Ecological analogies between estuarine bottom trawl fish assemblages from Patos Lagoon, Rio Grande do Sul, Brazil and York River, Virginia, USA

João P. Vieira

Departamento de Oceanografia, Universidade Federal do Rio Grande. Caixa Postal 474, 96201-900 Rio Grande, Rio Grande do Sul, Brasil. E-mail: vieira@mikrus.com.br

ABSTRACT. The structure of estuarine fish assemblages at temperate latitudes in Patos Lagoon (32°05'S, 52°04'W), Rio Grande do Sul, Brazil and York River (37°17'N, 76°33'W), Virginia, USA was compared using mid and late 1970's data from bottom trawl collection to investigate whether geographically isolated fish assemblages have similar ecological structure given similar latitudinal positions on the warm-temperate southwestern and northwestern Atlantic regions, respectively. Since estuarine species often exhibit an ontogenetic shift in habitat requirements or preferences we examined Capture per Unity of Effort by size class (CPUE-SC) and split species into "size ecological taxa" (SET) for analysis. The use of CPUE-SC also allowed the abundance of a SET to be computed by summing the mean CPUE of each size class within that SET and use this information to follows SET's temporal and or spatial abundance. A total of 65 and 63 species was collected during a year of bottom trawling in the Patos Lagoon and York River estuaries, respectively. In both localities the strongest modal size class was < 80 mm TL, and several abundant species were smaller than 100 mm TL. The size between 80 and 100 TL effectively separated several species into discrete SET's in both systems. Those SET's could have different ecological preferences, temporal and spatial distributions and so identified as different "ecological taxa". In warm months, when predation by large fish is most likely, the abundance of fish between 80 and 100 mm TL in "bottom trawl" demersal fish assemblages was low in both systems. Only the sea catfishes, in Patos Lagoon, protected by strong dorsal and pectoral spines, and the Hogchoker, in the York River, protected by burrowing in the bottom substrate, peak in abundance at this size class. The seasonal pattern of estuarine use was similar between localities and did not differ from other warm-temperate estuarine fish assemblages.
KEY WORDS. Distribution; estuarine fishes; size; south-north comparison; zoogeography.

RESUMO. **Analogias ecológicas entre as assembléias de peixes de fundo dos estuários da Laguna dos Patos, Rio Grande do Sul, Brasil e York River, Virginia, EUA.** A estrutura das assembléias de peixes de dois estuários temperados – Lagoa dos Patos, Brasil e York River, Estados Unidos – foi comparada usando dados de rede de arrasto de fundo, da década de 70, em ambas as regiões. O objetivo do trabalho foi o de investigar se a fauna de peixes de dois estuários, localizados em duas regiões temperadas-quente do Atlântico, embora isolados geograficamente (Hemisfério Sul e Norte), apresentavam a mesma estrutura ecológica. Considerando a ontogenia das espécies utilizou-se o método da Captura por Unidade de Esforço por Classe de Tamanho (CPUE-CT) para separar as espécies dominantes em Unidades Ecológicas de Tamanho (UET). O uso da técnica do CPUE-CT permite que a abundância das UET seja computada através da soma da abundância de cada uma das classes de tamanho que incorporam estas UET e desta forma usar o CPUE das UET para estudar sua variação temporal ou espacial de abundância. Após um ano de coleta mensal foram observadas 65 espécies nas coletas de arrasto de fundo na Laguna dos Patos e 63 espécies no York River. Em ambas as localidades as maiores modas de tamanho foram menores que 80 mm de comprimento total (CT), e diversas espécies ocorrem em tamanho menor do que 100 mm CT. Entre 80 e 100 mm CT foi possível separar efetivamente diversas espécies em UET. Diferentes UET de uma mesma espécie ocorrem em diferentes habitats e em épocas distintas, podendo assim ser classificadas como "Taxas Ecológicos" distintos de uma mesma espécie. Nos meses quentes, quando ocorre a maior pressão de predação dos grandes peixes piscívoros, a abundância dos peixes com tamanhos entre 80 e 100 mm CT nas coletas de arrasto de fundo é baixa em ambos os sistemas. Somente dois grupos de peixes são abundantes neste tamanho, os bagres marinhos da Laguna dos Patos que estão protegidos da predação pelos espinhos dorsais e peitorais, e o linguado-Zebra no York River, que se enterra no substrato evitando a predação.
PALAVRAS CHAVE. Comparação sul-norte; distribuição; peixes estuarinos; tamanho; zoogografia.

What processes determine biological community structure, the number, relative abundance and size distribution of species? Precise descriptions of ecological patterns are fundamental to create hypotheses about both the patterns and the mechanisms generating them (PETRIK & LEVIN 2000). One way of testing hypotheses about the roles of different processes is to search for patterns, i.e. similarities or differences between the structures of specific communities occurring at geographically separate areas with similar climatic regimes (HARVEY *et al.* 1983). Although the comparability of historical datasets is limited by differences in sampling regimes and methodologies (STOKESBURY *et al.* 1999, MATHIESON *et al.* 2000), comparative ecology can generate hypotheses, test existing theory, and draw attention to unique features of each entity under comparison (FEINSINGER 1990). Furthermore, comparisons between faunas of distinct regions are necessary to increase our understanding of several ecosystems. But comparisons between geographically distant systems are never perfectly controlled experiments. As closely as two sites can be matched, one can always find some environmental differences between them by going into fine detail (WESTOBY 1988, MATHIESON *et al.* 2000).

Although the isotherms of 18-20°C may not represent precise boundaries between warm-temperate and tropical faunas, they approximate the average conditions where changes in estuarine fish species compositions generally occur. In this sense, the Patos Lagoon (32°S) and the York River (37°N), belong to two geographically distant but similar zoogeographic regions: the warm-temperate southwestern Atlantic and warm-temperate northwestern Atlantic regions, respectively (EKMAN 1953, VIEIRA & MUSICK 1994, MURDY *et al.* 1997, ARÁUJO & AZEVEDO 2001).

Any expectation of similarities between estuarine bottom trawl fish assemblages in such attributes as numbers of species, individual size distribution, or species organization relies on the assumption that the sampling gear used collect similar fish assemblage (STOKESBURY *et al.* 1999) and that estuarine fish communities respond in similar ways to limited arrays of similar adaptive zones in similar environmental complexes (VIEIRA & MUSICK 1993). Consequently if ecological similarity exists between Patos Lagoon and the York River such similarities might better be called ecological analogies (BLONDEL 1991). Therefore the objective of this study was to determine whether geographically isolated estuarine fish assemblages have similar structural patterns given similar sampling gear, design and estuarine environmental conditions.

METHODS

Patos Lagoon estuary (32°05'S; 52°04'W), Brazil: The data we used was from the BELAP Project, Laboratório de Ictiologia – Fundação Universidade Federal do Rio Grande, Brazil (CHAO *et al.* 1982, 1985, VIEIRA & CASTELLO 1997). The subset chosen consists of data collected during January to December 1979. The study area extended from the lagoon mouth northward to about 40 km inside the lagoon. Sampling was conducted monthly from the 15 m yacht R/V Larus. In each month, a set of about 20 randomly selected stations were chosen, and when conditions permitted, bottom hauls were made using an 8 m (head rope) shrimp trawl (11 m ground rope, 2 m legs on each side, 1.3 cm bar mesh wings and body with a 0.5 cm bar mesh cod end liner, and a pair of weighted otter doors).

York River estuary (37°17'N; 76°33'W), Chesapeake Bay, USA: The data for this portion of the study was obtained from ILLOWSKY & COLVOCORESSES (1975). A subset of 12 months (May 1973 to April 1974) was used in our analyses. The study area extended from the mouth of the river, where it joins the Chesapeake Bay, northwestward 18 km up the river. Samples were taken monthly at approximately 40 random-selected stations. Bottom hauls were made using a 4.9 m (head rope) semi-balloon shrimp trawl (7 m ground rope, 1.9 cm bar mesh, 0.63 cm bar mesh cod end liner and a pair of weighted otter doors). Tows were made from either the R/V Restless, or the R/V Brooks, both 10 m wooden workboats.

Although the net used at the York River was slightly smaller than the one used in the Patos Lagoon, mesh sizes where similar and it was assumed that both nets completely sampled the bottom trawl fish association, so any difference in size selectivity between the two would be inconsequential.

In both studies, hydrographic data including temperature and salinity were collected from bottom waters at each station. Selected beach seine stations (< 1 m depth) also were sampled monthly in both areas. In this paper, data from beach seine samples will be used only to complement information on bottom trawl data and to further elucidate the movement patterns of fish assemblages.

Fish were identified to species, enumerated, and their total biomass determined. For large catches, after sorting to species, and according to the size of the catch, samples were divided into four to twenty sub-samples of equal weight. Two to teen randomly selected sub-samples were processed individually, and the total number of individuals was then estimated by extrapolating from the mean of the counted sub-samples (mean number of fishes per unit weight).

Lengths (total or fork length where applicable) for all individuals of each species were measured and recorded in each sample unless sub-sampling was required. Where sub-sampling was used, proportional length frequencies were based upon the sub-samples.

For the 10 most numerically abundant species in each data set (Patos Lagoon and York River), CPUE by size class per sample was obtained by multiplying the ratio of the total number of individuals caught to the total number of individuals measured by the number of individuals measured for each 10 mm size class (GARCIA *et al.* 2001). The monthly mean CPUE of each size class for each species was plotted and analyzed for each data set. Based on the shape of this size class distribution and an examination of the data matrices for size-specific distribution patterns, one or two size groups per species were identified. At this stage, the upper and lower level of the size range of each species sub-group was adjusted. The first size sub-group (juveniles) consisted of post-larvae and young-of-the-year. The second consisted of sub-adults or adults. The size groups selected for each species using this procedure were identified as "ecological taxa" (Polis 1984, Gelwick 1990), or "Size Ecological Taxa" (SET). The CPUE of a SET was computed by summing the mean CPUE of each size class (10 mm) within that SET (Whiteside & Hatch 1997, Garcia *et al.* 2001).

Abundance data (CPUE) of each SET (10 dominant species) and remaining species were pre-screened for the presence of unusual catches whose reliability was uncertain. To further reduce the effects of contagion, the numerical abundance data (CPUE) of each of the entities were transformed [$\log_{10}$ (CPUE+1)] before cluster analysis. The similarity coefficient used was the Canberra Metric. The clustering strategy used was flexible fusion with beta set at the conventional value of -0.25. Entities (SET or species) were eliminated from cluster analysis if they contributed less than 0.01% to the total abundance (CPUE) or if they occurred in fewer than three monthly samples.

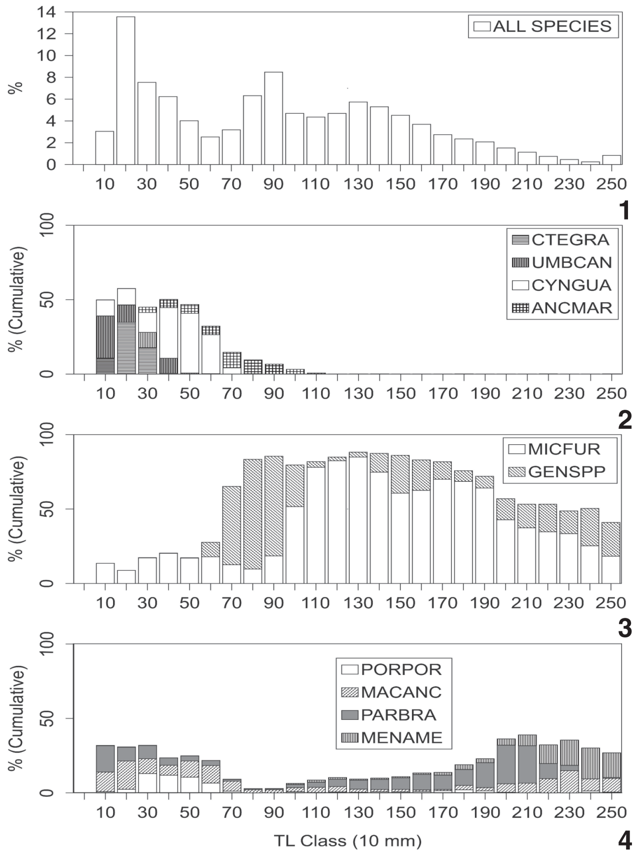
RESULTS

Patos Lagoon, Brazil

A total of sixty five species and 91,916 individuals, were collected from 253 samples taken from January-December of 1979 (Tab. I). Ten species constituted about 94% of the total catch in number. The remaining 55 species each represented less than 1% of the total catch and accounted for a low average number of individuals per sample (CPUE).

The 10 dominant species were: seven sciaenids: *Micropogonias furnieri* (Desmarest, 1823), *Cynoscion guatucupa* (Cuvier, 1830), *Macrodon ancylodon* (Bloch & Schneider, 1801), *Ctenosciaena gracilicirrhus* (Metzelaar, 1919), *Paralonchurus brasiliensis* (Steindachner, 1875), *Umbrina canosai* Berg, 1895, and *Menticirrhus americanus* (Linnaeus, 1758); one Batrachoididae: *Porichthys porosissimus* (Cuvier, 1829); one Engraulididae: *Anchoa marinii* Hildebrand, 1943; and three ariids: *Genidens* spp. Both *Netuma barba* (Lacepède, 1803) synonyms *Genidens barbus* (Lacepède, 1803) and *Netuma planifrons* Higuchi, Reis & Araújo, 1982 synonyms *Genidens planifrons* (Higuchi, Reis & Araújo, 1982) were collected in these samples. *Genidens planifrons* was not recognized as a separate species at the time these data were collected. Therefore, *Genidens* spp will be used in this paper to refer to *G. barbus* and *G. planifrons* collectively. The third ariid *Genidens genidens* (Cuvier, 1829) was easier identified.

Fish species in the Patos Lagoon collections were represented mostly by post-larvae, young-of-the-year and sub-adults, most ranged in length between 10 and 250 mm (Fig. 1). Figure 2 to 4 shows the cumulative percentage of the 10 dominant species in each 10 mm size class. Individuals less than 60 mm were encountered in all dominant species but *Genidens* spp., and several sciaenids were almost often restricted to this size class (*e.g.* *Ctenosciaena gracilicirrhus*, *Umbrina canosai* and *Cynoscion guatucupa*). The majority of individuals between 60 and 90 mm were *Genidens* spp. Individuals larger than 90 mm were mainly *Micropogonias furnieri*, other sciaenids (*Paralonchurus brasiliensis, Macrodon ancylodon, Menticirrhus americanus*), and *Genidens* spp.



Figures 1-4. Percent (%) size frequency distribution by 10 mm length class of all species caught at Patos Lagoon estuary (1). Cumulative percent contribution (% cumulative) per size class (10 mm) of 10 dominant species (2-4). Note that each column of figures 2 to 4 add to almost 100%, the remainder being attributable to non-dominant species. Species codes according to table I. January to December 1979.

Micropogonias furnieri ranked first in number in bottom trawl samples and also was ranked among the four dominant species in beach seine samples (Tab. I, Fig. 5). This species occurred year-round in the Patos Lagoon estuary, with a size range of 10 to ≥ 250 mm (Fig. 5). The overall size frequency distribution suggested a bi-modal distribution. The first modal class (10-70 mm) occurred mainly from January to April in bottom trawl and beach seine samples but with peak abundance in May-June in beach seine samples. The second modal class (≥ 80 mm) occurred almost exclusively in bottom trawl samples year-round. Two SET's were selected (MICFUR-I and MICFUR-II) based upon the distinct temporal pattern of abundance and

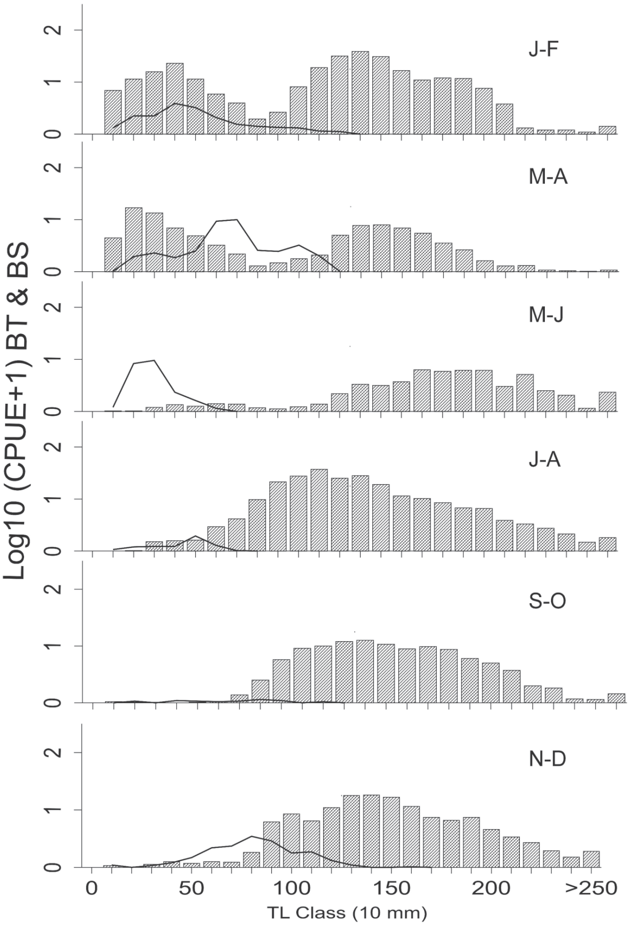


Figure 5. Bi-monthly CPUE by size class (10 mm) of *Micropogonias furnieri* caught at Patos Lagoon estuary. (BS) Beach seine samples (lines), (BT) bottom trawl samples (bars), January-February (J-F) to November-December (N-D) 1979.

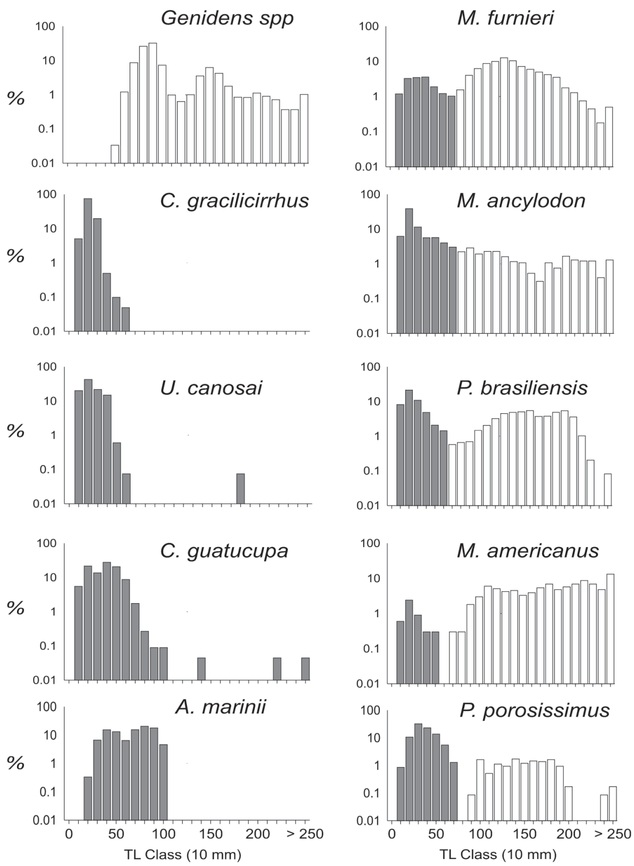


Figure 6. Percent size frequency distribution by 10 mm class length of 10 most abundant species at Patos Lagoon. Dark bars are Ecological Taxon I and open bars Ecological Taxon II. January to December of 1979.

occurrence of individuals smaller and larger than 80 mm (Fig. 6). This cutoff effectively separated the two cohorts during months both were taken in the bottom trawl samples (Fig. 5).

Sea catfish *Genidens* spp (size range = 50 to > 250 mm) ranked second in number in bottom trawl samples, and occurred year-round in the Patos Lagoon estuary (Tab. I, Fig. 6). Even though two size groups (< 120, and ≥ 120 mm) could be observed, subsequent cluster analyses revealed no temporal or spatial differences between these groups. The species was therefore treated as a single SET for subsequent cluster analysis.

Three sciaenids and *Porichthys porosissimus* were abundant and occurred year-round in the Patos Lagoon estuary with a size range of 10 to ≥ 250 mm (Tab. I, Fig. 6). Based upon the distinct temporal pattern of abundance and occurrence of individuals smaller and larger than 60 mm (*M. americanus*), 70 mm (*P. brasiliensis*) and 80 mm (*M. ancylodon* and *P. porosissimus*), two SET's for each species were selected. Only post-larvae and small juveniles (< 70 mm) of *Ctenosciaena gracilicirrhus* were caught. This species occurred mostly from March to June, although it accounted for 6.6% by number of the total fishes captured between January and December of 1979 (Tab. I, Fig. 6). Post-larvae and small juvenile (< 70 mm) *Umbrina canosai* represented 3.9% of the total catch of fishes (Tab. I). A few large individuals (180 mm size class) were caught in September, but are excluded from the subsequent analysis (Fig. 6).

Post-larvae and young-of-the-year of *Cynoscion guatucupa* (< 110 mm) occurred throughout the year, and its abundance peaked from July to October. This species was ranked third in number but sub-adults and adults were caught only occasionally in January and February. Individuals larger than 110 mm were infrequently collected and these were excluded from the analysis (Tab. I, Fig. 6). *Anchoa marinii* occurred year-round at a size range of 10 to 100 mm, and this species was most abundant in winter. Two size modes (< 60 and ≥ 60 mm) could be

Table I. More frequent and abundant species of fish caught in the Patos Lagoon estuary from January to December 1979 sorted by average CPUE (mean capture per unit of effort). Numerical abundance (ABUN), percent abundance (%CPUE), and number of monthly frequency occurrence (FO).

Species	Species code		ABUN	CPUE	%CPUE	FO
Micropogonias furnieri	MICFUR	#	34524	134.58	38.94	12
Genidens spp.	GENSPP	#	17176	59.88	17.32	12
Paralonchurus brasiliensis	PARBRA	#	6092	24.51	7.09	12
Cynoscion (striatus) guatucupa	CYNGUA	#	6604	22.41	6.48	10
Macrodon ancylodon	MACANC	#	6184	22.37	6.47	12
Ctenosciaena gracilicirrhus	CTEGRA	#	6094	20.32	5.88	3
Umbrina canosai	UMBCAN	#	3613	13.42	3.88	7
Anchoa marinii	ANCMAR	#	2449	12.05	3.49	11
Porichthys porosissimus	PORPOR	#	2743	11.67	3.38	10
Menticirrhus americanus	MEMAME	#	940	3.36	0.97	12
Peprilus paru	PEPPAR	#	591	2.29	0.66	8
Lycengraulis grossidens	LYCGRO	#	531	2.11	0.61	12
Prionotus punctatus	PRIPUN	#	528	1.99	0.58	11
Pogonias cromis	POGCRO	#	554	1.74	.50	8
Lagocephalus laevigatus	LAGLAE	#	349	1.70	0.49	5
Syngnathus folleti	SYNFOL	#	486	1.64	0.47	11
Achirus garmani	ACHGAR	#	391	1.53	0.44	9
Trichiurus lepturus	TRILEP	#	276	1.08	0.31	6
Engraulis anchoita	ENGANC	#	247	1.08	0.31	3
Symphurus jenynsi	SYMJEN	#	246	0.98	0.28	12
Selene setapinis	SELSET	#	189	0.74	0.21	5
Urophycis brasiliensis	UROBRA	#	197	0.69	0.20	12
Trachinotus marginatus	TRAMAR	#	128	0.46	0.13	7
Stellifer rastrifer	STERAS	#	92	0.43	0.12	4
Pomatomus saltatrix	POMSAL	#	78	0.29	0.08	7
Stromateus maculatus	STRMAC	#	59	0.21	0.06	4
Genidens genidens	GENGEN	#	59	0.21	0.06	8
Percophis brasiliensis	PERBRA	#	61	0.20	0.06	6
Parapimelodus (valenciennesi) nigribarbis	PARNIG	#	43	0.16	0.05	3
Menticirhus littoralis	MENLIT	#	35	0.13	0.04	7
Ramnogaster arcuata	RAMARC	#	29	0.13	0.04	4
Pimelodus (clarias) maculatus	PIMMAC	#	26	0.11	0.03	3
Selene vomer	SELVOR	#	26	0.10	0.03	3
Sympterygia bonaparte	SYMBON	#	24	0.08	0.02	6
Sympterygia acuta	SYMACU	#	17	0.07	0.02	5
Paralichthys orbignyana	PARORB	#	13	0.05	0.01	6
Chloroscombrus chysurus	CHLCRI	#	13	0.05	0.01	3
Odontesthes bonariensis	ODOBON	#	13	0.04	0.01	5
Mugil platanus	MUGPLA		10	0.04	0.01	2
Ophichthus gomesii	OPHGOM	#	10	0.04	0.01	6

# Denotes species used in cluster analysis.Total: 65 species; 91,916 individuals; 12 months; 253 samples.

observed, but subsequent cluster analyses revealed no temporal or spatial differences between these groups. The species was therefore treated as a single SET for subsequent cluster analysis (Tab. I, Fig. 6).

Forty-three entities (10 SET's plus 33 species) were selected for cluster analysis (Tab. I). Pooled data on entities abundance by month resulted in cluster groups (Fig. 7) that could be characterized into the following seasonal groups: summer (January to March), fall (April and May), winter (June to August) and spring (September to December).

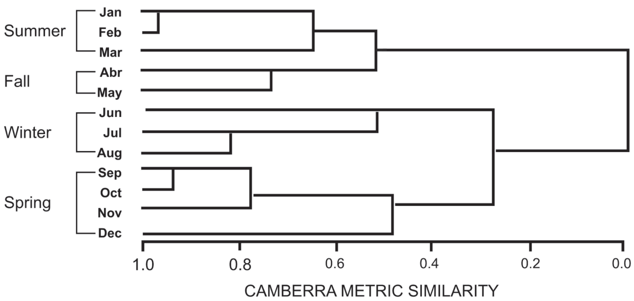


Figure 7. Dendogram of normal cluster analysis in the Patos Lagoon estuary.

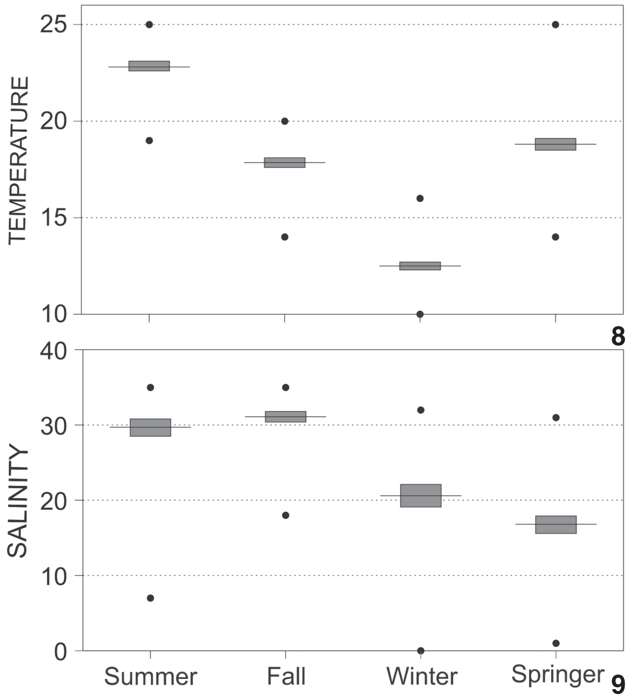


Figure 8-9. Salinity (8) and temperature (9) data within seasonal groups in the Patos Lagoon estuary. Mean (horizontal line), standard error of the mean (Box), and range (Dots).

Environmental data within these seasonal groups are summarized in figures 8 and 9. Water temperature ranged between 19-25ºC in the summer group and 10-16ºC in winter. Wide temperature ranges were observed in all seasonal groups, but mean water temperature was considerably lower in winter (12.5ºC) than in the other seasons. Salinity ranged from 0 to 35 but was highly variable in summer, winter and spring. Summer and fall mean salinity was considerably higher than winter and spring.

Inverse cluster analysis identified 11 groups of entities, ranging in content from one to six entities per group (Tab. II). Groups A through E were characterized by presence throughout the year. Group J was missing in the summer, group F in summer and fall, group K in summer and spring, group I in winter, and *Ctenosciaena gracilicirrhus* (group H) together with group G in winter and spring.

York River, Virginia, USA

A total of sixty three species and 107.476 individuals, were collected from 495 samples taken from July 1973 to June 1974 (Tab. III). Ten species constituted about 99% of the total catch in number, while the remaining 53 species represented less than 0.1% of the total catch and a low average number of individuals per sample (CPUE < 0.2). Dominant species were: *Anchoa mitchilli* (Valenciennes, 1848) (Engraulididae), four species of Sciaenidae {*Leiostomus xanthurus*, Lacepède, 1802, *Micropogonias undulatus* (Linnaeus, 1766), *Cynoscion regalis* (Bloch & Schneider, 1801), and *Bairdiella chrysoura* (Lacepède, 1802)}, *Trinectes maculatus* (Bloch & Schneider, 1801) (Soleidae), *Paralichthys dentatus* (Linnaeus, 1766) (Bothidae), *Opsanus tau* (Linnaeus, 1766) (Batrachoididae), *Urophycis regia* (Walbaum, 1792) (Gadidae) and *Menidia menidia* (Linnaeus, 1766) (Atherinidae).

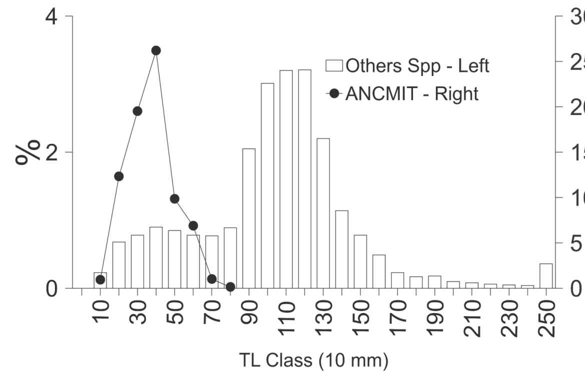
Fish species in bottom trawl collections from the York River were represented predominately by post-larvae, young-of-the-year, and sub-adults ranging in length between 10 and 250 mm or larger (Fig. 10). *Anchoa mitchilli* dominated the size classes between 10 and 60 mm of length (Fig. 10). Figure 11 shows the percent contribution of the three top remaining dominant species to the total number of individuals taken in each 10 mm size class (*A. mitchilli* was excluded). Individuals less than 70 mm were encountered in all dominant species, *Micropogonias undulatus* dominated this size range after *A. mitchilli* was removed. *Leiostomus xanthurus* showed a peak of dominance between 90 and 160 mm, a size range that also encompassed most of the *Trinectes maculatus* captured. Individuals larger than 160 mm were well represented by all dominant species, except for *A. mitchilli*.

Leiostomus xanthurus ranked second in number in bottom trawl samples and also was ranked among the three dominant species in beach seine samples (Tab. III). This species occurred year-round in the York River, and most individuals were 90 to 150 mm (Fig. 12). Individuals less than 30 mm started

Table II. Graphical characterization of CPUE variation of seasonal groups and species groups in the Patos Lagoon. Size range (mm).

Groups	Species	Size Range	SUM	FAL	WIN	SPR
A	*Anchoa marinii*	10-100	+++	+++	+++++	++++
	Symphurus jenynsi	30-230	++++	+++	++++	+++
	Syngnathus folleti	40-170	+++	++	++++	+++
	Lycengraulis grossidens	10-210	++++	+++++	+++	++++
	Urophycis brasiliensis	20->250	+++	+++	+++	+++
	Pogonias cromis	60->250	++	++	++++	++++
B	*Macrodon ancylodon* I	10-70	+++++	++++	++++	+++
	Micropogonias furnieri I	10-70	+++++	++++	++++	+++
	Paralonchurus brasiliensis I	10-60	+++++	++++	++++	+++
	Prionotus punctatus	10-60	++++	+++	+++	+++
C	*Cynoscion guatucupa*	10-110	++++	+++	+++++	+++
	Genidens spp.	50 >250	+++++	+++++	+++++	+++++
	Micropogonias furnieri II	80 >250	+++++	+++++	+++++	+++++
	Paralonchurus brasiliensis II	70 >250	+++++	++++	+++++	++++
	Macrodon ancylodon II	80 >250	++++	++++	++++	++++
	Menticirrhus americanus II	70 >250	++++	++++	++++	++++
D	*Achirus garmani*	60-160	++++	+++	+++	++++
	Genidens genidens	60 >250	+++	+++	++	+++
	Peprilus paru	10-240	++++	++++	++	+++
	Porichthys porosissimus I	10-70	+++++	++++	++	++
E	*Paralichthys orbignyana*	120 >250	++	++	++	++
	Sympterygia bonaparte	80 >250	++	+++	+++	+
F	*Ramnogaster arcuata*	20-120				+++
	Stromateus maculatus	10-130			++	+++
	Pimelodus maculatus	160 >250			+++	+++
G	*Lagocephalus laevigatus*	30-140	++++	++		
	Selene setapinis	30-100	+++	++++		
	Stellifer rastrifer	20-100	++++	++		
	Menticirrhus americanus I	10-50	+++	++		
	Selene vomer	40-120	++	+++		
H	*Ctenosciaena gracilicirrhus*	10-60	+++++	+++		
I	*Porichthys porosissimus* II	90 >250	++++	+++		+++
	Trachinotus marginatus	50-180	+++	++++		+++
	Trichiurus lepturus	30 >250	++++	+++		++
	Umbrina canosai	10-60	+++	+++		+++
	Menticirhus littoralis	30 >250	+++	++		+++
	Ophichthus gomesii	220≥250	++	++		++
J	*Odontesthes bonariensis*	100-230		++	++	+++
	Sympterygia acuta	140≥250		++	+++	++
	Percophis brasiliensis	170≥250		+++	+++	+++
	Pomatomus saltatrix	90-250		+++	+++	++
K	*Chloroscombrus chysurus*	30-110		+++	++	
	Engraulis anchoita	30-110		++++	+++	

Absent (empty), very low (+ < 0.01), low (++ > 0.01), moderate (+++ > 0.1), high (++++ > 1.0), very high (+++++ > 10).



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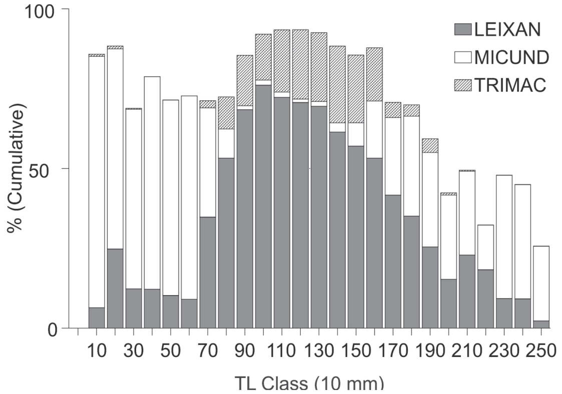


11

Figure 10-11. Percent size frequency distribution by 10 mm class length of Anchoa mitchilli (ANCMIT – line – right y-scale) and other species (Others spp. – bars – left y-scale) caught at York River estuary (10). Percent contribution per size class (10 mm) of the three dominant species after *Anchoa mitchilli* was excluded (11). Species codes according to table III. July 1973 to June 1974.

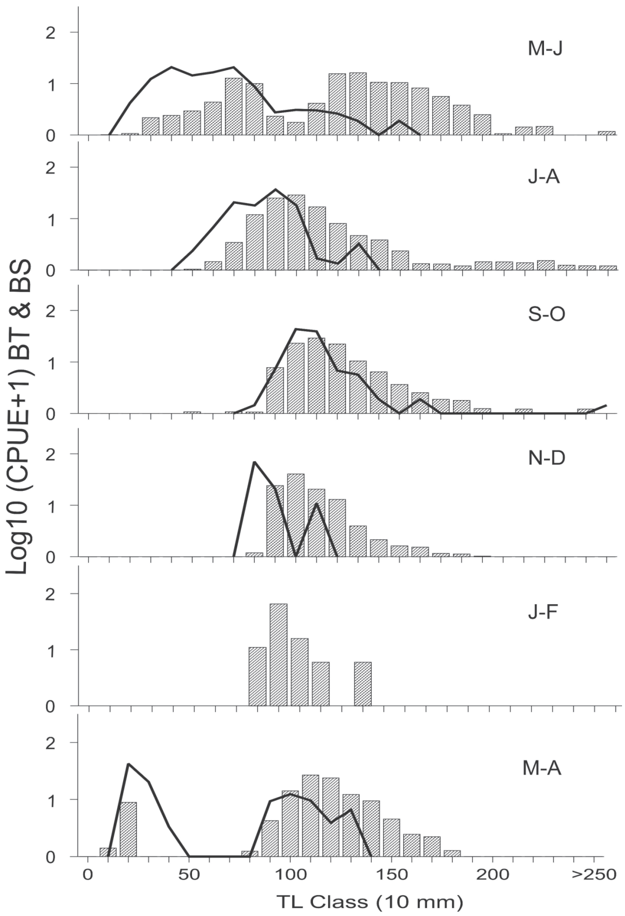


Figure 12. Bi-monthly CPUE by size class (10 mm) of *Leiostomus xanthurus* caught at the York River estuary. BS = beach seine samples (lines), BT = bottom trawl samples (bars), May-June (M-J) 1973 to March-April (M-A) 1974.

recruiting to the beach seine samples in March and to bottom trawl collections in April. Two annual cohorts were clearly evident in April, May and June, but they were not readily distinguishable from July to February as the older cohorts (1+) either because they became less susceptible to gears or left the area. Based upon the different temporal pattern of occurrence of those cohorts, two SET's were designated LEIXAN-I (< 80mm length), and LEIXAN-II (> 80mm length). This cutoff effectively separated the two annual cohorts during months both were taken in the samples (Figs 12 and 13).

Anchoa mitchilli ranked first in number in bottom trawl samples and occurred year-round in the York River, with a size range of 10-80 mm (Tab. III, Fig. 13). Most individuals were 30-40 mm. This species also ranked among the top five most abundant fishes in shallow water (beach seine samples) but was not caught in all months. Although the 40 mm cutoff level effectively separates small and rapidly growing new recruits from the larger, slower growing older individuals, subsequent cluster analyses revealed no temporal or spatial differences between those groups. The species was therefore treated as a single SET for subsequent cluster analysis.

Micropogonias undulatus ranked third in bottom trawl samples and occurred year-round (Tab. III, Fig. 13). The overall size frequency distribution suggested a bi-modal or tri-modal distribution. Cluster analysis suggested no major temporal differences in occurrence of individuals between 10-80 mm in length, and this size group was therefore treated as a single SET (MICUND-I). Based on the distinct temporal pattern of abundance of individuals larger than 80 mm, a second SET category was selected (MICUND-II).

Trinectes maculatus ranked fourth in bottom trawl samples and occur year-round (Tab. III, Fig. 13). Overall and temporal size frequency distributions suggested a uni-modal distribution. Only very few individuals less than 70 mm were collected from July to December, therefore this species was treated as a single SET for future cluster analyses.

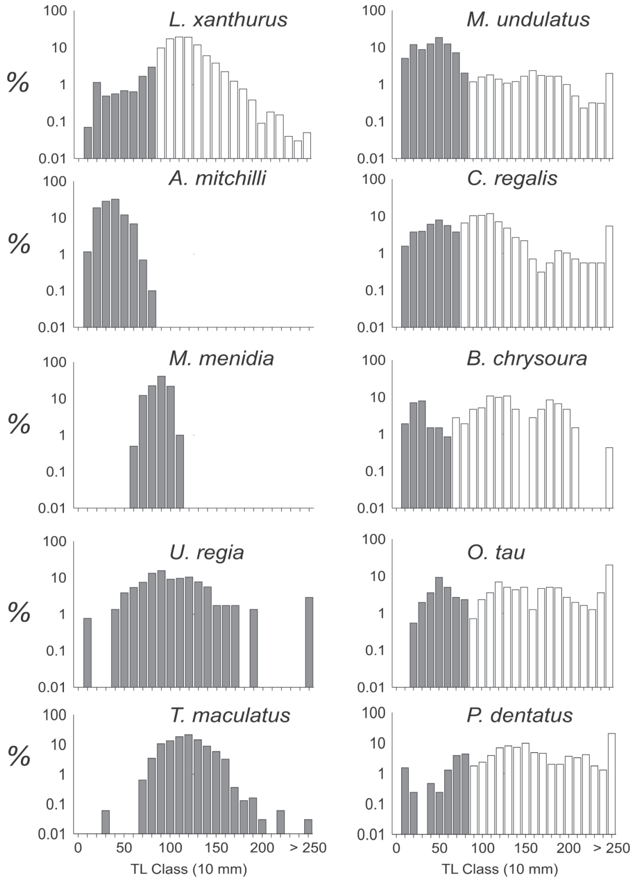


Figure 13. Percent size frequency distribution by 10 mm class length of 10 most abundant species at York River. Dark bars are Ecological Taxon I and open bars Ecological Taxon II. July 1973 to June 1974.

Cynoscion regalis ranked fifth in bottom trawl samples (Tab. III, Fig. 13) and was absent in collections made on January and February. Monthly and overall size frequency distributions suggested a tri-modal distribution, with at least two annual cohorts. Since larger individuals (> 200 mm) of this species are generally not trawl-vulnerable, and occurred at a very low monthly abundance (CPUE < 0.3), we did not attempt to characterize larger individuals as separate SET. Based on monthly size distributions, two SET's were selected for future cluster analysis, CYNREG-I (< 80 mm) and CYNREG-II (> 80 mm).

The remaining 5 dominants species occurred in most month samples but at an average total CPUE of less than 1 (Tab. III, Fig. 13). *Menidia menidia* ranked seventh in bottom trawl samples but first in beach seine samples in the York River. This species occurred year-round in near shore areas, but only from November to March in bottom trawl samples, where most individuals were 80 to 100 mm. Based on the limited size range represented in bottom trawl samples, the species was treated as a single SET for future cluster analysis.

Paralichthys dentatus, Opsanus tau, and *Bairdiella chrysoura* occurred mainly throughout the year in size ranges from 10 to 255 mm or larger and with several modal classes. Since larger individuals (generally > 70 mm) of those species occurred monthly at very low abundance, and for each individual species, cluster analysis suggested no major temporal difference in occurrence among them, only characterized the first modal class of those species as SET-I and included all larger sizes in one category (SET-II). Also for *Urophycis regia* cluster analyses revealed no temporal or spatial differences between individuals smaller and larger than 90 mm; therefore this species was treated as a single SET in subsequent cluster analysis.

Twenty four entities (12 SET's and 12 species) were selected for cluster analysis (Tab. III). Pooled data on entities abundance by month resulted in the following seasonal groups (Fig. 14): summer (June 1974 and July 1973), fall (August 1973 to October 1973), winter-1 (November 1973 to January 1974), winter-2 (February- March 1974) and spring (April-May 1974).

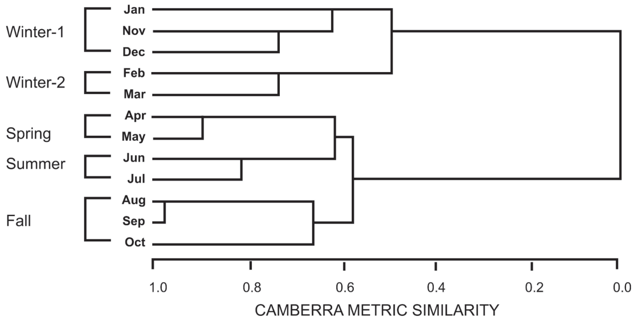


Figure 14. Dendogram of normal cluster analysis in the York River estuary.

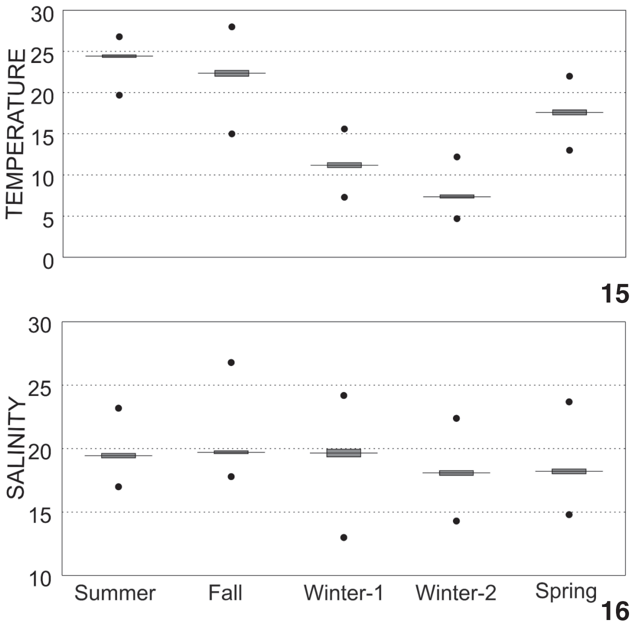
Environmental data within these seasonal groups are summarized in figures 15 and 16. Water temperature ranged between 15.0-28.0ºC in fall, and 4.7-12.2ºC in winter-2. Wide temperature ranges were observed in all seasonal groups (7-13ºC of difference) but mean water temperatures were considerably lower in the two winter groups. Salinity variation was low in the portion of the river studied and ranged from 13.0 to 26.8.

Inverse cluster analysis identified 10 groups of entities, ranging in content from one to five entities per group (Tab. IV). Groups A, B, and I were typified by numerically dominant entities (high to very high average individual CPUE), and together with groups C (low to moderate CPUE) occurred year-round. Entities of group D, although similar in abundance and occurrence to group C, were absent from the samples in February and March, suggesting winter emigration from the sampling area or gear avoidance (*e.g.* mud burrowing) for the majority of the entities of this group. Entities of group E were restricted in occurrence to winter months. Entities of group F were absent summer through fall. Entities of group G were

Table III. More frequent and abundant species of fish caught in the York River estuary from July 1973 to June 1974 sorted by average CPUE (mean capture per unit of effort). Species codes (SPCODE), numerical abundance (ABUN), CPUE, percent abundance (%CPUE), and number of monthly frequency occurrence (FO).

Species	Species code		ABUN	CPUE	%CPUE	FO
Anchoa mitchilli	ANCMIT	#	84240	178.89	75.95	12
Leiostomus xanthurus	LEIXAN	#	14064	34.67	14.72	12
Micropogonias undulatus	MICUND	#	3421	10.21	4.33	12
Trinectes maculatus	TRIMAC	#	3060	5.89	2.50	12
Cynoscion regalis	CYNREG	#	585	1.11	0.47	9
Paralichthys dentatus	PARDEN	#	386	0.83	0.35	12
Menidia menidia	MENMEN	#	182	0.75	0.32	5
Urophycis regia	UROREG	#	237	0.52	0.22	7
Opsanus tau	OPSTAU	#	247	0.48	0.20	11
Bairdiella chrysoura	BAICHR	#	211	0.40	0.17	9
Syngnathus fuscus	SYNFUS	#	86	0.17	0.07	8
Brevoortia tyrannus	BRETYR	#	75	0.15	0.06	5
Symphurus plagiusa	SYMPLA	#	61	0.13	0.06	7
Menticirrhus saxatilis	MENSAX		57	0.11	0.05	2
Alosa sapidissima	ALOSAP	#	35	0.11	0.04	5
Morone americana	MORAME	#	43	0.09	0.04	5
Chaetodipterus faber	CHAFAB		45	0.08	0.04	2
Prionotus carolinus	PRICAR		44	0.08	0.04	3
Alosa pseudoharengus	ALOPSE	#	25	0.07	0.03	5
Anchoa hepsetus	ANCHEP		35	0.07	0.03	2
Alosa aestivalis	ALOAES		28	0.06	0.03	3
Centropristis stiata	CENSTR	#	29	0.06	0.03	6
Peprilus triacanthus	PEPTRI		27	0.05	0.02	3
Synodus foetens	SYNFOE		26	0.05	0.02	3
Orthopristis chrysoptera	ORTCHR		23	0.04	0.02	3
Anguilla rostrata	ANGROS		22	0.04	0.02	3
Prionotus evolans	PRIEVO		14	0.04	0.02	3
Peprilus alepidotus	PEPALE		20	0.04	0.02	3
Hypsoblennius hentzi	HYPHEN	#	15	0.04	0.02	4
Menticirrhus americanus	MENAME		16	0.03	0.01	2
Gobiosoma bosci	GOBBOS		14	0.03	0.01	3
Syngnathus floridae	SYNFLO		15	0.03	0.01	2
Lagodon rhomboides	LAGRHO		13	0.02	0.01	2
Cynoscion nebulosus	CYNNEB		3	0.02	0.01	1
Apeltes quadracus	APEQUA		5	0.01	0.01	2
Tautoga onitis	TAUONI		6	0.01	0.01	3
Pomatomus saltatrix	POMSAL		4	0.01	0.01	1

# Denotes species used in cluster analysis.Tota:l 63 secies; 107,476 individuals; 12 months; 495 samples.



Figures 15-16. Salinity (15) and temperature (16) within seasonal groups in the York River estuary. Mean (horizontal line), standard error of the mean (Box), and range (Dots).

absent from winter-2 to spring months. Entities of group H were absent from spring samples. Juveniles of *Paralichthys dentatus* (PARDEN-l, Group J) were absent from winter-1 months and occurred at low abundance during the rest of the year.

DISCUSSION

The total number of species captured in most estuaries is moderate compared with nearby marine or freshwater systems, and Patos Lagoon and York River fish assemblages were numerically dominated by a few species, a characteristic that is also shared by other temperate and war-temperate estuaries (DEEGAN 1989, VIEIRA & MUSICK 1993, VIEIRA & CASTELLO 1997, POTTER & HYNDES 1999). No dominant species were shared between both estuarine systems, but three dominant families and two genera were common to both data sets (Engraulididae – *Anchoa*, Sciaenidae – *Micropogonias* and Batrachoididae). When comparing the less abundant species, several were common to the Patos Lagoon and the York River (e.g., *Menticirrhus americanus*, *Selene setapinnis, Selene vomer, Pomatomus saltatrix, Peprilus paru*), and more than ten genera were common to both data sets.

Patos Lagoon fish assemblages have higher diversity than York River at any particular point in time, but the seasonal pattern of use of the estuary (i.e., nursery and feeding grounds) was similar between localities, and did not differ from other temperate or tropical estuaries. The total number of species (65 and 63, respectively) collected over a year of bottom trawling in Patos Lagoon and York River, was about the same. Sixty-five species represented 79% of all species reported from a three-year bottom trawl fish survey in Patos Lagoon estuary (CHAO *et al*. 1982, 1985, VIEIRA & CASTELLO 1997). Sixty-three species represented 95% of those species taken by bottom trawl during a three year period in the York River (ILLOWSKY & COLVOCORESSES 1975).

Within broad limits, the Patos Lagoon and York River structural assemblage patterns were correlated with temperature changes, although the intensity of seasonal changes differed between them. The major difference seems to occur in the winter months (June to August in Patos Lagoon, and November to March in the York River), where the cold season duration was longer in the York River than Patos Lagoon (5 vs 3 months, respectively), and the average monthly winter temperatures were consistently lower in the York River. The lowest winter temperatures in the York River were correlated with a pronounced seasonal species emigration from the estuary and the arrival of the boreal gadid *Urophycis regia*.

Several authors recommended the use of ecological guild classification scheme for further studies on comparison among geographically different estuarine fish assemblages (see MATHIESON *et al*. 2000 and THIEL *et al*. 2003 for review), but those classification is reductive and agglomerative and the procedure of identified "size ecological taxa" SET (POLIS 1984, GELWICK 1990) among abundant species is divisive and based on the axiom that the "species" category is not always appropriate as the smaller ecological entity. Since estuarine fishes often exhibit ontogenetic shifts in habitat requirements and/or preferences (DEEGAN 1989, VIEIRA & CASTELLO 1997) this procedure reduces the noise caused by lumping together large and small individuals of the same species, which have different temporal and spatial distributions and may not belong to a specific spatial ecological guild. Also the information gained by using SET treatment is important in the way to analyze and understand differences in temporal and spatial dynamics of fish assemblages. In order to do such numerical comparisons CPUE's by size classes, or SET´s CPUE, has to be analyzed. Another advantage of the use of CPUE's by size classes is that the technique allow the growing in size and the reduction in numbers of one cohorts to be fallow in time and space (WHITESIDE & HATCH 1997).

Fish species in experimental bottom trawl collections of Patos Lagoon and the York River were primarily represented by post-larvae, young-of-the-year and sub-adults ranging in length between 10 and 250 mm or larger. In both localities the strongest modal class was < 80 mm TL. Around the cutoff size of 80-100 mm we effectively separated SET's for 5 and 6 numerically dominant species in both systems. In addition another 5 abundant species were smaller than 100 mm TL. Exceptions to the low abundance of the 80-100 mm size range in the York River were: Adults of *Menidia menidia*, that occurred year-round in the near shore areas (ILLOWSKY & COLVOCORESSES 1975, WAGNER & AUSTIN 1999), but only in winter months in bottom trawl samples (but most individuals were 80 to 100 mm TL), *Urophycis regia* that also was only captured in cold months and *Trinectes*

Table IV. Graphical characterization of CPUE variation of seasonal groups and species groups in the York River. Size range (mm).

Groups	Species	Size range	SUM	FAL	WIN-1	WIN-2	SPR
A	*Anchoa mitchilli*	10-180	+++++	+++++	++++	+++++	++++
	Leiostomus xanthurus II	90 > 250	++++	++++	++++	++++	++++
	Micropogonias undulatus I	10-70	++	+++	++++	++++	+++
B	*Trinectes maculatus*	30-240	+++	+++	++	+++	+++
	Micropogonias undulatus II	80 > 250	+++	+++	+++	+++	++
	Paralichthys dentatus II	90> 250	++	++	+++	+++	++
C	*Symphurus plagiusa*	30-150	++	+++	++	+++	++
	Opsanus tau I	20-80	++	++	++	+++	++
D	*Opsanus tau* II	90 > 250	++	++	++		++
	Cynoscion regalis II	80 > 250	++	+++	++		++
	Bairdiella chrysoura II	70-240	++	+++	++		++
	Syngnathus fuscus	60-210	+++	+++	++		++
	Centropristis stiata	20 >250	++	++	++		++
E	*Alosa pseudoharengus*	10-110			+++	++	
	Alosa sapidissima	10-120			+++	++	
	Menidia menidia	60-110			+++	++	
F	*Brevoortia tyrannus*	20-200			++	++	+++
	Urophycis regia	10 > 250			++	+++	+++
G	*Cynoscion regalis* I	10-70		+++	+		
	Bairdiella chrysoura I	10-60	++	++	++		
H	*Hypsoblennius hentzi*	20-80		++	++		
	Morone americana	100 > 250	+++		+++	++	
I	*Leiostomus xanthurus* I	10-80	+++	++	++	++	+++
J	*Paralichthys dentatus* I	10-80	++	+		+	++

Absent (empty), very low (+ < 0.01); low (++ > 0.01); moderate (+++ > 0.1); high (++++ > 1.0); very high (+++++ > 10.

maculatus, a year-round estuarine-resident, with most individual between 90 and 160 mm TL but protected by mud burrowing. Only one exception occurred at Patos Lagoon, three species of sea catfish of the genus *Genidens*, in which the majority of the 0+ individuals were between 60 and 90 mm TL (VIEIRA & CASTELLO 1997), and which occurred year round but protected by strong dorsal and pectoral spines. In warm months, when predation by large fish may be strongest (BUCKEL *et al*. 1999b, HARTMAN 2000), the abundance of fish between 80 and 100 mm TL was lower in demersal fish assemblages in both systems. Only the sea catfish *Genidens* spp (Patos Lagoon), and the flounder *Trinectes maculatus* (York River), peak in abundance at this size class because they are protected from predation.

In this study many similarities (ecological analogies) were observed between estuarine bottom trawl fish assemblages in two geographically isolated systems within warm-temperate latitudes of the western Atlantic. We document deep water use of both estuaries for post-larvae and young-of-the-year recruitment, nursery, shelter and feeding grounds, with is also shared by other western Atlantic temperate estuaries (SHAW *et al*. 1988, VIEIRA & CASTELLO 1997) and elsewhere in the world (POTTER & HYNDES 1999, MATHIESON *et al*. 2000). Another important information that complements this observation is that around 80 and 100 mm TL many species in both systems left the area or moved to shallow water to avoid predation. Future works have to be done in order to investigate why the 80 to 100 mm TL fish were absent from bottom trawl waters (this work) but occurs frequently as food items of estuarine piscivorous fish such as bluefish *Pomatomus saltatrix* and striped bass *Morone saxatilis* (BUCKEL *et al*. 1999a, b, MANDERSON *et al*. 1999, HARTMAN 2000) and also wading birds (FÁVERO *et al*. 2001).

The results presented hear was consistent with the hypothesis of a trade-off between the feeding benefit and predation risk, and our findings provide empirical support for the hypothesis that the size around 80 and 100 mm TL are an important breakpoint between to be small, live in the water column and feed on zooplancton food chain or to be large enough to migrate to the bottom, explore estuarine abundant benthos resources, and run from predation (POWER 1987 in HELFMAN *et al*. 1997).

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