

Original Article

Seasonality of juvenile fish community structure and diversity in a tropical seagrass meadow at Watamu, Kenya

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Abstract

Seagrass are important marine habitats that function as nursery grounds for juvenile fish. Human activities and other natural factors have contributed to their decline, and this has compromised their role as nurseries, specifically in non-continuous patchy seagrass beds. In this study, juvenile fish abundance from tropical seagrass beds of Watamu were examined, while testing the hypothesis that seagrass cover and seasonality influenced juvenile fish abundance and diversity. Two sampling stations were identified, Watamu Blue Lagoon (WBL) and Watamu Beach (WB), based on seagrass cover, and were sampled for a period of 10 months that included two south-east monsoon (SEM) and two north-east monsoon (NEM) seasons. Monthly samples were collected by seining within the shallow seagrass habitats of WBL and WB. A total of 31 juvenile fish families were obtained, the dominant taxa being Lutjanidae and Siganidae. Seasonal and interannual variability in juvenile abundance was observed over the two years ($p < 0.05$); year 1 recorded higher abundance than year 2, specifically during the SEM. In year 2 a higher mean abundance was recorded during the NEM when compared to the SEM. Chlorophyll *a* ($p < 0.05$) and salinity ($p < 0.05$) were found to significantly influence juvenile fish abundance.

Keywords: juvenile fish, seasonality, seagrass beds, abundance, diversity, Watamu, Kenya

Introduction

A nursery is a habitat that enhances growth and survival of juveniles and contributes to the recruitment of the adult population. A nursery also contributes to growth and maturity of juveniles before they are able to move to other habitats as sub-adults as well (Beck *et al.*, 2001; Parsons *et al.*, 2014). A suitable nursery allows connectivity between habitats enabling colonization by juveniles or larvae, migration of subadults to adult habitats, and adequate interaction within the

community (Whitfield and Patrick 2015; Berkström *et al.*, 2013; Irsson *et al.*, 2015). The proximity of seagrass beds to other habitats like coral reefs facilitates trophic transfers and cross-habitat utilization by fishes (Barnes *et al.*, 2012; Berkström *et al.*, 2013).

Shallow coastal habitats such as mangroves, seagrass beds and patch reefs, are important nursery habitats for fishes of economic and biodiversity importance (Igulu *et al.*, 2014; McDevitt-Irwin *et al.*, 2017;

de Andrade-Tubino *et al.*, 2020). Seagrass beds in particular provide a structural complex of intertwined seagrass shoots that serve as nursery, providing shelter and protection of juveniles from predation (McCloskey and Unsworth, 2015). Dense seagrass cover also influences zooplankton and phytoplankton abundance, the major food source of ichthyoplankton, and plant detritus, thus attracting a greater assemblage of fauna (Gross *et al.*, 2017; Mateo and Tobias, 2008; Mwaluma, 2010; Parsons *et al.*, 2014). The shelter provided by shoot structure provide hiding spaces for larvae and juveniles because it limits movement and vision of larger predators (Gross *et al.*, 2019). This allows enough time for the development of larvae and juveniles, until they are able to migrate to a suitable adult habitat (Brown *et al.*, 2004; Berkström *et al.*, 2013; Igulu *et al.*, 2014). Seagrass beds are connected to other habitats, and thus create supportive conditions for marine organisms and fisheries in general (Cullen-Unsworth *et al.*, 2014). Seagrass therefore influence fish abundance, distribution, and their recruitment, supporting fish growth and survival through the pelagic larval phase (Berkström *et al.*, 2013).

It is hypothesized that dense seagrass meadows attract higher abundance of juvenile fish (Cullen-Unsworth *et al.*, 2014; McCloskey and Unsworth, 2015). However, due to both natural and anthropogenic disturbances, the distribution of seagrass has decreased by about 60 % globally since the 1980s (Copertino *et al.*, 2016; Soe-Htun, 2017). The same has been reported along the Kenyan coast where nearly half of the seagrass of Diani Chale lagoon was destroyed by sea urchin herbivory between 2001 and 2006 (Daudi *et al.*, 2013). Both natural and human activities are associated with decreasing seagrass cover, which subsequently compromise their nursery roles by limiting habitation of juveniles (McCloskey and Unsworth 2015; Moussa *et al.*, 2019).

Studies along the East African coast have concentrated on adult fishes in the seagrass habitats and mangroves (Kimirei *et al.*, 2011; Kimirei, 2012; Lugendo, 2007; Wainaina *et al.*, 2010; Kimani *et al.*, 1996; Huxham *et al.*, 2004, 2008). A few studies have identified the role that seagrass beds and mangroves can play in replenishing coral reef fish populations (Wanjiru *et al.*, 2021; Alonso *et al.*, 2014; Kimirei *et al.*, 2011; Lugendo, 2007). In most cases, the studies involving juvenile abundance have applied Underwater Visual Census including one that studied the distribution of juveniles in the rocky intertidal shallow habitats of Watamu Marine National Park (Igulu *et al.*, 2014; Kimirei

et al., 2011; Okemwa *et al.*, 2019; Sindorf *et al.* 2015). In the coastal Kenya, a study by Kimani *et al.*, (1996) was conducted at Gazi Bay, investigating fish communities using beach seines while another by Wanjiru *et al.* (2021) investigated the community structure of fishes and crustaceans in the Vanga mangrove ecosystem, Kenya, using fyke nets.

Higher fish catches and juvenile abundance have been reported during the NEM season in some studies (Okemwa *et al.*, 2019). Other studies have recorded high abundances of fish in the month of June, which falls in the SEM season (Kimani *et al.*, 1996). Environmental factors such as Chlorophyll-*a* and zooplankton abundance have been associated with fish abundance (Kamau *et al.*, 2021; Osore *et al.*, 2004; Kimani *et al.*, 1996).

In this study, a comparison of juvenile fish abundance and diversity was made between two sites in Watamu, with a null hypothesis that seasonality and abiotic factors do not influence fish juvenile abundance and diversity. A second objective was comparing juvenile abundance between the two sites at WBL and WB.

Methodology

Study area

The research was conducted in the Watamu Marine Reserve on the north coast of Kenya, which is adjacent to the Watamu Marine National Park. Both sites were enclosed lagoons with low uniform topography dominated by a mosaic of seagrass beds interspersed with varying seagrass cover. Two sites were identified as Site 1: Watamu Blue Lagoon coded WBL, which was composed of seagrass that was relatively continuous and with seagrass cover of 65 % and above. The dominant seagrass species were *Thalassodendron ciliatum* (Forsskål) which has average cover of 34 %. A second site was located at Watamu Beach coded WB, selected for comparison and termed as Site 2, was composed of seagrass cover of at least 62 %. The dominant seagrass species at this site were *T. ciliatum*, *Cymodocea rotundata* and *Halodule uninervis* which covered an average of 18 %, 17 % and 11 % respectively. The second site consisted of mixed meadows comprising of pioneer species that may have been as a result of previous reported urchin herbivory that had severely affected the region as evidenced by seagrass stumps seen during this study. The tidal cycle in both sites was mixed semidiurnal with two maxima and two minima per day with a tidal range of about 2.0 at the neap tide and 2.9 during spring tide (Mwaluma *et al.*, 2011).

Field procedures and laboratory analysis

In this study a beach seine was used for sampling as it is considered effective in sampling relatively shallow water, and effective in estimation of relative abundance (Hahn *et al.*, 2007). At both sites, juveniles were sampled using a seine net measuring 4 m in length, 2.5 m in height, and 1.5 cm mesh size. The sampled area was approximately 250 m². The area was determined by measuring length (50 m) and width (50 m), using a tape and marked with buoys. At each station, eight replicate samplings were randomly conducted within the measured perimeter. Sampling was done during spring low tide in the SEM months of July and August

name were taken before preservation in absolute alcohol. The fish species was recorded and the total length for each specimen was measured to the nearest 0.1 cm on a standard fish length measuring board before being preserved in absolute alcohol. The fish that were not identified at the site were coded and preserved for identification in the laboratory using Anam and Mostrada (2012), Heemstra and Smith (1986) and Lieske and Myers (2004).

The length at maturity for each fish species was checked before classifying it as a juvenile. The fish sampled were classified as juveniles only if (i) their length

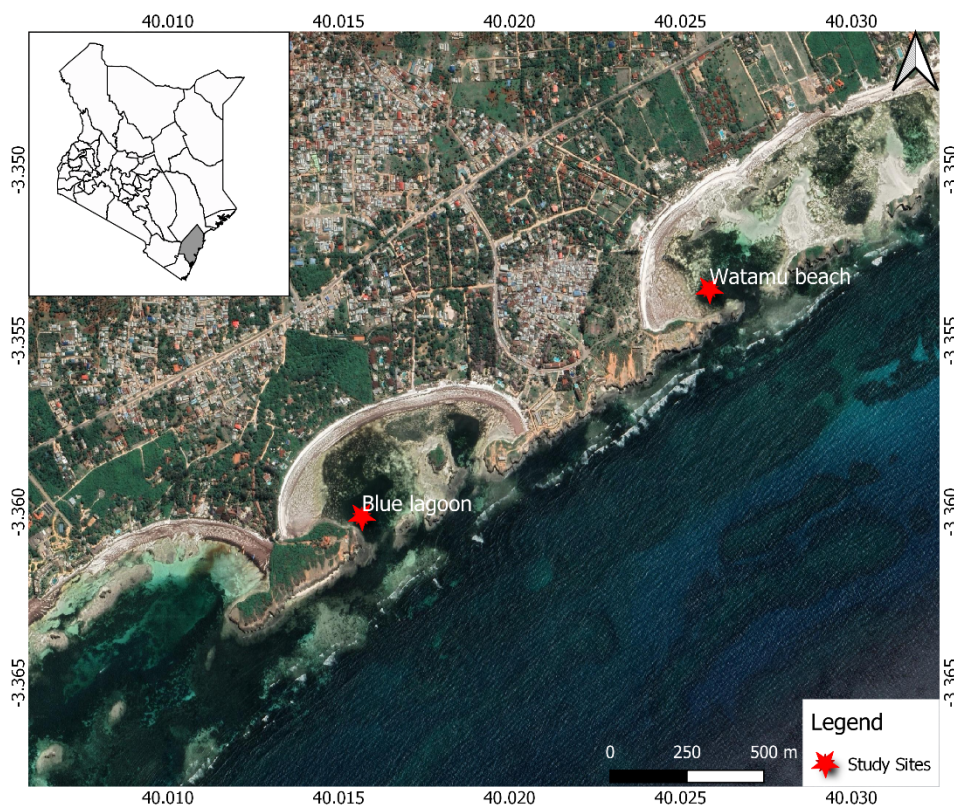


Figure 1. Map with the location of the study sites: Watamu Blue Lagoon (Site 1) and Watamu Beach (Site 2).

2019/2020, and June, July, and August 2020/2021, and the NEM months (November, December, January) of 2019/2020 and 2020/2021. The net was laid perpendicular to the shore by two fishermen wading in the water on foot. The net was hauled towards the shore through a 90-degree arc against the current. Two more persons assisted the fishermen by lifting the net and collecting the fish after hauling. The same fishermen conducted the seining throughout the study period. The operation ranged between 20-30 minutes for a single haul. The total length of fish and the species

was less or equal to the minimum age at maturity, as reported in Fish Base (Froese and Pauly, 2016), and (ii) if their sizes were <25 % of maximum adult total length (Nagelkerken and Velde, 2002; Okemwa *et al.*, 2019).

Water quality analysis

At each site, monthly water quality parameters (temperature, Chlorophyll-*a* and salinity) were measured. Water temperature and salinity were measured using a YSI multi-parameter probe, while for Chlorophyll-*a*, 5 L of seawater was filtered through 47 nm GFF filters.

In the laboratory, 10 mL of acetone was added to the filtrate and left overnight for the extraction process to take place. The contents were then centrifuged at 4000 rpm for 10 minutes. The absorbance was measured using a spectrophotometer (UV-S) at a wavelength 750 nm, with 90 % acetone used as a blank.

Data analysis

Shannon-Weiner diversity (H), Pielou's index of evenness (J), and Margalef's index of richness (d) were applied in the assessment of community biodiversity, calculated on the R studio package Vegan (version 2.5-6) (Oksanen *et al.*, 2013). Juvenile fish abundance was compared using PERMANOVA to test for differences between sites, months, and years.

Community analysis was assessed using nMDS clusters. To ascertain the effect of biophysical factors on juvenile fish, stepwise generalized linear regression models (GLM) were used to obtain the significance and correlation coefficients of the interaction between juvenile abundance against temperature, salinity, and Chlorophyll-*a* (Martinez, 2016).

Results

Environmental variables

The environmental variables showed a significant variation between seasons and months. Temperature and salinity were highest during the NEM season months of November/December compared to the SEM months of June /July for both years (2019 and 2020) (Fig. 2).

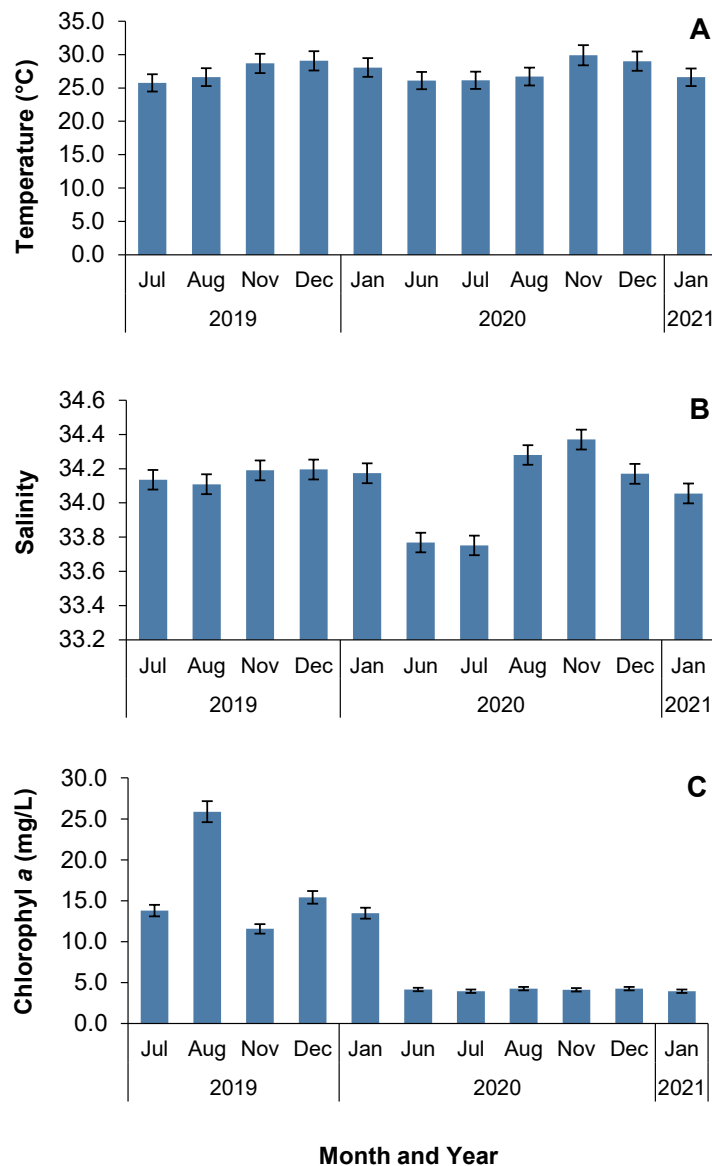


Figure 2. Mean monthly and seasonal variation in temperature (A), salinity (B), and Chlorophyll-a (C) measured between July 2019 and January 2021.

Table 1. The composition and abundance of juvenile fish found in Watamu Blue Lagoon (Site 1) and Watamu Beach (Site 2) sampled between July 2019 and January 2021.

Family	Taxa	Blue Lagoon (Site1)		Watamu Beach (Site 2)	
		Abundance (n)	Size range (cm)	Abundance (n)	Size range (cm)
Acanthuridae	<i>Acanthurus auranticavus</i> (Randall, 1956)	1	6.3	0	
	<i>Acanthurus triostegus</i> (Linnaeus, 1758)	0	0	2	4.9-5.2
	<i>Zebrasoma desjardini</i> (Bennett, 1836)	1	5.0	0	
Apogonidae	Apogonidae n.d.	1	4.8	0	
Belonidae	<i>Tylosurus crocodilus</i> (Péron & Lesueur, 1821)	7	15.0-30.0	0	
Diodontidae	<i>Diodon liturosus</i> (Shaw, 1804)	1	27.0	0	
Ephippidae	<i>Platax teira</i> (Forsskål, 1775)	2	8.9-11.8	11	4.0-13.0
Fistulariidae	<i>Fistularia commersonii</i> (Rüppell, 1838)	2	42.0 -52.0	0	
	<i>Fistularia petimba</i> (Lacepède, 1803)	4	18.0 -39.0	2	14.0-16.0
Gerreidae	<i>Gerres oyena</i> (Forsskål, 1775)	0		2	
Haemulidae	<i>Plectorhinchus schotaf</i> (Forsskål, 1775)	2	11.8-13.5	0	
Labridae	<i>Cheilinus oxycephalus</i> (Bleeker, 1853)	4	3.7-5.0	0	
	<i>Cheilio inermis</i> (Forsskål, 1775)	1	13.3	1	10.0
	<i>Thalassoma hardwicke</i> (Bennett, 1830)	0		1	7.0
Lethrinidae	<i>Lethrinus harak</i> (Forsskål, 1775)	13	4.9-13.0	6	5.0-15.5
	<i>Lethrinus lentjan</i> (Lacepède, 1802)	5	5.4-7.9	2	5.0-9.0
	<i>Lethrinus mahsena</i> (Forsskål, 1775)	1	8.0	2	7.0-8.9
	<i>Lethrinus nebulosus</i> (Forsskål, 1775)	1	10.0	2	7.0 -7.1
Lutjanidae	Lutjanidae n.d.	0		2	5.5-8.4
	<i>Lutjanus fulviflamma</i> (Forsskål, 1775)	26	5.2-10.6	60	4.0-11.5
Monacanthidae	<i>Amanses scopas</i> (Cuvier, 1829)	1	5.3	3	3.0-4.0
	Monacanthidae n.d.	1	4.0	1	5.9
Mugilidae	<i>Crenimugil seheli</i> (Forsskål, 1775)	2	10.1-11.1	0	
Mullidae	<i>Mulloidichthys vanicolensis</i> (Valenciennes, 1831)	9	6.0-12.0	1	5.0
	<i>Parupeneus macronemus</i> (Lacepède, 1801)	1	9.0	0	
Ostraciidae	<i>Lactoria cornuta</i> (Linnaeus, 1758)	2	8.9-9.5	1	5.0
	<i>Lactoria diaphana</i> (Bloch & Schneider, 1801)	0		9	2.0-6.5
	<i>Lactoria fornasini</i> (Bianconi, 1846)	0		2	4.5-6.3
	Ostraciidae n.d.	0		1	1.2
Plotosidae	<i>Plotosus lineatus</i> (Thunberg, 1787)	0		5	
Pomacentridae	<i>Abudefduf septemfasciatus</i> (Cuvier, 1830)	0		4	6.0 -6.5
	<i>Abudefduf sexfasciatus</i> (Lacepède, 1801)	0		2	6.0-7.0
	<i>Abudefduf vaigiensis</i> (Quoy & Gaimard, 1825)	3	5.0-5.7	1	5.0
	<i>Dascyllus trimaculatus</i> (Rüppell, 1829)	2	2.0-3.8	0	
	Pomacentridae n.d.	3	9.2-10.0	0	
	<i>Pomacentrus</i> sp.	0		1	5.0
Scaridae	<i>Leptoscarus vaigiensis</i> (Quoy & Gaimard, 1824)	7	7.0-11.0	8	5.0 -9.5
Scorpaenidae	<i>Scorpaenopsis oxycephala</i> (Bleeker, 1849)	0		5	4.2-6.2
	<i>Scorpaenopsis venosa</i> (Cuvier, 1829)	0		1	5.0
Siganidae	<i>Siganus luridus</i> (Rüppell, 1829)	0		1	4.0
	<i>Siganus sutor</i> (Valenciennes, 1835)	38	3.4-12.2	30	4.1-10.6
Soleidae	<i>Pardachirus marmoratus</i> (Lacepède, 1802)	0		1	5.6
Sphyaenidae	<i>Sphyaena jello</i> (Cuvier, 1829)	1	13.5	0	
Syngnathidae	<i>Syngnathus acus</i> (Linnaeus, 1758)	0		3	11.8-13.5
Tetraodontidae	<i>Canthigaster valentine</i> (Bleeker, 1853)	1	6.0	1	4.0
	<i>Tetraodon lineatus</i> (Linnaeus, 1758)	0		1	8.0
Tetrarogidae	<i>Ablabys macracanthus</i> (Bleeker, 1852)	0		1	4.2

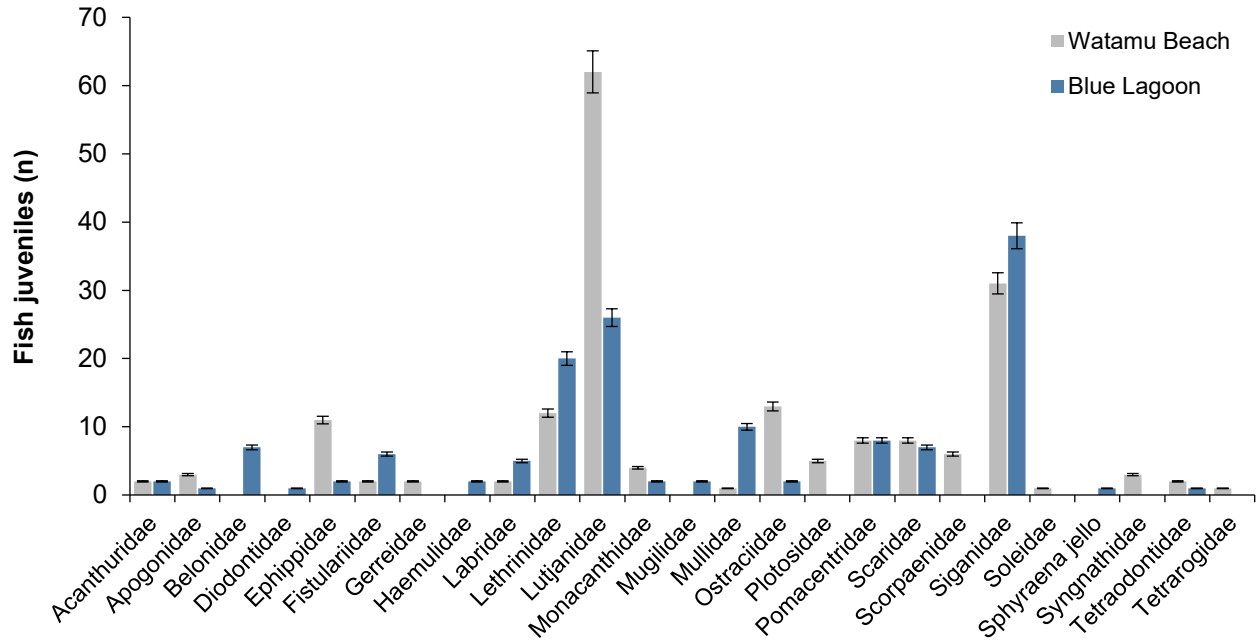


Figure 3. Distribution of juvenile fish families in Watamu Blue Lagoon (Site 1) and Watamu Beach (Site 2).

Chlorophyll-*a* on the contrary was highest during the SEM month of June 2019, but lower during the subsequent years indicating interannual variability.

Species composition and abundance

A total of 192 hauls were performed and 659 fish were collected over the 11-month study period at both sites. Of these 319 were considered juveniles after sorting

using length at minimum maturity. The identified juveniles were from 41 species and 25 families (Table 1). Dominant families were Lutjanidae, Siganidae and Lethrinidae which contributed about 27.59 %, 21.63 %, and 10.03 % of total fish juveniles sampled, respectively (Fig.3). In the monthly samples, numbers ranged between 2-32 for Lutjaniids, and 1-23 for Siganids. Dominant species in order of abundance were

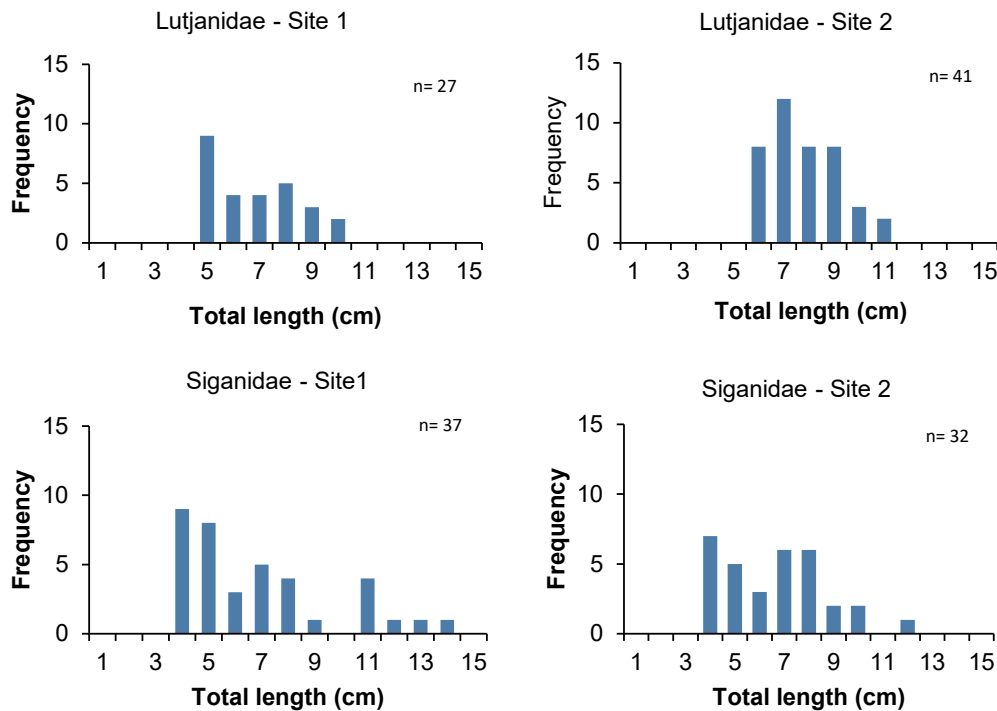


Figure 4. Length frequencies (%) of Lutjanidae, and Siganidae in Watamu Blue Lagoon (Site 1) and Watamu Beach (Site 2).

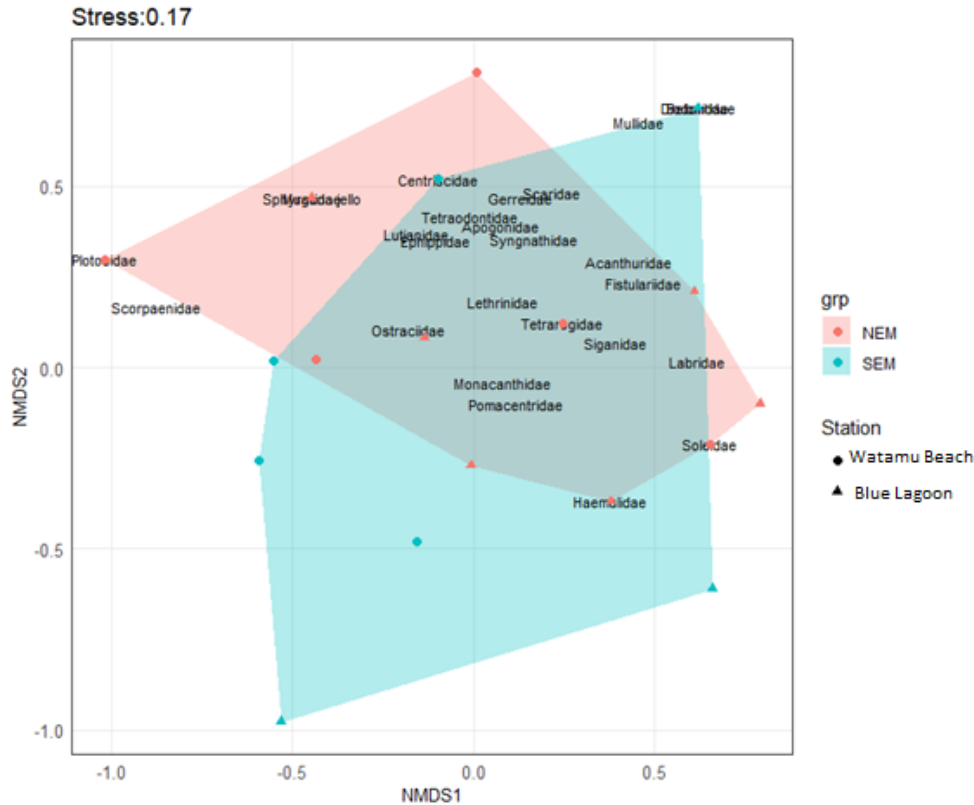


Figure 5. Ordination chart showing the distribution of juveniles in the two sites during the two seasons. Ordination is based on abundance, using Bray-Curtis distance matrix (Labrid- Labridae, Scarid- Scaridae, Watamu Blue Lagoon (Site 1) and Watamu Beach (Site 2).

Lutjanus fulviflamma, *Siganus sutor*, *Lethrinus harak* and *Leptoscarus vaigiensis* (Table 1). No significant difference in abundance was observed between the two sites.

Overall, a higher number of juvenile fish were found distributed at WB (Site 2) as compared to WBL (Site 1) (Fig. 3). The dominant families were Lutjanids (*Lutjanus fulviflamma*) and Siganids (*Siganus sutor*). Lutjanids which were found to be more abundant at Site 2, along with Lethrinidae (*Lethrinus harak*) and Scaridae (*Leptoscarus vaigiensis*).

Size range distribution of dominant species

Modal lengths of Lutjanidae and Siganidae indicated no difference between the two sites (Fig. 4). The dominant size range for Siganidae was 4 cm at both sites. Lutjanids were dominated by a size range of between 5-7 cm.

Species diversity

Overall species diversity (H') during the study period was higher at WB ($H'=3.03$) as compared to WBL ($H'=2.83$). There was no significant difference in species richness between the two sites, although it was slightly higher at WB ($d = 5.5$) compared to WBL ($d = 4.6$).

Evenness (J) was significantly lower in WB ($J = 0.94$) compared to WBL ($J=0.95$)

Juvenile communities showed an overlap as is evident from the ellipses representing the two sites. However, a few families showed distinct associations with specific stations. For instance, Lutjanidae, Centriscidae, Labridae, Scaridae, and Siganidae were closely associated with WHS, while Lethrinidae and Pomacentridae were associated with both sites.

Seasonal variation

Juvenile fish varied immensely between months and between seasons with interannual variability (Fig. 6). The highest abundance of juveniles was recorded in July 2019 at both Site 1 and 2. The abundance of juveniles was almost constant between the months of August 2019 to June 2020, with minimum variation. Peaks were observed in the year 2 NEM season.

The GLM results showed that salinity and Chlorophyll-*a* had a significant positive correlation with juvenile abundance, while the temperature was significantly inversely correlated ($p < 0.05$; Table 1).

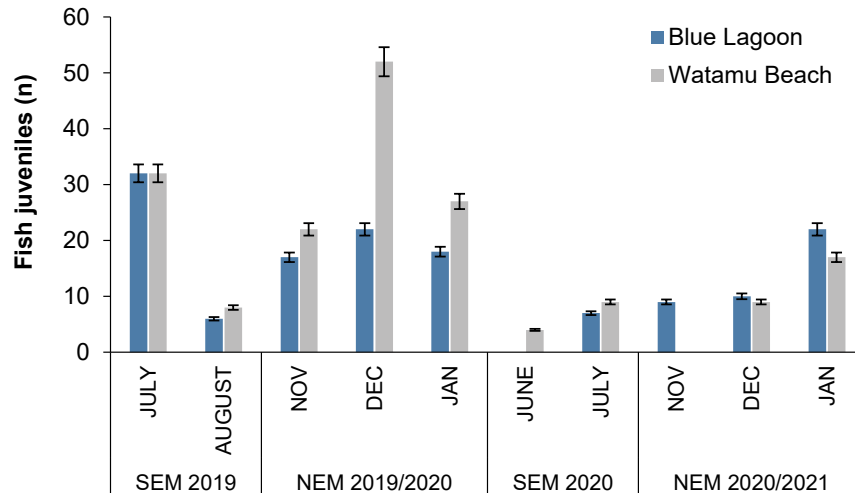


Figure 6. Monthly and seasonal variation in fish juvenile abundance at Watamu Blue Lagoon (Site 1) and Watamu Beach (Site 2) between July 2019 and January 2021.

Discussion

Species composition

Watamu Beach and Watamu Blue Lagoon registered a total of 25 families and 41 species. The dominant families were Lutjanidae, Siganidae and Lethrinidae for both sites. However, there was no significant difference in the abundance of juveniles between WB and WBL indicating that the sites were similar. Other studies have reported a similar community in seagrass beds within the tropics (Ambo-Rappe *et al.*, 2013; Kopp *et al.*, 2010; Lugendo, 2007). Other studies carried out nearby in the intertidal shallow lagoons of Watamu Marine National Park, however reported a dominance of Gobiidae, Blenniidae, Pomacentridae, and Labridae was reported (Sindorf *et al.*, 2015). The differences in species may be attributed to differences in habitat composition, the current study having sampled fish in seagrass beds while the other sampled in a rocky intertidal site.

The count of families sampled is lower than in other studies carried out in Kenya, possibly due to differences in physical characteristics such depth, effort and other operational details and the length of the sampling period. Although commonly used in shallow water studies beach seining is not suitable for catching faster-swimming fish and larger pelagic fish (Kimani *et al.*, 1996). In another study by Okemwa *et al.* (2019) using underwater visual census (UVC) 190 species were found at five shallow fringing-lagoon reef sites in Kenya with the dominant families being Pomacentridae and Labridae. Even so, it is important to note that there have been very few studies on seasonal juvenile fish recruitment patterns within seagrass beds of the

western Indian Ocean region that applied similar sampling methods. While most studies on recruitment have applied UVC, the current study sampled juveniles using a beach seine net. Because there have been few studies for comparison with the current study, it would be important to carry out similar studies using UVC in future to compare the methodologies.

Fish families such as Lutjanidae (*Lutjanus argentimaculatus*, *L. fulviflamma*), and Mullidae (*Parupeneus barberinus*, *P. rubescens*) that were found during this study inhabit the reef as adults, associating with seagrass beds that are adjacent to reefs as juveniles (Dorenbosch *et al.*, 2006). The presence of these families suggest that the seagrass beds at Watamu function as nurseries for fish that inhabit the neighbouring reefs. These families can therefore be classified as transient, spending part of their life in the seagrass habitats but will migrate to the reef due to a shift in ontogeny, using shallow habitats during the juvenile stages before moving to adult habitats. Similarly, while looking at juvenile abundance associated with both seagrass and reefs, Kimirei *et al.* (2011) found a high abundance of reef-associated species (*Lethrinus harak*, *L. lentjan*, *Siganus sutor*, and *Lutjanus fulviflamma*) in the seagrass beds of Mbegani, Tanzania, while the same adults were found in the adjacent reef habitats, a clear indication of ontogenetic habitat shift that occurs to meet changing dietary and physiological requirements such as spawning and competition (Kimirei *et al.*, 2013; Sheaves, 1995). In this study, *Lutjanus fulviflamma* was found abundantly in both stations, suggesting utilization of the seagrass beds obligately, because there are no mangroves within the proximity

of the site, as it has been shown to prefer mangrove nurseries to seagrass beds in its juvenile stage (Kimirei *et al.*, 2011). It is also suggested that seagrass beds are capable of retaining fish larvae for several months before moving to other habitats. Therefore, most of the individuals sampled in these beds may have been retained after dispersal, before moving to the subadult habitats (Bell *et al.*, 1987; Jelbart *et al.*, 2007; McNeill and Fairweather, 1993).

From the ordination charts, it was evident that specific families were associated with specific stations. Labridae and Siganidae which were closely associated with WBL, are known to be seagrass-associated while Lethrinidae and Apogonidae are reef fish that use the seagrass beds as nurseries. Scaridae and Labridae are typically seagrass dwellers (Lugendo *et al.*, 2005; Kopp *et al.*, 2010).

Seasonal distribution

Environmental variables such as salinity and temperature are influenced by season and in turn may influence fish community structures (Wanjiru *et al.*, 2021). The overall juvenile fish abundance during the SEM was higher as was evenness, richness, and diversity. This observation concurs with results of Kimani *et al.* (1996) and Wanjiru *et al.* (2021) who studied juvenile fish from Gazi and Vanga on the south coast of Kenya, respectively. Even though reproductive activity of East African fish is not restricted to particular seasons (Nzioka *et al.*, 1979; Okemwa, 2019), it is possible that fishes spawned offshore in the NEM season move into the mangrove and seagrass nursery habitats during the rougher SEM seasons (Wanjiru *et al.*, 2021) because during this season seagrass beds offer refuge and shelter between the reefs and the inshore habitats with reduced wave action (Parsons *et al.*, 2014; Björk *et al.*, 2008).

The interannual variability observed in this study may be due to several factors such as recruitment of temporary residents, the timing of adult spawning, the timing of settlement, count of individuals settling at a given time, and fishes shifting to adult habitats (Middleton *et al.*, 1984). One study for instance showed that some of the common seagrass fishes in the Caribbean appeared to show seasonal variation with major recruitment pulses from late summer to late fall (Mateo and Tobias, 2008). Okemwa *et al.* (2019), working in shallow lagoons of Kuruwitu, found that recruitment occurred year-round with a consistent unimodal peak in recruit densities occurring between December and April.

Effect of biophysical factors

Many studies in tropical systems report seasonal influences on recruitment patterns. Increasing sea temperatures during the NEM season have been found to trigger spawning events when biological cues such as food availability become more suitable (Okemwa *et al.*, 2019). In this study Chlorophyll *a*, salinity and zooplankton abundance positively influenced juvenile abundance. These were found to vary annually and seasonally. The variation is possibly influenced by the interannual variability in juvenile abundance. The variation is caused by the occurrence of monsoon cycles that result in two seasons. The higher abundance of juveniles during a particular season may be associated with abundant food supply.

Conclusion

The results of this study indicate that coral reef-associated fish use seagrass habitats as nursery grounds; with the most common families being Lutjanidae, Siganidae and Lethrinidae. The presence of these families suggests that the seagrass beds at Watamu function as nurseries for fish that inhabit the neighbouring reefs. The higher abundance of juveniles associated with reefs found in the degraded sites suggests the transient nature of the juveniles and the interconnectedness of the two habitats studied, making it difficult to confidently identify why this preference exists. In this study, no significant difference in the abundance of juvenile fish was found between the two habitats. Seasonality is seen to play an important role with higher numbers of juveniles recorded during the SEM season. A higher abundance in the seagrass beds during this season could be due to the calm weather, with reduced currents, making the beds suitable for feeding and shelter. Biophysical factors are influenced by the monsoon cycle which consequently causes the interannual variability in juvenile abundance. Chlorophyll-*a* significantly affected the presence of juveniles, as higher juvenile abundance during SEM coincided with higher Chlorophyll-*a* in the samples.

This study confirmed that both continuous and patchy seagrass beds are critical nursery habitats for fish. Both types had similar juvenile abundance, suggesting they play similar roles in enhancing the survival and recruitment of juveniles. Sustainability in the provision of fishery services is dependent on sustainable exploitation and management of seagrass habitats. As a management measure, conservation of seagrass meadows is key to enhancing the nursery habitat

function for juvenile fish and is key for replenishment of fish populations in coastal lagoons in East Africa.

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