Spatial variability of planktonic invertebrate larvae in the Canary Islands area

J.M. LANDEIRA[1], F. LOZANO-SOLDEVILLA[1], S. HERNÁNDEZ-LEÓN[2] AND E.D. BARTON[3]

[1]Departamento de Biología Animal, UDI Ciencias Marinas, Universidad de La Laguna, Spain, [2]Laboratorio de Oceanografía Biológica, Facultad de Ciencias del Mar, Universidad de Las Palmas de Gran Canaria, Spain, [3]Departamento de Oceanoloxía, IIM Consejo Superior de Investigaciones Científicas, Vigo, Spain

In October 1991, invertebrate larvae abundances were analysed to study the influence of the disturbance of the Canary Current flow by the Canary Islands archipelago on the variability of larval distribution. Two transects and two time-series stations located to the north (non-perturbed zone) and the south (perturbed zone) of the Canary Islands were sampled. Oceanographical data showed a highly stratified water column and zonally uniform salinity and temperature seaward of the African upwelling in the non-perturbed zone, while the perturbed zone presented strong turbulence in the form of mesoscale eddies. Invertebrate larval abundances were lower for most taxa studied in the non-perturbed zone and northern time-series station. Significant differences ($P < 0.001$) of invertebrate larval abundance between the two zones sampled were found. Decapod larvae were the most abundant larval group in both zones. Stations located in eddy structures presented the highest values of larval densities. Specifically, the larvae collected at Station 18, located in the core of an anticyclonic eddy, represented $60 \pm 18\%$ of total larvae collected in the south transect. Finally, our results suggest that eddies, mainly anticyclonic eddies, act as a strong larval retention zone south of the islands, and that there is a local northward transport from the Canary Islands.

INTRODUCTION

Most invertebrate species produce planktonic larvae, which can stay in the plankton from a few minutes to several months (Shanks, 1995). This phase of development can constitute the most important dispersal period in their life cycle. The degree of dispersal of invertebrate larvae and recruitment mainly depends on pelagic larval duration and the local oceanographical features. In this sense, Shanks & Eckert (2005) found a positive correlation between the larval duration and their dispersal distance from a compilation of data on the larvae of benthic marine organisms. The dispersal facilitates rapid range expansion and the colonization of new habitats and can minimize competition for food among siblings and decrease benthic predation. On the other hand, having a planktonic larval stage can bring many disadvantages because of the increased vulnerability to planktonic predators and distancing from favourable parental habitat. Finally, the larvae might metamorphose under suboptimal conditions of substrate (Pechenik, 1999).

According to Largier (2003), information on larval dispersal can be obtained in several ways: genetic populations, invasion of exotic species, microchemistry of exoskeletons, shells or otoliths, correlations between oceanographical features and settlement, meroplankton distribution studies and numerical models of larval dispersal. Several studies suggest that there is clear

Corresponding author:
J.M. Landeira
Email: jmlandei@ull.es

evidence of connectivity between marine populations of Macaronesian Islands (Azores, Madeira, Canaries and Cape Verde). Recently, studies have revealed gene flow among these archipelagic populations in different marine invertebrate species. This flux was observed in fish, *Parablennius parvicornis*, *P. sanguinolentus*, *Chromis limbata* and *Tripterigion delaisi* (Almada *et al.*, 2005; Domingues *et al.*, 2006, 2007) crabs, genus *Xantho* (Reuschel & Schubart, 2006) and limpets, *Patella aspera* and *P. ulyssiponensis* (Weber & Hawkins, 2005). The development of oceanographical knowledge of the Canary Current (Molina, 1973; Molina & Laatzen, 1986; Müller & Siedler, 1992; Barton *et al.*, 1998; Machín *et al.*, 2006) and mesoscale processes in the Canary Islands (Hernández-Guerra *et al.*, 1993; Arístegui *et al.*, 1994, 1997; Barton *et al.*, 2004; Sangrà *et al.*, 2007) allowed the study of ichthyoplankton distribution in this area. In this sense, Rodríguez *et al.* (2000) suggested an interconnection between the neritic fish populations of the Macaronesian archipelagos with long larval development in the plankton, in a north–south sense by the Azores and Canary Currents. Moreover, Rodríguez *et al.* (2001) showed that the island of Gran Canaria and its eddy system act as a retention zone for fish larvae due to the upstream stagnation point off the north of the island and the lee region to its south. Finally, the offshore transport in the Cape Juby upwelling filaments was reported as a mechanism for introducing neritic fish larvae to the Canary Islands (Rodríguez *et al.*, 1999) affecting the abundance and composition of the fish larvae community there (Rodríguez *et al.*, 2004, 2006; Bécognée *et al.*, 2006).

In the present study, we investigated spatial variability of invertebrate larvae in the Canary Islands region during

autumn. Our aim was to compare densities of invertebrate larvae (paying special attention to the decapod larvae) in two oceanographical transects located to the north and the south of the Canary Islands and confirm previous ichthyo-planktonic results. Our main hypothesis was that highest larval densities should be found at the southern transect because the eddy system developed leeward of the Canary Islands would act as a larval retention zone. Taking into account oceanographical, genetic and meroplanktonic studies, we discuss the geographical origin and fate of the larvae to understand the connectivity between populations of the Canary Islands and adjacent areas.

MATERIALS AND METHODS

The cruise CANARIAS 9110 on board RV 'Ignat Pavlyuchenkov', 18–24 October 1991, took place during a period of strong stratification of the water column and weak wind in the Canaries region. Two transects (north and south) were sampled at stations separated by 20 km to compare conditions upstream and downstream of the archipelago (Figure 1). In addition, two stations were occupied every 6 hours over a 24 hour period, one north of Gran Canaria (N station) and one in the lee, south of this island (S station). The time-series stations were not towed simultaneously. Two consecutive days were spent to complete the two cycles. Time-series stations allow some averaging out of the variability between individual stations separated by tens of kilometres, which are affected by the patchiness of open ocean waters (Barton *et al.*, 1998).

Hydrographical data were gathered with Neil Brown Mark III CTD casts at each station (Vélez-Muñoz, 1992). Wind data were obtained from the airport on the east coast of Gran Canaria Island supplied by the Spanish 'Instituto Nacional de Meteorología'. To study the abundance of invertebrate larvae, oblique hauls from 200 m depth up to the surface were carried out at selected stations only, because of time constraints (Figure 1). These samples were taken with a 0.40 m diameter mouth Bongo net fitted with 250 μm mesh and
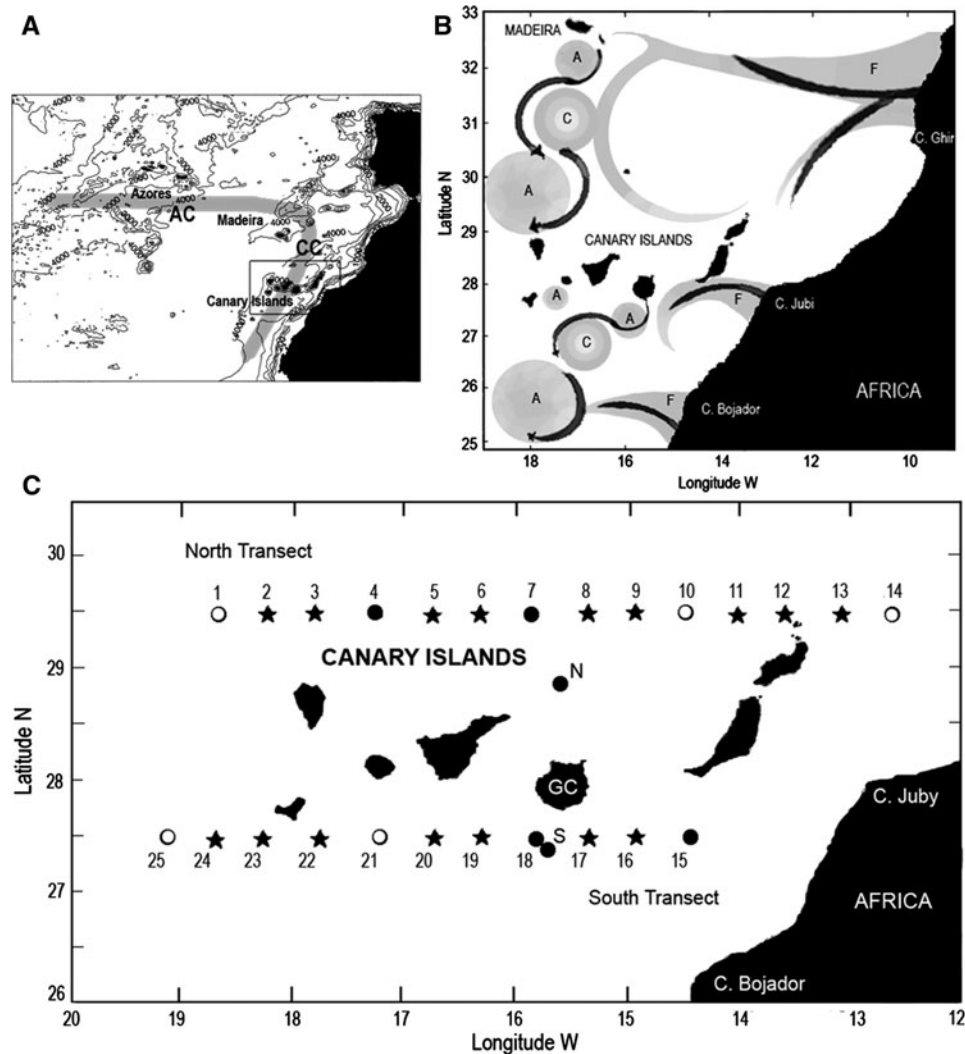

Fig. 1. (A) North-east central Atlantic region showing the eastern boundary currents of Azores Current (AZ) and Canary Current (CC); (B) schematic map showing the main mesoscale features (eddies and upwelling filaments) present in the Madeira–Canaries region; (C) Canary Islands archipelago, showing location of sampling stations. Stars, stations sampled for hydrography; circles, stations sampled for hydrography and zooplankton (filled circles represent night stations and open circles day stations); N, northern time-series stations; S, southern time-series stations; A, anticyclonic eddy; C, cyclonic eddy; F, upwelling filament.

equipped with two General Oceanics flowmeters. Five and four stations were sampled for invertebrate larvae study on the north and south transects respectively. One of the paired samples was preserved in 5% buffered formaldehyde, prepared using seawater.

All invertebrate larvae were sorted and counted in the laboratory. The counts were standardized to number of larvae per 100 m^{-3}. The invertebrate larvae abundances of the stations located at approximately the same longitude were plotted forming pairs of stations (1–25, 4–21, 7–18 and 10–15). Samples collected at approximately the same time of day at the north and south fixed station were also plotted.

The decapod larvae group was identified to the lowest taxonomic level possible following the specific descriptions and identification guides given by dos Santos & Lindley (2001) and dos Santos & González-Gordillo (2004). Decapod larvae were grouped into two functional groups depending on whether adults were distributed in the pelagic or benthic zone. Data on depth-range distributions of adult decapods were obtained from Zariquiey-Álvarez (1968), González-Pérez (1995) and Udekem D'Acoz (1999). The Amphionidae larvae were identified according to Heegaard's descriptions (Heegaard, 1969).

With the aim of detecting differences in larval abundances between north and south transects, non-parametric analyses were carried out. On one hand, these analyses were performed for high invertebrate larvae taxa (Mollusca, Echinodermata, Cirripedia, Decapoda and Polychaeta) and, on the other hand, were carried out for the identified species of decapod larvae. The ordinations were based on the average abundance of larvae (number 100 m^{-3}) for each taxon in each station. These ordinations were graphically displayed with non-metric multidimensional scaling (MDS) plots. The ordinations were based on their respective matrix of Bray–Curtis similarities, generated from the fourth-root transformed abundances data to stabilize the variance (Clarke & Warwick, 2001).

In order to test differences between groups one-way analysis of similarities (ANOSIM) was performed. High R values indicate differences between groups (Clarke & Warwick, 2001). Similarity percentages analysis (SIMPER) was used to determine the contribution of decapod species in the possible differences between sampled transects after fourth-root transformation data and assuming a cut-off at 95%. All multivariate analyses were performed using the software package PRIMER® v.6.1 (PRIMER-E Ltd, Plymouth, UK).

On the other hand, the parametric statistical method (Student's t-test, $P > 0.05$) was used to evaluate the retention capacity of the cyclonic and anticyclonic eddies by means of differences among larval abundances collected in a cyclonic eddy (Station 21) and in an anticyclonic one (Station 18) previously tested for homogeneity of variances using Levene's test. Finally, to detect day–night influence on the larval abundance Student's t-test was also performed, grouping the stations towed during night time (4, 7, 15 and 18) and during day time (1, 10, 14, 21 and 25) (Figure 1). These parametric analyses were performed using the SPSS system for Windows v.12.0.

RESULTS

The Canary Current (CC) is the natural extension of the Azores Current (AZ), flowing in the north-east central Atlantic region (Figure 1a). The incident flow of the CC and the Trade Winds is disturbed by the topography of islands of the Madeira and Canary Islands archipelagos. Shedding of eddies and from the islands results in mesoscale turbulences that interact with the cool water filaments generated in the Ghir, Juby and Bojador capes of Africa (Figure 1b) (Barton et al., 2004; Machín et al., 2006).

Conditions during the cruise were typified by the presence of weak south-easterly winds (<15 km h^{-1}) as expected at this time of year (Arístegui et al., 1997). The strong surface heating produced a strong stratification of the water column during this period of the annual cycle. Comparisons between both transects showed that the southern was significantly more variable in terms of isotherm excursions and presented a shallower depth of chlorophyll maximum. This resulted, outside the coastal upwelling band, in quite high surface temperature and zonally uniform salinity, temperature and chlorophyll-a, with a shallow mixed layer (<50 m) along the north transect (Figure 2), typical of the far field (Arístegui et al., 1997; Barton et al., 1998). The south transect presented more variability, showing significant perturbations and eddy-like structures, presumably caused by the islands, although the strong stratification of the surface water almost overrode the effect of the cyclonic domes in the upper 100 m (Arístegui & Montero, 2005). In this sense, clear influence of cold-core cyclonic eddies is seen at Stations 16 and 20 (Figure 2), south-west of Fuerteventura and Gran Canaria and an anticyclonic eddy is identifiable at Station 18 (Barton et al., 1998). However, the persistent cloud cover did not allow following the development of the eddy and the upwelling filament by AVHRR images of sea-surface temperature (Barton et al., 1998).

In total, 340 invertebrate larvae were counted (127 Decapoda, 2 Amphionidacea, 29 Cirripedia, 5 Stomatopoda, 48 Echinodermata, 81 Polychaeta and 48 Mollusca). Decapod larvae were identified, constituting 23 different taxa (Table 1). Gathered in the higher decapod taxa, Dendrobranchiata were constituted by 8 taxa, Caridea by 5 taxa, Anomura and Brachyura by 4 taxa respectively, and Palinura by only one taxon. No Astacidea or Stenpodidea were recorded.

Relative abundances for invertebrate larvae taxa on each transect studied are shown in Table 1 and Figures 3 & 4. Higher abundances of invertebrate larvae were found in the perturbed former for each of the taxa studied. In this respect, decapod larvae were the most abundant taxa of the meroplanktonic community, showing average values of 2.8 and 15.2 individual · 100 m^{-3} for non-perturbed and perturbed zones respectively (Table 1). However, the northern Station 1 presented higher densities than the corresponding pair of hauls carried out at the south (Figure 1a, b), due to the relatively high abundance of early larval stages (zoea 1 and 2) of *Galathea intermedia* and *Anapagurus* spp. In addition, benthic decapod larvae groups were more abundant than pelagic ones for the two sampled zones. With respect to relative abundances, there are two groups of benthic species. The first is made up of larvae of species that appear only in the southern zone, such as *Alpheus macrocheles* (zoeas 6 and 7), *Dardanus arrosor* (zoea 4), *Atelecyclus* spp. (megalopa), *Calappa granulate* (zoea 5) and *Percnon gibbesi* (zoea 2) (Table 1). The second group is constituted of *Periclimenes* spp. (zoea 2), *Scyllarides latus* (zoea 3), *Galathea intermedia* (zoea 2 and 3), *Anapagurus* spp. (zoea 1) and *Calcinus*
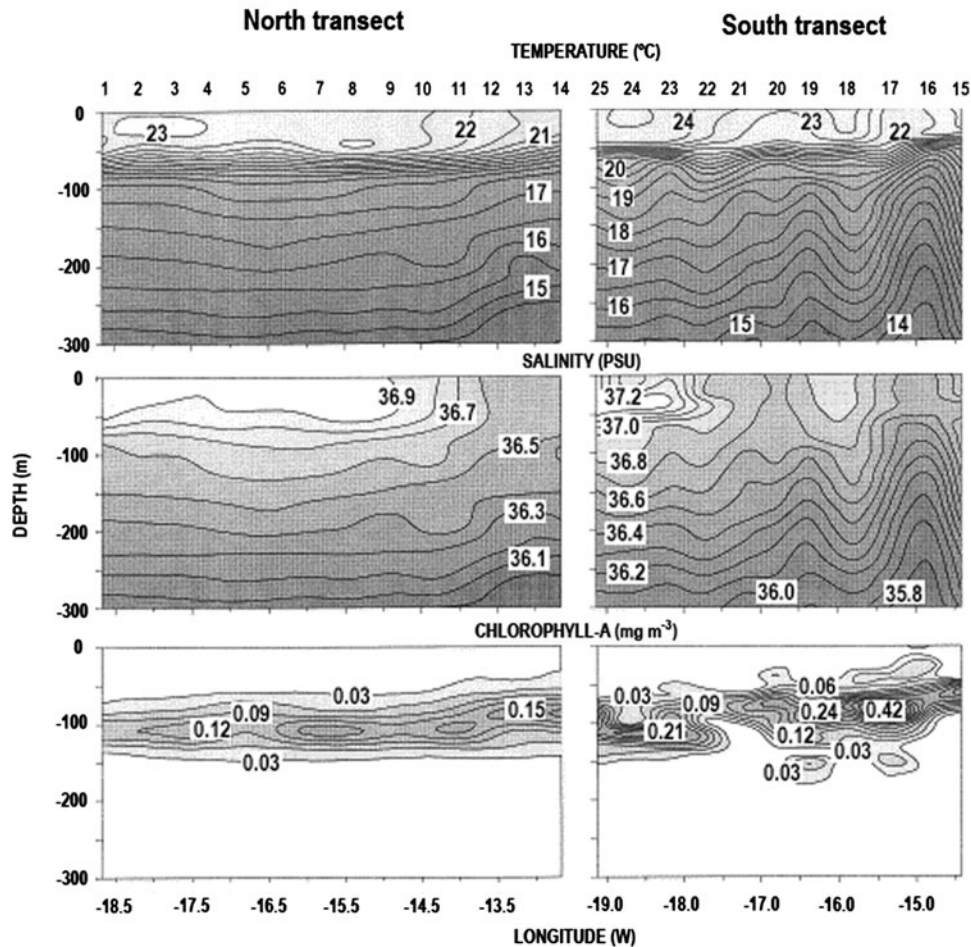
Fig. 2. Vertical sections of temperature, salinity and chlorophyll-*a* for the north and south transects sampled (based on Barton *et al.*, 1998).

tubularis (zoea 3 and megalopa), which were collected only in the northern stations (Table 1).

Polychaeta larvae was the second most abundant group of the meroplanktonic community with densities about 5.5 and 0.5 individual 100 m^{-3} in the south and north transects respectively (Table 1). Mollusca, Echinodermata and Cirripedia larvae formed the following groups. Mollusca and Echinodermata were found almost exclusively in the south, and only one sea urchin larva was caught at Station 10 (Figure 3e, f). However, Cirripedia larvae presented relatively homogeneous distributions in both zones (Figure 3c). Stomatopod and Amphionidacea larvae were rare (Table 1).

Before analysing the influence of the perturbations in the larval distribution we tested the possible differences on larval abundance between stations during night and day due to daily migrations. In this sense, the *t*-test did not reveal significant differences between day–night abundances ($P > 0.05$). The use of non-metric multidimensional scaling analysis (nMDS) on invertebrate groups and decapod larvae abundance highlighted the differences between sampled stations (Figure 5a, b). Larval groups and decapod larvae nMDS plots separated the stations into two main groups (Figure 5a, b): (1) contained stations located in the north transect; and (2) grouped stations located in the south of the archipelago. ANOSIM routines revealed that these differences were significant for high groups of invertebrate larvae (Global $R = 0.713$, $P = 0.008$) and for decapod larvae assemblages (Global

$R = 0.663$, $P = 0.01$). The SIMPER test showed an average dissimilarity between the north and south transects of 91.83% and that the decapod larvae species mainly responsible for these dissimilarities among north and south transects only displayed a distribution in the south zone, such as: *Sergestes curvatus*, *Atelecyclus* spp., *Gennadas elegans*, *S. cornutus*, *S. pectinatus*, *Dardanus arrosor* and *Percnon gibbesi*.

Highest densities for most of the taxa studied were found at Stations 18 and 21 (Figure 3), representing high retention zones strongly influenced by eddies (Figure 2). Station 18, located in the core of the anticyclonic eddy, presented the $60 \pm 18\%$ of the larvae collected in the south transect. On the other hand, Station 21, located in the edge of the cyclonic eddy presented the $28 \pm 14\%$ (Figure 6). The *t*-test revealed significant differences in larval abundance between cyclonic and anticyclonic zones at the level $P < 0.001$. Evidence of upstream–downstream differences across the archipelago was supported by comparisons of the two 24-hour time-series made north (N station) and south (S station) of Gran Canaria (Figure 4). At S station, close to a cyclonic eddy, the relative abundance of larvae was significantly higher than the densities observed at the N station (Figure 4). The difference between the north and the south transects was more evident in the time-series stations than individual stations in the north and south transects because they avoid the patchiness effect of the open ocean zooplankton distribution and indicate variability at somewhat larger scales.

Table 1. List of invertebrate larvae caught, their adult habitat, the mean values of abundance (ind · 100 m^{-3} ± standard deviation), the larval stage found and their numeric percentage in the north and south transects of the Canarias 9110 cruise. P, pelagic habitat; B, benthic habitat; PZ, protozoea; Z, zoea; M, megalopa; the numbers show the substage of development.

Taxa	Habitat	North transect			South transect		
		Larval stage	Mean	%	Larval stage	Mean	%
Decapoda			2.82 ± 1.96	70.04		15.16 ± 7.63	63.85
Gennadas elegans	P				PZ3	0.17 ± 0.32	0.70
Sergestes atlanticus	P	PZ2	0.08 ± 0.23	1.91			
Sergestes curvatus	P				PZ(1,3)	0.54 ± 0.10	2.28
Sergestes cornutus	P				PZ(1,2)	0.17 ± 0.46	0.70
Sergestes pectinatus	P				Z(1,2); M	1.26 ± 1.54	5.32
Sergestes sargassi	P	Z2	0.34 ± 0.69	8.55			
Sergestes vigilax	P	PZ3	0.13 ± 0.25	3.13	Z2	0.38 ± 0.71	1.60
Lucifer typus	P	Z2; M	0.29 ± 0.31	7.16	M	0.17 ± 0.23	0.70
Acantephyra purpurea	P	Z5	0.09 ± 0.12	2.34	Z(5,7)	0.39 ± 0.72	1.64
Plesionika spp.	B	Z2	0.06 ± 0.17	1.46	Z(1,2,4,6)	0.95 ± 0.93	4.00
Pandalidae spp.	B	Z(6,7)	0.16 ± 0.11	4.08	Z4	0.13 ± 0.37	0.55
Periclimenes spp.	B	Z2	0.34 ± 0.69	8.55			
Alpheus macrocheles	B				Z(6,7)	0.62 ± 0.73	2.61
Scyllarides latus	B	Z3	0.06 ± 0.17	1.46			
Galathea intermedia	B	Z(2,3)	0.32 ± 0.41	7.92			
Anapagurus spp.	B	Z1	0.21 ± 0.41	5.25			
Calcinus tubularis	B	Z3; M	0.45 ± 0.63	11.26	Z(2,5)	1.74 ± 2.22	7.33
Dardanus arrosor	B				Z4	0.17 ± 0.32	0.70
Atelecyclus spp.	B				M	0.10 ± 0.26	0.40
Calappa granulata	B				Z5	0.41 ± 0.82	1.72
Percnon gibbesi	B				Z2	0.17 ± 0.27	0.70
Brachyura unidentified	B	Z(5,6); M	0.27 ± 0.53	6.60	Z(2,4); M	0.34 ± 0.63	1.45
Amphionidacea	P					0.20 ± 0.57	0.85
Amphionides reynaudii						0.20 ± 0.57	0.85
Cirripedia	B		0.87 ± 1.46	21.53		1.09 ± 1.00	4.60
Stomatopoda	B		0.07 ± 0.16	1.67		0.28 ± 0.55	1.20
Echinodermata	B		0.18 ± 2.50	4.68		4.18 ± 9.10	19.20
Echinoidea			0.08 ± 0.20	1.88		3.03 ± 5.81	12.76
Asteroidea			0.11 ± 0.31	2.80		0.87 ± 1.88	3.65
Ophiuroidea						0.66 ± 1.86	2.79
Polychaeta	B		0.49 ± 0.43	12.15		5.74 ± 3.66	24.20
Mollusca	B					5.06 ± 6.03	21.30
Gastropoda						3.37 ± 5.79	14.19
Bivalvia						0.17 ± 0.47	0.70
Cephalopoda						1.52 ± 1.83	6.41
Total			4.03 ± 2.88	100.00		23.74 ± 22.97	100.00

DISCUSSION

Our results suggest a close relationship between the larval distribution and the mesoscale oceanographical variability in the Canary Islands region. Indeed, the differences between the densities of invertebrate larvae from the north area and the non-perturbed zone (south transect) were quite clear in the present study. In this sense, higher densities of invertebrate larvae in the southern transect and southern time-series station than the stations located to the north were general. Stations 18 and 21, influenced by eddy structures, presented the highest densities for most of the studied taxa. Specifically, Station 18 located in the core of an anticyclonic eddy acted as a strong retention mesoscale structure for invertebrate larvae. Rodríguez et al. (2000) also obtained higher abundances of fish larvae and mesozooplankton biomass in the southern transect for the same cruise. They explained these differences as the consequence of the cyclonic and anticyclonic eddies generated downstream of the archipelago, when the south-eastern flow of the Canary Current and the Trade Winds crash into the abrupt islands. In addition, Hernández-León et al. (2001) observed strong variability of zooplankton biomass around Gran Canaria, with higher biomass associated with the presence of an anticyclonic eddy and lower biomass in the core of a cyclonic eddy.

Eddies act as retention zones, trapping larvae in the core of the anticyclonic eddies and in the boundary of cyclonic structures, near the islands. Eddies frequently have been proposed to enhance larval retention along continental shelf systems and near islands (Sponaugle et al., 2002; Queiroga & Blanton, 2004). Moreover, Wing et al. (1995a, b) related the presence of an eddy system formed on the leeward side of Point Reyes, California, to intense settlement and recruitment of invertebrates. Similarly, Rodríguez et al. (2001) suggested that the cyclonic eddy located downstream of Gran Canaria Island may participate in maintaining the neritic ichthyoplankton near the island. Further, cyclonic eddies increase plankton production by pumping nutrients into the euphotic zone (Arístegui et al., 1994, 1997) and can provide an appropriate environment for larval survival (Queiroga & Blanton, 2004).
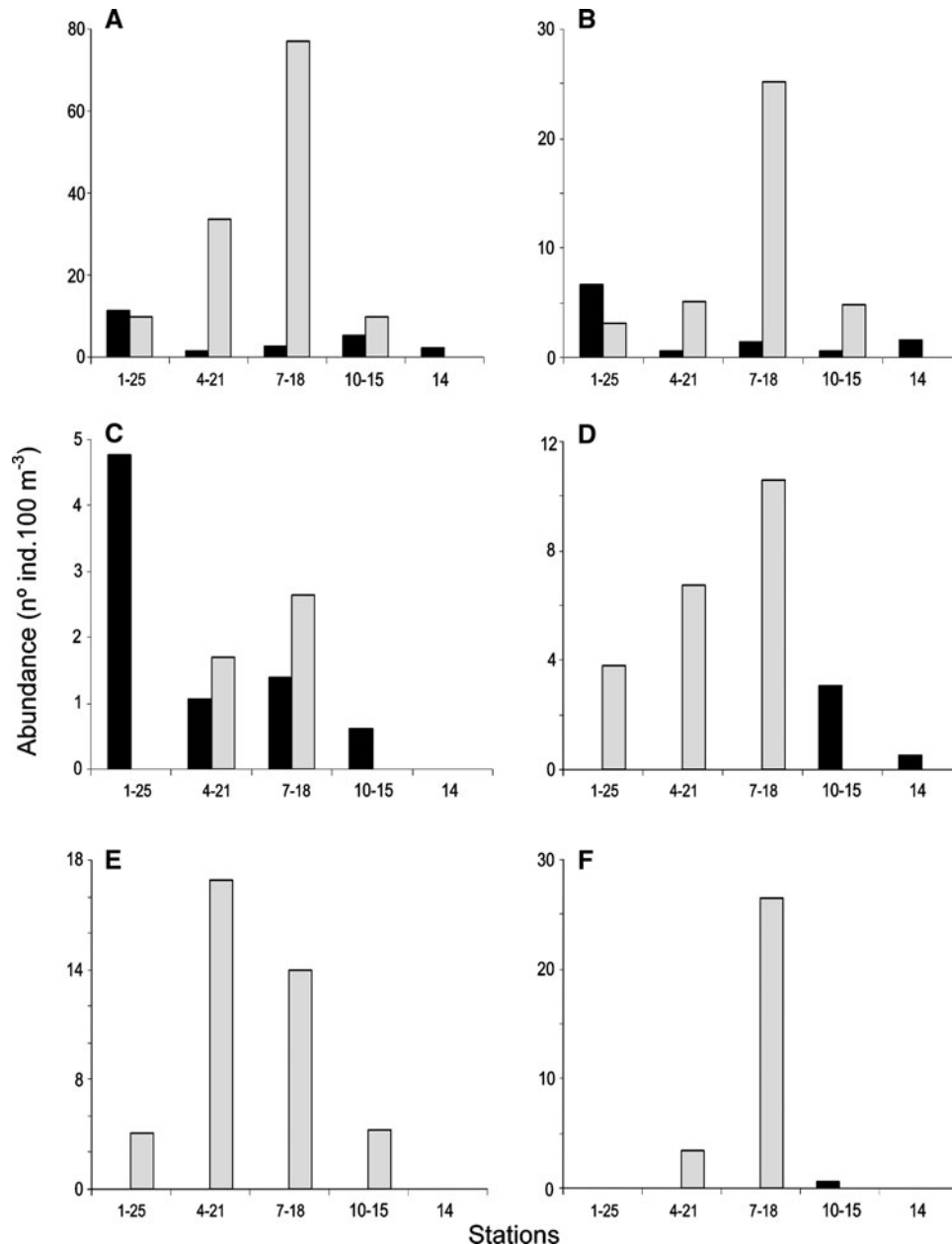
Fig. 3. Distribution of: (A) total larvae; (B) Decapoda larvae; (C) Cirripedia larvae; (D) Polychaeta larvae; (E) Mollusca larvae; (F) Echinodermata larvae abundances (ind · 100 m^{-3}) for paired north (black) and south (grey) transect stations.

The larvae are trapped and circulated around the edge of the cyclone. If they are near the coast, small-temporal-scale processes to larval transport, such us internal waves and internal tidal bores, could move them onshore (Pineda *et al.*, 2007), otherwise they rotate around the eddy which itself will drift slowly south-west (Rodríguez *et al.*, 2000). The capability of long distance dispersal is related to their pelagic larval duration and the presence of morphological adaptations. In this sense, we found neritic decapod crustacean larvae with adaptive characteristics. For example, *Calappa granulata* and *Percnon gibbesi* collected at the perturbed zone presenting long carapace spines, which can help them to maintain their position in the water column and to travel southward into the eddies as long as the mesoscale feature does not disintegrate.

Regarding the larvae collected in the north, Rodríguez *et al.* (2000) suggested the archipelagos located north of the Canary Islands as the original source of these larvae. Stramma (1984) detected large anticyclonic eddies between the Azores and Madeira archipelagos, and Machín *et al.* (2006) showed strong mesoscale activity (cyclonic and anticyclonic eddies) between Madeira and the Canary Islands. These eddies could be aiding the Canary Current to transport larvae towards the equator and connecting the marine populations of Azores, Madeira and the Canary Islands and, therefore support the Rodríguez hypothesis. Another oceanographical feature which could support a northern origin is the Cape Ghir filament, which could introduce African neritic larvae into the north of Canary Islands waters. In this sense, upwelling filaments off Cape Juby have been reported as an offshore transport mechanism for neritic fish larvae (Rodríguez *et al.*, 1999) which can arrive at the Canary Islands affecting the abundance and composition of the local fish larvae
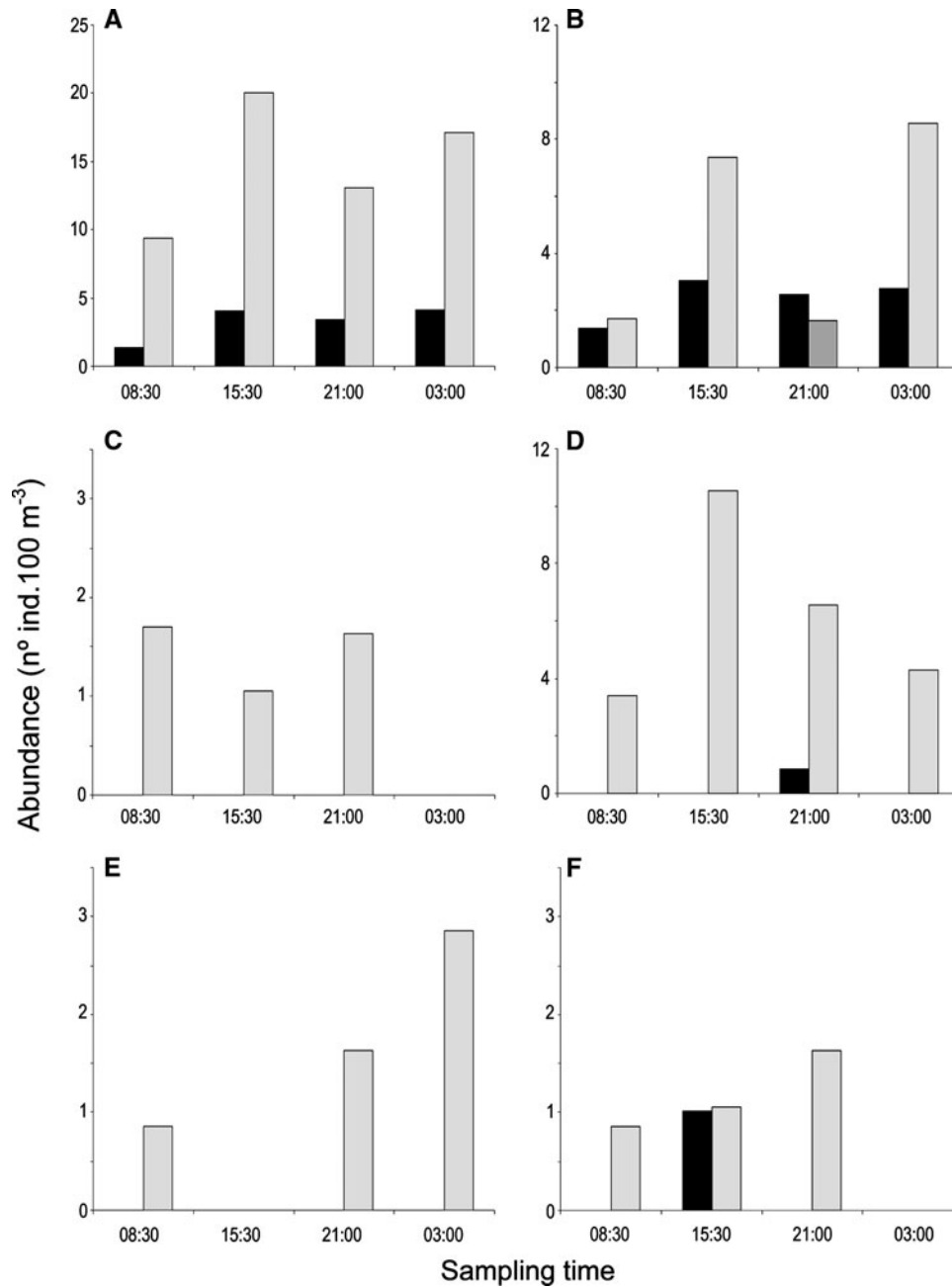
Fig. 4. Temporal comparison at north (black) and south (grey) fixed stations of: (A) total larvae; (B) Decapoda larvae; (C) Cirripedia larvae; (D) Polychaeta larvae; (E) Mollusca larvae; (F) Echinodermata larvae abundances (ind · 100 m^{-3}).

community (Rodríguez *et al.*, 2004; Bécognée *et al.*, 2006). Nerverthless, our findings in the north transect cannot be related to a transport from northern areas, through eddies and filaments. The larvae of neritic species collected in the north area present stable adult populations in the Canary Islands (González-Pérez, 1995). In this sense, we found larvae of benthic species in early life stages of development, such as four larvae (zoea 1) of *Anapagurus* spp. at Station 1, and two larvae (zoea 2) of *Periclimenes* spp. at the northern time-series station. These early age larvae cannot be transported from the north; they must have been coming from the Canaries archipelago. In addition, we found in the north larvae of other neritic species such as *Calcinus tubularis* (zoea 3 and megalopa) and Scyllarides latus (zoea 3), but taking into account the long distance to other archipelagos

upstream and the low densities of these larvae, we suppose their most probable origin is the Canary Islands. These findings support the idea of local transport of invertebrate larvae towards the north, probably due to a random dispersion by tides and local turbulences from the hatchery area in the Canary Islands

In conclusion, our results suggest specific retention mechanisms for the larvae of invertebrate populations in the south of Canary Islands waters related to the particular physical oceanography of the area (Barton *et al.*, 1998). Higher densities of invertebrate larvae were found in the south, the perturbed zone, because of an island mass effect caused by the archipelago. The cyclonic and anticyclonic eddies, located in the perturbed zone, trap and retain the larvae near the islands which can return to the coast by convergence. Also,
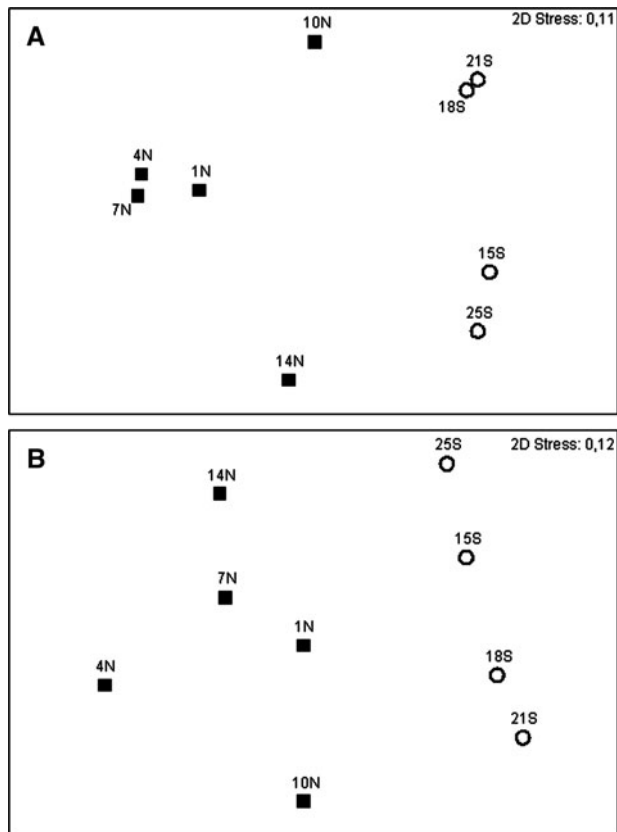
Fig. 5. Non-metric multidimensional scaling (nMDS) plots showing samples assemblages based on a Bray–Curtis similarity matrix of the larval abundances of the high invertebrate groups (A) and of decapod crustacean species (B). The spatial segregation of samples reflects differences among the north and south transects.
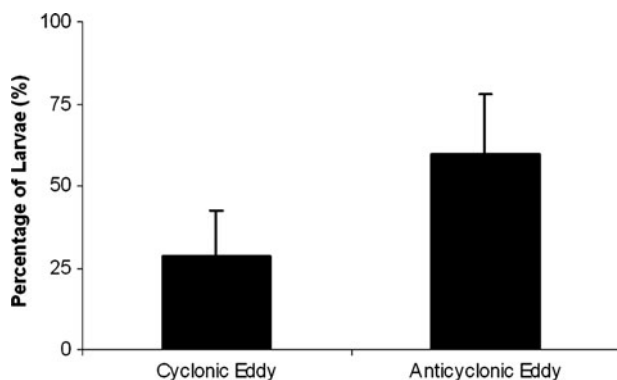

Fig. 6. Percentage of invertebrate larvae relative to the totality of larvae collected in the perturbed zone in the cyclonic eddy and anticyclonic eddy.

the results suggest a local northward larval transport of neritic species. In the future, genetic analysis of the larvae collected in the course of multidisciplinary oceanographical surveys could help us to understand in detail the larval fluxes between the Canary Islands and their surrounding areas.

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Correspondence should be addressed to:
J.M. Landeira
Departamento de Biología Animal, UDI Ciencias Marinas
Universidad de La Laguna, Spain
email: jmlandei@ull.es