

Investigations on larvae of commercial fish from Hurghada, Red Sea with notes on the spawning seasons and grounds of some species

Abu El-Regal M.A.^{1*}; Mohamed Maaly A.²; Abd EL-Naby A.S.²

Received: December 2016

Accepted: February 2017

Abstract

The present work deals with the study of fish larvae of coral reef fishes in the Red Sea (Hurghada). It was aimed to study the spatial and temporal variations of fish larvae for management purposes. Sampling stations were chosen at Marina, Sheraton, Magawish and Arabia. The samples were taken monthly throughout the period of the study from August 2014 to July 2015 using plankton nets of different mesh sizes (150, 350, and 500 micron). The highest density of larvae was observed in July when 841 larvae 1000m^{-3} were collected whereas, the lowest density was recorded in March and October at 11 1000m^{-3} . The highest number of species was recorded in Sheraton with 28 species followed by Magawish with 27 species recorded followed by Marina with 26 species recorded while the lowest was recorded in Arabia with 25 species. Concentration of larvae was significantly different between months and sites. There was a significant difference in the number of species between months but not between stations. Larvae of mullid fish were abundant in summer while larvae of clupeids were observed all year round.

Keywords: Fish larvae, Commercial fish, Red Sea, Fisheries management

1-Marine Science Department, Faculty of Science, Port Said University, Egypt

2-Fish Biology and Ecology Lab, Central Laboratory for Aquaculture Research, Agricultural Research Center. Abbassa, Sharqya, Egypt

*Corresponding author's Email: M_abuelregal@yahoo.com

Introduction

The life cycle of the fish includes not only adult stage but also eggs, larvae and juvenile that have their own ecological requirements that may be completely different from those of the adult. Fish eggs and larvae represent the meroplanktonic stages of fishes that can be collected by planktonic gear and are found mainly in the upper 200 meters of the water column. They can be used to determine the geographical distribution of fishes (Leis, 1986; Leis and McCormick, 2002) because they have a broader range than their reef sedentary demersal adult stages (Sale, 1980, 2002). They also serve to estimate the spawning stock, the spawning seasons and spawning grounds of the commercial fishes. Determining the abundance of eggs and larvae in an area is usually less expensive to do than sampling the adults because it is possible to sample several species over broad areas with simple plankton net. Besides, the plankton samples contain not only the fish larvae but also part of their potential zooplanktonic prey and predator (Smith and Richardson, 1977). Although the adult reef fishes of the tropical Indo-Pacific in general and the Red Sea in particular are well studied (Botros, 1971; Randall, 1983; Debelius, 1998), very little is known about their larval stages. There have been no previous studies on the larvae of coral reef fishes in the Red Sea. Literature describing the larval stages of coral reef fishes is also sparse or even lacking due to the difficulty in their identification (Leis and Rennis, 1983; Houde *et al.*,

1986). Problems associated with the larval work can be summarized in taxonomy and sampling. Difficulties in identification stem from the fact that the pelagic stages of reef fishes are totally morphologically different from their adults. Fish larvae are so difficult to be identified that more work on fish larvae has not been done. The understanding of the biology of fishes cannot be adequate unless the natural history and ecology of the larvae are well studied (Leis and Rennis, 1983). Most of studies on fisheries biology and fisheries management in the Red Sea focus on the adult stage and ignore other stages of the life history especially eggs and larvae (Abu El-Regal, 2013a). Early life stages of fishes (eggs and larvae) traditionally have played an important role in fishery management and promise to contribute significantly to supplementation and conservation of fish stocks in the future. They have been used to estimate recruitment and adult abundance and to characterize unit stocks, the basic unit of management. The biomass or relative abundance of a fish stock can be estimated from the abundance of its spawn, thus providing a cost effective alternative to sampling adult stages or using fishery-dependent data for estimating stock biomass.

Data on eggs and larvae can be used as a way to monitor trends in population abundance of the adults and tell when populations are declining, often more rapidly than monitoring adults. As many species in the Red Sea are now exploited or even overfished, actions should be taken to protect the

spawning stocks of these species. For these actions to be effective they should be built upon a solid scientific base that uses a different approach. A new approach to management, flexible enough to respond to the evolution of the fishery resources, is necessary to ensure a stable and sustainable long-term exploitation. The new technique should help managers to have data on many species in a very short time. This could be easily achieved by studying the early stages of fishes that include eggs and larvae which allow quantitative sampling of several species over broad areas in a short time with simple plankton nets handled by different types of vessels without major installation of equipment.

The present study aimed to investigate diversity, abundance and distribution of fish larvae at Hurghada on the Egyptian Red Sea and utilize data for fisheries management in the Red Sea.

Materials and methods

Sampling sites

This study was carried out in northern Hurghada on the Egyptian coast on the Red Sea. The area of study covers about 300km² and lies between the Hurghada coast and the Giftun Island (Fig. 1, Table 1). Twelve stations in each of the four transects representing four habitats, coral reef, sea grass, shallow lagoons and open water areas were surveyed for the presence, abundance and distribution of fish larvae.

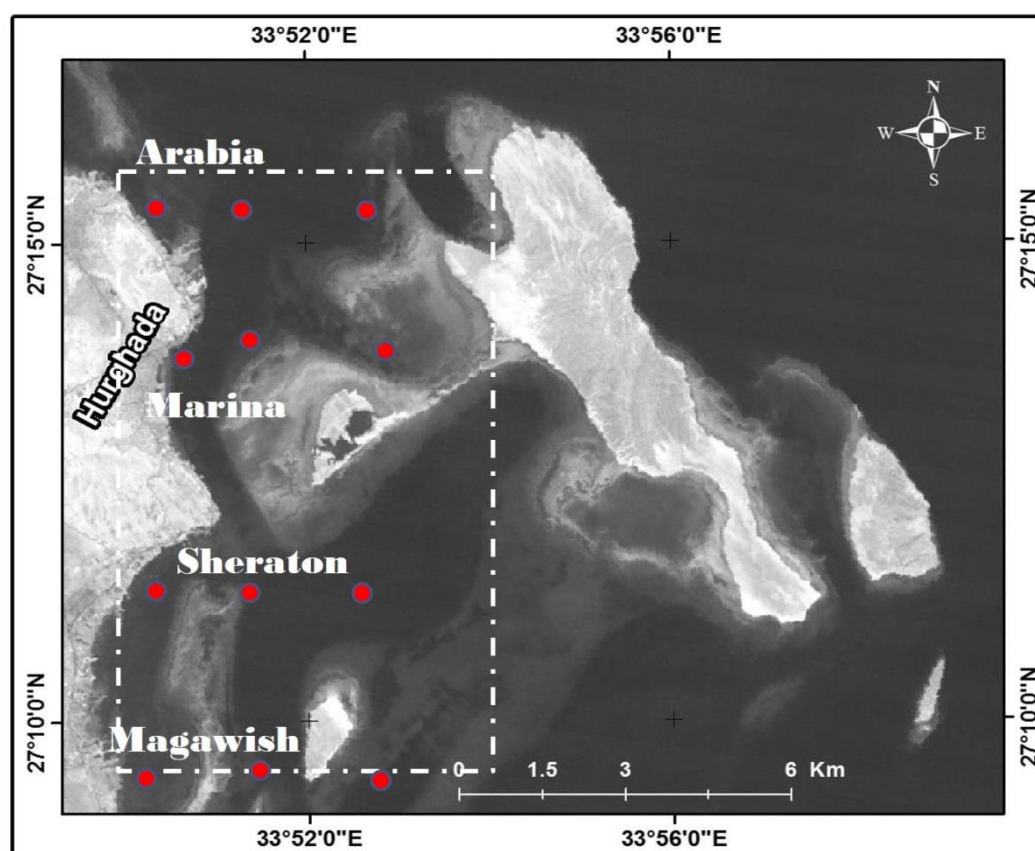


Figure 1: The area of study and the sampling stations.

Table 1: Sites, transects, code and coordinates of the sampling sites.

Site	Transect	Code	Lat (N)	Long(E)
Marina	MAR	MAR	27°13'31.06"	33°50'34.70"
		MAR1	27°13'32.07"	33°50'55.46"
		MAR2	27°13'33.53"	33°51'12.26"
		MAR3	27°13'34.51"	33°51'28.09"
Sheraton	SHR	SHR	27°11'43.80"	33°50'35.79"
		SHR1	27°11'28.41"	33°50'47.93"
		SHR2	27°11'9.26"	33°51'4.73"
		SHR3	27°10'47.94"	33°51'23.54"
		SHR4	27°10'27.19"	33°51'43.21"
Magawish	MAG	MAG	27° 8'35.30"	33°49'54.63"
		MAG1	27° 8'35.69"	33°50'5.09"
		MAG2	27° 8'36.23"	33°50'14.69"
		MAG3	27° 8'37.14"	33°50'26.01"
Arabia	ARB	ARB	27°14'30.49"	33°50'52.45"
		ARB1	27°14'36.25"	33°51'23.50"
		ARB2	27°14'42.01"	33°51'55.65"
		ARB3	27°14'46.71"	33°52'28.53"

Table 2: Habitat description of the sampling stations.

Site	Distance from shore	Depth	Substrate type
Arabia 1	100 m	30	Coral reef
Arabia 2	1000m	70-90	Coral reef
Arabia 3	3000m	7-12	Sandy
Marina 1	150m	40	Sandy
Marina 2	1000m	120	Sandy
Marina 3	3200m	10-12	Sandy
Sheraton 1	500m	15	Sandy
Sheraton 2	1500m	25	Seagrass
Sheraton 3	3500m	30	Seagrass
Magawish 1	300m	20	Coral reef
Magawish 2	1500m	50	Open water
Magawish 3	3000m	110-120	Open water

Measurement of physical parameters

The environmental parameters of temperature, and salinity, were measured simultaneously by using the Multi-probe device (Aquaread AP 5000)

Sampling and preservation

Ichthyoplankton samples were collected monthly during the period from August 2014 to July 2015 using plankton nets with mesh sizes of 150 μ , 350 μ and 500 μ .

The net was equipped with a flow-meter to calculate the volume of water filtered which was calculated from the following equation:

$$V = \pi r^2 df$$

Where V is the volume of water filtered, πr^2 is the mouth area of the net in m^2 , d is the distance cut by the ship in meters, and f is the filtration coefficient. The net was towed horizontally parallel to the reef and about 10-100 m away from the reef edge for 5-10 minutes depending on the prevailing wind with a towing speed of 1.5 to 2.5 knots. Samples were taken early in the morning and plankton samples were preserved in buffered 5% formalin solution in seawater on board for further examination in the laboratory.

Sorting and identification of fish larvae

Fish larvae were transported to 95% ethanol and were counted under an Olympus stereomicroscope. Abundance of larvae was expressed as the number of eggs in 1000m³ based on the following equation:

$$A=N/V$$

Where A is the density of fish larvae; N is the number of fish larvae collected; V is the volume of water filtered.

The sorted larvae were identified to the lowest possible taxonomic separation (Leis and Rennis, 1983; Abu El-Regal, 1999; Leis and Carson-Ewart, 2002; Abu El-Regal *et al.*, 2008 a, b; Mohamed Abu El-Regal *et al.*, 2014 a or b). Larvae were divided into pre-flexion, flexion and post-flexion according to the degree of bending of the notochord.

Data analysis

The univariate statistics were done in SPSS v.22.0, using ANOVA to determine differences in the number of individuals and number of species between months and sites. All data were tested for homogeneity of variance and where the samples were not homogeneous, data were either transformed or the non-parametric Kruskal-Wallis test was used. Diversity indices (species richness, the evenness and diversity index), were calculated using PRIMER (Plymouth Routines in

Multivariate ecological Research) v 5.2. Raster maps were performed using R package. Correlation coefficient was used to test if the number of fish larvae and species was correlated to the water depth.

Results

Environmental parameters

The surface water temperature in the study area as a warm area showed the seasonal variations experienced in the Red Sea. The temperature attained its highest value during summer with a maximum of 30.90 °C in August, and then gradually decreased throughout autumn and winter reaching its minimum (19.8 °C) in February. The temperature reached its maximum of 30 °C in Hurghada in August.

Salinity in the Hurghada area was relatively high with an average change all year round between 40.4 and 41.6 ppt. The salinity measurements were above 40 ppt in most months with a maximum of 44 ppt in May.

Larvae of commercial fish

Out of 3342 larvae collected throughout the study period, 2510 larvae representing 31 species in 24 families and representing 75% of all larvae belonged to commercial fish (Fig. 2).

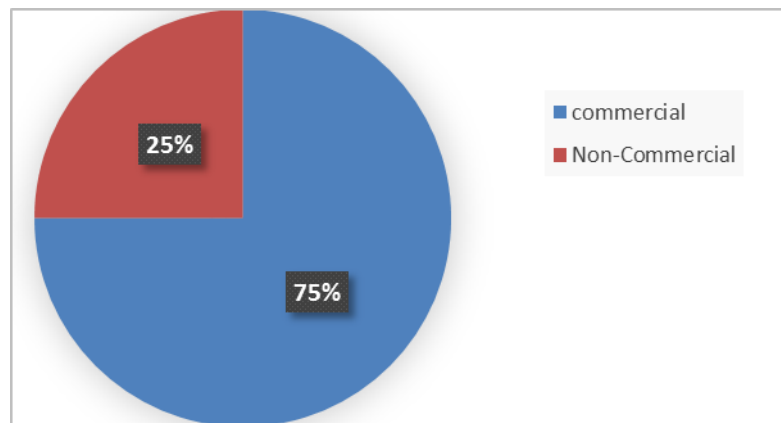


Figure 2: Ratio of the commercial to non-commercial fish at different sites.

Larvae of commercial fish were recorded all the year round with higher abundances in the warmer seasons (Spring-summer). A total of 1125 fish larvae were collected in summer followed by 881 larvae in spring. Larvae were rare both in autumn and winter at 315 and 189 larvae, respectively (Fig. 3).

Regarding the monthly variations, the highest abundance was recorded in August with 623 larvae 1000m^{-3} . There were other rises in May with 487 larvae and July with 382 larvae 1000m^{-3} . Only two larvae were taken in February and 6 larvae were taken in March (Fig. 4).

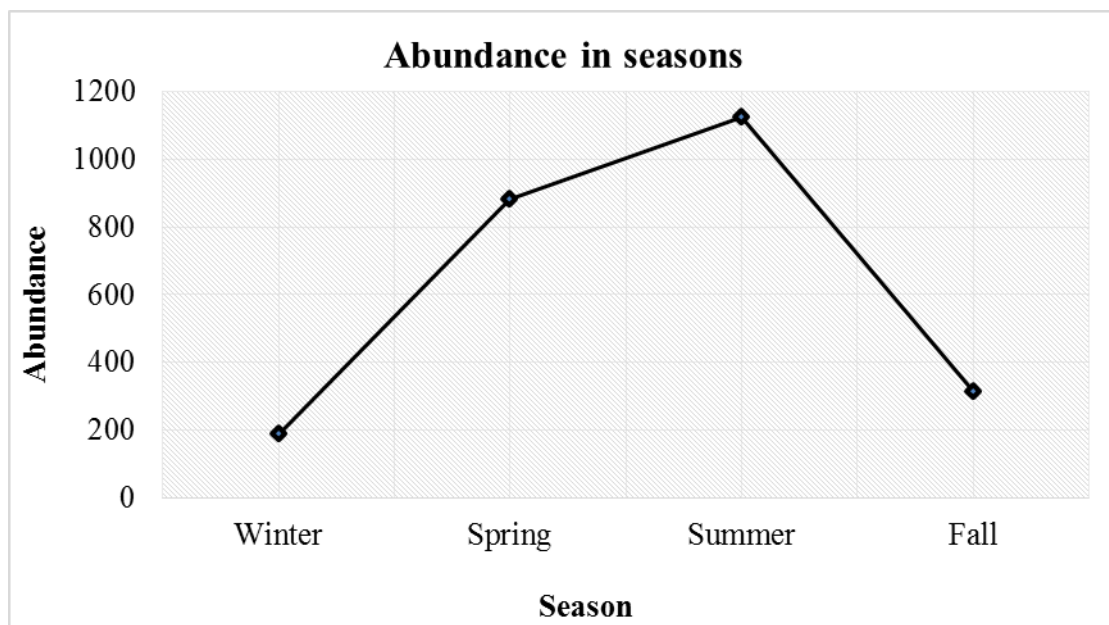


Figure 3: Abundance of larvae of commercial fish in different seasons.

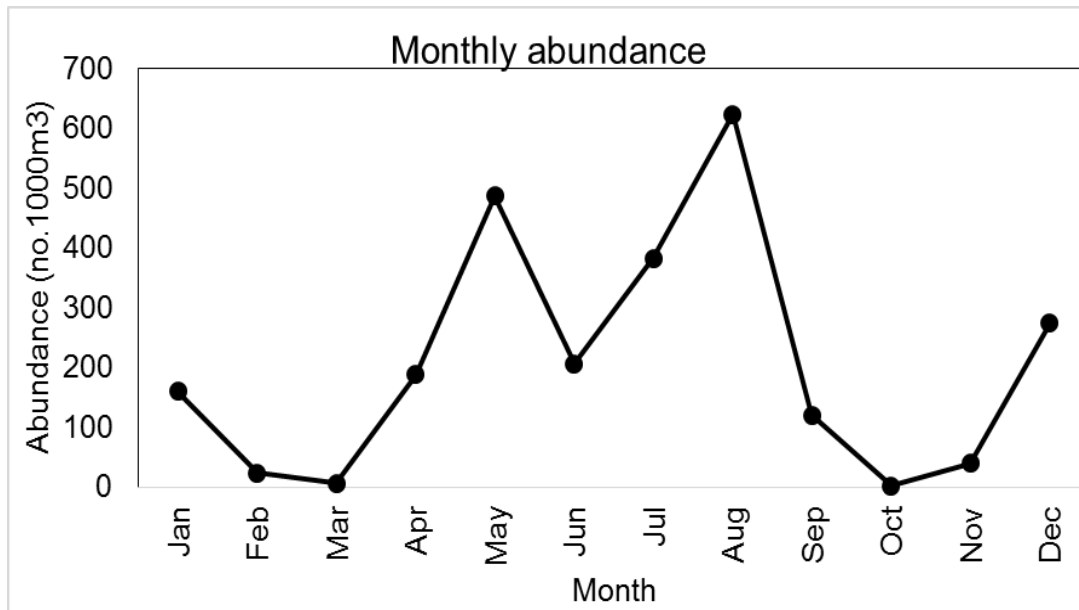


Figure 4: Monthly variations in abundance of larvae of commercial fish.

The highest number of fish larvae were recorded in the Arabia region where 996 larvae were taken indicating the importance of the area as a spawning ground for commercial fish. The Marina region came second after Arabia with 705 fish larvae, whereas,

Sheraton had the lowest number of fish larvae (325) (Fig. 5). The analysis of variance (ANOVA) showed that larval concentrations were significantly different between months ($F=2.1$, $p<0.05$) and sites ($F=6.1$, $p<0.05$).

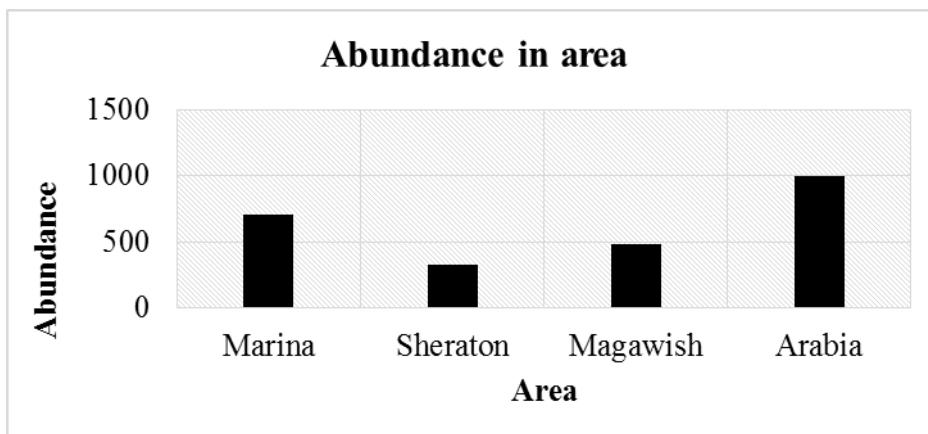


Figure 5: Variations in the abundance of larvae of commercial fish in different areas.

Among the sites, Arabia 2 (MGH2) harbored the largest number of fish larvae with 623 larvae 1000m⁻³

whereas, Marina3 (MAR3) had the lowest number (6 larvae 1000m⁻³) (Fig. 6).

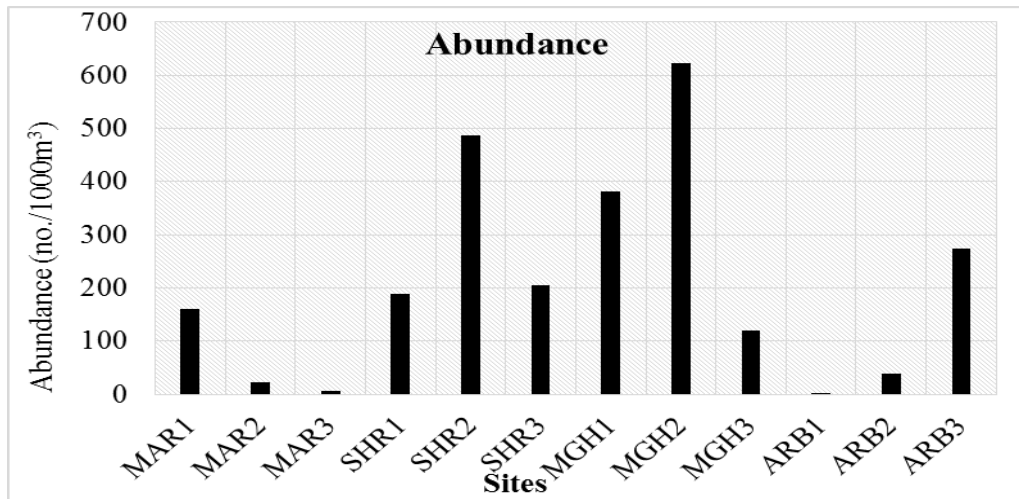


Figure 6: Variations in the abundance of larvae of commercial fish in different sites.

Of the 24 families recorded during the present study, 21 families were found in Magawish 1 (MGH1) and 15 families were recorded in Sheraton 3 (SHR3) (Fig. 8). The lowest number of families were found in Magawish 3 (2 families) and Arabia 1 and Marina 2

where only 3 families were found (Fig. 7).

There was a significant difference in the number of species between months ($F=6.25, p<0.05$) but not between stations ($F=1.2, p<0.05$).

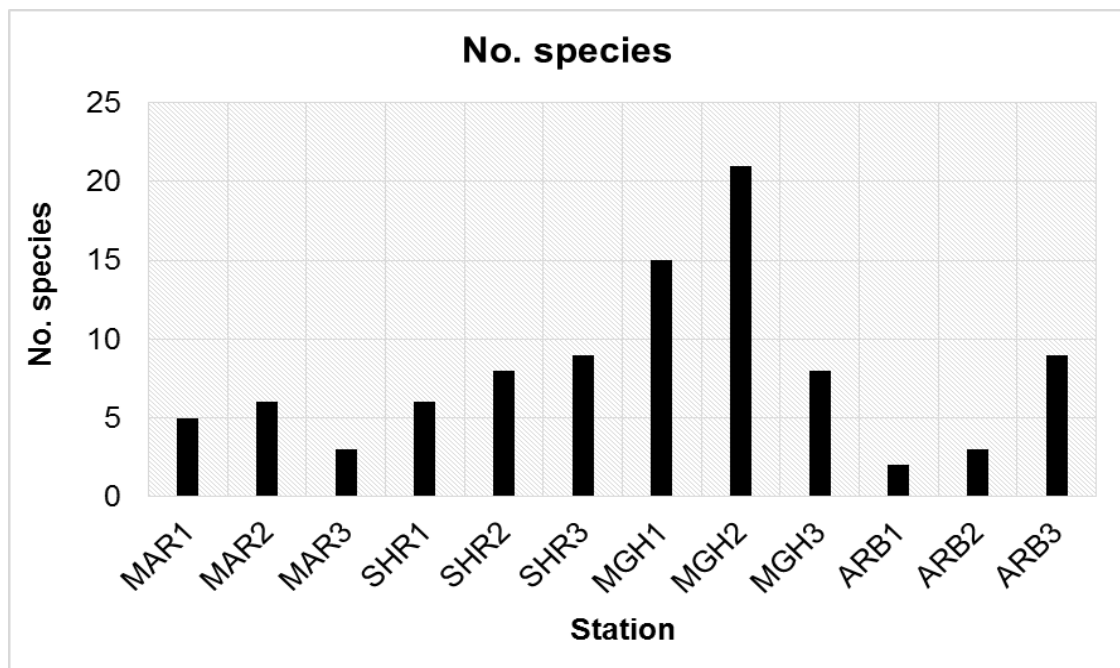


Figure 7: Variations in number of species of larvae of commercial fish in different sites.

Richness of commercial species ranged from the minimum of 0.55 in Arabia 3

to the maximum of 3.11 in Magawish 2 (Fig. 8).

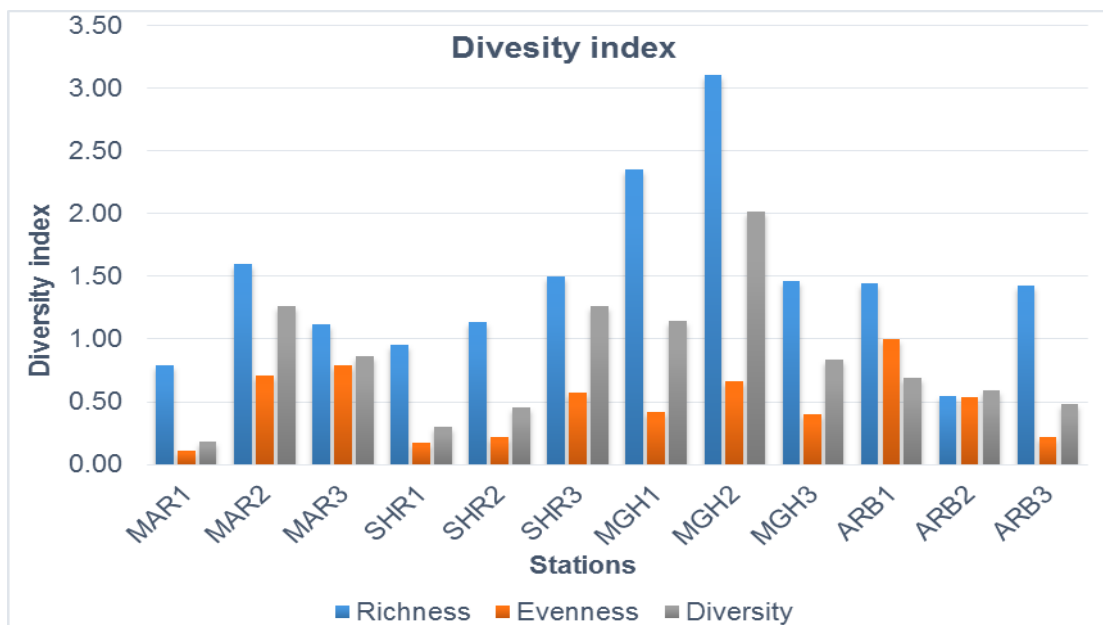


Figure 8: Variations in diversity indices, richness, evenness and diversity.

The equitability or evenness value reached its maximum value in ARB1 (1) indicating that all species are present in almost equal abundance. The lowest value of evenness was recorded in MAR1 (0.11) indicating the dominance of certain species. Shannon-Wiener values ranged from 0.18 in MAR1 to 2.01 in MGH2 which surprisingly is not in accordance with the number of species that had the highest value in MGH1 with 21 species.

Whereas, MGH2 harbored 8 species (Fig. 8).

The fish larval community was greatly dominated by goatfish larvae (Family: Mullidae) that formed 71% of all larvae collected. The most abundant five families formed about 90% of all larvae. The second most abundant family was Clupeidae that accounted for about 9% followed by Carangidae and Scombridae that formed 3% of all larvae collected (Fig. 11).

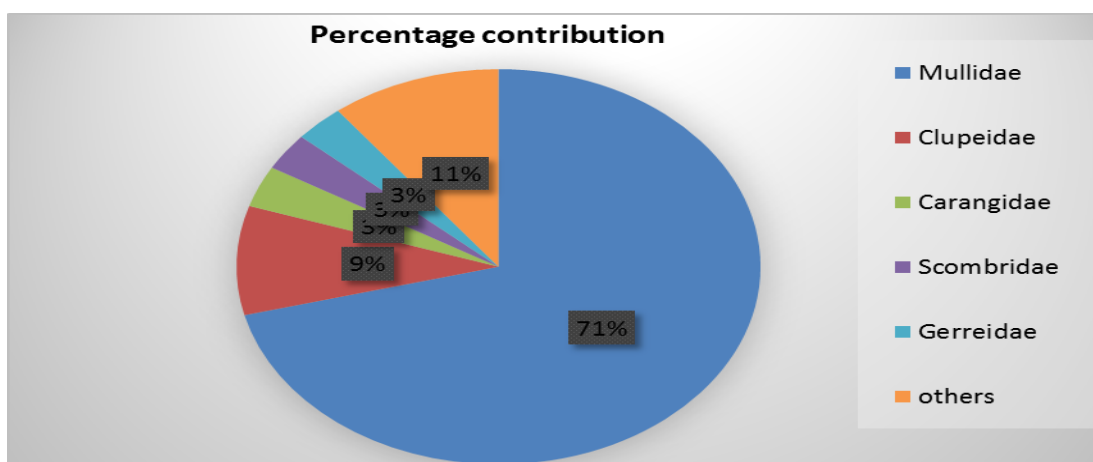


Figure 9: Percentage contribution of the most abundant families.

According to their spawning seasons, fishes could be categorized into 6 groups (Fig. 10). These were, the spring, the spring /summer, the summer, the summer/autumn spawners, summer-winter and winter season groups. The highest number of spawners comes under the summer

spawners group with 11 taxa involved. Whereas, summer/autumn spawners had only one taxon (Scaridae). In general, most of the fish recorded during the current survey were found to spawn in the warmer months of the year (Figs. 10, 11).

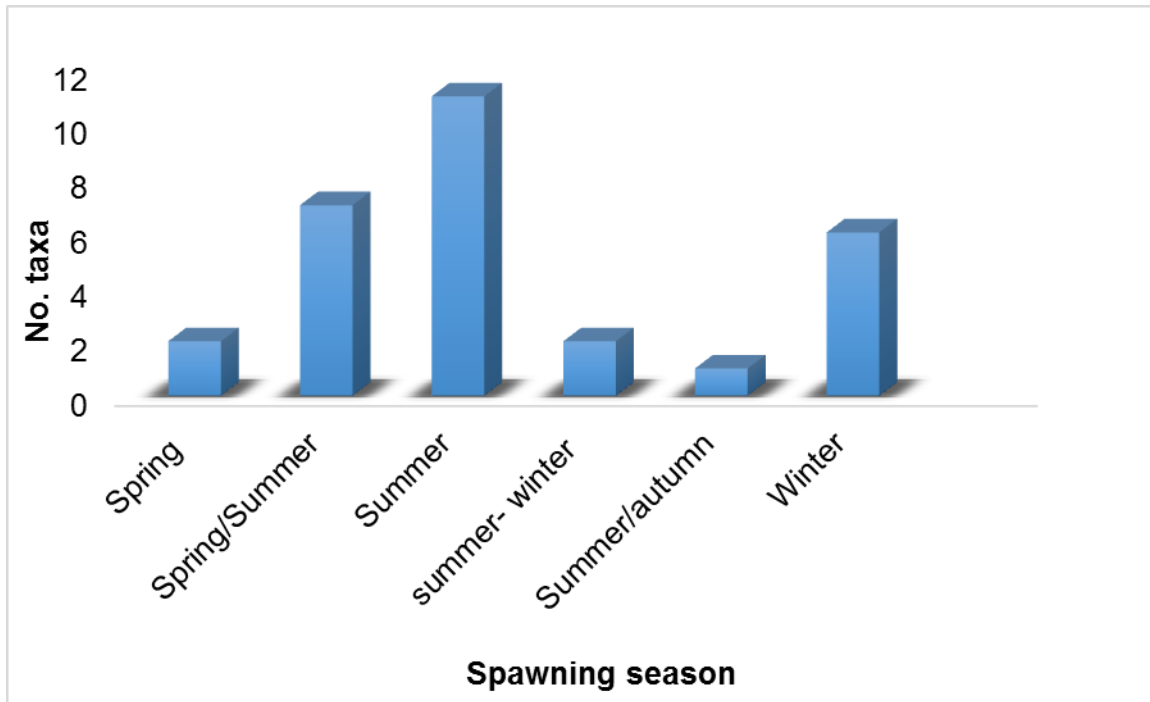


Figure 10: Spawning seasons of the commercial fish.

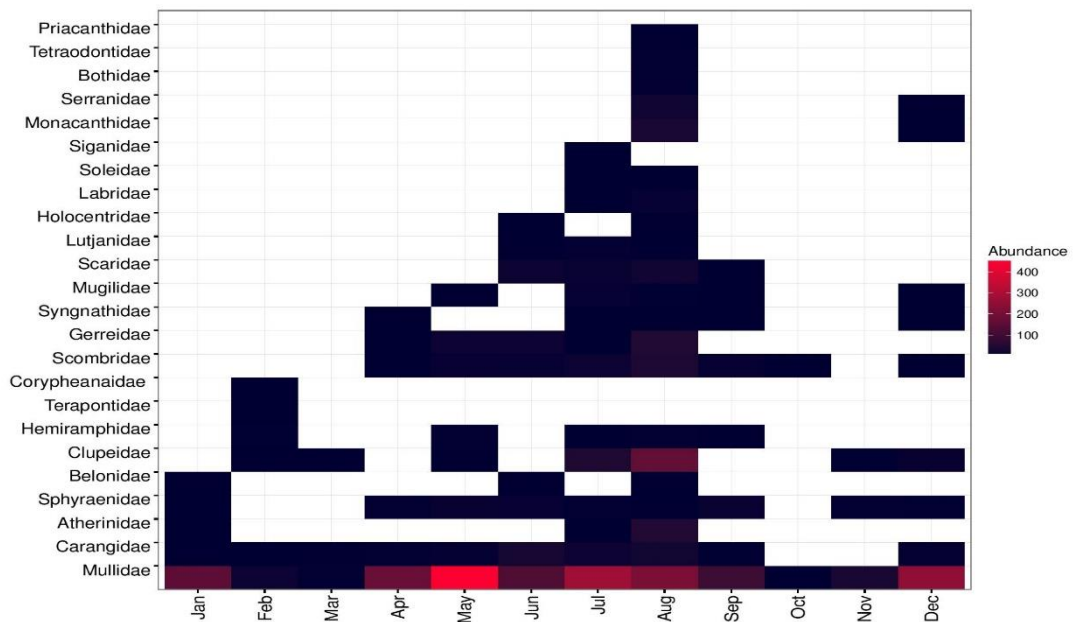


Figure 11: Raster plot of monthly distribution of larvae of commercial species.

Regarding the spawning grounds, fishes were divided into several categories according to the area where their larvae were collected. Nine species were

found to occur in two areas whereas seven taxa were collected from all stations. Five species were collected only from Arabia (Figs. 12, 13).

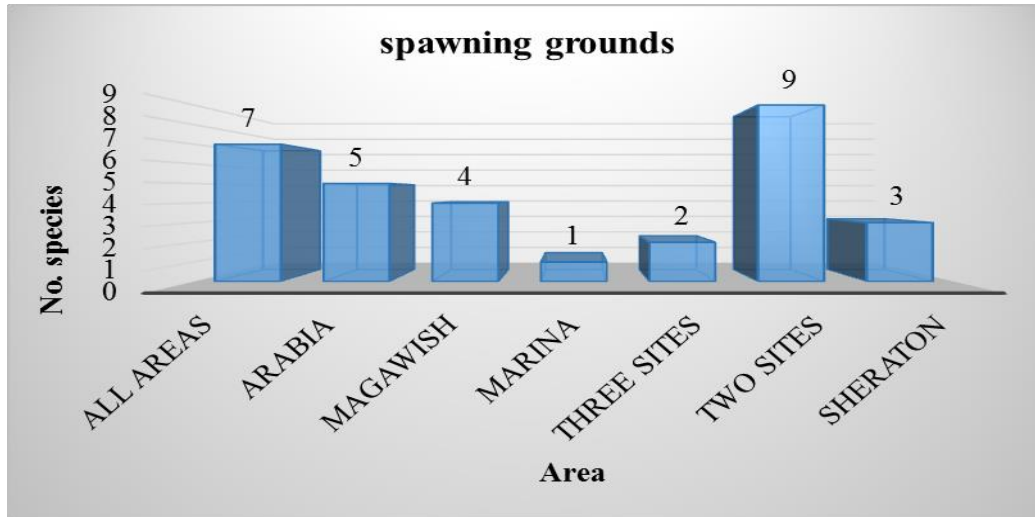


Figure 12: Spawning grounds of the commercial fish.

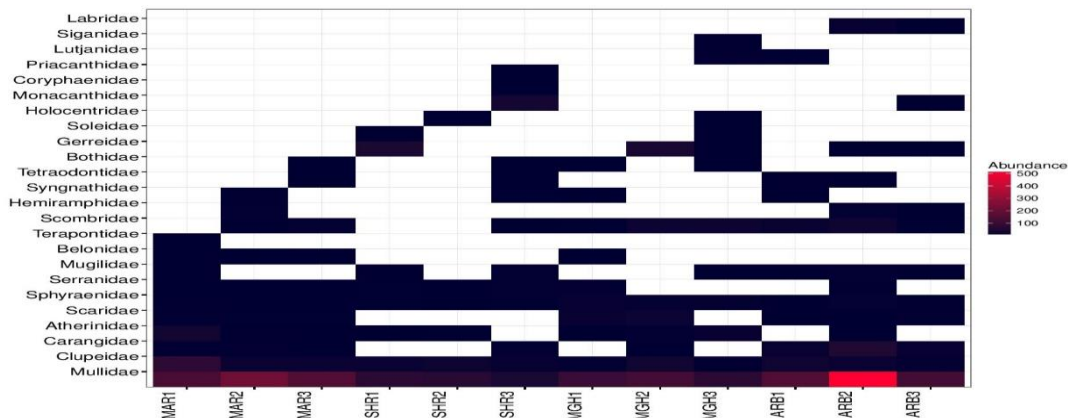


Figure 13: Raster plot of spatial distribution of larvae of commercial species.

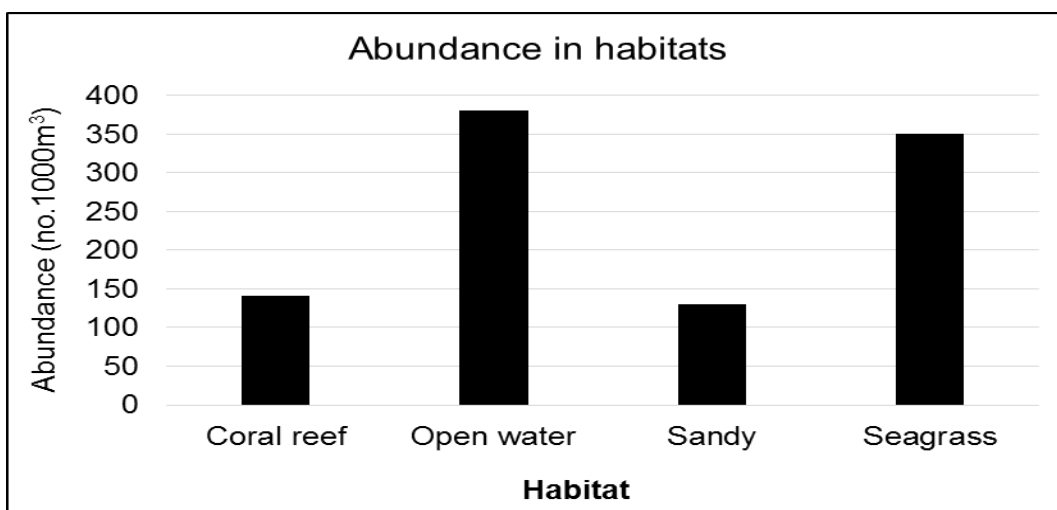


Figure 14: Abundance of fish larvae in different habitats.

The highest number of fish larvae were recorded in open waters where 380 larvae were taken followed by seagrass beds where 350 larvae were found. Surprisingly, areas very close to the coral reef had the lowest number of fish larvae (Fig. 14). Furthermore, the highest number of species were taken from the open water and seagrasses whereas, the lowest number of species were found near the reef areas (Fig. 15).

However, the analysis of variance ANOVA showed that number of fish larvae taken was not significantly different in various habitats and the number of species was not either. There was no correlation between the number of larvae and the number of species on one side and the depth of the water where larvae were collected on the other side (Fig. 16).

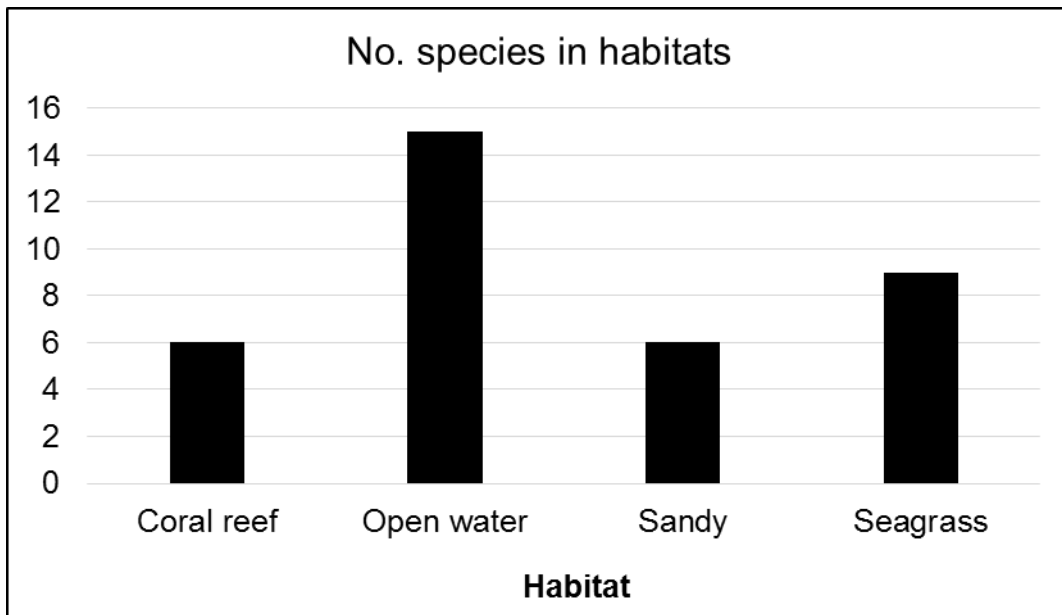


Figure 15: Number of species of fish larvae in different habitats.

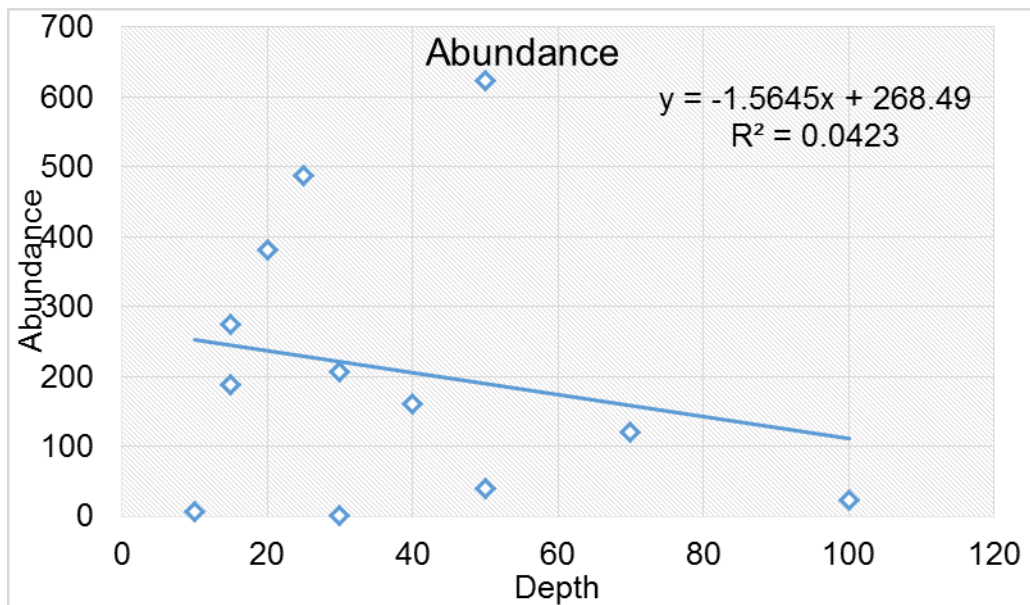


Figure 16: Correlation between depth and abundance of fish larvae.

Family: Mullidae (Goatfishes)

Family Mullidae was the dominant family in the collection. Larvae of this family dominated the collection with 1784 larvae constituting 71% of all larvae collected. Two species of family Mullidae, the yellowstripe goatfish, *Mulloidichthys flavolineatus* and the rosy goatfish *Parupeneus rubescens* were recognized.

Larvae of *M. flavolineatus* occurred from May to October with a peak in May with an abundance of 443 larvae 1000m^{-3} and showed the lowest abundance of 1 larvae 1000m^{-3} in October. Most of the larvae were concentrated in the ARB2 with an abundance of 516 larvae 1000m^{-3} and they showed the lowest abundance in MGH4 with an abundance of 12 larvae 1000m^{-3} . Mullidae larvae were absent from SHR4.

Whereas larvae of *P. rubescens* were collected from November to February with a peak in December, they were collected from all stations but dominated in the Arabia region.

Family: Clupeidae (Sardine)

Larvae of the family Clupeidae were the second most abundant with a total abundance of 224 individuals/ 1000m^3 . They accounted for about 9% of all larvae collected. They peaked in August at 166 larvae 1000m^{-3} and showed the lowest abundance in March with an abundance of 1 larvae 1000m^{-3} . Most of the larvae were concentrated in MAR1 with an abundance of 77 larvae 1000m^{-3} and they showed the lowest abundance in MGH3. Clupeid larvae were absent from SHR4 and MGH4. Most of the

clupeid larvae belong to delicate round herring, *Spratelloides delicatulus*. However, some other larvae could not be identified.

Family: Gerreidae (Mojarras).

Gerreidae is one of the most important commercial fish in the Red Sea particularly in Hurghada area. Their larvae were common in spring and summer. All collected larvae were identified as *Gerres oyena* based on morphological features. Family Gerreidae was the fifth most abundant family with a total abundance of 77 larvae 1000m^{-3} . They represented about 3% of all larvae collected.

The first larva of the 77 gerreid larvae appeared in April and the abundance increased to 14 larvae in May which is believed to be the spawning season of this species. A very sharp peak of abundance was found in August where 44 larvae were found. A sudden disappearance of gerreid larvae occurred in September. The absence of gerreid larvae continued from October to March.

Larvae of family Gerreidae were restricted to certain sites. Most of the larvae were collected from SHR1 and MGH2 where 40 larvae and 33 larvae, respectively were collected. One larva was taken from MGH3, ARB2 and two larvae were taken from ARB3. Larvae were absent from all other sites.

Discussion

Fisheries of the Red Sea comprise about 12% of the total fisheries production of Egypt and provide foreign exchange revenue and an important source of

domestic protein and employment. However, Red Sea fisheries are encountering many problems. Lack of information about the spawning seasons and grounds and stocks of the commercial fishes, lack of planning, the mismanagement of the natural resources, and destruction of nursery grounds are the major ones (Barrania and Ahmed, 2003). In addition, most fishing activities in the Red Sea take place during the spawning seasons and affect the recruitment (Abu El-Regal, 2013; Mehanna *et al.*, 2014; Osman, 2014; Abu El-Regal, 2016). Moreover, many of the reef fishes perform spawning migration in a definite time to definite areas through well-known routes. These migratory species are overfished or even exploited (Al-Kholy, 1964; Boraey, 1969). Fisheries management in the Red Sea depends mainly on the traditional approach that focuses on the management of a single species. However, very few species have been studied. The high fish diversity of the Red Sea (more than 1000 species) (Golani and Bogorodeski, 2010; Fricke and Abu El-Regal, 2017) makes it very difficult, costly and time consuming to depend on such traditional tools.

Studies on the early stages of fish are used to estimate the size of a spawning stock and to determine the spawning seasons and spawning grounds of the commercial fishes, and information is necessarily and urgently needed as a tool to manage the Red Sea fisheries and its coral reefs (Abu El-Regal, 2008). The present study has complemented the previous studies on

the larvae of the coral reef fishes in the Red Sea: southern Red Sea (Nellen, 1973), Sharm El-Sheikh (Abu El-Regal, 1999), Aqaba (Froukh, 2001) and Hurghada (Abu El-Regal, 2008; Abu El-Regal *et al.*, 2008 a; Abu El-Regal *et al.*, 2014a; Abu El-Regal, 2016). All of these studies aimed to identify larval fish in the studied area and to give some information about their seasonal and regional distribution (El-Sherbiny, 1997; Cuschnir, 1991; Abu El-Regal, 1999, 2009; Froukh, 2001; Abu El-Regal *et al.*, 2014 a, b; Abu El-Regal, 2016).

The interest in fish larval communities has increased noticeably during the last decades as a tool to provide insights into the ecology and dynamics of marine fish larvae (Moser and Smith, 1993). In the Red Sea, the interest in the early stages of fish started in 1999 with the first ichthyoplanton sample taken from Sharm El-Sheikh in 1996 (Abu El-Regal, 1999). Measuring the dispersal of fish larvae is the greatest challenge facing marine ecologists and managers (Jones *et al.*, 2005). Larval distribution depends on a complex interaction between biological and physical factors that can strongly modify the distribution and abundance of larval stages. Understanding of where the larvae spend their time away from the reef is basic to all other studies on the pelagic stage. The traditional view that larvae were essentially passive plankters whose distribution was determined entirely by currents has largely been discarded (Leis and Carson-Ewart, 1997).

In the current work, there were significant differences in water temperature between seasons but not between sites whereas salinity did not have significant difference in sites or seasons. Hence temperature may influence the temporal but not the spatial distribution of fish larvae in the area of study. The highest abundance and taxa richness of fish larvae in summer months may be due to high temperatures. In contrast, Lowe-McConnell, (1979) studied the influence of temperature on distribution of fish larvae in tropical waters and concluded that temperatures do not limit fish spawning and that seasonality of larvae is imposed by nutrient levels and predation avoidance.

The distribution patterns of fish larvae were found to be independent of the habitat and the depth where the adults live and are dependent on the spawning mode of species (Borges *et al.*, 2007; Abu El-Regal, 2008). Open water habitats were found to have the largest number of fish larvae and species. This finding is in agreement with those of Maaty *et al.* (2015) who found that open waters off Hurghada recorded the highest number of individuals and species. Temporal pattern of fish larval abundance corresponds with seasonality of reproduction (Lazzari, 2001). Mac Gregor and Houde, (1996) studied the pattern and daily variation of kilometer scale, and onshore-offshore distributions of anchovy eggs and larvae in the Chesapeake Bay. They found that eggs and recently hatched larvae were 30-200 times more

abundant offshore than inshore and that most spawning occurred offshore. With the exception of Sheraton, SHR1 eggs were more abundant in the offshore sites than inshore sites. Abundance in MAR3, MGH3 and ARB3 were twice the total eggs in the other sites in the area.

Little is known about where most fish species spend their pelagic period. Larvae of many species have been collected inshore and others have been collected at great distances offshore. Some studies have been carried out on the species composition of larval fish inshore and offshore (Clark, 1991; Leis, 1986, 1991a; Abu El-Regal, 2017). In the present study, fish larval abundance offshore and inshore was equal (300 larvae 1000m^{-3}). Although, abundance was similar, there were differences in the larval richness and species composition between offshore and inshore sites. Leis, (1986) noticed a consistent pattern of horizontal distribution of fish larvae from plankton samples around the Lizard Island, Great Barrier Reef. Few types of larvae were most abundant in Lizard island lagoon, all of which were small larvae. Forty percent of the 57 types of studied larvae differed in abundance between windward and downward side of the island. Most types of old larvae were found in greatest abundance off the windward than the downwind.

The previous research efforts on the larvae of the reef fish in the Red Sea resulted in the identification of about 100 taxa out of more than 1100 species in 158 families recorded in the Red Sea (Golani and Bogorodeski, 2010; Abu

El-Regal and El-Moselhy, 2013; Fricke and Abu El-Regal, 2017a, b). The present study focuses on the spatial and temporal distribution of fish eggs and larvae of the commercial species to help determine the spawning season and spawning ground of these species for management purposes. Out of 35 fish families recorded during the present work, 24 families belong to commercially important families.

Spawning seasons and grounds

Determination of spawning seasons and grounds depends mainly on the stage of larvae that were collected and the site where it was collected. The utilization of the earliest stages of eggs and yolk-sac larvae is a good indicator of spawning and spawning grounds. On the other hand *Gerres oyena* preferred the sheltered sides as indicated by the large number of larvae recorded in the SHR1. The measurements of the larval size indicates that *G. oyena* spawn close to the coast.

Mulloides flavolineatus performs an annual migration to the sandy shores in May, June, July and August. All the small and preflexion larvae of this species were abundant in the exposed sides of the reef but not very close to the fringing reef. Of the 1784 larvae belonging to Mullidae, 1019 larvae were taken from the exposed areas. Larvae of this species were first most abundant of all species constituting approximately 73% of all collected larvae with a total abundance of 1809 individuals/1000 m³. These larvae were restricted to the warmer months of the year (June-August). Most of larvae

collected were small and preflexion and few larvae were large postflexion. The size ranged from 2 mm to 10 mm. most of the small preflexion larvae were taken from the exposed sides of the coral reefs whereas, all the larger postflexion larvae were found in sheltered sides of the reef. Juveniles of *M. flavolineatus* were collected from sandy shores using beach seine in January.

Spartelloides delicatulus seems to spawn in the coastal and reef lagoons as larvae of different size classes were collected from these lagoons in very large numbers. Spawning grounds used by reef fishes could be categorized into three categories; reef, lagoon and open waters according to the characteristics of each area.

Determination of spawning seasons by larval fishes coincides with that determined by the reproductive biology. *M. flavolineatus* has a peak of spawning from June to August as indicated by the gonado-somatic index analysis and abundance of fish larvae. Data about the spawning season of *M. flavolineatus* is in agreement with the very few reports about the species either globally (Munro *et al.*, 1973; Houde *et al.*, 1986) or locally in the Red Sea (Boraey, 1969). In the Arabian Gulf, mullid larvae were abundant from late spring to autumn and were absent in winter (Houde *et al.*, 1986). In the Caribbean Sea, ripe females were caught in March and April (Munro *et al.*, 1973). This study presents important information on the spawning seasons and grounds of reef fishes in the area that form baseline data concerning the seasons and areas

of spawning of commercial fishes. It reflects the importance of the survey of eggs and larvae in fisheries management. However, the larvae of some fishes whose adults are important constituents of the Egyptian fisheries were rare or even missing in the collection. This may be due to the behavior of the adult or the behavior of the larvae (Leis, 1991b; Montgomery *et al.*, 2001). Larvae of lethrinid fishes were absent in the ichthyoplankton samples during the present study and previous studies in the Egyptian Red Sea (Abu El-Regal, 1999, 2008, 2009). Lethrinid larvae were found to preferentially settle near the seagrass-replete reef (Olney and Boehlert, 1988). These findings may confirm that these fishes migrate to areas more favorable for their spawning (Johannes, 1978). The absence of these larvae could also be attributed to the sampling methods that are used during the current study which depends mainly on surface sampling. Most reef fishes in the Red Sea are of commercial importance and should be protected by law.

In the present study, most reef fishes spawn in the warmer months of the year (May to August) based on the occurrence of their larvae. According to their spawning seasons, fishes could be categorized into 7 groups. These are, the spring, the spring/summer, the summer, the summer/autumn spawners, summer and winter and the prolonged spawning season groups. The highest number of spawners comes under the summer spawners group with taxa involved representing about 51% of all taxa. Whereas, summer/autumn

spawners had only one taxon (Scaridae). In general, most of the fish recorded during the current survey were found to spawn in the warmer months of the year.

Determination of spawning and nursery grounds depends mainly on the stage of larvae that were collected and where they was collected. The utilization of the earliest stages of eggs and yolk-sac larvae is a good indicator of spawning and nursery grounds.

Fish larvae were divided into 7 groups according the area where they were collected.

Larvae that were collected from all sites, collected from two areas, those collected from two sites, larvae that were collected from Arabia, larvae that were collected from Marina, larvae that were collected from Magawish and those collected from Sheraton. The highest number of species occurred in two sites where 9 species were collected from two different sites. Among these were *Trachurus* sp that were collected from the Marina and Arabia regions and *Atherinomorous lacunosus* that was collected from Marina and *Coryphaena hippurus* collected from Magawish. The second group contained larvae which were collected from all areas. This group was represented by 7 species examples of which were Mullidae and Clupeidae. The least frequently occurring group was taken from Marina region. The only species collected from this region was *Euleptorhamphus viridis* that was absent from other regions.

This study presents important information on the spawning seasons and spawning grounds of some reef and edible fish in the Red Sea that forms a baseline of data concerning the larvae of commercial fishes as essential part in fisheries management. However, larvae of some fishes whose adults are important constituents of Egyptian fisheries were rare or even absent in the collection. This may be due to the behavior of the adult or the behavior of the larvae (Leis, 1991b; Montgomery *et al.*, 2001). Larvae of lethriniid fishes were absent in the ichthyoplankton samples during the period of study and other studies in the Red Sea (Abu El-Regal, 1999, 2008, 2009). These fishes may migrate to areas more favorable for spawning (Johannes, 1978).

Acknowledgments

This work is a part of the project entitled 'Utilization of ichthyoplankton (fish eggs and larvae) for the management of the Red Sea fisheries' funded by the Science and Technology Development Funding STDF.

References

- Abu El-Regal, M.A., 1999.** Some biological and ecological studies on the larvae of coral reef fishes in Sharm El-Sheikh (Gulf of Aqaba-Red Sea). M.Sc. Thesis. Marine Science Department, Faculty of Science Suez Canal University. 167 P.
- Abu El-Regal, M.A., 2008.** Ecological studies on the ichthyoplankton of coral reef fishes in Hurghada, Red Sea, Egypt. Ph.D. Thesis Marine Science Department, Faculty of Science, Suez Canal University, Ismailia, Egypt. 225 P.
- Abu El-Regal, M.A., Ahmed, A.I., El-Etreby, S.G., El-Komi, M. and Elliott, M., 2008a.** Abundance and diversity of coral reef fish larvae at Hurghada, Egyptian Red Sea. *Egyptian Journal of Aquatic Biology and Fisheries*, 12(2), 17-33.
- Abu El-Regal, M.A., Ahmed, A.I., El-Etreby, S.G., El-Komi, M. and Elliott, M., 2008b.** Influence of ecological guilds of coral reef fishes on the distribution of their larval near coral reefs at Hurghada, Egyptian Red Sea. *Egyptian Journal of Aquatic Biology and Fisheries*, 12(2), 35-50.
- Abu El-Regal, M.A., 2009.** Spatial distribution of larval fish assemblages in some coastal bays along the Egyptian Red Sea coast. *Journal of Egyptian Academic Society for Environmental Development*, 10, 19-31.
- Abu El-Regal, M.A., 2013a.** Spawning seasons, spawning grounds and nursery ground of some Red Sea fishes. *Global Journal of Fish Aquatic Research*, 6(6), 126-140.
- Abu El-Regal, M.A., 2013b.** Adult and larval reef fish communities in coastal reef lagoon at Hurghada, Red Sea, Egypt. *International Journal of Environmental Science and Engineering*, 4, 39-49.
- Abu El-Regal, M.A. and El-Moselhy, K., 2013.** First record of the slender sunfish *Ranzania leavis* from the Red Sea. *Journal of Fish Biology*, 83, 1425-1429.

- Abu El-Regal, M.A., Abu Zeid, M.M., Hilal, A. and Maaty, M.M., 2014a.** Abundance and diversity of reef fish larvae in Mabahiss Bay, on the Egyptian Red Sea coast. *Egyptian Journal of Aquatic Biology and Fisheries*, 18, 61-77
- Abu El-Regal, M.A., Abu Zeid, M.M., Hilal, A. and Maaty, M.M., 2014b.** Adult and larval fish assemblages in Mabahis Bay, northern Red Sea, Egypt. *International Journal of Environmental Science and Engineering*, 5, 111-126
- Abu El-Regal, M.A., 2016.** Spatial and temporal distribution of larvae of coral reef fishes in northern Red Sea, Egypt. *Iranian Journal of Fisheries Science*. Accepted.
- Abu El-Regal, M.A., 2017.** Spatial and temporal distribution of larvae of coral reef fishes in northern Red Sea, Egypt. *Iranian Journal of Fisheries*, (accepted).
- Al-Kholy, A., 1964.** Red Sea fisheries. General Egyptian Organization of Aquatic Resources. Cairo. 345 P.
- Barrania, A. and Ahmed, A.I., 2003.** Fisheries management plan in the Red Sea. U.S. Agency for International Development. Program Support Unit. Egyptian Environmental Policy Program. MOBIS Task Order No. 263-M-00-03-00002-00. 68 P.
- Boraey, F.A., 1969.** Family Mullidae of the Red Sea. M.Sc. Thesis. Cairo University.
- Borges, R., Ben-Hamadou, R., Chicharo, P. and Goncalves, E.J., 2007.** Horizontal spatial and temporal distribution patterns of nearshore larval fish assemblages at a temperate rocky shore. *Estuarine Coastal and Shelf Science*, 71, 421-428.
- Botros, G.A., 1971. Fishes of the Red Sea. Oceanography and Mar. Biol. An Annual Review. 9: 221-348**
- Clark, T., 1991.** Larvae of nearshore fishes in oceanic waters near Oahu, Hawaii. *NOAA Technical report NMFS*, 101, 1-19.
- Cuschnir, A., 1991.** Taxonomic diversity, biological and ecological Interspecific Relationships, and Annual cycle of Distribution of Ichthyoplankton in the Northern end of the Gulf of Elat (Red Sea). Ph.D. Thesis.
- Debelius, H., 1998.** Red Sea reef guide. IKAN-Unterwasserarchiv. Frankfurt. 321 P.
- El-Sherbiny, M.M., 1997.** Some ecological studies on zooplankton studies in Sharm El-Sheikh area (Red Sea). M. Sc. Thesis. Marine Science Department, Faculty of Science, Suez Canal University, Egypt. 151 P.
- Froukh, T.J., 2001.** Studies on taxonomy and ecology of some fish larvae from the Gulf of Aqaba. M.Sc. Thesis. Faculty of Graduate Studies. University of Jordan. 103 P.
- Fricke, R. and Abu El-Regal, M.A., 2017a.** *Schindleria elongata*, a new species of paedomorphic goby from the Red Sea (Teleostei: Schindleriidae). *Journal of Fish Biology*, (accepted). DOI:10.1111/jfb.13280

- Fricke, R. and Abu El-Regal, M.A., 2017b.** *Schindleria nigropunctata*, a new species of paedomorphic goby from the Red Sea (Teleostei: Schindleriidae). *Marine Biodiversity*. DOI:0.1007/s12526-017-0831
- Fuiman, L., 2002.** Special considerations of fish eggs and larvae. In: Fuiman, L.A., Werner, R.G. (Eds.), *Fishery Science. The Unique Contributions of Early Life Stages.* Fishery Blackwell Publishing. pp. 206-221.
- Golani, D. and Bogorodsky, S., 2010.** The fishes of the Red Sea-reappraisal and updated checklist. *Zootaxa*, 2463, 1–135.
- Houde, E.D., Almatar, S., Leak, J.C. and Dowd, C.E., 1986.** Ichthyoplankton abundance and diversity in the Western Arabian Gulf. *Kuwait Bulletin of Marine Science*, 8, 107-393
- Johannes, R.E., 1978.** Reproduction strategies of coastal marine fishes in the tropics. *Environmental Biology of Fishes*, 3, 141-160 .
- Jones, G.P., Planes, S. and Thorrold, R., 2005.** Coral reef fish larvae settle close to home. *Current Biology*, 15, 1314-1318.
- Lazzari, M.A., 2001.** Dynamics of larval fish abundance in Penobscot Bay, Maine. *Fisheries Bulletin*, 99, 81-93.
- Leis, J.M. and Rennis, D.S., 1983.** The larvae of Indo-Pacific coral reef fishes. New South Wales Univ. Press, Sydney, Australia. 269 P.
- Leis, J.M., 1986.** Vertical and horizontal distribution of fish larvae near coral reefs at Lizard Islands, Great Barrier Reef. *Marine Biology*, 90, 505-516.
- Leis, J.M., 1991a.** The pelagic stage of reef fishes: The larval biology of coral reefs. In: Sale, P. F. the *Ecology of Fishes on Coral Reefs.* Academic Press, San Diego: CA. pp. 183-230.
- Leis, J.M., 1991b.** Vertical distribution of fish larvae in the Great Barrier Reef lagoon, Australia. *Marine Biology*, 109, 157-166 .
- Leis, J.M. and Carson-Ewart, B.M., 1997.** In situ swimming speeds of the late pelagic larvae of some Indo-Pacific coral reef fishes. *Marine Ecology Progress Series*, 159, 165-174.
- Leis, J.M. and Carson-Ewart, B.M., 2002.** Larvae of Indo-Pacific coastal fishes. An identification guide to marine fish larvae. (Fauna Malesiana Handbooks 2). E. J. Brill, Leiden. 850 P.
- Leis, J.M. and McCormick, M.I., 2002.** The biology, behaviour, and ecology of the pelagic larval stage of coral reef fishes. In: Sale, P.F. (Ed), *Coral reef fishes: dynamics and Diversity in a complex ecosystem.* Academic press, San Diego. pp. 171-199.
- Lowe-McConnell, R.H., 1979.** Ecological aspects of seasonality in fishes of tropical waters. *Symposium Zoological Society*, 44, 219-241.
- Mehanna, S.F.M. and Abu-El-Regal, Osman, Y.A., 2014.** Age and growth based on the scale readings of the two scarid species *Hipposcarus harid* and *Chlorurus sordidus* from Hurgada Fishing

- Area, Red Sea, Egypt. *International Journal of Marine Science*, 4(31), 1-12
- Montgomery, J.C., Nicholas, T. and Haine, O.S., 2001.** Active habitat selection by presettlement reef fishes. *Fish and Fisheries*, 2, 261-277.
- Moser, H.G. and Smith, P.E., 1993.** Larval fish assemblages of the California Current Region and their horizontal and vertical distributions across a front. *Bulletin of Marine Science*, 53, 645-691.
- Munro, J.L., Thompson, R.V. and Gaut, C., 1973.** The spawning seasons of Caribbean reef fishes. *Journal of Fish Biology*, 5, 69-84.
- Nellen, W., 1973.** Kinds and abundance of fish larvae in the Arabian Sea and the Persian Gulf In: B. Zeitzschel. Ed. The biology of the Indian Ocean. New York. Verlag. pp. 415-430.
- Osman, Y.A., 2014.** Population dynamics and stock assessment of the most important species of family scaridae (parrot) in Hurghada, red sea. MSc. Thesis. Marine Science Department, Faculty of Science, Port Said University. pp. 1-113
- Randall, J., 1983.** Red Sea reef fishes. IMMEL Publishing, London. 192 P.
- Sale, P.F., 1980.** The ecology of fishes on coral reefs. *Oceanography and Marine Biology*, 18, 367-421.
- Sale, P.F., 2002.** Coral reef fishes: dynamics and diversity in a complex ecosystem. Academic Press, San Diego. 549 P.
- Smith, P.E. and Richardson, S.L., 1977.** Standard techniques of pelagic eggs and larvae surveys. FAO Fish. *Tech. Pap*, 175, 1-100.