Larval distribution of *Libinia spinosa* Milne-Edwards, 1834 (Decapoda, Brachyura, Majidae) off southern Brazil.

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Abstract

Larval distribution and abundance of *Libinia spinosa* (Milne Edwards 1834) were studied in southern Brazilian coastal waters from plankton samples taken during two seasonal surveys. Larvae were present during all seasons with abundance peaks in spring and summer. Highest seasonal abundance (ind./ 100m^3) were 515 in summer, 56 in spring, 19 in autumn and 2 in winter. First zoeal stage larvae were abundant nearshore, indicating recent spawning activity in coastal waters. The co-occurrence of the second zoeal stage and the megalopa in the same region of hatching, and scarcity in offshore samples suggests that larval dispersion of *Libinia spinosa* is low and that this species shares a common hatching and recruitment area. Both larval stages and megalopa were restricted to the inner shelf up to 50 m isobath within the area of major Coastal Water influence, where zooplankton biomass was high.

Key words: larvae, abundance and distribution, majid, *Libinia spinosa*, Brazil.

Introduction

In Brazil, the information on distribution and abundance of meroplankton is generally restricted to broad zooplankton studies. In southern Brazilian coastal waters, studies on systematic and distribution are rare and only recently aspects on reproduction, trophic relationships and bioenergetic have gained more attention. There are some studies on decapod larval systematic and ecology lately published for Rio Grande do Sul region (Brandini *et al.*, 1997). In this work, distribution and abundance of the pelagic larvae of the spider crab *Libinia spinosa* were studied. The species' distribution ranges from Brazil (Espirito Santo State) to Argentina (Santa Cruz State) (Melo, 1996). In southern Brazil the adults are found over the shelf within 200 m depth, in water of salinity higher than 27 and temperature ranging from 6.6° to 25° C (Souza, 1994). This species is a common by-catch of demersal fishing and it also comprises an important food item for many fish species commercially explored in the area (Teixeira, 1987; Capitoli *et al.*, 1995).

Material and Methods

Study Area

The southern Brazilian continental shelf is under the influence of the Subtropical Convergence. The Convergence is formed by the southward flow of warm high-salinity Tropical Water (TW; T >20° C, S >36.00) from the Brazilian Current and by the coastal branch of the northward flowing Malvinas (Falkland) Current transporting cold low-salinity sub-Antartic Water (SAW; T 4-15° C, S 33.70-34.15) (Garcia, 1997). The seasonal migration of the Convergence determines the variability of the thermohaline properties of the shelf waters with a the predominance of TW in summer and of SAW in winter (Miranda, 1972). The thermohaline structure of Coastal Water (CW) over the shelf region vary between seasons and years, depending on the continental runoff and the direction and velocity of winds. It is moderately stratified in summer, and strongly stratified during winter and spring due to influence of the discharges from Lagoa dos Patos estuary and the La Plata River (Lima *et al.*, 1996; Garcia, 1997).

The samples collected in the area of Rio Grande do Sul were part of two projects: "Projeto Crustáceos" (PC) and "Estudo do Ecosistema Pelágico do Extremo Sul do Brasil" (ECOPEL) (Fig. 1).

The PC project was accomplished during the period between November 1982 and August 1983. Four cruises were conducted between 31° 49'S and 33° 00'S using the R/V *Atlântico Sul* of the University of Rio Grande The area was divided in 17 subareas 10 nm length each and width given by four depth levels: 10 to 15 m (6 subareas), 15 to 20 m (6 subareas), 20 to 30 m (3 subareas) and 30 to 60 m (2 subareas). The sampling position in each subarea 2 among the 10 and 20 m isobaths, 4 between 20 and 30 m isobaths, and 6 among the 30 and 60 m isobath (Calazans, 1994) (Fig. 1a).

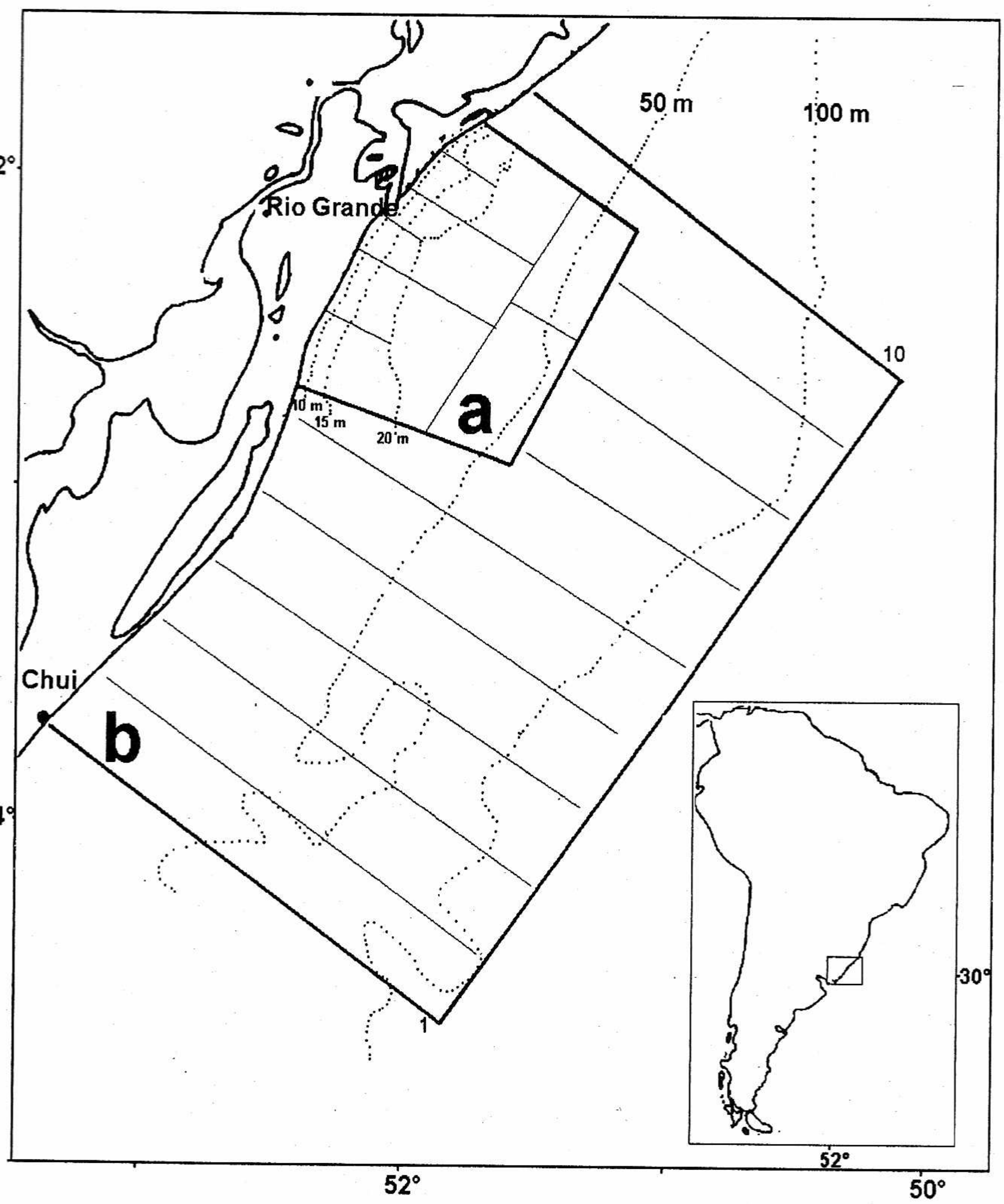

Figure 1: Study region in southern Brazil and overlapping of sampling areas. a, PC. b, ECOPEL. 1-10, profiles 1 to 10 in ECOPEL cruises.

The ECOPEL project included four cruises: October 1987 (spring), September 1988 (winter), February 1990 (summer) and June-July 1991 (autumn). The study area was located between Farol da Conceição (31° 40'S; 51° 30'W), Chuí (33° 45'S; 53° 30'W), and the 200 m isobath in spring and winter cruises, and the 1000 m isobath in summer and autumn cruises. The sampled area comprised ten profiles perpendicular to the coastline. At each profile, 5 or 6 stations were sampled depending on its distance from the coast, totalling 56 fixed stations (Fig. 1b). Bad weather conditions during the cruises resulted in a lower number of station (Table I).

Table I: Dates and number of stations per Cruise during PC and ECOPEL surveys.

Project	Cruise	Date	N° of Stations
PC	Spring	17 Nov 82 - 21 Nov 82	43
	Summer	19 Jan 83 - 23 Jan 83	43
	Autumn	17 May 83 - 22 May 83	24
	Winter	03 Aug 83 - 06 Aug 83	41
ECOPEL	Summer	19 Oct 87 - 27 Oct 87	49
	Winter	18 Jun 91 - 02 Jul 91	54
	Autumn	06 Feb 90 - 21 Feb 90	51
	Spring	07 Sep 88 - 15 Sep 88	49

Zooplankton samples were collected with oblique hauls using a Bongo net mesh size of with 330 µm, and mouth diameter of 60 cm, equipped with a flowmeter mounted centrally in the mouth. Hauls were accomplished from 1-2 m above the bottom to the surface. During the ECOPEL cruises, at stations with 200 m depth, hauls were done from 200 m to the surface. All samples were fixed with 4% formaldehyde-seawater solution neutralised with borax. Temperature and salinity data were obtained at all cruises using bottles with an inversion thermometer, excepting the autumn (ECOPEL) cruise, where conductivity, temperature and pressure (CTD) cast were conducted.

Larvae of *L. spinosa* were separated from total sample and identified based on the descriptions of Boschi and Scelzo (1968), Salman (1982), Bakker *et al.* (1990) and Clark *et al.* (1998). Larvae were sorted in the laboratory using a NIKON MZ10 dissecting microscope and, when necessary, an OLYMPUS BX50 biological microscope for the correct identification of the species.

Contour maps based on a geometric progression of base 3 of the abundance data was used to allow a rapid interpretation of distributional patterns (Calazans, 1994). The abundance was standardized in number of individuals per 100 m^3 of filtered seawater. Surface temperature and salinity contour maps were constructed in order to study the relationship between larval distribution and oceanographic conditions.

Results

Physical environment

According to the sea surface temperature, during spring the area was under the influence of TW originated from Brazilian Current flowing southward in the northern part of the shelf. The warm TW continued flowing southward until occupying most of the area in summer. During fall the Brazilian Current still influenced the area but with the onset of this season SAW flowing northward from the south reached the region. In winter most of the shelf was occupied by this cold low-salinity water, still present during spring in the southern area. (Figs. 2 and 3).

Low salinity waters present in PC cruises near the mouth of Lagoa dos Patos estuary denoted the influence of continental outflow over the shelf. According to Lima *et al.*, (1996), the flow is higher during winter and spring, especially in years of intense rainfall (Figs. 2 and 3).

Table II summarizes the range of sea surface and bottom temperature and salinity registered during the PC and ECOPEL surveys. Mean surface and bottom temperatures did not show any marked variations north and south of the lagoon mouth during the PC cruises and seasonal variation was also insignificant. Surface temperature was consistently higher than bottom temperature. Mean salinity values were lower at surface during winter, spring and autumn, probably as a result of the freshwater outflow from the combined zoeal stages; right, megalopa. (Contour abundance intervals are expressed as geometric progressiom of base 3 of ind./100m^3).Patos Lagoon. During summer, no differences between salinities of surface and bottom samples were detected. During ECOPEL cruises there was more variation across the whole area because of the different water masses present in the area and prevailing conditions during different years. Temperature and salinity ranges were broader than those during the PC cruise.

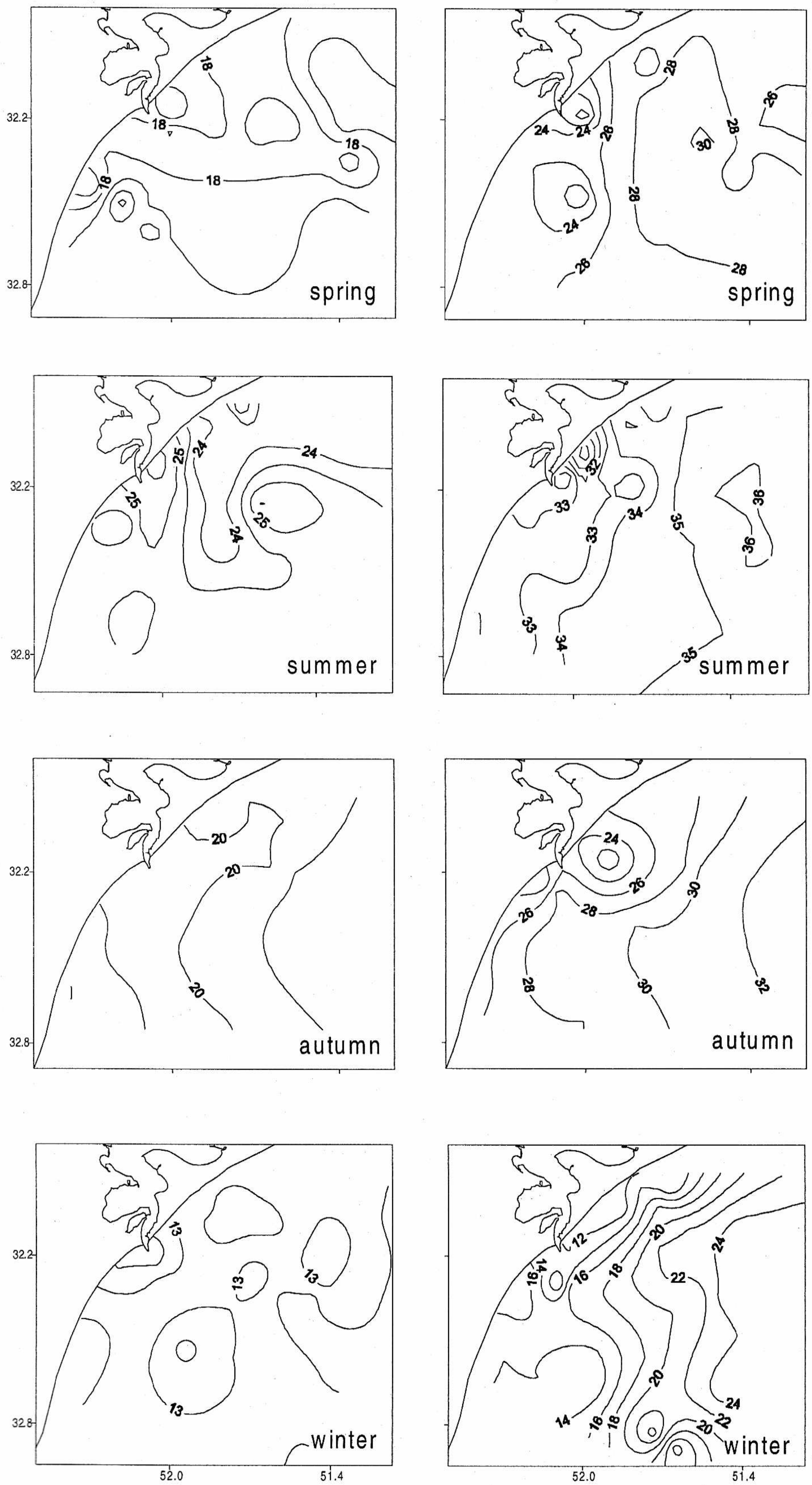

Figure 2: Surface temperature (left) and salinity (right) during PC cruises.

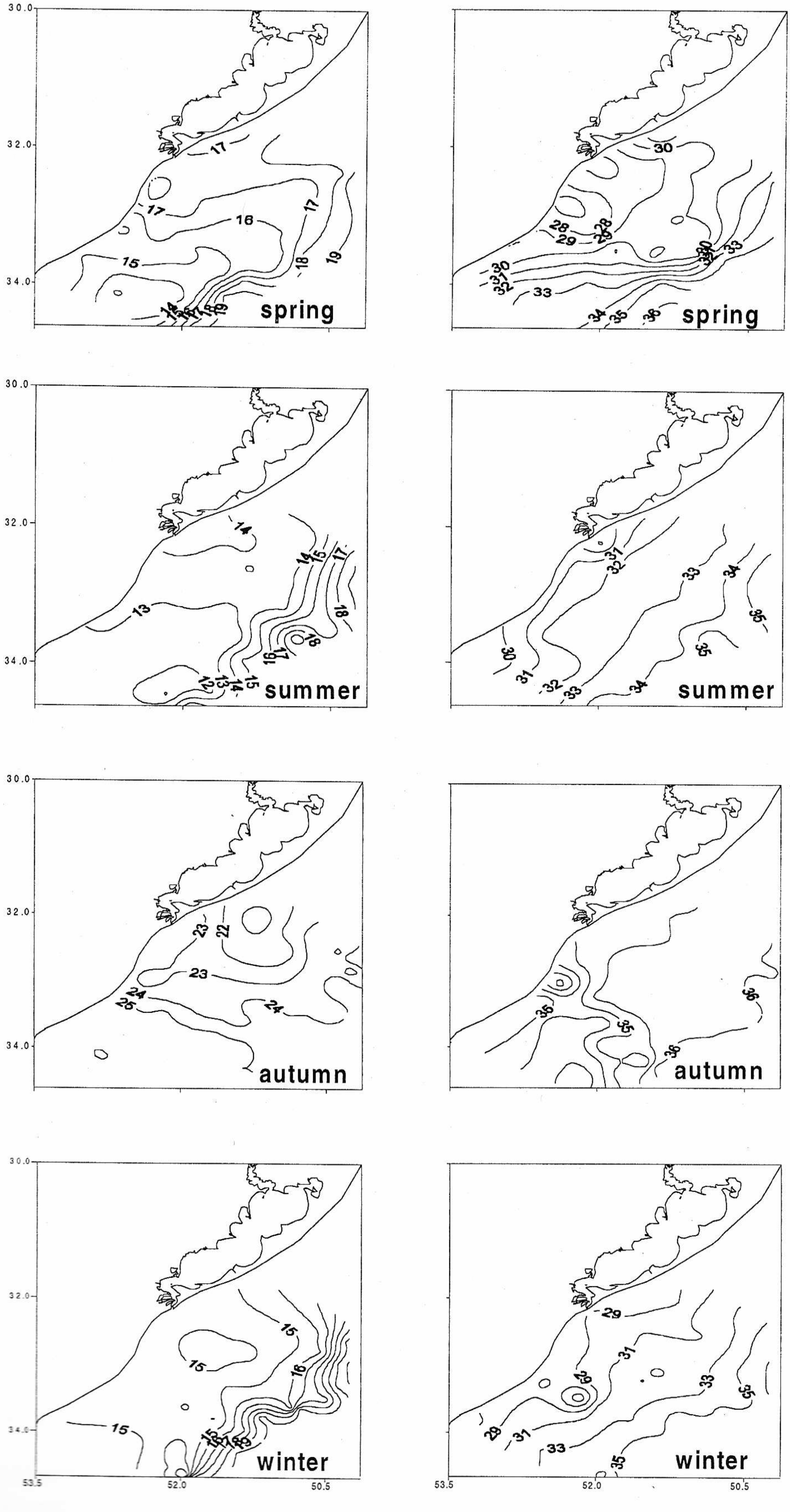

Figure 3: Surface temperature (left) and salinity (right) during ECOPEL cruises.

(Contour abundance intervals are expressed as geometric progressiom of base 3 of ind./100m^3).The larvae of *Libinia spinosa* were caught during the four seasons, but they were less abundant during winter (Figs. 4 and 5). Highest values of larval abundance per 100 m^3 observed during PC and ECOPEL cruises were, 64 and 515 in summer, 22 and 56 in spring, 17 and 19 in autumn and 2 in winter (PC), respectively. Highest abundance corresponded to the zoeal phase, mainly to the first stage. Zoea larvae were present in all seasons, whereas megalopa were present only from spring to autumn, most conspicuously in summer (Figs. 4 and 5). Zoea and megalopa were widely distributed over the inner shelf in waters with less than 50 m depth, showing peak abundance in the southernmost part of the sampled area.

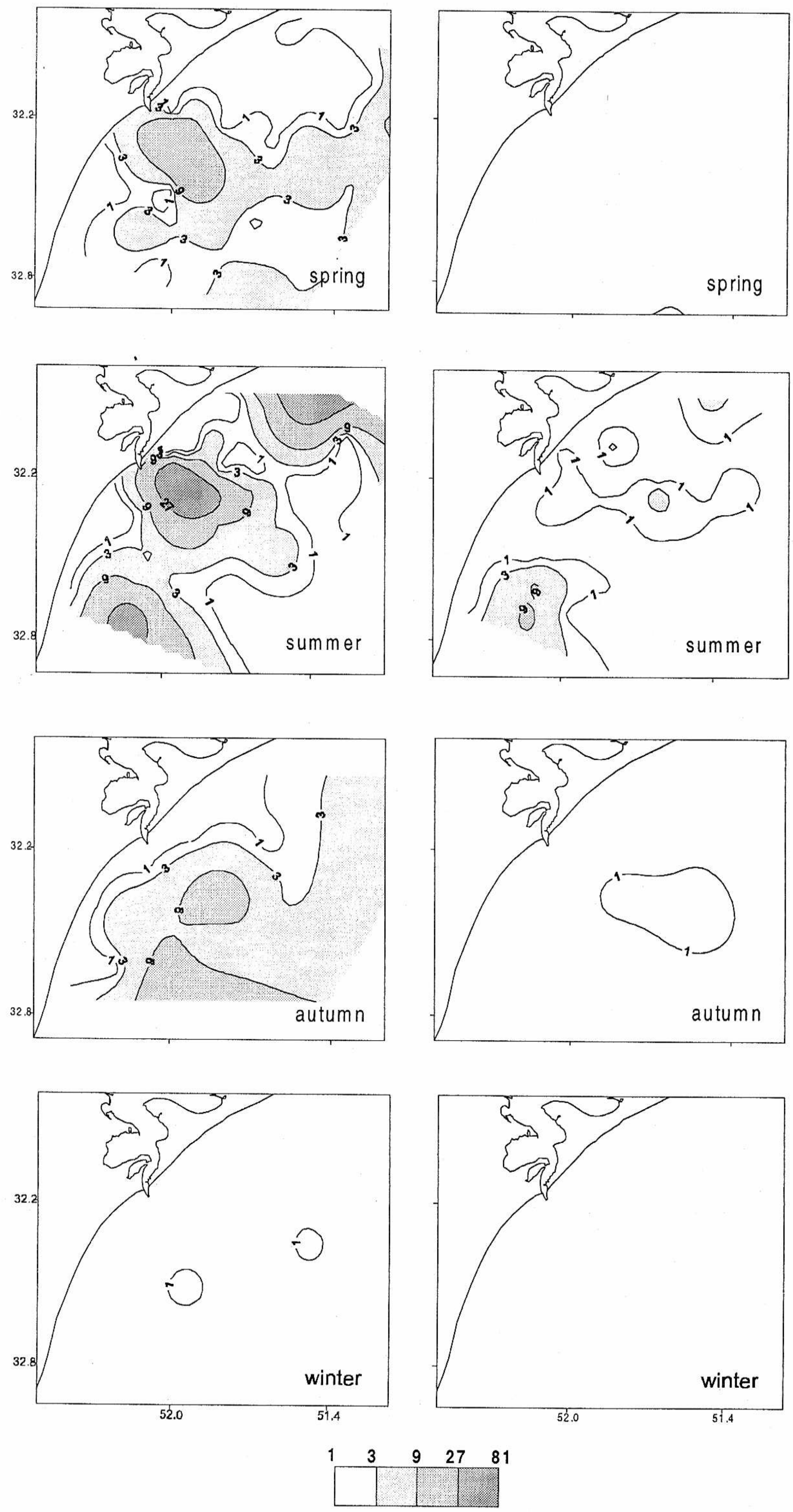

Figure 4: Larval distribution of *Libinia spinosa* in southern Brazilian coast during PC cruises. Left, combined zoeal stages; right, megalopa. (Contour abundance intervals are expressed as geometric progressiom of base 3 of ind./100m^3).

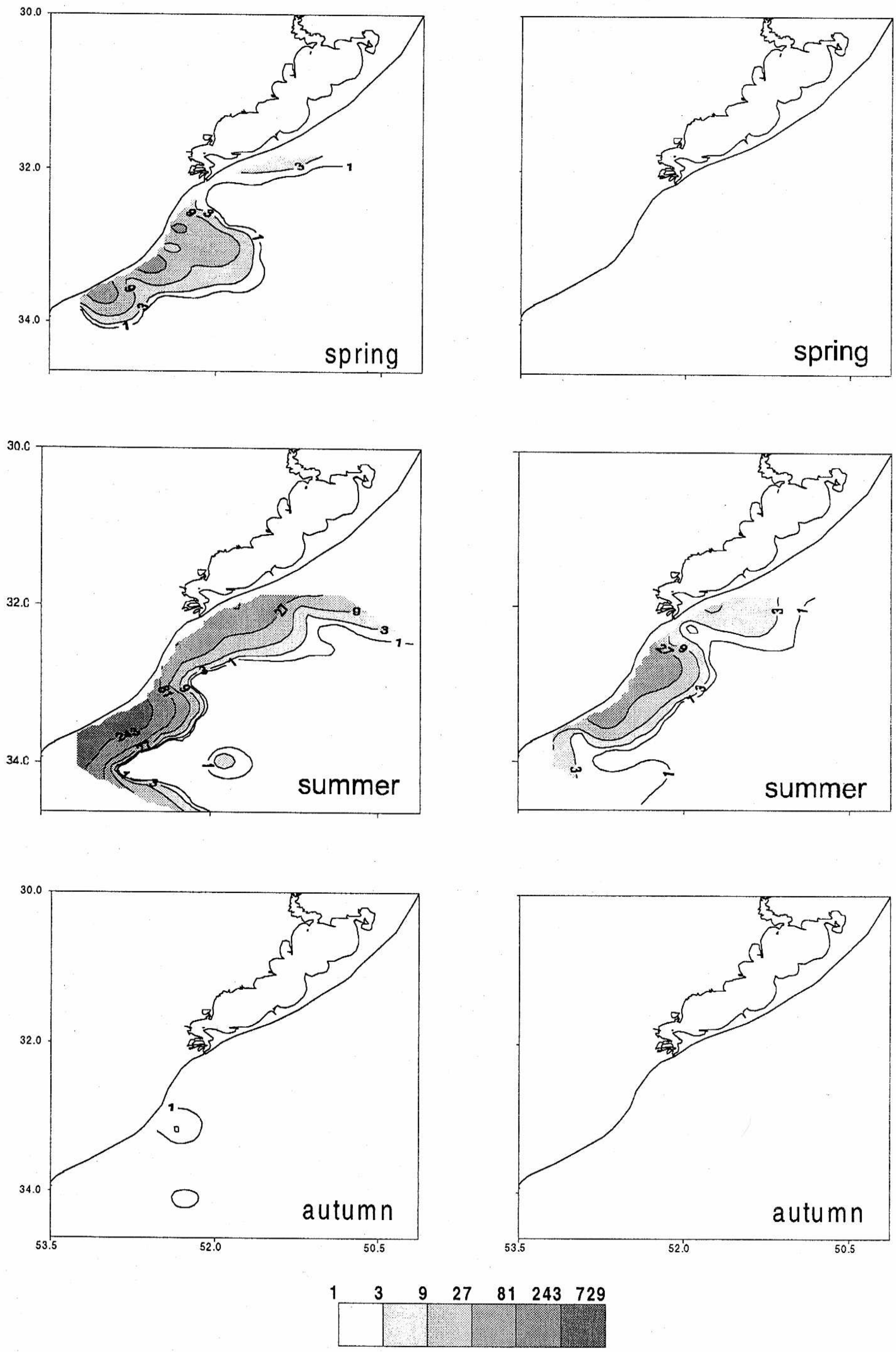

Figure 5: Larval distribution of *Libinia spinosa* in southern Brazilian coast during ECOPEL cruises. Left, combined zoeal stages; right, megalopa.

Highest peaks of abundance of first zoeal stage indicate that hatching, corresponded to the warmest months, suggesting thr influence of temperature on reproductive activity (Figs. 4 and 5). Considering all the stations where larvae were present, sea surface temperature and salinity values were generally higher than 14° C and 25 for spring and autumn cruises, 20° C and 31 for summer cruises and about 12° C and 14 for the winter cruise, respectively.

Discussion

Reproduction means a complex integration between physiological and behavioural processes and the environment. At medium and high latitudes, where temperature, photoperiod and food supply fluctuate, reproduction tends to be seasonal. The appearance of the larvae in the water column coincides with increasing temperature and of the primary production in spring and summer (Thorson, 1950; Sastry, 1983).

Table II: Sea surface and bottom temperature and salinity conditions per Cruise during PC and ECOPEL surveys.

Project	Cruise	Temperature		Salinity	
		surface	bottom	surface	bottom
PC	Spring	17.0 - 19.8	13.7 - 18.1	15.0 - 30.0	23.0 - 35.0
	Summer	23.1 - 25.6	15.9 - 24.9	29.0 - 36.0	30.0 - 36.0
	Autumn	19.0 - 20.9	18.8 - 20.8	20.0 - 33.0	20.0 - 35.0
	Winter	12.3 - 13.7	12.0 - 15.6	10.0 - 26.0	11.0 - 33.0
ECOPEL *	Spring	12.9 - 18.3	9.2 - 17.8	27.5 - 33.6	27.5 - 35.6
	Summer	20.3 - 26.0	11.4 - 26.0	33.2 - 36.0	33.2 - 36.1
	Autumn	13.5 - 21.5	11.9 - 21.1	26.5 - 36.4	28.7 - 36.6
	Winter	10.9 - 16.2	9.0 - 17.2	29.2 - 34.0	29.6 - 35.8

* values considering only stations where bottom depht is ≤ 200 m.

Temperature is recognised in this study as an important factor in the reproduction of *L. spinosa* in southern Brazilian coast. The larvae were present in all sampled periods, except for September 1988, with peak abundance in spring and summer. Ovigerous female are present in southern Brazil during the whole year (umpublished data), and hatching occurs throughout the year. In winter 1983, few larvae in the first zoeal stage were present in two stations only. Surface and bottom temperatures for both stations were 12° C and 15° C and have probably affected egg hatching and larval survival. The absence of larvae in winter 1988 could be explained by the marked influence of cold waters during this year (bottom temperature between 9.2° and 13.6°C down to 60 m depth). The low number of larvae observed in 1991 could be link to the fact that the temperature in the autumn-winter transition decreased (bottom and surface temperature between 14° and 17° C), affecting hatching and larval development (Hereu and calazans, 1999), as suggested by the presence of the first zoeal stage only. So, in colder conditions in winter, embryonic development is retarded (Wear, 1974), and hatching occurs when the water becomes warmer, in early spring. The observation of delayed embryo development in ovigerous females captured during winter in the area, and kept in the laboratory at 15° C for approximately two months, reinforces this conclusion. Therefore, the larvae that appear as a product of winter hatching would have a reduced role in the recruitment of *Libinia spinosa* whereas in spring and summer, and also in early fall, more favourable conditions may have enhanced larval survival and recruitment.

When analysing the pattern for this species on the Argentinean shelf, it was observed that adult of *L. spinosa* were abundant (Boschi, 1964) and larvae appeared in the plankton samples only from late November to early March (Hereu, unpublished). During this period mean water temperature ranges from 17°-18°C (Cousseau *et al.*, 1979). Besides, it is likely that this species reproduces during the whole year at lower latitudes of its distributional range, as we observed ovigerous females from the Ubatuba region (23°26'S, 45°05'W) carrying eggs in an advanced stage of development throughout the year. The average water temperature in that area is approximately 23.2° ± 3° C (ranging from 20° to 28°) (Nakayaki and Negreiros-Fransozo, 1998).

Besides temperature other factors to consider in larval dynamic analysis are related to currents and circulation patterns. The direction and periodicity of the horizontal displacement of planktonic organisms are generally determined by its vertical position in the water column, which influences the direction and magnitude of the dispersion (Johnson, 1985; Scheltema, 1986). A short period of permanence in the water column, as is the case of majids larvae (Rice, 1980) is also a way to minimize the danger for larvae to be transported either downward to deeper strata or offshore.

According to Pereira (1989) and Zavialov *et al.* (1998), the area adjacent to the coast presents complex dynamic conditions controlled primarily by local factors such as freshwater input, local wind and bottom topography. The adults of *L. spinosa* can be found down to 200 m depth but the hatching area, as indicated by the presence of the first stage, occurs mainly in the inner shelf (to 50 m). The vertical distribution of the larvae of this species is unknown, but the pattern observed for other species of the genus *Libinia* indicated that distribution of zoeal stages was mainly at the surface and mid-depth, while megalopae were found at mid-depth and near-bottom (Sandifer, 1973; Johnson, 1985; Dittel and Epifanio, 1982; Shanks, 1998). Thus, with the presumed existence of a vertical migratory pattern of larvae of *L. spinosa*, and a short permanence in the water column (about 10 days for the zoea phase; Hereu and Calazans 1999), there is little probability of being transported deeper or offshore, where their survival and megalopa settlement would not be favoured.

Comparing samples from both surveys, it can be observed that larvae were less abundant close to the mouth of the estuary, where salinity is low, mainly during winter and spring. Only the first zoea was more abundant there, whereas the second zoea and the megalopa were scarce. The presence of larvae of *L. spinosa* in an area with low salinity conditions could be explained by the capacity of larvae to move in the water column in response to salinity or thermal gradients (McConnaughey and Sulkin, 1984; Sulkin, 1984; Forward, 1989, Hereu and Calazans, 1999).

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References

Bakker, C.; Montú, M.; Anger, K. and Harms, J. 1990. Larval development of a tropical spider crab, *Libinia ferreirae* Brito Capello, 1871 (Decapoda: Majidae), reared in the laboratory. Meeresforsch, 33: 90-103.

Boschi, E. E. 1964. Los crustáceos decápodos Brachyura del litoral Bonaerense (R. Argentina). Boletín del Instituto de Biología Marina, Mar del Plata, 6: 1-76

Boschi, E. E. and Scelzo, M. A. 1968. Larval development of the spider crab *Libinia spinosa* H. Milne Edwards, reared in the laboratory (Brachyura, Majidae). Crustaceana, 2: 170-180.

Brandini, F. P.; Lopes, R. M.; Gutseit, K. S.; Spach, H. L. and Sassi, R. 1997. Planctonologia na Plataforma Continental do Brasil - Diagnose e revisão bibliográfica. Avaliação do potencial sustentável de recursos vivos na zona econômica exclusiva -REVIZEE. MMA, CIRM, FEMAR.

Calazans, D. 1994. Morphology, abundance and distribution of larval phases of two sergestids in the southern brazilian coast. Nauplius, Rio Grande, 2: 75-86.

Capítoli, R. R.; Ruffino, M. L. and Vooren, C. M. 1995. Alimentação do tubarão *Mustelus schmitti* Springer na Plataforma costeira do estado do Rio Grande do Sul, Brasil. Atlântica, Rio Grande, 17: 109-122.

Clark, P. F.; Calazans, D. and Rodrigues, S. S., 1998. *Libinia spinosa* H. Milne Edwards, 1834 (Crustacea: Majidae: Pisinae): A reappraisal of larval characters from laboratory reared material. Invertebrate Reproduction and Development, 33(2-3): 145-157.

Cousseau, M. B.; Hansen, J. E. and Gru, D. 1979. Campañas realizadas por el buque de investigación "Shinkai Maru" en el mar argentino, desde abril de 1978 hasta abril de 1979. Organización y reseña de datos obtenidos. Contribución del Instituto Nacional de Investigación y Desarrollo Pesquero, Mar del Plata, 373. 625 pp.

Dittel, A. I. and Epifanio, C. E., 1982. Seasonal abundance and vertical distribution of crab larvae in Delaware Bay. Estuaries, 5(3): 197-202.

Forward, R. B. 1989. Behavioral responses of crustacean larvae to rates of salinitiy changes. Biological Bulletin, 176: 229-238.

Garcia, C. A. E. 1997. Coastal and marine environments and their biota: Physical Oceanography. In: Subtropical convergence environments: the coastal and sea in the Southwestern Atlantic. U. Seeliger,

C. Odebrecht and J.P. Castello (eds.). Springer Verlag. pp. 94-96.

Hereu, C. M. and Calazanz, D. 1999. Desarrollo larval de *Libinia spinosa* Milne Edwards 1834 (Brachyura, Mjidae) en diferentes condiciones de temperatura y salinidad. IV Taller sobre Cangrejos y Cangrejales-I Jornadas Argentinas de Carcinología. 5 al 8 de abril. Buenos Aires, Argentina. Abstracts. p. 36

Johnson, D. F. 1985. The distribution of brachyuran crustacean megalopae in the waters of the York River, lower Cheaspeake Bay and adjacent shelf: implications for recruitment. Eastern Coastal Shelf Sciences, 20: 693-705.

Lima, I. D.; Garcia, C. A. E. and Möller, O. O. 1996. Ocean surface process on the suthern Brazilian shelf: characterization and seasonal variability. Continental Shelf Research, 16(10): 1307-1317.

McConnaughey, R. A. and Sulkin, S. D. 1984. Measuring the effects of thermoclines on the vertical migration of larvae of *Callinectes sapidus* (Barchyura, Portunidae) in the laboratory. Marine Biology, 81: 139-145.

Melo, G. A. S. 1996. Manual de identificação dos Brachyura (Caranguejos e Siris) do Litoral Brasileiro. Pleiade (ed.), São Paulo, 604 p.

Miranda, L. B. 1973. Propriedades e variáveis físicas das águas da plataforma continental do Rio Grande do Sul. São Paulo, 189 pp. (Universidade de São Paulo-USP, Ph. D. Thesis).

Nakagaki, J. M. and Negreiros-Fransozo, M. L. 1998. Population biology of *Xiphopenaeus kroyeri* (Heller 1862) (Decapoda: Penaeidae) from Ubatuba Bay, Sao Paulo Brazil. Journal of Shellfish Research, 17(4): 931-935.

Pereira, C. S. 1989. Seasonal variability in the coastal circulation on the Brazilian continental shelf (29°S-35°S). Continental Shelf Research, 9(3): 285-299.

Rice, A. L. 1980. Crab zoeal morphology and its bearing on the classification of the Brachyura. Trans. Zoological Society of London Sympossium,35: 271-424.

Salman, S. S. 1982. Larval development of the spider crab *Eurynome aspera* (Pennant), reared in the laboratory, with a key to the known larvae of the subfamily Pisinae (Brachyura, Majidae). Crustaceana, 43(1): 78-88.

Sandifer, P. A. 1973. Distribution and abundance of decapod crustacean larvae in the York River estuary and adjacent lower Cheasapeake Bay, Virginia, 1968-1969. Cheasapeake Sciences, 14(4): 235-257.

Sastry, A. N. 1983. Pelagic Larval Ecology and Development. In: The Biology of Crustacea. F. J. Vernberg and Vernberg, W. B. (eds.). New York, Academic Press. 7: 214-282.

Scheltema, R. S. 1986. On dispersal of planktonic larvae of benthic invertebrates: an eclectic overview and summary of problems. Bulletin of Marine Science, 39(2): 290-322.

Shanks, A. L. 1998. Abundance of pos-larval *Callinectes sapidus*, *Penaeus spp.*, *Uca spp.* and *Libinia spp.* collected at an outer coastal site and their cross-shelf transport. Marine Ecology Progress Series, 168: 57-69.

Souza, J. A. F. 1994. Distribuição dos Brachyura (Crustacea: Decapoda) da plataforma rio-grandina (Rio Grande do Sul). Recife, 131 p. (Universidade Federal de Pernambuco, Master Thesis).

Sulkin, S. D. 1984. Behavioral basis of depth regulation in the larvae of brachyuran crabs. Marine Ecology Progress Series, 15: 181-205.

Teixeira, R. L. 1987. Distribuição, reprodução e hábitos alimentares de *Prionotus punctatus* e *P. nudiguia* (Pisces-Triglidae) entre solidão (30° 43' S) e Chui (33° 45'). Rio Grande, 76 pp. (Universidade Federal de Rio Grande-FURG, Master Thesis).

Thorson, G. 1950. Reproductive and larval ecology of marine bottom invertebrates. Biological Revieus, 25: 1-45.

Wear, R. 1974. Incubation in British decapod crustacea and the effects of temperature on the rate and success of embryonic development. Journal of Marine Biology Ass. U.K.,(54): 745-762.

Zavialov, P. O.; Ghisolfi, R. D. and Garcia, C. A. E., 1998. An inverse model for seasonal circulation over the southern Brazilian shelf: Near-surface velocity from the heat budget. Journal of Physical Oceanography, 28: 545-562.

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