Use of mangrove habitat for reproductive activity by the fish assemblage in the Guaratuba Bay, Brazil

Paulo CHAVES [a], Jean-Luc BOUCHEREAU [b]*

[a] Department of Zoology, Universidade Federal do Paraná, CP 19020, 81531-990, Curitiba, Brazil
[b] Marine and Continental Hydrobiology Laboratory, UMR-5556, University of Montpellier 2, 34830 Montpellier cedex 05, France

Received 20 July 1999; revised 22 November 1999; accepted 17 December 1999

Abstract – The role played by a southwestern Atlantic mangrove in the breeding activity of estuarine fishes was evaluated. This fish assemblage represented 85 % of the total catches of the experimental fishery surveyed between 1993 and 1997. To evaluate the maturation and spawning processes, qualitative (macroscopic stages of maturation) and quantitative (gonadosomatic index) attributes were considered which were combined in a reproductive activity index. Four types of occupation were found in the mangrove, according to the reproductive patterns presented by each species. It was estimated that the Guaratuba mangrove is used as a spawning site – either regularly or occasionally – by about 40 % of the species, that make up 41 % to 46 % of the total abundance of this fish assemblage. However, besides the spawning species, the mangrove attracts other species at advanced stages of maturation. The use of mangrove habitat for reproductive activity by the species is 52 to 57 % of the total fish abundance. Spring and summer are the seasons most associated with the maturation and spawning processes. Although most of the assemblage is formed by species that do not permanently inhabit the system, the Guaratuba mangrove is a significant site for the life cycle of estuarine and marine species occupying this coastal region. © 2000 Ifremer/CNRS/IRD/Éditions scientifiques et médicales SAS

reproduction patterns / mangrove / fish assemblage / migrant and resident species

Résumé – Rôle de la mangrove pour la reproduction des poissons dans la baie de Guaratuba, Brésil. Le rôle joué par la mangrove d'une baie de l'Atlantique sud-ouest dans l'activité reproductive de la communauté de poissons a été étudié. Ces espèces représentent 85 % de l'abondance totale des pêches expérimentales entreprises de 1993 à 1997. Pour évaluer les processus de maturation et de ponte, les stades macroscopiques de maturation des gonades et l'indice gonadosomatique ont été considérés puis combinés en un indice d'activité reproductrice. Quatre modes d'occupation de la mangrove ont été répertoriés selon les modalités de reproduction de chaque espèce. La mangrove de Guaratuba est considérée comme un site de ponte, de façon régulière ou temporaire, pour environ 40 % des espèces constituant 41 à 46 % de l'abondance totale de l'assemblage. Cependant, à côté des espèces effectuant leur ponte dans la mangrove, ce milieu attire d'autres espèces dont le degré de maturation sexuelle est avancé. La contribution de la mangrove à l'activité reproductrice du peuplement de poissons s'élève à 52 et 57 % de l'abondance totale. Les processus de maturation et de ponte s'expriment principalement au printemps et en été. Bien que de nombreuses espèces n'occupent pas en permanence la mangrove de Guaratuba, celle-ci constitue un site d'accueil important pour les espèces habitant la région estuarienne et littorale. © 2000 Ifremer/CNRS/IRD/Éditions scientifiques et médicales Elsevier SAS

modes de reproduction / mangrove / assemblage de poisson / espèces migrantes et résidantes

* Correspondence and reprints: bouchero@hyd.univ-montp2.fr

PII: S0399-1784(00)00130-4/FLA

1. INTRODUCTION

Estuarine ecosystems are traditionally known as nursery areas important for the earlier phases of life cycles [26] of both estuarine-resident and temporary-resident species. In fact, even the populations that inhabit the coastal regions can use the mangrove and lagoon areas for breeding and spawning activities [2].

The northern region of Guaratuba Bay, an estuarine system located in southern Brazil (25° 52' S; 48° 39' W), is occupied by a mangrove area with approximately 500×10^4 m^2, where 60 fish species were recorded from 1993 to 1997 [12]. It is known that some of them use this region during their maturing or spawning phases [8, 9, 15–17]. However, the reproductive activity by the fish assemblage as a biological unit and the role played by the mangrove area have not been quantified. The present work aims to evaluate the fish community's reproductive pattern within the mangrove, using the Reproductive Activity Index (RAI) proposed by Agostinho et al. [1].

2. MATERIAL AND METHODS

Samples were collected monthly from July 1993 to February 1997 using an otter trawl (20 mm mesh size), in the mangrove of Guaratuba Bay (*figure 1*). From the 60 species registered by Chaves and Corrêa [12] in this region, 18 were considered for this study (*table I*). They represent 90 % and 85 % of the total abundance (total catches of fish in number and weight per trait of trawl net equalling 7 minutes long) in this study, as well as more than 75 % of the abundance registered from September 1993 to August 1996 in the same region by Chaves and Bouchereau [11]. These authors used the same method. Therefore, they constitute appropriate material for analysing the reproductive patterns of the fish assemblage. The reproductive patterns of nine species in this area were obtained in various literature reports; for the other nine species, the reproductive activity was assessed by the present research. In this latter group, the macroscopic stages of maturation (A, immature; B, developing; C, ripe; D, post-spawned) [27] and the

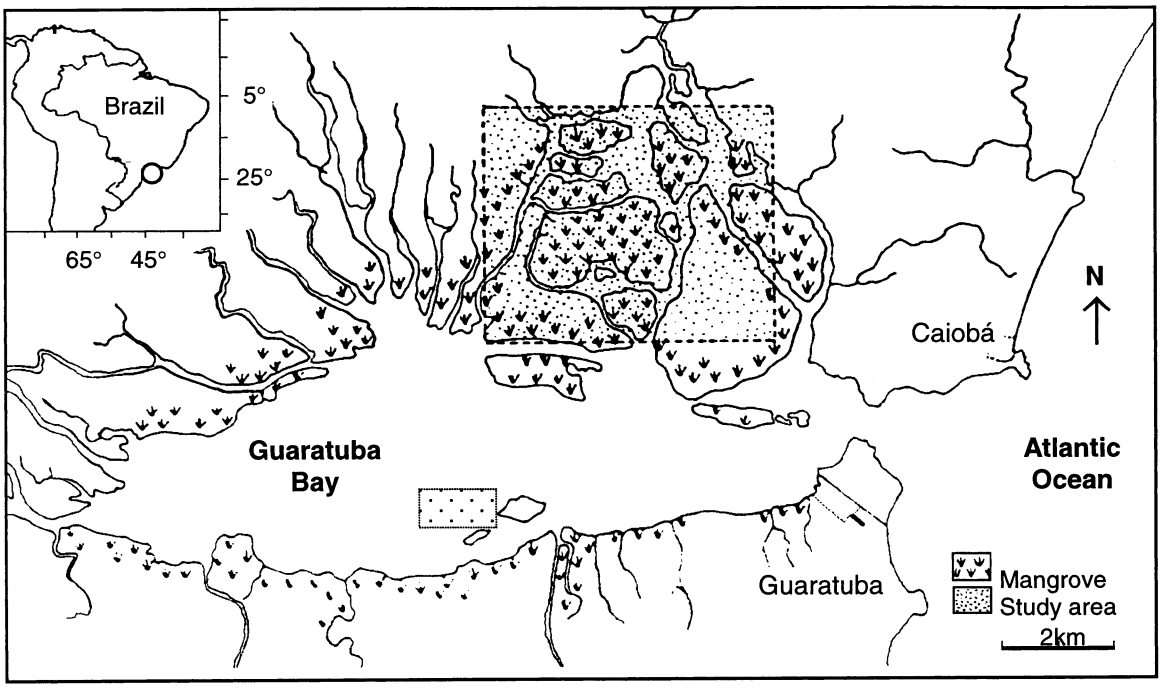

Figure 1. Map of Guaratuba Bay, south of Brazil, indicating the studied mangrove.

Table I. Reproductive observations in the 18 species investigated at Guaratuba mangrove. In brackets: species code; R: their ranking in numerical abundance in experimental catches from September 1993 to February 1997; P.O.: present observations, with the number of specimens analysed and their length interval.

Species (code)	R	Observations in mangrove	**References**
Stellifer rastrifer (Sr)	1	Usual spawning activity, winter, spring	[17]
Pomadasys corvinaeformis (Pc)	2	Maturation or spawning activity not found	[10]
Bairdiella ronchus (Br)	3	Usual spawning activity (spring, summer)	[9]
Diapterus rhombeus (Dh)	4	Maturation activity found in spring; spawning activity not found	[13]
Citharichthys arenaceus (Ca)	5	Spawning activity found in spring, summer	[16]
Genidens genidens (Gg)	6	Eggs and larvae mouth breeding, summer	[8]
Eucinostomus argenteus (Ea)	7	Maturation activity found in spring, summer; spawning activity not found	[14]
Isopisthus parvipinnis (Ip)	8	Maturation activity found in spring, summer; spawning not found	[15]
Eucinostomus melanopterus (Em)	11	Maturation activity found in spring; spawning activity not found	[14]
Chaetodipterus faber (Cf)	12	Only pre-adults found in the mangrove	P.O. (n = 42;53–170 mm)
Micropogonias furnieri (Mf)	13	Maturation or spawning activity not found	P.O. (n = 113;80–560 mm)
Centropomus parallelus (Cp)	14	Maturation, eventual spawning activity found; histology: post-ovulatory follicles in spring	P.O. (n = 85;115–405 mm)
Diplectrum radiale (Dr)	16	Maturation, eventual spawning activity found; histology: post-ovulatory follicles in spring	P.O. (n = 63;104–205 mm)
Cetengraulis edentulus (Ce)	18	Maturation, eventual spawning activity found; histology: mature follicles in spring	P.O. (n = 45;120–157 mm)
Harengula clupeola (Hc)	19	Maturation and spawning activities not found	P.O. (n = 42;95–166 mm)
Menticirrhus americanus (Ma)	20	Maturation, eventual spawning activity found; histology: post-ovulatory follicles in spring	P.O. (n = 55;107–375 mm)
Paralonchurus brasiliensis (Pb)	22	Maturation activity found; spawning activity not found	P.O. (n = 41;118–242 mm)
Trichiurus lepturus (Tl)	29	Maturation activity found; spawning activity not found; histology: mature follicles in summer	P.O. (n = 22;920–1260 mm)

histological indicators of a recent spawning (empty follicles) observed in the individuals, were analysed in each species.

Seventeen species were also analysed with respect to the RAI [1]. This index aims to combine, for each species, the qualitative data obtained by the number of mature females in a sampling unit with the quantitative ones obtained by the gonadosomatic average values. The use of logarithm minimises the effects of the difference between the size of the samples. This index is defined as:

$$RAI = [\ln N_i((n_i/\Sigma_{i:1\rightarrow 17} n_i) + (n_i/N_i)).GSI_i/GSI_e] / [\ln N_m(n_m/\Sigma_{i:1\rightarrow 17} n_i + 1)].100$$

where:

ln is the neperian logarithm,

N_i, the number of individuals in the sampling unit (*su*) '$_i$', composed by all specimens sampled in each one of the 17 species,

n_i the number n of mature individuals in the *su* '$_i$',

N_m the highest number of individuals in one *su*,

n_m the number of mature individuals in the *su* with the highest n,

GSI_i the average value of the Gonadosomatic Index [100·(weight of gonads/total weight)] of the mature individuals in the *su* '$_i$', and

GSI_e the greatest individual value of the Gonadosomatic Index in the *su* '$_i$'.

In *Genidens genidens* the gonad weight was not obtained, thus the RAI was not calculated for this species, and its reproductive activity was analysed only by qualitative observations.

3. RESULTS

Based on the literature (*table I*) it appears that all species, except *Pomadasys corvinaeformis*, *Harengula clupeola*, *Chaetodipterus faber* and *Micropogonias furnieri*, show evidence of gonadal maturation in the Guaratuba mangrove. Some of them effectively spawn in the mangrove area, either regularly (*Stellifer rastrifer*, *Bairdiella ronchus*, *Citharichthys arenaceus* and *Genidens genidens*), or sporadically (*Centropomus parallelus*, *Diplectrum radiale*, *Cetengraulis edentulus* and *Menticirrhus americanus*). Other species (*Diapterus rhombeus*, *Eucinostomus argenteus*, *E. melanopterus*, *Isopisthus parvipinnis*, *Paralonchurus brasiliensis* and *Trichiurus lepturus*) do not spawn in the mangrove, but inhabit the mangrove during part of their gonadal maturation.

Spring is the most frequent season associated with the reproductive activity in this assemblage. The species probably spawn during this season and also in summer, in or outside the mangrove.

The values of the RAI varied from 0.0 to 8.0, depending on the species (*figure 2*). The highest values were presented by *B. ronchus* and *S. rastrifer* (over 7.0) and *C. arenaceus* (3.2); those of *C. edentulus*, *M. americanus*, *I. parvipinnis* and *D. rhombeus* were placed in a range varying between 1.7 and 1.0; other species presented values between 0.0 and 0.8. The lowest values of RAI were found in a large spectrum of maximal individual length by species (170 to 1 500 mm), while the values higher than 3.0 were reduced to species whose maximal individual length is 350 mm or less (*figure 2*).

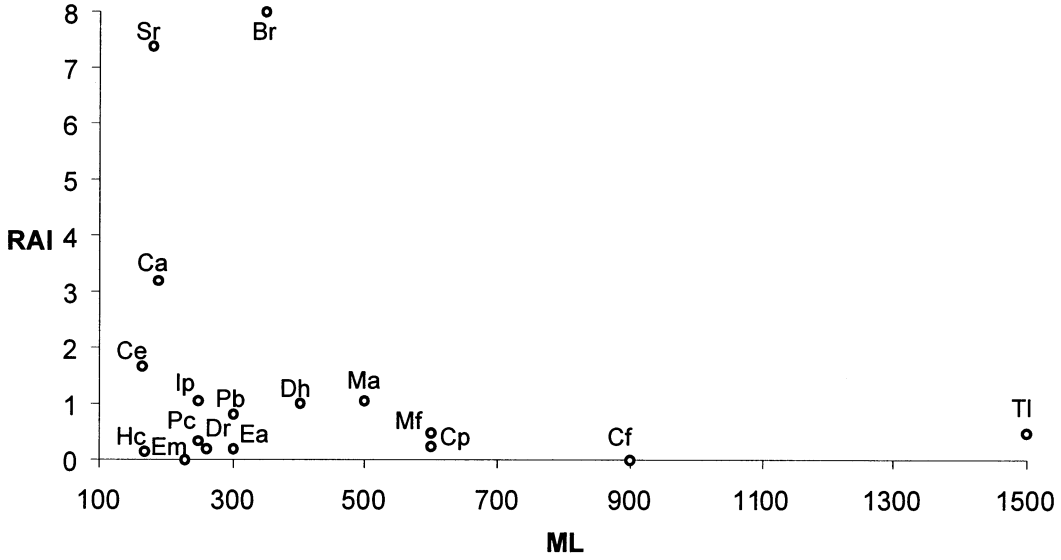

Figure 2. Maximal individual length of the species studied (in mm), according to Figueiredo and Menezes [18, 19], and Menezes and Figueiredo [23, 24]) and values of the Reproductive Activity Index (RAI). Species code: *table I*.

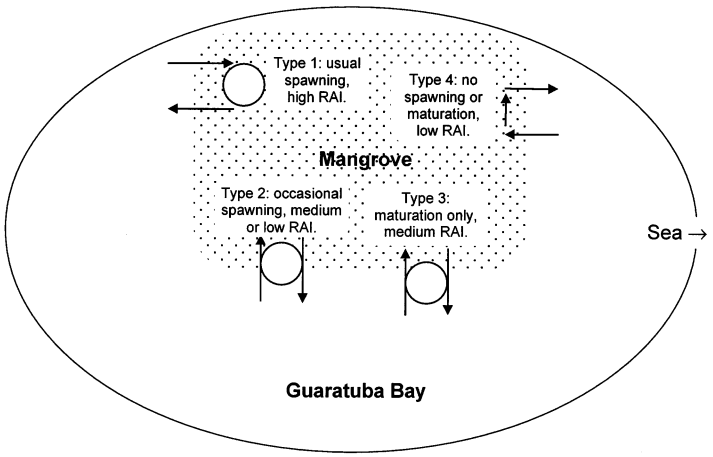

Figure 3. Relative contribution of each pattern found in the Guaratuba assemblage. The values are expressed as a percentage of species richness, weight and number, with respect to the total catch from September 1993 to February 1997.

Based on these results, the reproductive patterns of the Guaratuba fish assemblage can be classified into 4 types, two of them comprise spawning in the mangrove.

Type 1-Regular spawners. The spawning activity occurs regularly in the mangrove. The species are not necessarily resident in the region, but they always use it to spawn. The RAI is relatively high (3.3–8.0), associating a great amount of individuals with an expressive proportion of spawning ones. Four species: *S. rastrifer*, *B. ronchus*, *C. arenaceus* and *G. genidens* (RAI unknown).

Type 2-Occasional spawners. The spawning activity in the mangrove is merely occasional. This region can be used to spawn, but there is no evidence that a great number of individuals in this group of species uses it. These species are not as abundant in the mangrove [11] as those of type 1, consequently the RAI values are medium (1.8) or low (0.2). Four species: *C. parallelus*, *D. radiale*, *C. edentulus* and *M. americanus*.

Type 3-Matures in system. The spawning activity does not occur in the mangrove, but this region is frequented regularly during the final phase of maturation. The index values of *D. rhombeus* and *I. parvipinnis* populations are medium (1.0–1.2) and as well as their relative abundance.

Type 4-Do not mature in system. The spawning activity does not occur in the mangrove, and the gonadal maturation, if present, does not occur in many individuals. Consequently, the index values are low (< 1.0) (*P. corvinaeformis*, *P. brasiliensis*, *T. lepturus*, *M. furnieri*, *E. argenteus*, *H. clupeola*) or zero (*E. melanopterus*, *C. faber*). For this last species, only juvenile individuals were found in the mangrove.

Each type comprises 7 % (type 1), 7 % (type 2), 3 % (type 3) and 13 % (type 4) of 60 species registered in the region during the study period; 41, 5, 11 and 27 % of its total weight; and 38, 3, 11 and 37 % of its total number (*figure 3*). Therefore, the spawning activity in a regular or eventual frequency (types $1 + 2$) concentrates on species that represent a minimum of 46 % (weight) or 41 % (number) of the stock that frequents the region. The participation in the reproductive process, in a larger sense (types $1 + 2 + 3$), concentrates on species that represent at least 57 % (weight) or 52 % (number) of the total abundance.

Considering the reproductive features of some of these species, more specifically populations from the south-southwest of Brazil (*table II*), it appears that they are generally multiple spawners, producing numerous, small eggs. It is assumed that they do not present any particular type of parental care. *G. genidens*, mouth-breeder species with a low fecundity, is an exception.

4. DISCUSSION AND CONCLUSION

We observed that, even if less than 50 % of the studied species spawn in Guaratuba mangrove and

Table II. Available information concerning reproductive parameters of some species studied.

Species	Remarks
Stellifer rastrifer	Multiple spawner [17][a]
Bairdiella ronchus	Multiple spawner [9][a]
Citharichthys arenaceus	Multiple spawner [16][a]
Genidens genidens	Multiple spawner; oocytes (7 to 30 each batch) larger than 2 mm [4][c]
Eucinostomus argenteus	Multiple spawner; mature oocytes smaller than 1 mm [7][b]
Isopisthus parvipinnis	Multiple spawner; mature oocytes smaller than 1 mm [7][b]
Micropogonias furnieri	Multiple spawner [22][b]; spawning activity (spring/summer) outside the estuary, mature individuals larger than 300 mm [21][d]
Harengula clupeola	Multiple spawner; mature oocytes smaller than 1 mm [7][b]
Menticirrhus americanus	Multiple spawner; mature oocytes smaller than 1 mm [7][b]; growth in nearshore [20][b]

[a] Guaratuba Bay.
[b] São Paulo coast.
[c] Rio de Janeiro coast.
[d] Rio Grande do Sul coast.

achieve their life cycle here, two factors make it an important site for the reproductive activity of fish. First, there is a large amount of fish that spawn in this area, with respect to the total assemblage, as the four type 1 species are placed among the six most abundant populations in this region (present data and also [11]). Second, there is a high number of species (10) whose individuals move to the mangrove at an advanced stage of maturation. These results agree with those obtained by Albaret and Diouf [2] on the West African coast, showing that the participation of an estuarine system in the reproductive process of its fish assemblage does not only concern the resident species. On the contrary, it can be assumed that in Guaratuba Bay the major part of the species uses temporally the mangrove for their reproductive process, because they are either migrant or occasional visitors.

The Reproductive Activity Index presents a new, additional view for analysis of the data. In this study, the RAI associates the abundance of each species with the percentage of mature/spawning individuals, so it is possible to differentiate species that spawn regularly in this region (type 1) from those that spawn occasionally here (type 2). A similar differentiation was obtained with respect to the occurrence or inoccurrence of the maturation activity in the mangrove (types 3 and 4). The values of RAI suggest that small fish (≤ 350 mm) use mangrove areas for maturation and spawning more than the larger ones (*figure 2*). However, it must be observed that the smaller species are also the most common in the mangrove [6], a fact that increases their frequency among the spawning species. This fact can be understood by the natural disposition, presented by the smaller species, to live in estuaries [3], as well as by the fact that the migrant species are, usually, larger than the resident ones [25].

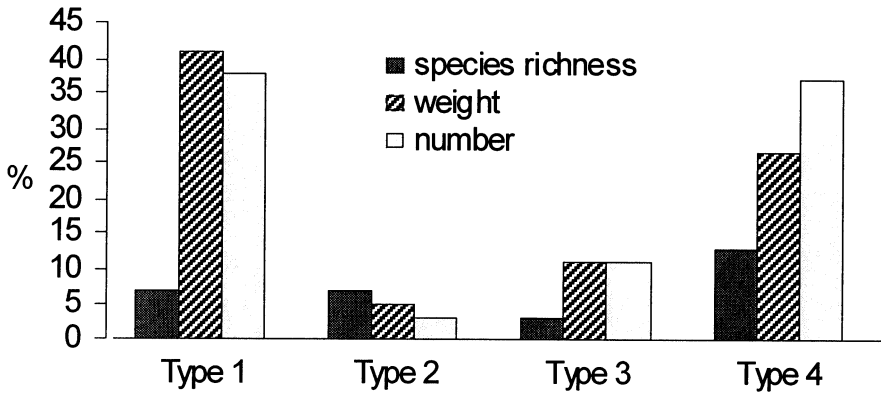

Figure 4. Schematic representation of the reproductive patterns (types 1 to 4) presented at Guaratuba mangrove by the 18 species investigated. Circles represent the reproductive activity: entirely or partially in the mangrove, or outside the mangrove. RAI: Reprodutive Activity Index.

Type 1 pattern represents resident and migratory species, while types 2, 3, 4, are migrant and occasional visitors. Two of them (1 and 4) are associated with large numbers of individuals, but only type 1 is directly associated with the reproductive process. Type 4, composed by species whose reproductive activity is not associated with the mangrove, includes the very common and abundant species *P. corvinaeformis*, which leaves the mangrove for spawning [10].

It is known that the reproductive strategy used by fish in estuaries can change geographically, according to the abiotic characteristics of these ecosystems [5]. The strategy most frequently observed at Guaratuba mangrove (multiple spawning, producing of small, numerous eggs, absence of parental care) are associated by Amanieu and Lasserre [3] to the physically controlled environments, suggesting a small influence of predatory activity on the regulation of stock size. *Figure 4* shows, schematically, the results obtained in the study of the reproductive activity of fish community living in the mangrove areas of the Guaratuba Bay.

Acknowledgements

Contribution number 1130 from The Zoology Department, UFPR. Financial support was provided by Fundação Universidade Federal do Paraná and by Conselho Nacional de Desenvolvimento Científico e Tecnológico (Brazil) grant to the first author.

REFERENCES

[1] Agostinho, A.A., Mendes, V.P., Suzuki, H.I., Canzi, C., Avaliação da atividade reprodutiva da comunidade de peixes dos primeros quilômetros a jusante do reservatório de Itaipu. Unimar, Maringá, 15 (supl.) (1993) 175–189.

[2] Albaret J.-J., Diouf P.S., Diversité des poissons des lagunes et des estuaries ouest-africains, Ann. Mus. r. Afr. Centr. Zool. 275 (1994) 165–177.

[3] Amanieu, M., Lasserre, G., Organisation et évolution des peuplements lagunaires, Oceanol. Acta, n.sp. (Actes Symposium International sur les lagunes côtières, Bordeaux, France, septembre 1981) (1982) 201–213.

[4] Barbieri L.R., Santos R.P., Andreata J.V., Reproductive biology of the marine catfish, *Genidens genidens* (Siluriformes, Ariidae), in the Jacarepaguá Lagoon system, Rio de Janeiro, Brazil, Environ. Biol. Fish 35 (1992) 23–35.

[5] Bouchereau, J.-L., Guelorget, O., Comparison of three Gobiid life history strategies over geographical range: *Pomatoschistus minutus* (Pallas, 1770), *P. microps* (Krøyer, 1838) and *Gobius niger* Linnaeus, 1758 (Teleostei: Gobiidæ), Oceanol. Acta 21 (3) (1998) 503–517.

[6] Bouchereau, J.-L., Chaves, P., Albaret, J.J., Use of maximum size of fishes to select species for fish farming (Bay of Guaratuba, Brazil), Brazilian Arch. Biol. Technol. Curitiba 43 (1) (2000) (in press).

[7] Chaves P.T., Desenvolvimento dos ovócitos em *Harengula clupeola*, *Urophycis brasiliensis*, *Eucinostomus argenteus*, *Isopisthus parvipinnis* e *Menticirrhus americanus* (Teleostei), Bolm. Inst. Oceanogr., S Paulo 37 (2) (1989) 81–93.

[8] Chaves P.T., A incubação de ovos e larvas em *Genidens genidens* (Valenciennes) (Siluriformes, Ariidae) da Baía de Guaratuba, Paraná, Brasil, Revta bras. Zool. Curitiba 11 (1994) 641–648.

[9] Chaves P.T.C., Atividade reprodutiva de *Bairdiella ronchus* (Cuvier) (Pisces, Sciaenidae) na Baía de Guaratuba, Paraná, Brasil, Revta bras. Zool. Curitiba 12 (1995) 759–766.

[10] Chaves P.T.C., Estrutura populacional de *Pomadasys corvinaeformis* (Steindachner) (Teleostei, Haemulidae) na Baía de Guaratuba, Paraná, Brasil, Revta bras. Zool. Curitiba 15 (1998) 203–209.

[11] Chaves P.T.C., Bouchereau J.-L., Biodiversité et dynamique des peuplements ichtyiques de la mangrove de Guaratuba, Brésil, Oceanol. Acta 22 (1999) 353–364.

[12] Chaves P.T.C., Corrêa M.F.M., Composição ictiofaunística da área de manguezal da Baía de Guaratuba, Estado do Paraná, Brasil (25° 52' S ; 48° 39' W), Revta bras. Zool. Curitiba 15 (1998) 195–202.

[13] Chaves P.T.C., Otto G., Aspectos biológicos de *Diapterus rhombeus* (Cuvier) (Teleostei, Gerreidae) na Baía de Guaratuba, Paraná, Brasil, Revta bras. Zool. Curitiba 15 (1998) 289–295.

[14] Chaves P.T.C., Otto G., The mangrove as a temporary habitat for fish: the *Eucinostomus* species at Guaratuba Bay (Brazil), Brazilian Arch. Biol. Technol. Curitiba 42 (1999) 61–68.

[15] Chaves P.T.C., Rickli A., Bouchereau J.L., Stratégie d'occupation de la mangrove de la Baie de Guaratuba (Brésil) par le sciaenidé prédateur *Isopisthus parvipinnis* (Teleostei, Pisces), Cah. Biol. Mar. France 39 (1998) 63–71.

[16] Chaves P.T.C., Vendel A.L., Indicadores reprodutivos das espécies de *Citharichthys* Bleeker (Teleostei, Pleuronecti formes) da Baía de Guaratuba, Paraná, Brasil, Revta bras. Zool. Curitiba 14 (1997) 73–79.

[17] Chaves P.T.C., Vendel A.L., Reprodução de *Stellifer rastrifer* (Jordan) (Teleostei, Sciaenidae) na Baía de Guaratuba, Paraná, Brasil, Revta bras. Zool. Curitiba 14 (1997) 81–89.

[18] Figueiredo, J., Menezes, N.A., Manual de Peixes Marinhos do Sudeste do Brasil. II. *Teleostei (1)*, Museu de Zoologia, Universidade de São Paulo, São Paulo, 1978, 110 p.

[19] Figueiredo, J., Menezes, N.A., Manual de Peixes Marinhos do Sudeste do Brasil. III. *Teleostei (2)*, Museu de Zoologia, Universidade de São Paulo, São Paulo, 1980, 90 p.

[20] Giannini R., Paiva-Filho A.M., Aspectos da bioecologia de *Menticirrhus americanus* (Teleostei, Sciaenidae) na Baía de Santos, SP, Brasil, B. Inst. Pesca (único) 19 (1992) 1–15.

[21] Haimovici, M., Umpierre, G., Variaciones estacionales en la estructura poblacional de corvina blanca *Micropogonias furnieri* (Desmarest, 1823) en el extremo sur de Brasil, Atlântica, Rio Grande, 18 (1996) 179–203.

[22] Isaac-Nahum V.J., Vazzoler A.E.A.M., Biologia reprodutiva de *Micropogonias furnieri* (Desmarest, 1823) (Teleostei, Sciaenidae), 2. Relação gonadossomática, comprimento e peso dos ovários como indicadores do período de desova, Bolm Inst. Oceanogr., S. Paulo 35 (1987) (1823) 123–134.

[23] Menezes, N.A., Figueiredo, J.L., Manual de Peixes Marinhos do Sudeste do Brasil, IV. *Teleostei (3)*, Museu de Zoologia, Universidade de São Paulo, São Paulo, 1980, 96 p.

[24] Menezes, N.A., Figueiredo, J.L., Manual de Peixes Marinhos do Sudeste do Brasil, V. *Teleostei (4)*, Museu de Zoologia, Universidade de São Paulo, São Paulo, 1985, 105 p.

[25] Roff D.A., The evolution of migration and some life history parameters in marine fishes, Environ. Biol. Fish. 22 (1988) 133–146.

[26] Sasekumar A., Chong V.C., Leh M.U., D'Cruz R., Mangrove as a habitat for fish and prawns, Hydrobiol. 247 (1992) 195–207.

[27] Vazzoler, A.E.A.M., Biologia da Reprodução de Peixes Teleósteos. Teoria e Prática, Universidade Estadual de Maringá/Sociedade Brasileira de Ictiologia, Maringá, 1996, 169 p.