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Scientific Article

SEASONAL EVALUATION OF THE CONDITION FACTOR IN A SURF-ZONE ASSEMBLAGE FROM SOUTHEASTERN BRAZIL

Eidi Kikuchi Santos[1]

Fernando Rafael De Grande[2]

Teodoro Vaske-Júnior[3]

[1]Laboratório de Recursos Pesqueiros Demersais e Cefalópodes, Instituto de Oceanografia, Universidade Federal do Rio Grande (FURG), Av. Itália, 474, 96201-900 Rio Grande, RS, Brasil. E-mail: eidikikuchi@hotmail.com (corresponding author)

[2]Programa de Pós-graduação em Ciências Biológicas (Zoologia), Instituto de Biociências de Botucatu, Universidade Estadual de São Paulo (UNESP), 18618-000 Botucatu, SP, Brasil.

[3]Laboratório de Zoologia, Instituto de biociência, Universidade Estadual de São Paulo (UNESP), Campus do Litoral Paulista, Praça Infante Dom Henrique, S/N, Parque Bitarú, 11330-900, São Vicente, SP, Brasil.

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ABSTRACT

The surf zone is a highly dynamic environment subject to seasonal fluctuations which could impose restrictions to the development of juvenile fish. The allometric condition factor index (K) provides a value of 'well-being' for fish, been used to compare populations under different environmental conditions. The aim of this study concerned on evaluate the effect of seasonality on surf-zone juvenile fish' K. Along two years the K values of the main fish species were analyzed. The temperature and abundance were also reported. We compared data between cold and hot seasons to test the effect of seasonality. A total of 955 individuals were collected, totaling 20 species. Despite the surf zone instability, most fish species showed a stable K regardless of season. We found that the condition factor in neritic *Atherinella blackburni*, *Mugil brevirostris*, *Trachinotus carolinus* and *Trachinotus goodei* did not vary. Only a demersal species, *Menticirrhus littoralis*, shown the lowest condition factor in the hot season, coinciding with maximum water temperature. We discussed how the surf zone provides conditions for the development of fish and reinforce the importance of this environment as a breeding site.

Key words: abundance; demersal; juvenile; neritic; seasons; temperature.

AVALIAÇÃO SAZONAL DO FATOR DE CONDIÇÃO EM UMA ASSEMBLEIA DE PEIXES DA ZONA DE ARREBENTAÇÃO NO SUDESTE DO BRASIL

RESUMO

A zona de arrebentação é um ambiente altamente dinâmico, sujeito a flutuações sazonais que podem impor restrições ao desenvolvimento de peixes juvenis. O fator de condição alométrico (K) fornece um valor de 'bem-estar' para peixes, usado para comparar populações sob diferentes condições ambientais. O objetivo deste estudo foi avaliar o efeito da sazonalidade sobre o K de peixes juvenis da zona de arrebentação. Durante dois anos, os valores de K para as principais espécies de peixes foram analisados. A temperatura e abundância também foram avaliadas. Nós comparamos os dados entre as estações fria e quente para testar o efeito da sazonalidade. Foram coletados 955 indivíduos, totalizando 20 espécies. Apesar da instabilidade da zona de arrebentação, a maioria das espécies demostraram um K estável independentemente da estação. Verificamos que o K para os neríticos, *Atherinella blackburni, Mugil brevirostris*, *Trachinotus carolinus* e *Trachinotus goodei* não variam. Apenas o demersal *Menticirrhus littoralis* apresentou o K mais baixo na estação quente, coincidindo com a maior temperatura da água. Nós sugerimos que a zona de arrebentação oferece condições para o desenvolvimento dos peixes juvenis ao longo do ano e reforçamos a importância deste ambiente como berçário.

Palavras-chave: abundância; estações; demersal; juvenis; nerítico; temperatura.

INTRODUCTION

The surf zone is a dynamic environment situated between the coastline and the outer limit of the breaking wave (Carter, 1988). Due to high primary productivity, low depth and high turbidity, this zone provides high food availability and protection against predators, which makes it an environment with great importance for the initial stages of ichthyofauna (Lasiak, 1981; Carter, 1988; Brown and Mclachlan, 1990). Thus, it is suggested as a refuge and nursery area for the ichthyofauna assemblage, especially in regard larval production, growth, survival and migration of juveniles (Bennett, 1989; Cowley et al., 2001; Inoue et al., 2005; Félix et al., 2007; Gondolo et al., 2011).

However, fishes of the surf zone are subject large variability at multiple scales in space and time as a consequence of changes in abiotic factors such as tidal, wave gradient, wind direction, salinity, temperature and moon phases (Giannini and Paiva-Filho, 1995; Araújo et al., 2008; Gaelzer and Zalmon, 2008). These factors are important variables, influencing the composition and abundance of the surf zone community (Kingsford and Finn, 1997, Gaelzer and Zalmon, 2003, 2008; Gondolo et al., 2011).

Among abiotic factors, temperature is considered the most important variable - related to species recruitment (Cushing, 1995; Rodrigues-Filho et al., 2016), abundance (Monteiro-Neto et al., 2003), occurrence (Lowe-Mcconnell, 1999), growth (Brander, 1995; Teal et al., 2008), reproduction, survivor and offspring development (Burt et al., 2011). Studies conducted in the surf zone showed a high fish abundance and diversity during warmer seasons, which decreased due to cooler water in the cold season (Ruple, 1984; Senta and Kinoshita, 1985; Ross et al., 1987; Gibson et al., 1993; Layman, 2000, Vendel et al., 2003). Clark et al. (1996), using multivariate techniques, showed that temperature is a determining factor in the seasonal abundance of most fishes. Monteiro-Neto et al. (2003) suggested that temperature influences reproduction and recruitment, as well as food availability for fishes. According to Felix et al. (2007), higher abundance during the warmer season is associated with reproductive period, since highest temperature in the summer favors phytoplankton production, providing food which will raise survival chances of juveniles.

Since the surf zone acts as a nursery for young fish, it has great importance in keeping the fish stock (Bennett and Attwood, 1993). However, it is also subject to constant pressure from environmental and anthropic stressors, e.g. recreation, pollution and coastal development, which impact and promote severe ecological disturbances to the beach environment and consequently affect local fish populations (Davenport and Davenport, 2006; Defeo et al., 2009). Thus, it is extremely important to raise ecological questions about the dynamics of this environment and its influence on the early developmental stages of fish fauna.

The length-weight relationship is an important tool used in fish biology and ecology (Le-Cren, 1951; Santos, 1978; Froese, 2006). With this parameter, it is possible to estimate the allometric condition factor (K) (Le-Cren, 1951), which provides information on the physiological condition of the animals. The basic assumption is that individuals of a given length that have more mass are in better body condition (Froese, 2006). Thus, it is possible to establish a ‘condition’, ‘fatness’, or ‘well-being’ () value for fish, which reflects recent nutritional conditions and/or spending of reserve in cyclical activities (Vazzoler, 1996; Froese, 2006).

The allometric condition factor may undergo changes due to external factors like temperature, salinity, photoperiod and feeding, and internal factors such as gonadal development, organic reserves, weight and length (e.g. Htun-Ha, 1978; Wootton et al., 1978; Björnsson et al., 1989; Herbinger and Friars, 1991; Jones et al., 1999; Lloret et al., 2002; Rätz and Lloret, 2003). This factor can therefore be used to compare populations that are subject to different seasonal conditions and are thus under the influence of different abiotic and biotic factors (Lambert and Dutil, 1997; Froese, 2006). Therefore, the allometric condition factor (K) is an efficient tool to analyze changes in the surf zone fish assemblage condition throughout the year. This work is a pioneer regarding the use of K to assess body condition of juvenile fish in the surf zone between seasons.

Surf zone ecological researches show and highlight the importance of this environment for the coastal fish species with the aim of generating proposals for preservation and conservation. Thus, in order to provide more knowledge about this environment, the aim of this study was to evaluate K variation of surf zone fishes that showed 100% occurrence over samples between cold and hot seasons. Our null hypothesis (H0) is that the ichthyofaunal allometric condition factor does not vary between hot and cold seasons. In addition, we assessed changes in water temperature (abiotic variable) and abundance (biotic variable).

MATERIAL AND METHODS

Sampling was carried out in the surf zone of Praia Grande beach, São Paulo, southeastern Brazil (23°59’57”S; 46°24’48”W). The study area is located in the central coast of State of São Paulo, characterized by coastal plains, delimited on the north by a continuous SW-NE mountain range with elevations varying from 800 m to 1200 m (‘Serra do Mar’) and on the south by Atlantic Ocean. The studied site is characterized as a high-energy dissipative beach, which has a long extension and is therefore more exposed, subject to higher energy waves (Souza, 2012). The coastal plain and associated continental shelf have wide and low topographic gradients (Souza, 2012), considered stable with no predominance of erosion or sediment deposition (Tessler et al., 2006). According to the Köppen classification system, the area is characterized as a tropical climate with no defined dry season (Alvares et al., 2013), with a normal average temperature ranging from ≥ 18oC (cooler month) to ≥ 22oC (hottest month) (Roling et al., 2007).

The allometric condition factor (K) was compared between cold and hot seasons. During the cold season, specimens were sampled in April and August 2013 (first sample year) and April and August 2014 (second sample year). For the hot season, collections were performed in October 2013 and March 2014 (first sample year) and October 2014 and February 2015 (second sample year). All samplings were made with a 10x2 m beach seine, with a 1 m2 bag (4 mm internode mesh). For each sampling station (n=8) three trawls were performed sequentially for five minutes at a depth of one meter, parallel to the beach face during the day time (Figure 1). Samples were placed in plastic bags and frozen. In each trawling, water temperature was recorded (by mercury thermometer with 1 °C accuracy). In the laboratory, fish were identified to the species level and quantified. Total length (cm) and total weight (g) of each fish were recorded.

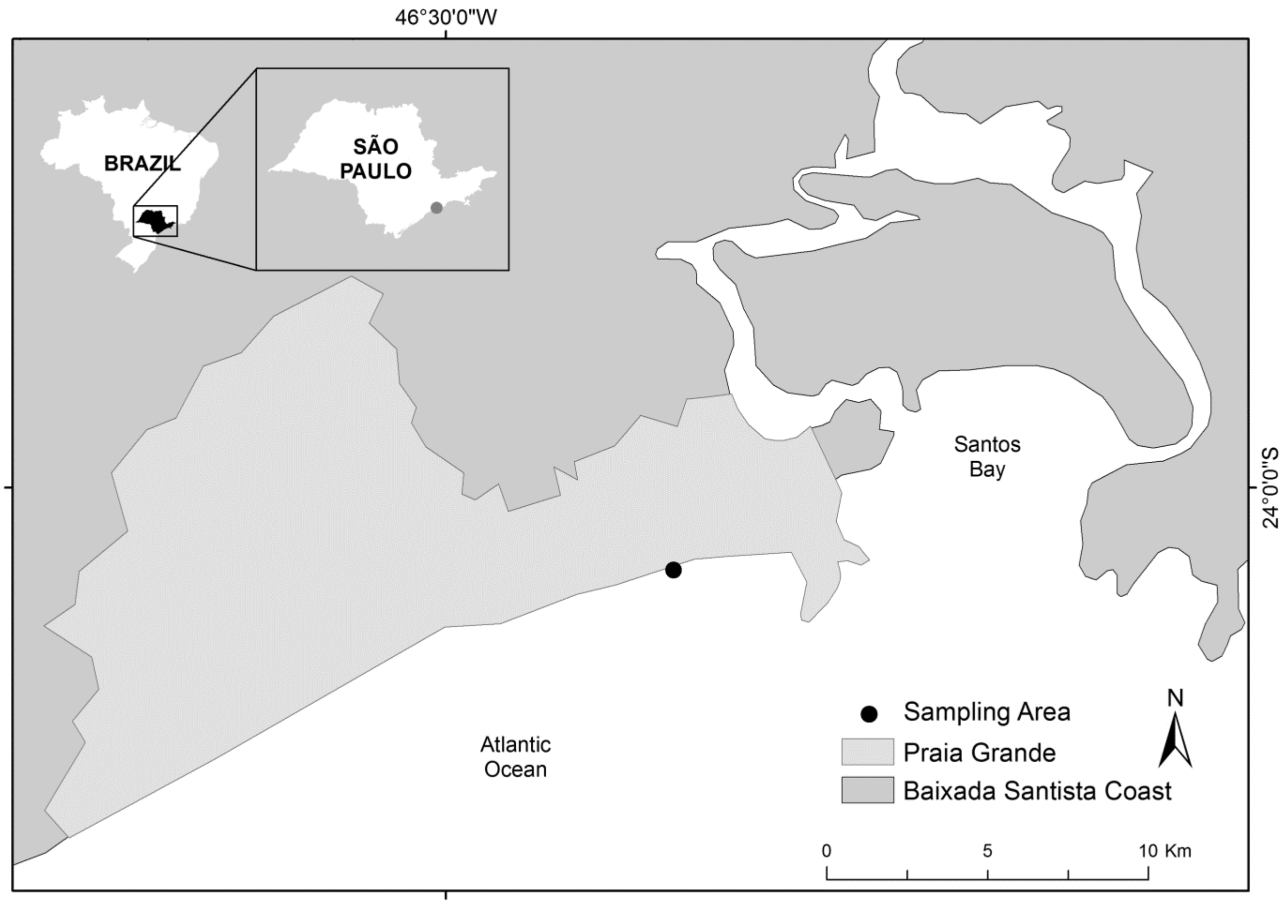

Figure 1. Location of the sampling area at Praia Grande beach, São Paulo.

For analyzes we used only constant species that showed 100% occurrence during the sampling period. The frequency of occurrence method (Brown et al., 2011), according to the formula $c = (ci/C) \times 100$ was calculated, where c is the value of the frequency of species, ci is the number of samples of the species and C is the total number of samples. For each constant species the relative abundance index was obtained by the Capture per Unit Effort (CPUE) in number (individuals/ trawling), calculated in the same way as other studies in the surf zone (i.e. Gaelzer and Zalmon 2003, 2006, 2008).

The length-weight relationship was obtained by $TW=aTLb$ where TW is observed fish total weight, TL is observed fish total length, and a and b are estimated by log $LW=log\ a+b\ log\ TL$ (i.e. a is the regression intercept and b is the allometric coefficient). The allometric coefficient was calculated of grouping all individuals to each constant species. Thus, b was used as a constant value in calculating K for all sub-samples, seasonal and annual, following the recommendations of Lima-Junior et al. (2002). The allometric condition factor was calculated via the equation $K=\frac{TW}{TLb}$ (Le-Cren, 1951).

To assess body condition of fish from the surf zone between cold and hot seasons, the average K of constant species was compared between seasons (fixed factor, with two levels: cold and hot) and between the two years of sampling (fixed factor, with two levels) by an analysis of variance (two-way ANOVA). Similarly, mean abundance (CPUE) of constant species and temperature were compared between seasons (fixed factor, with two levels: cold and hot) and between years (fixed factor, with two levels) also via a two-way ANOVA. Assumptions of normality and homoscedasticity were evaluated by Levene's test. In cases of heteroscedastic or non-normality data, the K values were corrected via [$log10$ (x + 1)] for the valid application of the parametric analyses of variance (Zar, 2010). In all cases, the minimum level of significance was assumed to be 5%. When significant differences were found, Tukey's test was used. All the statistical analyses were performed on R software (R Core Team, 2018).

RESULTS

We collected 955 individuals, encompassing 20 species (Table 1), with five species representing 83.56% of the sample: 29.42% of *Mugil brevirostris* (Ribeiro, 1915), 19.37% of *Menticirrhus littoralis* (Holbrook, 1860), 15.39% of *Trachinotus carolinus* (Linnaeus, 1766), 10.57% of *Genidens barbus* (Lacepède, 1803) and 8.79% of *Anchoviella lepidentostole* (Fowler, 1911). Only five species were constant throughout the sampling period: the beach silverside *Atherinella blackburni* (Schultz, 1949), the pompanos *Trachinotus goodei* (Jordan and Evermann, 1896) and *Trachinotus carolinus*, the gulf kingfish *Menticirrhus littoralis*, and the mullet *Mugil brevirostris*.

Table 1. Fish abundance in cold and hot seasons during two years of sampling in the surf zone of Praia Grande, SP. * Represents species that showed 100% occurrence in this period.

Species	Seasons and year				
	Cold		Hot		
	Sample 1	Sample 2	Sample 1	Sample 2	Sum
*Mugil brevirostris**	10	7	14	250	281
*Menticirrhus littoralis**	10	112	20	43	185
*Trachinotus carolinus**	9	12	13	113	147
Genidens barbus	0	0	0	101	101
Anchoviella lepidentostole	0	72	0	12	84
*Atherinella blackburni**	10	8	12	11	37
*Trachinotus goodei**	6	8	7	9	30
Harengula clupeola	1	3	0	21	25
Atherinella brasiliensis	0	17	0	0	17
Polydactylus virginicus	3	0	6	4	13
Sardinella brasiliensis	1	7	0	0	8
Stellifer rastrifer	5	0	3	0	8
Leptocephalus	0	0	5	1	6
Menticirrhus americanus	1	0	3	0	4
Symphurus tesselatus	3	0	0	0	3
Etropus crossotus	1	0	0	1	2
Chaetodipterus faber	1	0	0	0	1
Prionotus punctatus	0	0	0	1	1
Cynoscion sp.	0	1	0	0	1
Caranx latus	0	1	0	0	1
Sum	61	241	83	567	955

Table 2. Results of the analysis of variance (ANOVA), comparing relative abundance of CPUEs between seasons and between two years of sampling from *Atherinella blackburni, Menticihhrus littoralis, Mugil brevirostris, Trachinotus carolinus* and *Trachinotus goodei* sampled in the surf zone of Praia Grande, SP. *Indicate significant differences in K (ANOVA, p< 0.05).

Species		df	MS	F	p
Atherinella blackburni	Season	1	0.066823	0.78288	0.426244
	Year	1	0.001434	0.01680	0.903130
	Season x Year	1	0.002083	0.02441	0.883424
	Error	4	0.085356		
Menticirrhus littoralis	Season	1	0.081089	0.59984	0.481872
	Year	1	0.496809	3.67505	0.127706
	Season x Year	1	0.184123	1.36202	0.308016
	Error	4	0.135184		
Mugil brevirostris	Season	1	0.891468	4.76029	0.094553
	Year	1	0.782432	4.17806	0.110437
	Season x Year	1	0.742689	3.96583	0.117258
	Error	4	0.187272		
Trachinotus carolinus	Season	1	0.298974	9.4032	0.037422*
	Year	1	0.553378	17.4045	0.014010*
	Season x Year	1	0.134161	4.2196	0.109174
	Error	4	0.031795		

Trachinotus goodei	Season	1	0.000949	0.010532	0.923199
	Year	1	0.014198	0.157509	0.711724
	Season x Year	1	0.010998	0.122005	0.744483
	Error	4	0.090144		

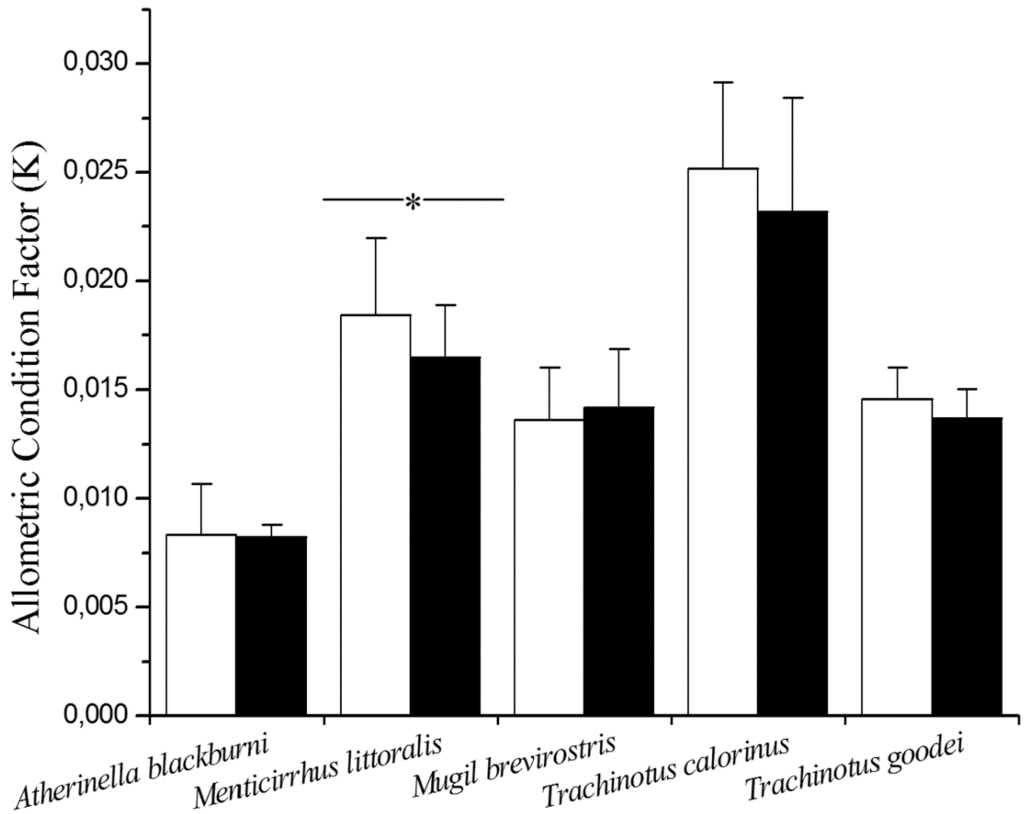

Figure 2. Condition factor (K) of fishes species *Atherinella blackburni*, *Menticihhrus littoralis*, *Mugil brevirostris*, *Trachinotus carolinus* and *Trachinotus goodei* sampled in the surf zone of Praia Grande, SP, between seasons: cold (white) and hot (black). *Indicate significant differences in K (ANOVA, p< 0.05).

The relative abundance of each species analyzed showed no significant difference between cold and hot seasons and between the years for constant species (Table 2): *A. blackburni, M. littoralis, M. brevirostris and T. goodei*. Only *T. carolinus* showed higher abundance in the cold season (F4,0.127=9.403, p=0.037) and in the second year (F4,0.127=17.40, p=0.014).

Among the analyzed species, *M. littoralis* showed a lower condition factor in the hot season than in the cold season (F161,0.001=10.876, p=0.001). The other species showed no seasonal significant differences in K (Figure 2).

Higher values for water temperature were observed in the hot season ($F_{20,135.18}$= 8.439, p=0.008), regardless of sampling year ($F2_{0,135,18}$=0.745, p=0.398). In the hot season, temperature varied from 22 to 28 °C (mean: 25.3 °C), while in the cold season temperature varied from 18 to 25 °C (mean: 22.5 °C).

DISCUSSION

Although the surf zone is an unstable environment, subject to constant variation of biotic and abiotic factors, most of the observed specimens in this study showed a stable allometric factor condition at succeeding seasons. Only the demersal juvenile *M. littoralis* presented a lower K value in the hottest season. The other fish analyzed had neritic habit and did not present variations in K, independent of temperature and abundance, suggesting that the life habit can be determinate in the maintenance of condition factor in the surf zone. Therefore, the idea of the surf zone as a fish nursery was reinforced in this study.

Only five species were constantly present throughout the study period: *M. brevirostris*, *T. carolinus*, *T. goodei*, *M. littoralis* and *A. blackburni*. Except for *A. blackburni*, all other sampled individuals were juveniles. The influence of seasonality on the condition factor was not observed for juvenile *M. brevirostris*, *T. carolinus*, *T. goodei* as well as *Atherinella blackburni*, which showed stable, values of K through the seasons. However, juvenile *M. littoralis* had a higher K in the cold season when lower water temperature values were observed.

Variation of K between fishes may be related mainly to their gonadal cycle development (), where higher K values indicate an increase in fish feeding activity and consequently accumulated energy reserves for the reproductive period (Le-Cren, 1951; Htun-Han, 1978; Millán, 1999; Kurita, 2003). Usually, there is a gradual increase in K during the reproductive cycle, which is normalized immediately following breeding season (Htun-Han, 1978). Thus, variation of the allometric condition factor reflects the state of gonadal development and consumption of fat reserve during spawning (Vazzoler and Vazzoler, 1965; Sutton et al., 2000).

In this study only *A. blackburni* was subject to reproductive cycles, so it was the only species in which this variable could influence K. But, similarly to the other species in this study, mainly juvenile individuals without reproductive cycle influence, *A. blackburni* showed no variation of K value between seasons. *Atherinella blackburni* is found only on the shores of the Atlantic Ocean, always occurring in the surf zone (Schultz, 1949; Gilbert and Caldwell, 1967; Gonzales and Vaske-Júnior, 2017). This is the only species among others in our study that presents a complete life cycle in this environment. As reported by Lopes and Oliveira-Silva (2001), the beach silversides showed individuals of different size classes in the Praia Grande surf zone. Despite the *A. blackburni* assemblage being composed by mature individuals in our study, we noted K remained stable over the sampled years and seasons. Among the few ecological studies on *A. blackburni*, the one by Mattox et al. (2008) showed that this species is predominantly diurnal, occurring in warm, salty water, with greater abundance of juveniles in the summer. However, we did not observe this predominance of juvenile occurrence despite temperature variation. We might suggest that temperature does not affect abundance or K in *A. blackburni* on Praia Grande beach.

Gonzales and Vaske-Júnior (2017) showed that the availability of food in the surf zone varies according to physicochemical conditions and season, but despite that, they confirm that *A. blackbuni* has a generalist strategy and feeds on any available organisms along the year. Considering the relative low temperature variation (betewn 18 oC and 22oC, see: Roling et al., 2007), the constantly available food at the study area (Lasiak, 1981; Carter, 1988; Brown and Mclachlan, 1990), and based on stable allometric condition factor we might suggest *A. blackburni* does not have a well-defined reproductive seasonality in the Brazilian southeastern coast. However, specific studies, like gonadosomatic index and maturation stage are necessary to determinate the influence of seasonal changes in *A. blackburni* reproductive cycle.

Since, *T. carolinus*, *T. goodei* and *M. brevirostris* were juveniles, they are not subject to intrinsic reproductive variables affecting K. The condition factor also indicates periods of dietary change and consequently fat accumulation (Sutton et al., 2000;). Thus despite the variation of abundance for *T. carolinus*, the stability of K observed in our study may be related to feeding habits of neritic species or indicates a constant availability of food in this environment. In surf zones, there are large concentrations of primary producers (phytoplankton and microphytobenthos) which are responsible for starting the flow of the trophic web (Sousa et al., 2009; Dring, 1992). Furthermore, the high energy in the surf zone provides suspension of large amounts of sediment, easily dislodging infauna and benthic microalgae from the substrate to the water column, which makes them viable prey for neritic fishes (Sousa et al., 2009; Domenico et al., 2009) such as pompanos, mullets and beach silverside. We did not measure the availability of fish food present in the environmental, but since the condition factor of juvenile fish remained constant throughout the year, we hypothesized that the surf-zone could constantly provide food for juvenile-neritic fish.

Different from neritic fish, *M littoralis* juveniles feed almost entirely on the bottom, showing a typical Sciaenid demersal feeding mode (Monteiro-Neto and Cunha, 1990). Rodrigues and Vieira (2010) observed seasonal feeding differences in M. littoralis juveniles. Haluch et al. (2009) also found seasonal trophic plasticity in surf zone Sciaenids; according to the authors, such change in diet throughout the season may be associated with availability of food items. Hernandez (2003) reported seasonal variation in the feeding habits and significant variation in mean K values during different months for Diplodus puntazzo (Walbaum, 1792), which mean K value decrease during the warmer months of the year. Seasonal and developmental fluctuations in the amount of lipid storage mean an evolutionary strategy which the patterns and utilization of lipid storages may reflect the specific life history of the animal (Sheridan, 1994; Hernandez, 2003). In the other hand, growth is generally associated with the feeding level and the dietary energy content, which appears to be the key factors accounting for the level of fat deposition in fish (Hernandez, 2003). Therefore, a dietary seasonal change might explain K variation in *M. littoralis*, but future seasonal dietary studies are required at specie-specific level. Besides the availability of food, other factors could explain the variation of the body condition of *M. littoralis*. The condition factor may change depending on extrinsic factors such as temperature (Rätz and Lloret, 2003), photoperiod (Björnsson et al., 1989) and food availability (Ferraton et al., 2007). Rodrigues and Vieira (2010) suggested that seasonal changes in temperature are the main element affecting frequency of *M. littoralis*, with higher abundances observed on spring and summer months (hot season). In our study, abundance of *M. littoralis* was not affected by temperature, but their condition factor could be affecting. We hypothesize that higher temperatures reduce K in juvenile *M. littoralis*, since higher increase in temperature can cause metabolic acceleration, decrease in water oxygen and so imposing metabolic limitations to growth (Pörtner and Knust, 2007).

In addition, organisms of different life habitats living under different thermal conditions probably have evolved different levels of metabolic control, suggesting different thermal tolerance responses (Sokolova and Pörtner, 2003; Magozzi and Calosi, 2015). Dynamic habitats with large thermal variations select organism with high thermal resistance (Madeira et al., 2012). Thus, the surf zone neritic fishes, *M. brevirostris*, *T. carolinus*, *T. goodei*, and *A. blackburni*, which spend most of their life in coastal regions with high dynamism (Bellinger and Avault, 1971; Carvalho Filho, 1999; Mattox et al., 2008; Madeira et al., 2012) are probably little affected by the seasonal variations of temperature, thus presenting a stable condition factor independent of temperature. In other hand, the gulf kingcroaker *M. littoralis* showed a lower K value in the warmer season, when higher water temperatures were observed. Demersal and neritic species tolerate specific ranges of environmental conditions, and should undergo appropriate abiotic conditions to survive, mature and reproduce successfully (Rijnsdorp et al., 2009). A pattern of larger fish inhabiting colder waters has often been reported for demersal spices (Macpherson and Duarte, 1991), moving to coastal regions during the reproductive period. (Palmeira and Monteiro-Neto, 2010). According to Madeira et al. (2012), demersal habitat species generally live in relatively more stable and lower temperature conditions, presenting a lower thermal tolerance when compared to habitats with higher thermal variability. Thus, the lower value of the condition factor presented by the juvenile *M. littoralis* in the warmer season may be associated with the demersal habit and the life history that presents a greater sensitivity to a thermal stress.

CONCLUSION

The stability of K in the surf zone may be attributed to: a) most of the surf zone resident fish assemblage is composed of juveniles which are not subject to the variation of K due to reproductive factors; b) the neritic habit life could contribute to K stability between seasons. However, variations in temperature between seasons could cause this condition factor behavior in *M. littoralis*. Since the present study is a pioneer in the analysis of the seasonal influence on the body condition of surf zone juvenile fish, some questions to be investigated have been highlighted. For example: The beach silverside *A. blackburni* does not have a well-defined reproductive seasonality? The life habit is determinant in the maintenance of the condition factor? The body condition of demersal juveniles is affected by temperature? Comparison of fishes by the allometric condition factor was presented as a good parameter for ecological analysis, mainly related to young populations, which still lack studies in the surf zone. Further investigation of the body condition factor in surf zone fish fauna should be carried out considering the importance of this environment for juvenile recruitment and maintenance of stocks.

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REFERENCES

Alvares, C.A.; Stape, J.S.; Sentelhas, P.S.; Gonçalves, J.L.M.; Sparovek, G. 2013. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, 22(6): 711-728. **https://dx.doi.org/10.1127/0941-2948/2013/0507**

Araújo, C.C.V.; Rosa, D.M.; Fernandes, J.M.; Ripoli, L.V.; Krohling, W. 2008. Composição e estrutura da comunidade de peixes de uma praia arenosa da Ilha do Frade, Vitória, Espírito Santo. Iheringia Zoologia, 1: 129-135. **https://dx.doi.org/10.1590/S0073-47212008000100016**

Bellinger, J.W.; Avalut, J.W. 1971. Food habits of juvenile pompano *Trachinotus carolinus*, in Lousiana. Transactions of the American Fisheries Society, 100: 486-494. **https://doi.org/10.1577/1548-8659(1971)100<486:FHOJPT>2.0.CO;2**

Bennett, B.A. 1989. The fish community of a moderately exposed beach on the southwestern cape coast of South Africa and an assessment of this habitat a nursery for juvenile fish. Estuarine Coastal and Shelf Science, 28: 293-305. **https://doi.org/10.1016/0272-7714(89)90019-X**

Bennett, B.A.; Attwood, C.G. 1993. Shore-angling catches in the De Hoop Nature Reserve, South Africa and further evidences for the protective value of marine reserves. South African Journal of Marine Science, 13: 213-222. **https://doi.org/10.2989/025776193784287202**

Björnsson, B.T.; Thorarensen, H.; Hirano, T.; Ogasawara, T.; Kristinsson, J.B. 1989. Photoperiod and temperature affect plasma growth hormone levels, growth, condition factor and hypoosmoregulatory ability of juvenile Atlantic salmon (Salmo salar) during parr-smolt transformation. Aquaculture, 82(1-4): 77–91. **https://doi.org/10.1016/0044-8486(89)90397-9**

Brander, K.M. 1995. The effect of temperature on growth of Atlantic cod (*Gadus morhua L*). ICES Journal of Marine., 52(1): 1–10. **https://doi.org/10.1016/1054-3139(95)80010-7**

Brown, A.C.; McLachlan, A. 1990. Ecology of sandy shores. New York: Elsevier. 328p.

Brown, S.C.; Bizzarro, J.J.; Cailliet, G.M.; Ebert, D.A. 2011. Breaking with tradition: redefining measures for diet description with a case study of the Aleutian skate *Bathyraja aleutica* (Gilbert 1896). Environmental Biology of Fishes, 95(1): 3–20. **https://doi.org/10.1007/s10641-011-9959-z**

Burt, J.M.; Hinch, S.G.; Patterson, D.A. 2011. The importance of parentage in assessing temperature effects on fish early life history: a review of the experimental literature. Reviews in Fish Biology and Fisheries, 21: 377-406. **https://doi.org/10.1007/s11160-010-9179-1**

Carter, R.W.G. 1988. Coastal environments: an introduction to the physical, ecological and cultural systems of coastlines. London: Academic Press. 617 p.

Carvalho-Filho, A. 1999. Peixes: costa brasileira. 3 ª ed. São Paulo: Editora Melro. 320p.

Clark, B.M.; Bennett, S.J.; Lamberth, S.J. 1996. Temporal variations in surf zone fish assemblages from False Bay, South Africa. Marine Ecology Progress Series, 131: 35-47. **https://doi.org/10.1007/s11160-010-9179-1**

Cowley, P.D.; Whitfield, A.K.; Bell, K.N.I. 2001. The surf zone ichthyoplankton adjacent to an intermittently open estuary, with evidence of recruitment during marine overwash events. Estuarine Coastal and Shelf Science, 52: 339-348. **https://doi.org/10.1006/ecss.2000.0710**

Cushing, D.H. 1995. Population Production and Regulation in the Sea: a Fisheries Perspective. Cambridge: Cambridge University Press. 354p.

Davenport, J.; Davenport, J.L. 2006. The impact of tourism and personal leisure transport on coastal environments: A review. Estuarine Coastal and Shelf Science, 67: 280-292. **https://doi.org/10.1016/j.ecss.2005.11.026**

Defeo, O.; McLachlan, A.; Schoeman, D.S.; Schlacher, T.A.; Dugan, J.; Jones, A.; Lastra, M.A.; Scapini, F. 2009. Threats to sandy beach ecosystems: a review. Estuarine Coastal and Shelf Science, 81: 1-2. **https://doi.org/10.1016/j.ecss.2008.09.022**

Domenico, M.D.; Lana, P.C.; Garrafoni, A.R.S. 2009. Distribution patterns of intersticial polychaetesin sandy beaches of southern Brazil. Marine Ecology, 30: 47-62. **https://doi.org/10.1111/j.1439-0485.2008.00255.x**

Dring, M.J. 1992. The biology of marine plants. Cambridge: Cambridge University Press. 199p.

Félix, F.C.; Spach, H.L.; Moro, O.S.; Schwarz, J.R.; Santos, C.; Hackradt, C.W.; Hostim, M.S. 2007. Utilization patterns of surf zone inhabiting fish from beaches in Southern Brazil. Pan-American Journal of Aquatic Sciences, 2: 27-39.

Ferraton, F.; Harmelin, V.M.; Mellon-Duval C.; Souplet A. 2007. Spatio-temporal variation in diet may affect condition and abundance of juvenile European hake in the Gulf of Lions (NW Mediterranean). Marine Ecology Progress Series, 337: 197–208. **https://doi.org/10.3354/meps337197**

Froese R. 2006. Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology, 22(4): 241–253. **https://doi.org/10.1111/j.1439-0426.2006.00805.x**

Gaelzer, L.R.; Zalmon, I.R. 2003. The influence of wave gradient on the ichthyofauna of southeastern Brazil: focusing the community structure in surf-zone. Journal of Coastal Research, 45: 456-462.

Gaelzer, L.R.; Zalmon, I.R. 2006. Surf-zone ichthyofaunal diel variation in Arraial do Cabo, southeastern Brazil. Journal of Coastal Research, 39: 1114-1117. **https://www.jstor.org/stable/25741756**

Gaelzer, L.R.; Zalmon, I.R. 2008. Tidal influence on surf zone ichthyofauna structure at three sandy beaches, southeastern Brazil. Brazilian Journal of Oceanography, 56(3): 165-177. **https://dx.doi.org/10.1590/S1679-87592008000300002**

Giannini, R.; Paiva-Filho, A.M. 1995. Análise comparativa da ictiofauna da zona de arrebentação de praias arenosas do litoral do Estado de São Paulo, Brasil. Boletim do Instituto Oceanográfico, 43: 141-52. **https://dx.doi.org/10.1590/S0373-55241995000200006**

Gibson, R.N.; Ansell, A.D.; Robb, L. 1993. Seasonal and annual variations in abundance and species composition of fish and macrocrustacean communities on a Scottish sandy beach. Marine Ecology Progress Series, 98: 89-105. **https://doi.org/10.3354/meps098089**

Gilbert, C.R.; Caldwell, D.K. 1967. The American atherinid fishes of the genus *Coleotropis*. Contributions in Science, 125: 1-16.

Gondolo, G.F.; Mattox, G.M.T.; Cinningham, P.T.M. 2011. Ecological aspects of the surf-zone ichthyofauna of Itamambuca Beach, Ubatuba, SP. Biota Neotropica, 11: 183-192. **https://dx.doi.org/10.1590/S1676-06032011000200019**

Gonzales, J.G.; Vaske-Júnior, T. 2017. Feeding ecology of the beach silverside *Atherinella blackburni* (Atherinopsidae) in a tropical sandy beach, Southeastern Brazil. Brazilian Journal of Oceanography, 65(3): 346-355. **https://dx.doi.org/10.1590/s1679-87592017131506503**

Haluch, C.F.; Freitas, M.O.; Corrêa, M.F.M.; Abilhoa, V. 2009. Variação sazonal e mudanças ontogênicas na dieta de *Menticirrhus americanus* (Linnaeus, 1758) (Teleostei, Sciaenidae) na baía de Ubatuba-Enseada, Santa Catarina, Brasil. Pan-American Journal of Aquatic Sciences, 4: 347-356.

Herbinger, C.M.; Friars, G.W. 1991. Correlation between condition factor and total lipid content in Atlantic salmon, *Salmo salar* L., parr. Aquaculture and Fisheries Management, 22: 527–529. **https://doi.org/10.1111/j.1365-2109.1991.tb00766.x**

Hernandez, M. 2003. Seasonal condition and body composition changes in sharpsnout seabream (*Diplodus puntazzo*) raised in captivity. Aquaculture, 220(1-4): 569–580. **https://doi.org/10.1016/S0044-8486(02)00638-5**

Htun-Han, M. 1978. The reproductive biology of the dab *Limanda limanda* (L.) in the North Sea: gonosomatic index, hepatosomatic index and condition factor. Journal of Fish Biology, 13(3): 369–378. **https://doi.org/10.1111/j.1095-8649.1978.tb03445.x**

Inoue, T.; Susa, Y.; Sano, M. 2005. Food habits of fishes in the surf zone of a sandy beach at Sanrimatsubara, Fukuoka Prefecture, Japan. Ichthyological Research, 52: 9-14. **https://doi.org/10.1007/s10228-004-0246-2**

Jones, R.E.; Petrell, R.J.; Pauly, D. 1999. Using modified length–weight relationships to assess the condition of fish. Aquacultural Engineering, 20: 261–276. **https://doi.org/10.1016/S0144-8609(99)00020-5**

Kingsford, M.; Finn, M. 1997. The influence of the moon and physical processes on the input of resettlement fishes to coral reefs. Journal of Fish Biology, 51: 176-205.

Kurita, Y. 2003. Oocyte growth and fecundity regulation by atresia of Atlantic herring (*Clupea harengus*) in relation to body condition throughout the maturation cycle. Journal of Sea Research, 49(3): 203–219. **https://doi.org/10.1016/S1385-1101(03)00004-2**

Lambert, Y.; Dutil, J.D. 1997. Can simple condition indices be used to monitor and quantify seasonal changes in the energy reserves of cod (*Gadus morhua*)? Canadian Journal of Fisheries and Aquatic Sciences, 54: 104–112. **https://doi.org/10.1139/f96-149**

Lasiak, T.A. 1981. Nursery grounds of juvenile teleosts: evidence from the surf-zone of King's Beach, Port Elizabeth. South African Journal of Science, 77: 388-390.

Layman, C.A. 2000. Fish assemblage structure of the shallow ocean surf-zone on the eastern shore of Virginia barrier islands. Estuarine Coastal and Shelf Science, 51: 201-213. **https://doi.org/10.1006/ecss.2000.0636**

Le-Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonadal weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology, 20: 201-219. **https://doi.org/10.2307/1540**

Lima-Junior, S.E.; Cardone, I.B.; Goitein, R. 2002. Determination of a method for calculation of allometric condition factor of fish. Acta Scientiarum, Biological Sciences, 24: 397-400.

Lloret, J.; Gil de Sola, L.; Souplet, A.; Galzin, R. 2002. Effects of large-scale habitat variability on condition of demersal exploited fish in the north-western Mediterranean. ICES Journal of Marine Science, 59: 1215–1227. **https://doi.org/10.1006/jmsc.2002.1294**

Lopes, P.R.D.; Oliveira-Silva, J.T. 2001. Registro de *Atherinella blackburni* (Schultz) (Actinopterygii, Teleostei, Atherinopsidae) na praia de Ponta da Ilha, Ilha de Itaparica, Bahia, Brasil. Revista Brasileira de Zoologia, 18: 117-122. **https://dx.doi.org/10.1590/S0101-81752001000100012**

Lowe-Mcconnell, R.H. 1999. Estudos ecológicos de comunidades de peixes tropicais. São Paulo: EDUSP. 536p.

MacPherson, E.; Duarte, C.M. 1991. Bathymetric trends in demersal fish size: is there a general relationship? Marine Ecology Progress Series, 71: 103-112. **https://doi.org/10.3354/meps071103**

Madeira, D.; Narciso, L.; Cabral, H.N.; Vinagre, C. 2012. Thermal tolerance and potential impacts of climate change on coastal and estuarine organisms. Journal of Sea Research, 70: 32-41. **https://doi.org/10.1016/j.seares.2012.03.002**

Magozzi, S.; Calosi, P. 2015. Integrating metabolic performance, thermal tolerance, and plasticity enables for more accurate predictions on species vulnerability to acute and chronic effects of global warming. Global Change Biology, 21: 181-194. **https://doi.org/10.1111/gcb.12695**

Mattox, G.M.T.; Gondolo, G.F.; Cunningham, P.T.M. 2008. *Atherinella blackburni* (Schultz, 1949) na praia de Itamambuca, Ubatuba, SP: caracterização ecológica e distribuição na costa brasileira (Teleostei: Atheriniformes: Atherinopsidae). Brazilian Journal of Biology, 68: 307-313. **https://dx.doi.org/10.1590/S1519-69842008000200011**

Millán, M. 1999. Reproductive characteristics and condition status of anchovy *Engraulis encrasicolus* L. from the Bay of Cadiz (SW Spain). Fisheries Research, 41(1): 73–86. **https://doi.org/10.1016/S0165-7836(99)00010-7**

Monteiro-Neto, C.; Cunha, L.P.R. 1990. Seasonal and ontogenetic variation in food habits of juvenile *Trachinotus marginatus* Cuvier, 1832 (Teleostei, Carangidae) in the surf zone of Cassino beach, RS, Brazil. Atlântica, 12: 45-54.

Monteiro-Neto, C.; Cunha, L.P.R.; Musick, J.A. 2003. Community structure of surf-zone fishes at Cassino Beach, Rio Grande do Sul, Brazil. Journal of Coastal Research, 35: 492-501.

Palmeira, L.P.; Monteiro-Neto, C. 2010. Ecomorphology and food habits of teleost fishes *Trachinotus carolinus* (Teleostei: Carangidae) and *Menticirrhus littoralis* (Teleostei: Sciaenidae), inhabiting the surf zone off Niterói, Rio de Janeiro. Brazilian Journal of Oceanography, 58: 1-9. **https://dx.doi.org/10.1590/S1679-87592010000800002**

Pörtner, H.O.; Knust, R. 2007. Climate change affects marine fishes through the oxygen limitation of thermal tolerance. Science, 315: 95-97. **https://doi.org/10.1126/science.1135471**

R Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Rätz, H.J.; Lloret, J. 2003. Variation in fish condition between Atlantic cod (*Gadus morhua*) stocks, the effect on their productivity and management implications. Fisheries Research, 60(2-3): 369–380. **https://doi.org/10.1016/S0165-7836(02)00132-7**

Rijnsdorp, A.D.; Peck, M.A.; Engelhard, G.H.; Möllmann, C.; Pinnegar, J.K. 2009. Resolving the effect of climate change on fish populations. ICES Journal of Marine Science, 66: 1570-1583. **https://doi.org/10.1093/icesjms/fsp056**

Rodrigues, F.L.; Vieira, J.P. 2010. Feeding strategy of *Menticirrhus americanus* and *Menticirrhus littoralis* (Perciformes: Sciaenidae) juveniles in a sandy beach surf zone of southern Brazil. Zoologia, 27: 873-880. **https://dx.doi.org/10.1590/S1984-46702010000600006**

Rodrigues Filho, J.L.; Couto, E.C.G.; Barbieri, E.; Branco, J.O. 2016. Ciclos sazonais da carcinofauna capturada na pesca do camarão-sete-barbas, *Xiphopenaeus kroyeri* no litoral de Santa Catarina. Boletim do Instituto de Pesca, 42(3): 648-661. **https://doi.org/10.20950/1678-2305.2016v42n3p648**

Roling, G.S.; Camargo, M.B.P.; Lania, D.G.; Moraes, J.F.L. 2007. Classificação climática de Köppen e de Thornthwaite e sua aplicabilidade na determinação de zonas agroclimáticas para o estado de São Paulo. Bragantia, 66(4): 711-720. **https://dx.doi.org/10.1590/S0006-87052007000400022**

Ross, S.T.; McMichael Jr, R.H.; Ruple, D.L. 1987. Seasonal and diet variation in the standing crop of fishes and macroinvertebrates from a Gulf of México surf zone. Estuarine Coastal and Shelf Science, 25: 391-412. **https://doi.org/10.1016/0272-7714(87)90033-3**

Ruple, D. 1984. Occurrence of larval fishes in the surf zone of a northern Gulf of Mexico barrier Island. Estuarine Coastal and Shelf Science, 18: 191-208. **https://doi.org/10.1016/0272-7714(84)90106-9**

Santos, E.P. 1978. Dinâmica de populações aplicada à pesca e piscicultura. São Paulo: EDUSP.

Schultz, L.P. 1949. A further contribution to the ichthyology of Venezuela. Proceedings of the United States National Museum, 99: 211. **https://doi.org/10.5479/si.00963801.99-3235.1**

Senta, T.; Kinoshita, I. 1985. Larval and juvenile fishes occurring in surf zones of western Japan. Trans American Fish Society, 114: 609-618. **https://doi.org/10.1577/1548-8659(1985)114<609:LAJFOI>2.0.CO;2**

Sheridan, M.A. 1994. Regulation of lipid metabolism in poikilothermic vertebrates. Comparative Biochemistry and Physiology, 107(B): 495–508. **https://doi.org/10.1016/0305-0491(94)90176-7**

Sokolova, I.M.; Pörtner, H.O. 2003. Metabolic plasticity and critical temperatures for aerobic scope in a eurythermal marine invertebrate (*Littorina saxatilis*, Gastropoda: Littorinidae) from different latitudes. Journal of Experimental Biology, 206: 195-207. **https://doi.org/10.1242/jeb.00054**

Sousa, E.B.; Costa, V.B.; Pereira, L.C.C.; Costa, R.M. 2009. Variação temporal do fitoplâncton e dos parâmetros hidrológicos da zona de arrebentação da Ilha Canela (Bragança-Pará-Brasil). Acta Botanica Brasilica, 23: 1084-1095. **https://dx.doi.org/10.1590/S0102-33062009000400018**

Souza, C.R. 2012. Praias arenosas oceânicas do estado de São Paulo (Brasil): síntese dos conhecimentos sobre morfodinâmica, sedimentologia, transporte costeiro e erosão costeira. Revista do Departamento de Geografia – USP, Volume Especial 30 Anos: 307-371. **https://doi.org/10.7154/RDG.2012.0112.0014**

Sutton, S.G.; Bult, T.P.; Haedrich, R.L. 2000. Relationships among fat weight, body weight, water weight and condition factors in Wild Atlantic Salmon Parr. Transactions of the American Fisheries Society, 129: 527–538. **https://doi.org/10.1577/1548-8659(2000)129<0527:RAFWBW>2.0.CO;2**

Teal, L.R.; De-Leeuw, J.J.; Van Der-Veer, H.W.; Rijnsdorp, A.D. 2008. Effects of climate change on growth of 0-group sole and plaice. Marine Ecology Progress Series, 358: 219-230. **https://doi.org/10.3354/meps07367**

Tessler, M.G.; Yoshikawa, P.S.; Hurtado, S.N.; Cazzoli, Y. Goya, S. 2006. Erosão e progradação do litoral do Estado de São Paulo. In: Dieter, M. Erosão e Progradação do litoral brasileiro. Ministério do Meio Ambiente, Brasilia. p. 297-346.

Vazzoler, A.E.A.M.; Vazzoler, G. 1965. Relation between condition factor and sexual development in *Sardinella aurita* (Cuv. and Val. 1847). Anais da Academia Brasileira de Ciências, 37: 353-359.

Vazzoler, A.E.A.M. Biologia da Reprodução de Peixes Teleósteos: Teoria e Prática. Maringá: Editora Universidade Estadual de Maringá; 1996.

Vendel, A.L.; Lopes, S.G.; Santos, C.; Spach, H.L. 2003. Fish assemblages in a tidal flat. Brazilian Archives of Biology and Technology, 46(2): 233-242. **https://dx.doi.org/10.1590/S1516-89132003000200015**

Wootton, R.J.; Evans, G.W.; Mills, L. 1978. Annual cycle in female Three-spined sticklebacks, (*Gasterosteus aculeatus* L.) from an upland and lowland population. Journal of Fish Biology, 12(4): 331-343.

Zar, J.H. 2010. Biostatistical analysis (5th ed.). New Jersey: Prentice-Hall/Pearson. 944p.