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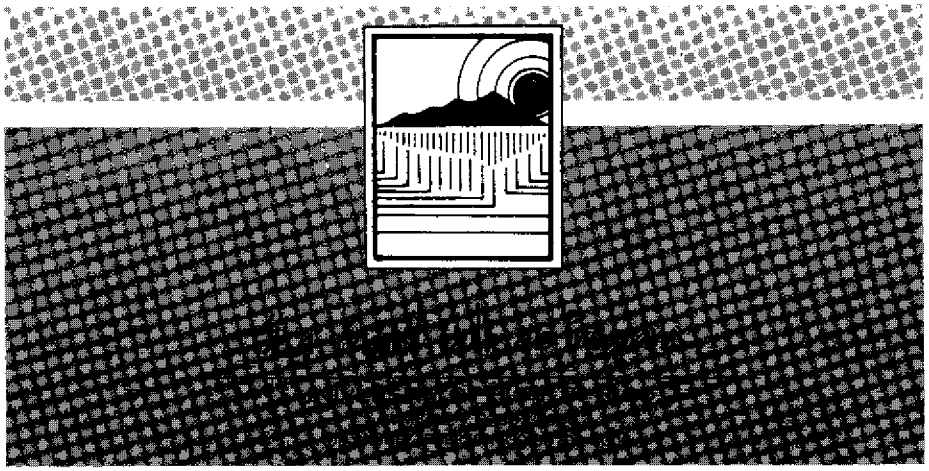

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Taxonomic structure and distribution of reef fish larvae across a neritic-oceanic gradient off La Parguera, Puerto Rico

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Abstract

Key words: fish larvae, larval dispersal, neritic, oceanic

Taxonomic structure, abundance and distribution patterns of fish larvae were examined across a neritic-oceanic gradient off La Parguera during three cruises (Feb/95, Dec/95 and May/96). Sampling stations positioned at 6, 10, 13, 17, 29 and 46 km from the coastline were occupied along three transects for a total of 18 stations sampled per cruise. A total of 34,799 larval fishes were collected, representing 81 families, of which 56 were from coral reef fishes. Taxonomic structure at inshore stations was dominated by larvae of Clupeiformes, Gobiidae, Pomacentridae, Blennioidei, and Lutjanidae. The shelf-edge station presented a mixed taxonomic assemblage of reef and oceanic taxa. Gobiidae were the most abundant larvae at the shelf-edge followed by Myctophidae and various families of coral reef fishes. Beyond the shelf-edge, total fish larval abundance declined markedly due to a two-fold decline in abundance of coral reef taxa. Relative abundance of oceanic fish larvae increased across the oceanic gradient, but reef fish larvae were the numerically dominant assemblage up to 29 kms from the coastline. In general, larvae of fishes characterized as small demersal spawners observed neritic distributions. Reef fishes that are pelagic spawners with relatively longer larval duration had oceanic distributions, mostly within 20 km from the shelf-edge. Nevertheless, important exceptions to this generalized pattern emerge from this study.

Introduction

Most coral reef fishes have a pelagic larval stage in which the highest rates of natural mortality occur, influencing recruitment to coastal environments (Sale, 1970; Doherty, 1981; Doherty and Williams, 1988; Richards and Lindeman, 1987; Leis 1991). Duration of the pelagic larval stage is species dependent and highly variable, ranging from 9 to over 100 days (Brothers et al., 1983; Victor, 1986; Thresher et al., 1989;). Offshore dispersal of pelagically spawned eggs has been proposed as an adaptive strategy to minimize egg and larval predation in coral reefs (Johannes, 1978), increase probability of survival in patchy distributed environments (Doherty et al.,1985), and to maximize dispersal from natal reefs (Barlow, 1981). Leis (1982), Richards (1984) and Victor (1987) reported reef fish larvae occurring hundreds of miles from the nearest reef. This observation has led reef fish ecologists to conclude that coral reef fishes live as predominantly open populations (Sale, 1978, 1980; Doherty, 1991). Hypotheses concerning the possibility that some pelagic larvae may indeed return to their natal reefs have been tested in the last few years (Sale,1970; Emery, 1972; Johannes, 1978; Lobel, 1978; Williams et al., 1984; Jahn and Lavenberg,1986; Leis 1986; Lobel and Robinson, 1988; Leis, 1994). Horizontal distributions have been associated with distance from mainland (Leis, 1982), proximity to reefs (Kingsford and Choat, 1989), linear oceanographic features (Kingsford et al., 1991), upwelling events (Olivar, 1990), topographically steered flows (Cowen and Castro, 1994), variation in both the lunar and tidal cycles (Sponaugle and Cowen, 1996) and adult habitat and egg type (Leis and Miller, 1976).

Materials and Methods

Samples were collected during three cruises (Feb/95, Dec/95 and May/96) along three parallel transects (18°N,67°00W'; 18°N,67°03'; and 18°N,67°06' W) running perpendicular to the coastline. Six stations positioned at 6, 10, 13, 17, 29, 46 km from the coast were occupied along each transect, for a total of 18 stations per cruise (Fig.1). Inshore stations (N-6 and N-10 km) were sampled by oblique tows encompassing the entire water column, except the last few meters from the bottom. Shelf-edge (SE-13) and offshore stations (OC-13, OC-17, OC-29 and OC-46) were sampled in vertically stratified, step-oblique tows at three discrete depths (0-20, 21-40 and 41-60 meters) with a 1 m^2 Tucker Trawl opening-closing system fitted with three 202 µm mesh nets and standard flow meters. An average of 300 m^3 were filtered per tow. Cruise speed during tows was of approximately 2 knots. The entire sample was sorted for fish larvae and specimens preserved in 95% ethanol. Larval abundance data here reported are water column means of the three stations occupied within each contour during three sampling dates.

Taxonomic identifications were made using the following references: Moser et al. (1984), Matarese et al. (1989), Leis and Trnski (1989), Leis and Rennis (1983), Randall (1968), Jones et al. (1978) and a set of drawings and meristics from larval fishes from the Central Atlantic (Richards, unpublished). Larval fishes were classified as pre-flexion or post-flexion, based on the upward flexion of the urostyle, which precedes formation of the caudal fin.

Information on the scope and taxonomic variability of larval distribution patterns among Caribbean reef fishes and oceanographic factors influencing such distributions is essential to our basic understanding of coral reef fish recruitment dynamics. Offshore occurrence of coral reef fish larvae has been observed in samplings performed throughout the Caribbean and the southern Gulf of Mexico (Richards,1984), but insular shelf zones, and particularly coral reef areas, were in most part excluded from the (MARMAP) sampling scheme. Largely based on night-light samplings, Smith et al. (1987) noted that the inshore (near-field) larval assemblage was comprised by only a small number of families, implying that community structure of Caribbean coral reef fishes is mostly dependent upon recruitment by offshore transported larvae (the far-field assemblage). In such case, an increase of the spawning stock biomass of overexploited reef fish populations, mediated by closure management strategies (e.g. marine fishery reserves) would have limited influence upon recruitment dynamics on local scales, unless offshore larval retention areas and/or return mechanisms to natal and/or adjacent reefs would be operant.

Dennis et al. (1991) reported 24 families of larval fishes from night collections in mangrove, seagrass, and inshore coral reef habitats at La Parguera. Night-light sampling methodology, however, can be highly selective (Doherty, 1987) and misrepresentative of the breath of larval fishes occurring in these neritic habitats. The purpose of this study has been to provide an assessment of the variations in taxonomic structure, development stage (pre-flexion, post-flexion) and abundance of larval fishes across a neritic-oceanic gradient off La Parguera, an area of extensive coral reef development on the southwest coast of Puerto Rico.

Results and Discussion

The total collection of larval fishes was comprised of 34,799 individuals, representing 81 families of which 56 have been considered as coral reef fishes (Randall,1968; Bohlke and Chaplin, 1968). Pre-flexion larvae represented 86 % of the total collection, whereas the remaining 14 % were flexion and post-flexion larvae. Taxonomic composition at neritic stations (e.g. composite of N-6 & N-10) included larvae from small demersal spawners (aprox. 53 %), such as Gobiidae, Pomacentridae, Microdesmidae, Trypteriigydae, Blenniidae, Apogonidae and also from pelagic spawners (aprox. 47 %) such as Clupeiformes (Engraulidae and/or Clupeidae), Lutjanidae and Haemulidae (Fig. 2a). A total of (45) coral reef fish families were collected at inshore stations of which 11,655 were pre-flexion, 1,602 post-flexion and 13,257 were collected both as pre and post-flexion. The shelf-edge station (SE-13) presented a mixed taxonomic assemblage of reef and oceanic taxa with Gobiidae as the most abundant family, followed by oceanic Myctophidae and various coral reef taxa such as Pomacentridae, Scaridae, Clupeiformes, Lutjanidae, Mullidae and Carangidae (Fig. 2b). Oceanic taxa (Myctophidae, Scombridae, Nomeidae, Gonostomatidae) accounted for more than the 50% of the total larvae collected at stations off the shelf-edge (e.g. composite of stations OC-17, OC-29 & OC-46), whereas reef larvae declined markedly in relative abundance as compared to neritic and shelf-edge stations. (Fig 2c).

Total larval abundance declined across the neritic-oceanic gradient (Fig. 3) ranging from 116.8 Ind/100m3 at the innermost station (N-6) to 19.8 Ind/100m3 at the station farthest from the coastline (OC-46). The gradient of abundance featured a

sharp drop (at least two-fold) off the shelf-edge, mostly associated with a decline in abundance of reef fish larvae, particularly Trypteriigydae, Blenniidae, Microdesmidae, Haemulidae, and Apogonidae. Nevertheless, reef fish larvae remained as the numerically dominant assemblage up to OC-29, beyond which they declined to less than 10 % of the total larvae at station OC-46. Abundance of oceanic taxa was somewhat lower at station OC-17, but otherwise mostly uniform throughout the offshore (oceanic) section of the gradient (Fig. 3).

Pre-flexion larvae of various reef fish families such as Labridae, Scaridae and Holocentridae were most abundant at oceanic stations, whereas Clupeiformes, Lutjanidae and Haemulidae were most abundant at neritic stations (Fig. 4 a). Clupeiform taxa (mostly Engraulidae) were found in highest abundance at the innermost station sampled (N-6) which corresponds to the fore-reef environments in the mid-shelf of La Parguera. Pre-flexion and post-flexion Engraulidae are the numerically dominant ichthyoplankton at nearshore environments in Puerto Rico (García, 1994; García et al. 1995), which seems indicative of their neritical larval life cycle. Interestingly, post-flexion individuals of Clupeiform taxa were also found at OC-46 (see Fig. 4b), suggesting that these larvae also carry the potential for long distance dispersal.

In the case of Lutjanidae and Haemulidae, pre-flexion stages were found in highest abundance at neritic stations located approximately two kms before the shelf-edge (Fig. 4a). These are deep stations (25- 30 meters) of coralline sandy bottom with small patch reefs within the shelf identified by Colin and Clavijo (1988) as important spawning grounds for a wide variety of coral reef fishes. The occurrence of such high amounts of lutjanid and haemulid early pre-flexion larvae suggest that these sites are important

sources of larvae for these commercially valuable taxa of coral reef fishes. Preliminary studies of water currents at neritic and shelf-edge stations within La Parguera (García et al., in prep.) have measured reverse flows associated with tides which could influence retention of larvae during their pre-flexion stage, when their "swimming" abilities are limited by lack of caudal fin development. Inter-reef dispersal and retention of *Acanthaster* (crown-of-thorns) larvae near natal reefs has been shown to be a function of the regional oceanographic characteristics of the GBR shelf, interaction between currents and reefs and the duration in the water column of a "freely drifting" larval stage (Black, 1993). In the specific case of reef fish larvae, however, it may be more appropriate to consider only pre-flexion stages as "freely drifting" because post-flexion larvae may be capable of directed movements (Leis, 91).

Short PLD's, small size and incomplete development at settlement are characteristics that share many reef fishes, including haemulids, which display neritic larval distributions (Victor, 1991). Haemulids are known to have a PLD of approximately 15-18 days before settlement (MacFarland, 1985, Shulman, 1985; Lindeman, 1986). Lutjanids, however, are believed to have longer PLDs of 25-35 days, in the range of many other reef taxa with oceanic larval development. Yet, pre-flexion lutjanids and haemulids presented a similar distribution pattern in La Parguera, suggesting other factors may be influencing their neritic distribution, in addition to short PLD. Such distribution is not unique for La Parguera, since pre-flexion haemulids and lutjanids were also found in high concentrations within the shelf at Guayanilla Bay (García et al., 1995). Palinurid larvae, with PLD exceeding that of most reef fishes (6-9 months) were observed in highest abundance at stations N-6 and N-10 during early stages I-III, which tends to support the theory of neritic retention during a period which

may last several weeks (Sabater and García, this volume).

Post-flexion haemulids were found in higher concentrations throughout a band fringing both the neritic and oceanic sides of the shelf-edge at stations N-10, SE-13 and OC-17 (Fig. 4b), but observed in negligible amounts farther offshore. Post-flexion lutjanids peaked at the shelf-edge station (SE-13) and declined rapidly offshore, but occurred in low abundance throughout the gradient. The neritic distribution of pre-flexion haemulids and lutjanids and the concentration of their post-flexion stages near the shelf-edge suggests a dominant inter-reef dispersal pattern with a strong potential for self-recruitment. Long distance transport appears to be a minor, but plausible strategy in the recruitment dynamics of lutjanid larvae. More comprehensive work on the specific taxonomy of lutjanid larvae most be accomplished before any conclusive arguments regarding their distributional ecology can be established.

A contrasting pattern of widespread oceanic distribution was observed in the case of labrids, holocentrids, scarids and other reef fish taxa collected in very low abundance (e.g. sphyraenids, chaetodontids, holacanthids, mugilids). For such taxa, pre-flexion stages were observed throughout the oceanic gradient with peak concentrations at station OC-29 (Fig. 4a), but rapidly declining to negligible numbers at OC-46. Scarids, labrids, holocentrids and other reef fish taxa distributed far from the shelf-edge as pre-flexion larvae were concentrated at or close to the shelf-edge (Fig. 4b) as post-flexion larvae, suggesting an ontogenetic flux toward potential recruitment reef sites. The shelf-edge appears to act as an important habitat for reef larvae due to the benefits of higher surface plankton productivity, reduced predation pressure and wide spectrum for vertical distributions.

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List of Figures

Fig. 1 Map of study area showing location of sample stations along three parallel transects.

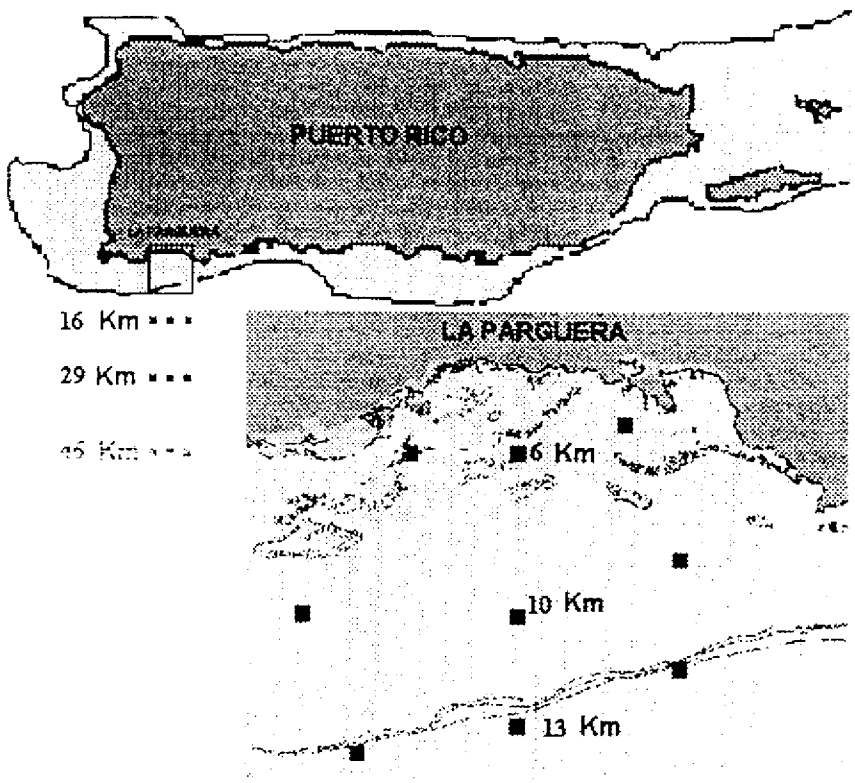
Fig. 2 Taxonomic structure of larval fishes from neritic, shelf-edge, and oceanic stations off La Parguera.

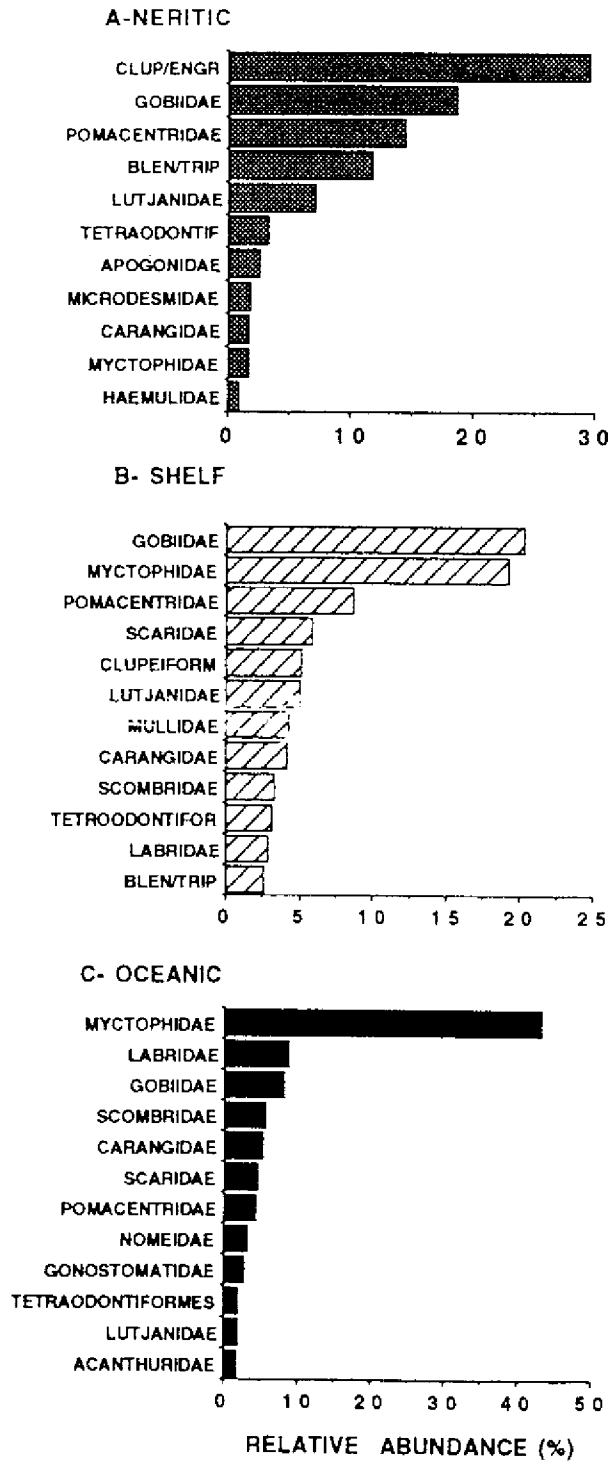
A) Neritic composite (STA : N-6 & N-10)
B) Shelf-edge (STA SE-13)
C) Oceanic composite (STA OC-16, OC-29 & OC-46)

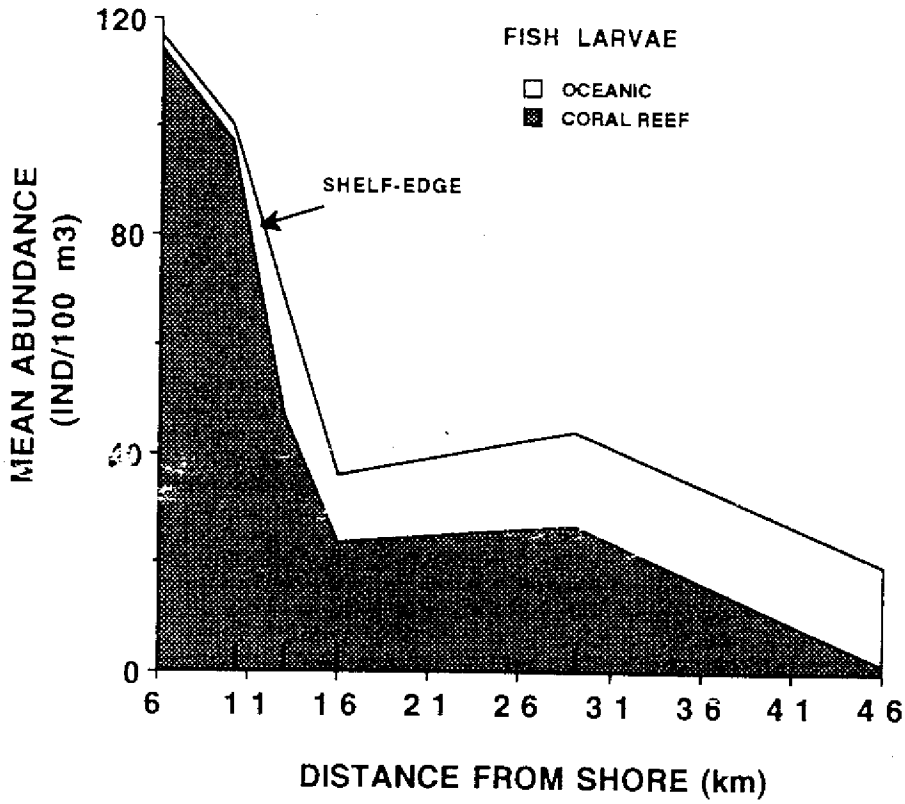
Fig. 3 Variations in abundance of coral reef and oceanic fish larvae across a neritic-oceanic gradient off La Parguera.

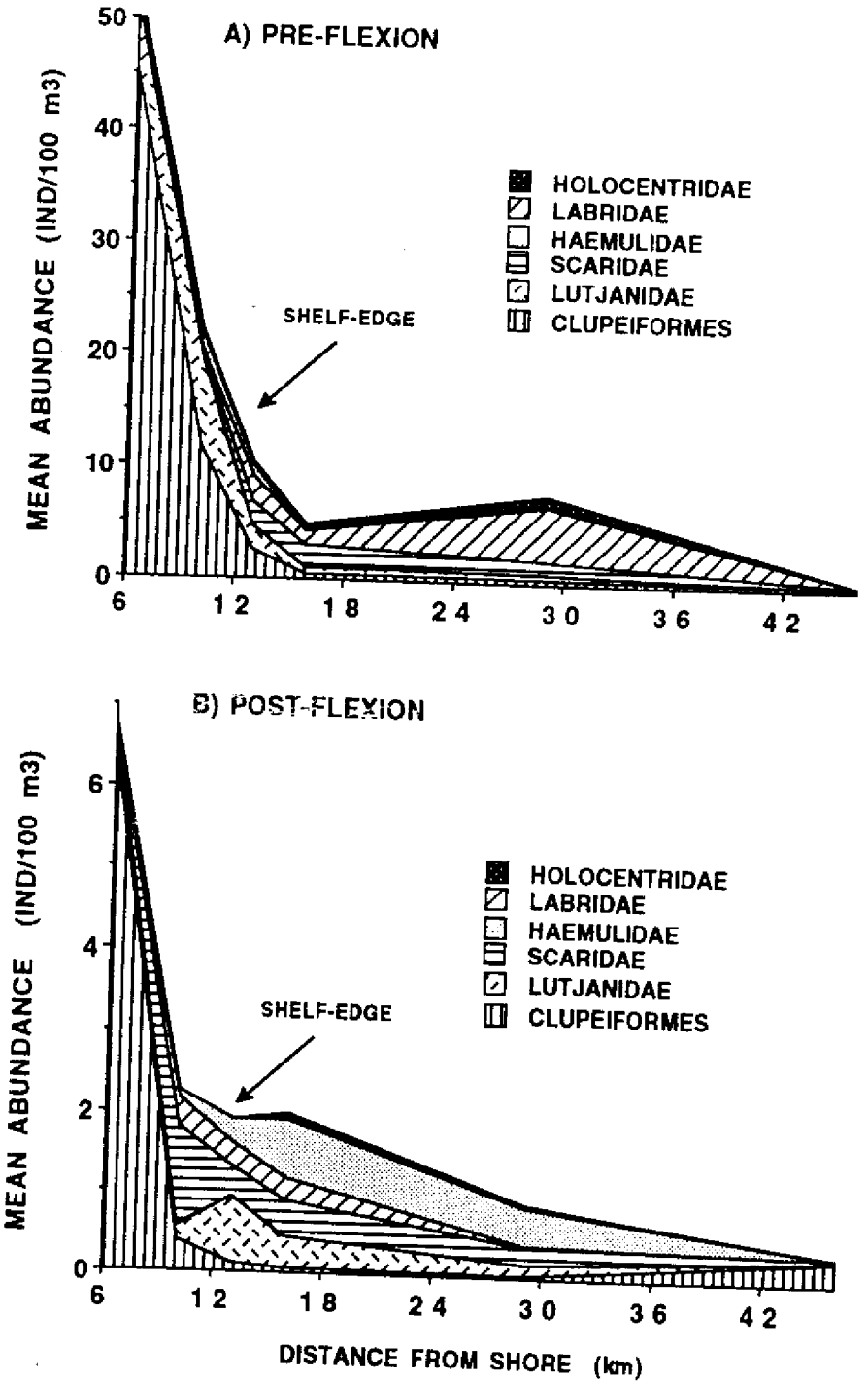
Fig 4 Taxon specific dispersal patterns of coral reef fish larvae off La Parguera.

A) Pre-flexion
B) Post-flexion


PUERTO RICO
LA PARGUERA
16 Km
29 Km
LA PARGUERA
6 Km
10 Km
13 Km


A-NERITIC
CLUP/ENGR
GOBIIDAE
POMACENTRIDAE
BLEN/TRIP
LUTJANIDAE
TETRAODONTIF
APOGONIDAE
MICRODESMIDAE
CARANGIDAE
MYCTOPHIDAE
HAEMULIDAE
0
10
20
30
B- SHELF
GOBIIDAE
MYCTOPHIDAE
POMACENTRIDAE
SCARIDAE
CLUPEIFORM
LUTJANIDAE
MULLIDAE
CARANGIDAE
SCOMBRIDAE
TETROODONTIFOR
LABRIDAE
BLEN/TRIP
0
5
10
15
20
25
C- OCEANIC
MYCTOPHIDAE
LABRIDAE
GOBIIDAE
SCOMBRIDAE
CARANGIDAE
SCARIDAE
POMACENTRIDAE
NOMEIDAE
GONOSTOMATIDAE
TETRAODONTIFORMES
LUTJANIDAE
ACANTHURIDAE
0
10
20
30
40
50
RELATIVE ABUNDANCE (%)


FISH LARVAE
OCEANIC
CORAL REEF
SHELF-EDGE
MEAN ABUNDANCE (IND/100 m3)
120
80
40
0
6
11
16
21
26
31
36
41
46
DISTANCE FROM SHORE (km)


A) PRE-FLEXION
MEAN ABUNDANCE (IND/100 m3)
50
40
30
20
10
0
6
12
18
24
30
36
42
SHELF-EDGE
HOLOCENTRIDAE
LABRIDAE
HAEMULIDAE
SCARIDAE
LUTJANIDAE
CLUPEIFORMES
B) POST-FLEXION
MEAN ABUNDANCE (IND/100 m3)
6
4
2
0
6
12
18
24
30
36
42
SHELF-EDGE
HOLOCENTRIDAE
LABRIDAE
HAEMULIDAE
SCARIDAE
LUTJANIDAE
CLUPEIFORMES
DISTANCE FROM SHORE (km)