton's CV values were twice as high as those of the phytoplankton for the entire 54 day long series (CV values for phytoplankton is 18.1%), and nearly 3 times higher for the diel series (CV values for phytoplankton are 6.9% and 7.6% for the away and Reef sites, respectively) . Overall, the shorter-term variations (scale of a day or less) of phytoplankton were surprisingly low, indicating a highly predictable regime on this temporal scale.

7- The roles of currents, behavior and localized predation of zooplankton in the generation of the observed variations.

Discussion 4.7

Our current measurements show the prevalence of a typical circulation for the west coast of the Gulf, where the surface water is moving with a shore-ward component, generating downwelling along the coast with a strong return, off-shoreward flow at the reef just above the bottom. Thus, open waters, rich with zooplankton is advected on to the reef at the upper layers of the water column. This water replenishes food for the benthic grazers and predators at the reef, causing the return waters to be relatively depleted of plankton. A clear correlation was found between the concentration of chlorophyll at the reef and the cross-shore component of the current: the stronger the on shore flow the higher was the chlorophyll concentration (Fig.4.7.1). No such relationships with the flow were found for zooplankton, suggesting that animal behavior, primarily active swimming in the vertical, may over dominate passive advection. Phytoplankton seems to better follow the paths of water flow.

The local distribution of planktivorous fish changed according to the direction of currents. Zooplankton occured in higher densities off shore of the reef than at the sites near the reef where the fish were abundant. Reduction in plankton density over coral reefs has been attributted to corals over horizontal structures(Glynn 1973) (Johannes&Gerber 1974) and fish on vertical drop offs (Hobson&Chess 1978).

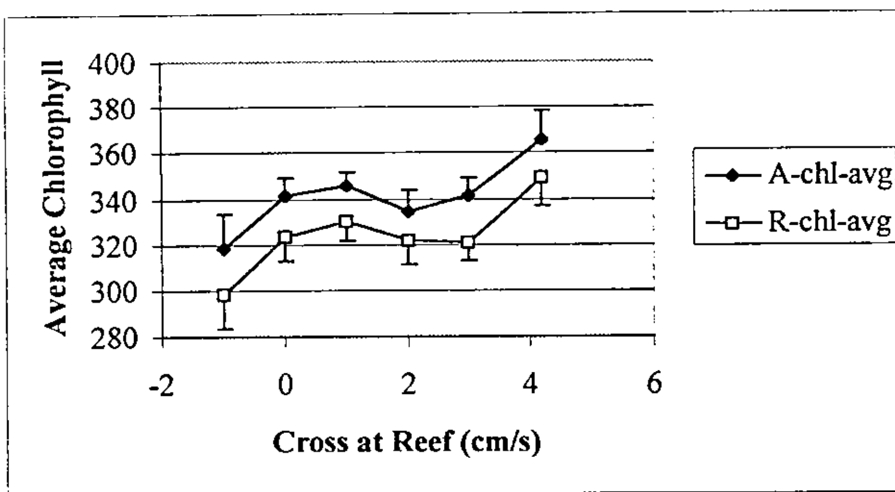

Figure 4.7.1 ***Relation Between the Average Concentration of Chlorophyll at the Reef and the Cross Component of the Current -10 October – 2 December in the Gulf of Aqaba***

Study Limitation

The traditional methods were used provide information on the distribution (abundance) and body size, but not behavior of zooplankton. The study of behavior of zooplankton need a new high technology known **FTV 3 D sonar.** This system allows both accurate 3-D localization of individual zooplankters, as well as tracking their motion (and, thus, their behavior) to investigate the process involved in the coupling between the open water and coastal habitate.

Future Suggestions

To take more samples in all the year to study the short terme variation of zooplankton in different seasons.

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Appendix (1) Showing g the sampling schedule For the Zooplankton starting From 10 October - 2 December 1999 in the Gulf of Aqaba in the Red Sea

		day-tim	night	24hrs
Day	Zoo	Daily	Day-Night	Diel
1	4	1	2	
2	2	1		
3	2	1		
4	4	1	2	
5	2	1		
8	4	1	2	
9	2	1		
10	2	1		
11	26	1	2	3
12	8	1		
15	2	1		
16	4	1	2	
17	2	1		
18	4	1	2	
19	2	1		
22	4	1	2	
23	2	1		
24	2	1		
25	24	1	2	3
26	12			
29	4	1	2	
30	2	1		
31	2	1		
32	4	1	2	
34	2	1		
36	2	1		
37	2	1		
38	2	1		
39	22	1	2	3
40	12			
43	4	1	2	
44	2	1		
45	2	1		
46	4	1	2	
47	2	1		
50	2	1		
51	2	1		
52	2	1		
53	22	1	2	3
54	12			

Appendix (2): Analysis of Coefficient Variation (CV) and Average for total zooplankton Biomass Data (day , night and 24 hr. diel cycles at the Reef and Open Water in the Northern part of Aqaba in Red Sea starting From 10 October - 2 December 1999

1	2	3	4	5	6	7	8	9	10
Date	Day	Period	counted-aliquote	Time 1	Time 2	Site	Filling T	Sample #	W.B.D
10/10/99	1	day	y	10:06	11:06	O.W	59	14	1.07692
10/10/99	1	night	y	20:04	21:04	O.W	58	16	1.09232
11/10/99	2	day	y	10:30	11:30	O.W	58	18	1.0817
12/10/99	3	day	y	10:04	11:04	O.W	60	45	1.0757
13/10/99	4	day	y	10:20	11:20	O.W	58	54	1.0799
13/10/99	4	night	y	19:45	20:45	O.W	60	47	1.0829
14/10/99	5	day	y	09:55	10:55	O.W	58	48	1.08679
17/10/99	8	day	y	11:04	12:12	O.W	59	44	1.11744
17/10/99	8	night	y	19:37	20:37	O.W	61	46	1.08888
18/10/99	9	day	y	09:26	10:29	O.W	59	50	1.08317
19/10/99	10	day	y	09:58	11:00	O.W	61	22	1.07594
20/10/99	11	05:00		05:19	06:22	O.W	62	27	1.08709
20/10/99	11	06:00		06:45	07:45	O.W	63	63	1.08704
20/10/99	11	08:00		08:00	9.07	O.W	63	25	1.08382
20/10/99	11	09:00	y	09:24	10:32	O.W	64	21	2.17538
20/10/99	11	11:00		10:55	12:08	O.W	63	64	1.09896
20/10/99	11	12:00		12:21	13:30	O.W	64	37	1.11306
20/10/99	11	14:00		14:00	15:08	O.W	63	7	1.08858
20/10/99	11	15:00		15:30	16:45	O.W	63	5	1.08777

Continued Appendix (2)

11	12	13	14	15.0000	16.0000
W.A.D	W.A.B	AFDW	vol.sampled	Biomass	Corrected for aliquote
1.18809	1.13593	0.05216	8.237288136	6.3322	7.0685
1.17872	1.13853	0.04019	8.379310345	4.7963	5.3541
1.16195	1.13124	0.03071	8.379310345	3.6650	4.0911
1.1598	1.12727	0.03253	8.1	4.0160	4.4830
1.12574	1.10897	0.01677	8.379310345	2.0014	2.2341
1.18008	1.14492	0.03516	8.1	4.3407	4.8455
1.1325	1.11365	0.01885	8.379310345	2.2496	2.5112
1.1812	1.15578	0.02542	9.33559322	2.7229	3.0395
1.17279	1.13548	0.03731	7.967213115	4.6829	5.2275
1.14592	1.12071	0.02521	8.649152542	2.9147	3.2537
1.13586	1.11337	0.02249	8.232786885	2.7318	3.0494
1.12726	1.10163	0.02563	8.230645161	3.1140	3.1140
1.15453	1.12399	0.03054	7.714285714	3.9589	3.9589
1.14023	1.11686	0.02337	8.614	2.7130	2.7130
2.22239	2.20233	0.02006	8.60625	2.3309	2.6019
1.12893	1.11279	0.01614	9.385714286	1.7196	1.7196
1.13571	1.12323	0.01248	8.7328125	1.4291	1.4291
1.11822	1.10718	0.01104	8.742857143	1.2627	1.2627
1.12586	1.10985	0.01601	9.642857143	1.6603	1.6603

Continued Appendix (2)

Date	Day	Period	counted-aliquote	Time 1	Time 2	Site	Filling T	Sample #	W.B.D
1	2	3	4	5	6	7	8	9	10
Date	Day	Period	Counted-aliquote	Time 1	Time 2	Site	Filling T	Sample #	W.B.D
01/12/99	53	23:00		23:30	24:30:00	O.W	65	19	1.09058
01/12/99	53	23:00		23:30	24:35:00	R.W	61	43	1.07986
02/12/99	54	24:00:00		0:55:00	01:55	O.W	65	7	1.0893
02/12/99	54	24:00:00		0:55:00	02:00	R.W	61	18	1.0816
02/12/99	54	02:00		02:05	03:00	O.W	64	29	1.08691
02/12/99	54	02:00		02:05	03:05	R.W	61	58	1.08936
02/12/99	54	03:00		03:15	04:15	O.W	64	5	1.08882
02/12/99	54	03:00		03:15	04:22	R.W	61	10	1.08229
02/12/99	54	04:00		04:40	05:40	O.W	64	2	1.08443
02/12/99	54	04:00		04:40	05:46	R.W	61	13	1.09035
02/12/99	54	05:00		05:50	06:50	O.W	66	9	1.08012
02/12/99	54	05:00		05:50	06:59	R.W	62	32	1.0864
02/12/99	54	07:00	y	07:00	07:55	O.W	66	55	1.08911
02/12/99	54	07:00	y	07:00	07:58	R.W	62	39	1.08469

Continued Appendix (2)

W.A.D	W.A.B	AFDW	vol.sampled	Biomass	Corrected for aliquote
11	**12**	**13**	**14**	**15**	
W.A.D	**W.A.B**	**AFDW**	**vol.sampled**	**Biomass**	
1.17764	1.13923	0.03841	7.476923077	5.1371	5.1371
1.1596	1.13135	0.02825	8.631147541	3.2730	3.2730
1.16963	1.13451	0.03512	7.476923077	4.6971	4.6971
1.16172	1.13635	0.02537	8.631147541	2.9394	2.9394
1.17645	1.13492	0.04153	6.9609375	5.9662	5.9662
1.17854	1.14948	0.02906	7.967213115	3.6474	3.6474
1.1724	1.1395	0.0329	7.59375	4.3325	4.3325
1.17015	1.13873	0.03142	8.896721311	3.5316	3.5316
1.1647	1.12797	0.03673	7.59375	4.8369	4.8369
1.1947	1.14956	0.04514	8.763934426	5.1507	5.1507
1.14346	1.11652	0.02694	7.363636364	3.6585	3.6585
1.15284	1.12914	0.0237	9.014516129	2.6291	2.6291
1.14902	1.12291	0.02611	6.75	3.8681	4.3179
1.14158	1.12382	0.01776	7.577419355	2.3438	2.6163
				CV:	0.4148
				min	1.1617
				max	10.4708
				average	3.6759
				count	222.0000

1	2	3	4	5	6
date	location	filling t	time 1	time 2	Period
12/10/99	O.W	60	10:00	11:00	D
13/10/99	O.W	58	10:21	11:30	D
14/10/99	O.W	58	09:55	10:55	D
17/10/99	O.W	59	11:04	12:12	D
18/10/99	O.W	59	09:26	10:27	D
19/10/99	O.W	61	09:58	11:00	D
20/10/99	O.W	64	09:24	10:32	D
21/10/99	O.W	62	10:00	11:00	D
24/10/99	O.W	59	10:00	11:00	D
25/10/99	O.W	63	10:00	11:00	D
26/10/99	O.W	63	10:10	11:10	D
27/10/99	O.W	63	10:20	11:18	D
28/10/99	O.W	63	10:00	11:01	D
31/10/99	O.W	63	10:15	11:15	D
01/11/99	O.W	63	10:30	11:30	D
02/11/99	O.W	64	10:30	11:30	D
03/11/99	O.W	64	10:00	11:00	D
04/11/99	O.W	63	08:45	09:45	D
07/11/99	O.W	63	10:40	11:40	D
08/11/99	O.W	64	10:00	11:00	D
09/11/99	O.W	63	09:54	10:55	D
10/11/99	O.W	62	10:05	11:05	D
12/11/99	O.W	61	09:50	10:50	D
14/11/99	O.W	61	10:15	11:15	D
15/11/99	O.W	61	12:20	13:20	D

7	8	9	[illegible]	[illegible]	12	[illegible]
	Number	Dilution	[illegible]			
volume	aliquotes:	factor	[illegible]	[illegible]	[illegible]	[illegible]
8.1	4	115.2	[illegible]	[illegible]	[illegible]	[illegible]
9.6362069	8	57.6	[illegible]	[illegible]	[illegible]	[illegible]
8.3793103	5	92.16	[illegible]	[illegible]	[illegible]	[illegible]
9.3355932	4	115.2	[illegible]	[illegible]	[illegible]	[illegible]
8.3745763	5	92.16	[illegible]	[illegible]	[illegible]	[illegible]
8.2327869	5	92.16	[illegible]	[illegible]	[illegible]	[illegible]
8.60625	6	76.8	[illegible]	[illegible]	[illegible]	[illegible]
7.8387097	8	57.6	[illegible]	[illegible]	[illegible]	[illegible]
8.2372881	8	57.6	[illegible]	[illegible]	[illegible]	[illegible]
7.7142857	8	57.6	[illegible]	[illegible]	[illegible]	[illegible]
7.7142857	4	115.2	[illegible]	[illegible]	[illegible]	[illegible]
7.4571429	7	65.82857	[illegible]	[illegible]	[illegible]	670.69655
7.8428571	6	76.8	1224.243716	1015.4	822.557377	607.12568
7.7142857	6	76.8	1762.177778	1466.47	1154.711111	886.04444
7.7142857	4	115.2	1938.8	1366.83	886	460.90333
7.59375	7	65.82857	5?7.4045502	450.777	372.757672	303.40741
7.59375	6	76.8	1112.493827	930.449	753.5185185	596.70123
7.7142857	5	92.16	2390.48	2090.67	1324.746667	1134.9333
7.7142857	6	76.8	[illegible]	[illegible]	[illegible]	[illegible]
7.59375	4	115.2	[illegible]	[illegible]	[illegible]	[illegible]
7.8428571	4	115.2	[illegible]	[illegible]	[illegible]	[illegible]
7.8387097	6	76.8	[illegible]	[illegible]	[illegible]	[illegible]
7.9672131	4	115.2	[illegible]	[illegible]	[illegible]	[illegible]
7.9672131	3	153.6	[illegible]		[illegible]	
7.9672131	2	230.4				[illegible]

[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
0	0	0	[illegible]
512	[illegible]	[illegible]	[illegible]
[illegible]	190.843906	0	[illegible]
[illegible]	283.666667	0	[illegible]
0	0	0	4554.666667
[illegible]	182.700529	69.380265	[illegible]
[illegible]	352.839506	60.908642	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	342.444444	0	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Appendix (3) Analysis of Coefficient Variation (CV) and Average for total zooplankton Density Data (day , night) at the Reef and Open Water in the Northern part of Aqaba in Red Sea starting From 12 October - 2 December 1999

1	2	3	4	5	6
date	location	filling t	time 1	time 2	Period
12/10/99	O.W	60	10:00	11:00	D
13/10/99	O.W	58	10:21	11:30	D
14/10/99	O.W	58	09:55	10:55	D
17/10/99	O.W	59	11:04	12:12	D
18/10/99	O.W	59	09:26	10:27	D
19/10/99	O.W	61	09:58	11:00	D
20/10/99	O.W	64	09:24	10:32	D
21/10/99	O.W	62	10:00	11:00	D
24/10/99	O.W	59	10:00	11:00	D
25/10/99	O.W	63	10:00	11:00	D
26/10/99	O.W	63	10:10	11:10	D
27/10/99	O.W	63	10:20	11:18	D
28/10/99	O.W	63	10:00	11:01	D
31/10/99	O.W	63	10:15	11:15	D
01/11/99	O.W	63	10:30	11:30	D
02/11/99	O.W	64	10:30	11:30	D
03/11/99	O.W	64	10:00	11:00	D
04/11/99	O.W	63	08:45	09:45	D
07/11/99	O.W	63	10:40	11:40	D
08/11/99	O.W	64	10:00	11:00	D
09/11/99	O.W	63	09:54	10:55	D
10/11/99	O.W	62	10:05	11:05	D
12/11/99	O.W	61	09:50	10:50	D
14/11/99	O.W	61	10:15	11:15	D
15/11/99	O.W	61	12:20	13:20	D

7	8	9	10	11	12	13
	Number	Dilution	Density per m^4			
volume	aliquotes:	factor	Cyc+Cal	Harpac	Nauplii	Molluscs
8.1	4	115.2	1436.444444	1123.56	810.6666667	497.77778
9.6362069	8	57.6	442.331723	376.58	322.7826087	274.96296
8.3793103	5	92.16	659.9111111	571.923	461.9377778	307.95852
9.3355932	4	115.2	1900.339869	1517.8	1048.888889	579.97386
8.3745763	5	92.16	1683.72459	1386.6	1023.440437	737.3173
8.2327869	5	92.16	1656.751254	1343.31	1063.455197	750.01577
8.60625	6	76.8	1811.520697	1534.88	1240.400871	936.99346
7.8387097	8	57.6	617.2444444	565.807	499.6740741	440.88889
8.2372881	8	57.6	1006.933333	874.074	748.2074074	615.34815
7.7142857	8	57.6	1149.866667	1015.47	888.5333333	746.66667
7.7142857	4	115.2	2404.266667	1806.93	1179.733333	597.33333
7.4571429	7	65.82857	1200.551724	997.517	838.6206897	670.89655
7.8428571	6	76.8	1224.043716	1018.4	822.557377	607.12568
7.7142857	6	76.8	1752.177778	1463.47	1184.711111	886.04444
7.7142857	4	115.2	1836.8	1358.93	896	462.93333
7.59375	7	65.82857	537.4645503	450.777	372.757672	303.40741
7.59375	6	76.8	1112.493827	930.449	758.5185185	596.70123
7.7142857	5	92.16	2580.48	2090.67	1624.746667	1134.9333
7.7142857	6	76.8	2040.888889	1712.36	1373.866667	1055.2889
7.59375	4	115.2	2912.711111	2214.87	1547.377778	819.2
7.8428571	4	115.2	2482.360656	1850.75	1204.459016	616.91803
7.8387097	6	76.8	1469.62963	1244.29	1038.538272	842.58765
7.9672131	4	115.2	2472.533333	1865.24	1286.874074	650.66667
7.9672131	3	153.6	2776.177778	1850.79	886.8345679	0
7.9672131	2	230.4	5725.866667	2949.69	115.6740741	115.67407

14	15	16	17
Append	Chaeto	Polychaet	Total
170.666667	170.666667	170.66667	4380.444444
221.165862	167.36876	119.54911	1924.740741
208.971852	87.9881481	87.988148	2386.678519
98.7189542	98.7189542	98.718954	5343.163399
416.179964	88.0378871	88.037887	5425.334791
414.187814	111.942652	111.94265	5451.607168
669.281046	374.797386	80.313725	6648.191721
374.755556	308.622222	257.18519	3064.177778
489.481481	370.607407	244.74074	4349.392593
604.8	477.866667	343.46667	5226.666667
0	0	0	5988.266667
512	344.275862	167.72414	4731.586207
421.071038	195.846995	0	4289.04918
587.377778	298.666667	0	6172.444444
0	0	0	4554.666667
216.719577	138.700529	69.350265	2089.17672
434.883951	252.839506	80.908642	4166.795062
633.173333	131.413333	131.41333	8326.826667
706.844444	348.444444	0	7237.688889
106.192593	106.192593	106.19259	7812.740741
0	0	0	6154.491803
627.041975	421.293827	166.55802	5809.935802
0	0	0	6275.318519
0	0	0	5513.797531
115.674074	115.674074	115.67407	9253.925926

date	location	filling t	time 1	time 2	Period
1	2	3	4	5	6
date	location	filling t	time 1	time 2	Period
13/10/99	R.W	59	19:50	20:50	N
17/10/99	R.W	60	19:38	20:39	N
20/10/99	R.W	59	20:30	21:30	N
25/10/99	R.W	60	20:20	21:30	N
27/10/99	R.W	60	19:35	20:38	N
31/10/99	R.W	60	19:45	20:45	N
03/11/99	R.W	61	19:45	20:47	N
07/11/99	R.W	62	18:15	19:17	N
10/11/99	R.W	59	18:05	19:10	N
17/11/99	R.W	60	19:30	20:41	N
21/11/99	R.W	59	19:30	20:37	N
24/11/99	R.W	59	18:07	18:55	N
28/11/99	R.W	60	19:13	20:06	N
01/12/99	R.W	60	19:00	20:08	N

	Number	Dilution	Density per m^4			
volume	aliquotes:	factor	Cyc+Cal	Harpac	Nauplii	Molluscs
7	8	9	10	11	12	13
	Number	Dilution	Density per m^4			
volume	aliquotes:	factor	Cyc+Cal	Harpac	Nauplii	Molluscs
8.2372881	8	57.6	769.1851852	678.281	594.3703704	510.45926
8.235	7	65.82857	1151.100703	1047.18	903.2943013	759.40671
8.2372881	9	51.2	745.8765432	671.289	596.7012346	528.32922
9.45	9	51.2	666.4126984	612.233	558.0529101	498.45503
8.505	8	57.6	954.9206349	826.243	704.3386243	589.20635
8.1	8	57.6	1024	910.222	789.3333333	661.33333
8.2327869	6	76.8	1408.611708	1184.73	960.8410992	718.29869
8.1	8	57.6	1095.111111	960	832	689.77778
8.9237288	9	51.2	1061.439696	969.64	877.8393162	786.03913
9.585	6	76.8	1442.253521	1185.85	945.4773083	697.0892
9.1983051	4	115.2	2241.804312	1703.27	1139.688226	613.67828
6.5898305	4	115.2	3111.703704	2377.48	1643.259259	874.07407
7.155	4	115.2	2753.207547	2189.69	1642.264151	1046.5409
9.18	4	115.2	1995.294118	1505.88	1003.921569	527.05882

Append	Chaeto	Polychaet	Total
14	15		
Append	**Chaeto**		
419.555556	328.651852	258.72593	3559.22963
623.512881	495.612802	375.70648	5355.815769
441.310288	354.291358	285.91934	3623.716872
449.693122	390.095238	330.49735	3505.439153
467.301587	358.941799	243.80952	4144.761905
540.444444	412.444444	277.33333	4615.111111
485.084827	270.528076	9.3285544	5037.419355
561.777778	426.666667	284.44444	4849.777778
688.501425	579.488699	470.47597	5433.423742
472.738654	232.363067	0	4975.774648
0	0	0	5698.441128
87.4074074	87.4074074	87.407407	8268.740741
418.616352	418.616352	418.61635	8887.54717
0	0	0	5032.156863
		average	5629.835826
		min	549.4518519
		max	11286.75556
		stdev	2008.715899
		CV	0.356798308
		N	102

Appendix (4)) Analysis of Coefficient Variation (CV) for zooplankton biomass during the day (day-time samples throughout our 54 - day long series) and nocturnal samples at the Away and Reef sites in the Northern part of Aqaba in Red Sea starting From 10 October - 2 December 1999

(Corrected for aliquote)			Biomass	Biomass
Date	Day	Period	**OW**	**Reef**
Date Time	Day		Away	Reef
10/10/99	1	day	7.0684871	4.45483
11/10/99	2	day	4.0911432	2.082965
12/10/99	3	day	4.4830356	3.013864
13/10/99	4	day	2.2340759	1.571061
14/10/99	5	day	2.5111706	2.119623
17/10/99	8	day	3.0395324	3.494324
18/10/99	9	day	3.253662	1.627255
19/10/99	10	day	3.0494093	2.642885
20/10/99	11	day	2.6018971	3.175239
21/10/99	12	day	1.3984278	1.161666
24/10/99	15	day	1.7393296	1.363828
25/10/99	16	day	1.2777272	1.207604
26/10/99	17	day	5.7664131	4.256773
27/10/99	18	day	2.8920634	3.341621
27/10/99	19	day	4.1062431	2.722016
31/10/99	22	day	3.3296152	2.116707
01/11/99	23	day	2.9418112	2.544694
02/11/99	24	day	2.2946674	2.133606
03/11/99	25	day	3.4574361	2.415744
04/11/99	26	day	3.4873414	2.490269
07/11/99	29	day	3.1197959	2.735353
08/11/99	30	day	5.5257238	4.393458
09/11/99	31	day	4.1560589	2.911591
10/11/99	32	day	2.8125203	2.473998
12/11/99	34	day	2.0455946	2.020926
14/11/99	36	day	3.3808354	2.565308
15/11/99	37	day	4.7553069	2.505842
16/11/99	38	day	3.5379874	3.416857
17/11/99	39	day	4.429105	2.762523
21/11/99	43	day	5.5359219	5.020307
22/11/99	44	day	3.3633562	3.130494
23/11/99	45	day	7.3823317	4.833932
24/11/99	46	day	10.470798	3.431527
25/11/99	47	day	8.0523252	4.721359
29/11/99	51	day	5.5404238	4.310245
30/11/99	[illegible]	day	6.1716411	4.822591
01/12/99	[illegible]	day	4.5962	2.7467
			0.4825089	0.362848

Date Time	Day		Away	Reef
10/10/99	1	day	7.0684871	4.45483
(Corrected for aliquote)			Biomass	Biomass
Date	Day	Period	**OW**	**Reef**
Date Time	Day		Away	Reef
Night Time:	Day		Away	Reef
10/10/99	1	night	5.3540556	4.617609
13/10/99	4	night	4.8454821	3.28354
17/10/99	8	night	5.2274749	4.076083
20/10/99	11	night	2.1860582	1.986772
25/10/99	16	night	4.8539346	3.14094
27/10/99	18	night	5.5353247	3.461059
31/10/99	22	night	3.6216236	3.475627
03/11/99	25	night	5.2924	4.2304
07/11/99	29	night	7.523107	4.363139
10/11/99	32	night	2.8535424	3.723965
17/11/99	39	night	5.4032	3.1083
21/11/99	43	night	7.9379911	7.991541
24/11/99	46	night	10.080008	7.79214
28/11/99	50	night	8.5247905	5.497933
01/12/99	53	night	5.4802	4.6205
	cv:		0.3736309	0.379697

Appendix (5): Analysis of Coefficient Variation (CV) of zooplnkton biomass for the single sampling days (N=4 single days, each consists of 16 - 17 samples for each sites

1	2	3	4	5	6	7	8	9	10	11	12	13
				Biomass	Biomass				11/12	11/12	25/26	25/26
Date	Day	Hour	DecDay	Away	Reef	CV		Hour	Away	Reef	Away	Reef
20/10/99	11	05:19	11.22	3.113972	2.264268	0.328493	0.314576	1	3.289787	3.094465	4 041481	2 30199
20/10/99	11	06:45	11.28	3.958889	3.012915			2	3.162545	2.935432		
20/10/99	11	08:00	11.33	2.713025	2.17679			3	3.494636	2.548034	3.896626	2 39316
20/10/99	11	09:24	11.39	2.330864	2.844482			4			4 376068	3.16508
20/10/99	11	10:55	11.45	1.719635	1.374353			5	3.113972	2.264268		
20/10/99	11	12:21	11.51	1.429093	1.495818			6	3.958889	3.012915	4.053333	2.8604
20/10/99	11	14:00	11.58	1.262745	1.713745			7			2.980185	2.06496
20/10/99	11	15:30	11.65	1.660296	1.731817			8	2.713025	2.17679	3.327737	2.62011
20/10/99	11	17:10	11.72	2.464056	2.982403			9	2.6019	3.1752		
20/10/99	11	18:48	11.78	3.198748	4.434608			10	1.719635	1.374353	3.4574	2.4157
20/10/99	11	20:30	11.85	1.958342	1.779815			11			4.688066	2.66593
20/10/99	11	22:05	11.92	3.891573	2.923457			12	1.429093	1.495818	2.848395	1.90325
20/10/99	11	23:40	11.99	3.543967	2.738426			13			2.456481	2 31425
21/10/99	12	01:06	12.05	3.289787	3.094465			14	1.262745	1.713745		
21/10/99	12	02:30	12.10	3.162545	2.935432			15	1.660296	1.731817	2.972131	2 41004
21/10/99	12	03:36	12.15	3.494636	2.548034			16			6.040741	4 62102
								17	2.464056	2.982403		
03/11/99	25	08:40	25.36	3.327737	2.620106	0.243999	0.293068	18	3.198748	4.434608	5.178348	4 34228
03/11/99	25	10:00	25.42	3.097284	2.164103			19			5.2924	4.2304
03/11/99	25	11:17	25.47	4.688066	2.665926			20	2.1861	1.9868		
03/11/99	25	12:35	25.52	2.848395	1.903255			21			5.163889	4 35863

Continued Appendix (5)

14	15	16	17	18	19	20	21
39/40	**39/40**	**53/54**	**53/54**	**Avg**	**Avg**	**Stdev**	**Stdev**
Away	**Reef**	**Away**	**Reef**	**Away**	**Reef**	**Away**	**Reef**
4.896111111	3.485971			4.075793	2.96081	0.464023	0.348257
		5.96615	3.64745	4.564348	3.29144	1.401803	0.356008
5.017962963	3.144781	4.33251	3.53164	4.185434	2.904404	0.326005	0.264508
4.699074074	3.561986	4.836872	5.15065	4.637338	3.95924	0.136557	0.606626
		3.658519	2.62909	3.386245	2.44668	0.272273	0.182412
3.607592593	2.79528			3.873272	2.889531	0.135608	0.064493
3.364242424	2.847922	4.3179	2.6163	3.554109	2.509726	0.397663	0.232219
3.501563786	2.254131	3.494979	2.4826	3.259326	2.383408	0.186489	0.102172
4.4291	2.7625	4.1175	2.4606	3.716167	2.799433	0.564348	0.207112
				2.588517	1.895026	0.868883	0.520674
3.858436214	2.648547	4.017778	2.57822	4.188093	2.630898	0.254183	0.026812
3.24345679	2.376277	3.988807	2.70978	2.877438	2.121284	0.537561	0.266161
2.819423868	2.65			2.637953	2.482127	0.181471	
		3.792593	2.38608	2.527669	2.049914	1.264924	0.336169
3.105925926	2.900285	4.506135	3.49486	3.061122	2.634249	0.581686	0.373728
4.264814815	3.823107			5.152778	4.222065	0.887963	0.398959
		5.565103	3.91708	4.01458	3.449742	1.550523	0.467339
5.02962963	3.426781			4.468908	4.067888	0.63653	0.32166
5.4032	3.1083	4.9093	4.1392	5.201633	3.825967	0.149625	0.359798
		5.492901	3.34741	3.839501	2.667107	1.653401	0.680307
4.437222222	3.08642			4.800556	3.722526	0.363333	0.636106

Continued Appendix (5)

1	2	3	4	5	6			9	10	11	12	13
				Biomass	Biomass				11/12	11/12	25/26	25/26
Date	Day	Hour	DecDay	Away	Reef			Hour	Away	Reef	Away	Reef
								2-hrs normalized:				
01/12/99	53	08:25	53.35	3.494979	2.482604	0.165026	0.236494	1.5	0.49548	0.478165	-0.045937	-0.68416
01/12/99	53	09:55	53.41	3.68856	2.204265			3.5	0.763951	0.011251	0.048928	-0.20703
01/12/99	53	11:30	53.48	4.017778	2.57822			5.5	0.805745	0.101809	-0.034085	-0.12575
01/12/99	53	12:59	53.54	3.988807	2.709784			7.5	-0.01766	-0.359993	-0.933458	-0.64362
01/12/99	53	14:30	53.60	3.792593	2.386083			9.5	-0.569918	-0.262007	-0.630019	-0.57045
01/12/99	53	15:55	53.66	4.506135	3.494856			11.5	-1.301593	-1.040965	-0.319188	-0.70156
01/12/99	53	17:30	53.73	5.565103	3.917081			13.5	-1.46794	-0.823038	-1.630937	-0.6719
01/12/99	53	19:00	53.79	4.397949	3.708061			15.5	-1.070389	-0.804967	0.419017	0.52938
01/12/99	53	20:30	53.85	5.492901	3.347415			17.5	0.100717	1.171722	1.090929	1.35612
01/12/99	53	22:00	53.92	4.8857	3.217417			19.5	-0.544585	-0.549983	1.204981	1.24425
01/12/99	53	23:30	53.98	5.13714	3.273029			21.5	1.160887	0.386674	0.787859	0.91651
02/12/99	54	0:55:00	54.04	4.697119	2.939354			23.5	0.813282	0.201643	0.03875	-0.33544
02/12/99	54	02:05	54.09	5.96615	3.647449							
02/12/99	54	03:15	54.14	4.33251	3.531638							
02/12/99	54	04:40	54.19	4.836872	5.150655							
02/12/99	54	05:50	54.24	3.658519	2.629093							
02/12/99	54	07:00	54.29	3.868148	2.343806							
					avg CV	0.241372	0.272655					

Continued Appendix (5)

14	15	16	17	18	19	20	21
39/40	39/40	53/54	53/54	Avg	Avg	Stdev	Stdev
Away	Reef	Away	Reef	Away	Reef	Away	Reef
				Away	Reef	Away	Reef
0.553874873	0.321109	1.394562	0.44034	0.599495	0.138865	0.297435	0.276375
0.51628228	0.188522	0.013103	1.13404	0.335566	0.281696	0.183102	0.295405
-0.734643646	-0.369582	-0.91307	-0.57801	-0.219013	-0.242885	0.390717	0.147449
-0.909333133	-0.613835	-0.665149	-0.65765	-0.6314	-0.568776	0.213366	0.070191
0.086863761	-0.402362	-0.454089	-0.7465	-0.39179	-0.495332	0.163675	0.104807
-0.791289737	-0.65245	-0.568296	-0.5631	-0.745092	-0.73952	0.209061	0.104488
-1.52281237	-0.514862	-0.778996	-0.82102	-1.350171	-0.707705	0.193379	0.073379
-0.656865868	0.196834	-0.065454	0.28775	-0.343423	0.052249	0.327275	0.294227
0.687393391	0.261919	0.993514	0.70998	0.718138	0.874935	0.223039	0.245395
1.060963761	-0.056562	0.629512	0.5362	0.587718	0.293476	0.39674	0.386957
0.812485984	0.054555	0.314111	0.01031	0.768836	0.342012	0.173864	0.209105
1.925801179	2.413087	0.345541	-0.10091	0.780844	0.544594	0.413539	0.632457

Appendix (6) : Analysis of major categories of zooplankton density (N = 102) showing the percentage of copepds in the Away and Reef site

1	2	3	4	5	6	7	8	9	10	11
		Away	Away	Away	Away	Away	Away	Away	Total	% away
daily	day	Cyc+Cal	Harpac	Nauplii	Molluscs	Append	Chaeto	Polychaet	Away	Copepods
12/10/99	1	1436.444	1123.556	810.6667	497.7778	170.6667	170.6667	170.66667	4380.444	0.7694805
13/10/99	2	442.3317	376.5797	322.7826	274.963	221.1659	167.3688	119.54911	1924.741	0.5931677
13/10/99	2	1035.378	898.8444	819.2	659.9111	512	364.0889	364.08889	4653.511	0.591687
14/10/99	3	659.9111	571.923	461.9378	307.9585	208.9719	87.98815	87.988148	2386.679	0.7096774
17/10/99	6	1900.34	1517.804	1048.889	579.9739	98.71895	98.71895	98.718954	5343.163	0.8360277
17/10/99	6	2968.968	2294.202	1388.089	578.3704	578.3704	578.3704	578.37037	8964.741	0.7419355
18/10/99	7	1683.725	1386.597	1023.44	737.3173	418.18	88.03789	88.037887	5425.335	0.7545639
19/10/99	8	1656.751	1343.312	1063.455	750.0158	414.1878	111.9427	111.94265	5451.607	0.7453799
20/10/99	9	1811.521	1534.885	1240.401	936.9935	669.281	374.7974	80.313725	6648.192	0.6899329
20/10/99	9	1382.4	1214.171	1038.629	848.4571	665.6	497.3714	321.82857	5968.457	0.6090686
21/10/99	10	617.2444	565.8074	499.6741	440.8889	374.7556	308.6222	257.18519	3064.178	0.5491607
24/10/99	13	1006.933	874.0741	748.2074	615.3481	489.4815	370.6074	244.74074	4349.393	0.6045016
25/10/99	14	1149.867	1015.467	888.5333	746.6667	604.8	477.8667	343.46667	5226.667	0.5842857
25/10/99	14	1941.807	1601.991	1274.311	934.4948	631.0874	351.9526	351.95259	7087.597	0.6797945
26/10/99	15	2404.267	1806.933	1179.733	597.3333	0	0	0	5988.267	0.9002494
27/10/99	16	1200.552	997.5172	838.6207	670.8966	512	344.2759	167.72414	4731.586	0.641791
27/10/99	16	1998.696	1645.985	1293.274	975.8341	623.123	293.9259	293.92593	7124.764	0.6930693
28/10/99	17	1224.044	1018.404	822.5574	607.1257	421.071	195.847	0	4289.049	0.7146119
31/10/99	20	1752.178	1463.467	1184.711	886.0444	587.3778	298.6667	0	6172.444	0.7129032
31/10/99	20	1064.26	912.2227	768.1875	616.1504	456.1114	312.0762	160.03907	4289.047	0.6399254
1/11/99	21	1836.8	1358.933	896	462.9333	0	0	0	4554.667	0.8983607
2/11/99	22	537.4646	450.7767	372.7577	303.4074	216.7196	138.7005	69.350265	2089.177	0.6514523
3/11/99	23	1112.494	930.4494	758.5185	596.7012	434.884	252.8395	80.908642	4166.795	0.6723301
3/11/99	23	1939.818	1539.73	1163.891	775.9271	412.2113	0	0	5831.577	0.7962578
4/11/99	24	2580.48	2090.667	1624.747	1134.933	633.1733	131.4133	131.41333	8326.827	0.7560976

Continued Appendix (6)

12	13	14	15	16	17	18	19	20
Reef	Reef	Reef	Reef	Reef	Reef	Reef	Total	% reef
Cyc+Cal	Harpac	Nauplii	Molluscs	Append	Chaeto	Polychaet	Reef	Copepods
428.879	410.2321	372.9383	326.321	251.7333	186.4691	102.55802	2079.131	0.5829596
300.2469	275.2263	250.2058	210.1728	175.144	135.1111	100.0823	1446.189	0.5709343
769.1852	678.2815	594.3704	510.4593	419.5556	328.6519	258.72593	3559.23	0.5736739
108.0889	108.0889	108.0889	81.06667	63.05185	54.04444	27.022222	549.4519	0.5901639
653.037	604.9185	556.8	488.0593	426.1926	323.0815	226.84444	3278.933	0.5534591
1151.101	1047.182	903.2943	759.4067	623.5129	495.6128	375.70648	5355.816	0.5791045
1197.214	1035.887	840.597	645.3068	433.0348	220.7629	16.981758	4389.784	0.7001934
1398.89	1208.823	1026.359	843.8955	638.6237	440.9544	228.07988	5785.626	0.6281209
1238.688	1070.866	927.018	775.1788	607.3566	423.5513	247.73757	5290.396	0.6117825
745.8765	671.2889	596.7012	528.3292	441.3103	354.2914	285.91934	3623.717	0.5557461
446.8148	391.8222	343.7037	288.7111	226.8444	178.7259	130.60741	2007.23	0.5890411
896	784	679.4667	560	448	350.9333	231.46667	3949.867	0.5973535
521.7185	470.2815	404.1481	330.6667	257.1852	198.4	154.31111	2336.711	0.5974843
666.4127	612.2328	558.0529	498.455	449.6931	390.0952	330.49735	3505.439	0.5239567
900.4175	775.5421	657.2391	552.0808	453.4949	341.7643	223.46128	3904	0.5976431
1160.998	990.7181	828.1784	673.3787	526.319	363.7793	185.75964	4729.131	0.6301146
954.9206	826.2434	704.3386	589.2063	467.3016	358.9418	243.80952	4144.762	0.5996732
988.4444	867.5556	739.5556	632.8889	497.7778	376.8889	263.11111	4366.222	0.5944625
1029.729	919.6815	809.6341	691.7263	565.9578	408.7473	259.39735	4684.873	0.5889262
1024	910.2222	789.3333	661.3333	540.4444	412.4444	277.33333	4615.111	0.5901387
1557.823	1298.186	1049.367	822.1843	562.5472	281.2736	281.27359	5852.654	0.6672828
397.9114	354.3898	323.303	292.2162	248.6946	223.8251	186.52095	2026.861	0.5306748
774.5641	682.6667	597.3333	505.4359	413.5385	321.641	229.74359	3524.923	0.5828678
1408.612	1184.726	960.8411	718.2987	485.0848	270.5281	9.3285544	5037.419	0.7055556
1016.889	910.2222	803.5556	696.8889	583.1111	462.2222	341.33333	4814.222	0.5672083

Continued Appendix (6)

		Away	Away	Away	Away	Away	Away	Away	Total	% away
daily	day	Cyc+Cal	Harpac	Nauplii	Molluscs	Append	Chaeto	Polychaet	Away	Copepods
1	2	3	4	5	6	7	8	9	10	11
		Away	Away	Away	Away	Away	Away	Away	Total	% away
daily	day	Cyc+Cal	Harpac	Nauplii	Molluscs	Append	Chaeto	Polychaet	Away	Copepods
1/12/99	51	2982.728	2254.55	1512.369	742.1812	0	0	0	7491.829	0.9009346
2/12/99	52	3857.067	2884.267	1928.533	955.7333	0	0	0	9625.6	0.9007092

Continued Appendix (6)

Reef	Reef	Reef	Reef	Reef	Reef	Reef	Total	% reef
Cyc+Cal	Harpac	Nauplii	Molluscs	Append	Chaeto	Polychaet	Reef	Copepods
12	13	14	15	16	17	18	19	20
Reef	Reef	Reef	Reef	Reef	Reef	Reef	Total	% reef
Cyc+Cal	Harpac	Nauplii	Molluscs	Append	Chaeto	Polychaet	Reef	Copepods
1995.294	1505.882	1003.922	527.0588	0	0	0	5032.157	0.8952618
2888.582	2219.648	1520.307	820.9655	91.21839	91.21839	91.218391	7723.157	0.8582677

Appendix (7): Analysis of Coeffecient Variation of zooplankton biomass and density with Chlorophyll Concentration at the Reef and Open water (day and Night)

		Chlorophyll			Zoo Biomass			Zoo counts		
		Away	Reef	avg	Away	Reef	avg	Away	Reef	avg
Day	Day/Night	Chl	Chl	chl	Away	Reef	biomass	Zoo	Zoo	zoo count
1	D	164.2587	173.654	168.956	6.332181	3.9908	5.1614815			
2	D	223.9353	208.829	216.382	3.664979	1.866	2.7654835			
3	D	261.0637	165.195	213.129	4.016049	2.6999	3.3579835	4380	2079	3229.78765
4	D	245.7344	217.054	231.394	2.001358	1.4074	1.7043827	1925	1446	1685.46502
5	D	226.5647	224.449	225.507	2.249588	1.8988	2.0742078	2387	549	1468.06519
8	D	165.189	175.678	170.433	2.722912	3.1303	2.9266207	5343	3279	4311.04837
9	D	211.7146	201.995	206.855	2.914736	1.4577	2.1862424	5425	4390	4907.5596
10	D	231.7193	216.1	223.91	2.73176	2.3676	2.5496714	5452	5786	5618.61669
11	D	256.9613	242.137	249.549	1.891072	1.921	1.9060551	6648	5290	5969.29374
12	D	273.5965	269.06	271.328	1.252757	1.0407	1.1467078	3064	2007	2535.7037
15	D	287.3182	284.198	285.758	1.558148	1.2218	1.3899547	4349	3950	4149.62963
16	D	315.2639	263.555	289.409	1.14463	1.0818	1.1132202	5227	2337	3781.68889
17	D	271.4294	270.559	270.994	5.165741	3.8134	4.4895483	5988	3904	4946.13333
18	D	366.4577	330.113	348.286	2.590805	2.9935	2.7921689	4732	4729	4730.35849
19	D	334.3617	318.137	326.249	3.678506	2.4385	3.0584886	4289	4366	4327.6357
22	D	243.486	242.997	243.242	2.982778	1.8962	2.4394966	6172	4685	5428.65886
23	D	244.8403	236.895	240.867	2.63537	2.2796	2.4574949	4555	5853	5203.66047
24	D	303.8304	274.463	289.147	2.055638	1.9114	1.9834959	2089	2027	2058.01884
25	D	317.355	292.798	305.076	3.283593	2.3335	2.8085606	4167	3525	3845.85907
26	D	325.1891	310.803	317.996	3.124074	2.2309	2.6774691	8327	4814	6570.52444
29	D	323.7608	297.114	310.437	2.794815	2.4504	2.6226165	7238	6056	6646.80143
30	D	305.4078	280.814	293.111	4.950123	3.9358	4.442963	7813	6073	6942.81481

Continued Appendix (7)

		Chlorophyll			Zoo Biomass			Zoo counts		
		Away	Reef	avg	Away	Reef	avg	Away	Reef	avg
Day	Day/Night	Chl	Chl	chl	Away	Reef	biomass	Zoo	Zoo	zoo count
31	D	296.6082	279.81	288.209	3.723133	2.6083	3.1657154	6154	6898	6526.41366
32	D	229.0079	235.755	232.381	2.519547	2.2163	2.3679178	5810	5068	5438.76639
34	D	359.6727	347.071	353.372	1.83251	1.8104	1.8214609	6275	6010	6142.61164
36	D	197.1557	197.776	197.466	3.028663	2.2981	2.6633745	5514	5053	5283.55556
37	D	345.6049	317.656	331.63	4.259959	2.2448	3.2523868	9254	5499	7376.59259
38	D	369.0839	342.413	355.749	3.169444	3.0609	3.1151882	6336	6959	6647.1914
39	D	363.7583	335.812	349.785	3.478123	2.7652	3.121679	7327	5426	6376.80684
43	D	454.8943	455.989	455.441	4.959259	4.4974	4.7283069	8484	6863	7673.56614
44	D	374.4852	372.388	373.436	3.013004	2.8044	2.9087011	5085	5591	5338.10963
45	D	265.8942	243.573	254.734	6.613333	4.3304	5.4718636	6351	5933	6142.0134
46	D	243.828	229.846	236.837	9.380082	3.0741	6.2270782	8313	3067	5689.97249
47	D	334.9966	334.297	334.647	7.213535	4.2295	5.7215413	8602	6573	7587.31852
51	D	336.4101	329.042	332.726	4.963292	3.8613	4.4122751	8455	4903	6679.11675
52	D	316.6624	283.307	299.985	5.528757	4.3202	4.9244956	8075	6669	7371.99059
53	D	368.3153	351.141	359.728	3.796543	2.4722	3.1343672	7731	5137	6434.0299
		chl	chl					zoo	zoo	
1	N	157.9111	164.809		4.796337	4.1366				
4	N	218.9502	199.089		4.340741	2.9415		4654	3559	
8	N	183.8235	169.414		4.682942	3.6515		8965	5356	
11	N	310.4969	290.621		3.219943	2.922		5968	3624	
16	N	220.3784	196.801		4.348313	2.8138		7088	3505	
18	N	310.8016	285.621		4.958724	3.1005		7125	4145	
		Chlorophyll			Zoo Biomass			Zoo counts		
		Away	Reef	avg	Away	Reef	avg	Away	Reef	avg

Continued Appendix (7)

Day	Day/Night	Chl	Chl	chl	Away	Reef	biomass	Zoo	Zoo	zoo count
22	N	248.5449	248.028		3.244368	3.1136		4289	4615	
25	N	330.9024	302.04		4.533475	3.251		5832	5037	
29	N	297.6727	281.593		6.739444	3.9086		6176	4850	
32	N	253	226		2.556296	3.336		4971	5433	
39	N	358.0281	341.482		5.015586	3.2135		7096	4976	
43	N	411.1016	404.239		7.111111	7.1591		11287	5698	
46	N	320.6442	261.501		9.03	6.9805		9127	8269	
53	N	361.3637	353.106		5.035392	3.4542		7492	5032	

Appendix (8): Analysis of daily average Currents for the entire 53 days at the Reef and Away sites in the Northern part of Gulf of Aqaba in the Red Sea

Dail;y averages of currents for entire 53 days

Day	Long away	Long reef	Cross away	Cross reef	Cross difference
1	-5.687875	-2.165666667	1.521916667	1.249291667	0.272625
2	-4.017	-2.194708333	0.708666667	1.579541667	-0.870875
3	0.884958333	-1.533666667	0.383791667	1.445	-1.061208333
4	7.262416667	0.848958333	-0.008875	1.499958333	-1.508833333
5	1.889833333	0.606083333	0.019375	0.937541667	-0.918166667
6	-5.865166667	-2.963166667	1.500416667	1.5035	-0.003083333
7	-3.321	-2.276041667	0.281083333	1.688125	-1.407041667
8	-1.854125	-1.81225	-0.403041667	1.817083333	-2.220125
9	7.06	1.693291667	-0.40425	1.511166667	-1.915416667
10	5.563875	0.97225	-0.336416667	1.565708333	-1.902125
11	6.249625	0.3445	-0.403833333	2.126791667	-2.530625
12	7.135166667	1.522916667	-0.244208333	1.761958333	-2.006166667
13	5.569458333	1.183541667	-0.004833333	1.604625	-1.609458333
14	2.998083333	0.006	-0.281583333	1.365166667	-1.64675
15	2.857041667	0.608041667	0.72075	1.296708333	-0.575958333
16	-0.7285	-0.467583333	0.667541667	0.954875	-0.287333333
17	-3.795333333	-2.480416667	1.482041667	1.560416667	-0.078375
18	0.980375	-1.3255	-0.040541667	1.619333333	-1.659875
19	3.894083333	0.332208333	0.269333333	1.36575	-1.096416667
20	2.862791667	-0.861833333	-0.680583333	1.254583333	-1.935166667
21	4.297583333	1.335083333	0.848041667	1.173083333	-0.325041667
22	0.315625	-0.852041667	-0.024125	1.286416667	-1.310541667
23	0.621125	-1.396166667	-1.327	2.209208333	-3.536208333
24	2.800083333	0.846416667	-0.832916667	1.567291667	-2.400208333
25	3.204916667	0.845958333	0.05	1.242041667	-1.192041667
26	6.6455	2.042833333	-1.218375	2.180166667	-3.398541667
27	3.76625	1.163625	-0.153125	0.986875	-1.14
28	3.193125	0.782291667	-0.63075	1.343125	-1.973875
29	2.485458333	-0.997041667	-1.778666667	2.063083333	-3.84175
30	2.37775	-0.712	-1.503166667	1.737041667	-3.240208333
31	3.151458333	-0.206833333	-0.449416667	1.21975	-1.669166667
32	0.380166667	-1.478541667	0.271416667	1.089833333	-0.818416667
33	-1.605166667	-2.471583333	-0.195166667	2.08175	-2.276916667
34	4.00975	-0.648291667	-1.221916667	2.505166667	-3.727083333
35	5.685833333	1.257	-1.332541667	2.131083333	-3.463625

Dail;y averages of currents for entire 53 days

	Long	Long	Cross	Cross	Cross
Day	away	reef	away	reef	difference
	Long	Long	Cross	Cross	Cross
Day	away	reef	away	reef	difference
36	6.265125	1.243541667	-1.510458333	2.390625	-3.901083333
37	4.068916667	-0.03625	-2.017208333	2.717458333	-4.734666667
38	0.674625	-1.969208333	-1.575541667	2.463333333	-4.038875
39	6.849666667	1.487708333	-1.873041667	1.778625	-3.651666667
40	7.545416667	2.119833333	-1.276958333	1.181541667	-2.4585
41	2.516333333	0.154166667	-0.5995	1.12875	-1.72825
42	-14.321875	-5.391458333	-1.615625	1.873916667	-3.489541667
43	-3.569041667	-2.564625	-1.622208333	1.186958333	-2.809166667
44	8.407958333	1.768125	-3.930541667	2.086916667	-6.017458333
45	-8.393166667	-1.843291667	-1.718041667	2.185125	-3.903166667
46	12.95945833	5.098541667	-2.3005	1.06725	-3.36775
47	1.590833333	-0.64925	-0.703916667	1.255541667	-1.959458333
48	2.657083333	0.365791667	-1.698375	2.168541667	-3.866916667
49	1.525458333	-0.787916667	-1.997708333	2.883041667	-4.88075
50	6.815	2.308125	-3.9525	3.753	-7.7055
51	6.802166667	2.870375	-2.296041667	3.098541667	-5.394583333
52	4.883	0.748458333	-3.12325	3.051583333	-6.174833333
53	6.216333333	2.870791667	-3.241125	2.921333333	-6.162458333
54	6.842833333	2.281791667	-3.091708333	2.71725	-5.808958333

Appendix (9) : Analysis of the average concentration of Chlorophyll at the Reef and the Cross- component of the Current

Reef-Cross	A-chl-avg	A-chl-std	A-chl_st.err	R-chl-avg	R-chl-std	R-chl_st.err	N
-1	318.274406	47.8238845	15.12324016	298.5035533	46.88292438	14.82568244	10
0	341.3110714	32.43687931	7.645445773	323.1916736	45.34850506	10.68874515	18
1	345.7304297	22.75771919	6.311855651	330.0382982	30.05755912	8.33646697	13
2	334.7649703	41.2471747	8.793927194	321.1725703	45.45473501	9.690982066	22
3	341.1360228	41.48818159	8.297636317	320.991037	42.13199449	8.426398899	25
4.2	365.3286943	35.46743886	13.40543184	349.4737463	33.03859584	12.48741547	7
Away-cross	A-chl-avg	A-chl-Std	A-chl-s.err	R-chl-avg	R-chl_std	R-chl.s.err	N
-6	357.9749248	17.34351232	7.080459256	349.1942029	9.932762712	4.055033397	6
-5	360.6431949	39.2432818	11.83229466	343.7151421	29.70181372	8.95543379	11
-4	354.9253488	35.77259904	11.31228908	334.8248919	36.33649738	11.49060939	10
-3	336.0138377	48.9263564	15.47187238	317.4530109	38.34469697	12.12565786	10
-2	333.7562217	31.01033128	7.309205178	324.5736393	46.63771679	10.99261527	18
-1	364.7552659	32.51458063	10.83819354	347.4142144	30.92977446	10.30992482	9
0	332.9358936	27.35387688	6.838469221	314.8262574	47.55870858	11.88967715	16
1	315.6541476	41.31714581	15.61641324	285.1749403	36.73405712	13.88416854	7
2	318.8347254	39.97916921	17.87922801	286.0046829	20.53812898	9.184930506	5
3.5	275.3056026	31.39857576	18.12797617	266.1799564	41.91303761	24.19850355	3
3	308.4049048	312.8374526	1				
4	258.7559514	242.8512083	2				
Grand Total	339.6986285	322.4197077	95				

ملخص

ان العمليات التي تحدث ما بين الكائنات الحية القادمة مـــن منطقـة الميــاه المفتوحة وتلك الموجودة في المياه الضحلة الساحلية عند ارتطام المياه مع بعضـــــها البعض هي عمليات غير معروفة . ان حدوث هذه العمليات يمكن أ ن يفسر لنا على أهمية العوالق الحيوانية في تغذية الأسماك والجزر المرجانيــة , وكذلــك تــأثيرات التيارات الأفقية الهوائية الفيزيائية على التغيرات المؤقتة في سلوك وافــتراس هــذه العوالق قرب المرجان وفي المياه المفتوحة .

وفي هذه الدراسة تم قياس هذه التغيرات المؤقتة (دقائق , ساعات , أيام) فــي توزيع العوالق الحيوانية بجانب الجزر المرجانية والمياه المفتوحة في خليج العقبـــة من تاريخ ١٠-١٠-١٩٩٩ الى ٢-١٢-١٩٩٩ وكذلــك تــم دراســة دور تــأثير التيارات المائية والتيارات الأفقية الهوائية الفيزيائية على التغــيرات المؤقتــة فــي سلوك العوالق الحيوانية.

في تجاربنا تم جمع عينات العوالق الحيوانية عن طريق فلتره الماء المضــخ من البحر بواسطة مضخات إلى شبك (حجم الثغــور فيـه ١٠٠ ميكروملميــتر)، وذلك حتى نقارن التغيرات المؤقتة في توزيع العوالق الحيوانيـــة وسـلوكها فــي المنطقتين المذكورتين فوق .

كذلك تم وضع جهازين مقياس تيار المـــاء (CURRENT METERS) لقياس سرعة واتجاه ودرجة حرارة تيار الماء في المنطقتين خلال أخذ العينات .

بينت النتائج أن : توزيع العوالق الحيوانية في منطقة الجزر المرجانية أقــل منها في المياه المفتوحة وذلك بسبب افتراسها في منطقة المرجان من قبل الأســماك والمرجان . هناك ازدياد في توزيع العوالق الحيوانية (في فــترتي الليــل والنــهار)

وذلك منذ بداية تجميع العينات من بداية شهر أكتوبر وحتى شـــهر ديســمبر ســنة ١٩٩٩ وذلك في كلا الموقعين وهذا بسبب المزج الخريفي(في طبقات الماء) والغناء الموسمي الذي يحدث في شمال العقبة في البحر الأحمر . هناك توافق فـــي توزيـــع العوالق الحيوانية في منطقتي الجزر المرجانية والمياه المفتوحة في طول الفترة التـــي أخذت فيها العينات وكذلك في العينات التي أخذت كل ساعة . بينت نتائج الـــدورات اليومية للعوالق الحيوانية بأن توزيع هذه العوالق في فترة الليل ضعف كميتـــها فـــي فترة النهار. لا يوجد علاقة(ارتباط) بين توزيع العوالق الحيوانية وتيار الماء بســبب سلوك العوالق الحيوانية حيث إنها نشطة في السباحة في عمود الماء .

إن هذه النتائج تؤيد التقارير الأولية على أهمية العوالق الحيوانية فـــي تغذيـــة الجزر المرجانية ، وكذلك تأثيرات التيارات الأفقية الهوائية الفيزيائية على التغـيرات المؤقتة في سلوك هذه العوالق قرب المرجان وفي المياه المفتوحة .