QUANTITATIVE APPROACH TO THE "PHYSIOGNOMIC ASSESSMENT OF HARD BOTTOM MARINE BENTHIC COMMUNITIES" METHOD: PRECISION ANALYSIS

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ABSTRACT

The "Physiognomic Assessment of Hard Bottom Marine Benthic Communities" (PCM) method proposes the use of operational units called `settlements`, allied to photographic sampling. The aim of this study is to detect variations on the precision of the quantitative approach of the method when performed by a) different researchers, and b) by the same researcher on different occasions. Thirty digital images were taken from Moela Island and Ponta do Munduba Munduba - Santos, São Paulo state, on the Brazilian southeastern coast, at depths between zero and five meters. Three researchers analyzed the images. One of the researchers did the analysis on two different occasions six months apart, while the other two did the analysis once. One of the researchers was unaware of the research objectives. Settlement Richness values varied from 13 to 19, generating Sørensen Similarity values between the different observers of always higher than 80%. The correspondence analysis (CA) on percent cover data showed no significant differences between the values found for Axes I, II, III and IV (corresponding to 42.8% of data variability) when compared by ANOVA (P being respectively 0.963; 0.975; 0.867; 0.894). The results here presented indicate that the quantitative approach of the PCM method is little researcher-dependentt, consequently making the cooperation between different researchers to describe large areas possible.

Keywords: Benthic communities, precision, quantitative approach and physiognomic survey.

RESUMO

ABORDAGEM QUANTITATIVA DO MÉTODO DE DESCRIÇÃO DE COMUNIDADES MARINHAS BENTÔNICAS DE SUBSTRATO CONSOLIDADO: ANÁLISE DA PRECISÃO. O método de Caracterização Fisionômica de Comunidades Marinhas Bentônicas propõe o uso da unidade operacional chamada Povoamento aliado à amostragem fotográfica. O objetivo deste estudo é testar a precisão da abordagem quantitativa quando submetido a: a) diferentes pesquisadores e b) diferentes análises realizadas pelo mesmo pesquisador. Trinta imagens digitais foram obtidas na Ilha da Moela e na Ponta do Munduba – Santos, SP – região sudeste do Brasil, entre zero e cinco metros de profundidade. Três pesquisadores analisaram essas imagens. Um o fez em dois diferentes momentos, com intervalo de seis meses, enquanto os outros dois somente uma vez, um destes últimos desconhecia os objetivos. Os valores de Riqueza variaram entre 13 e 19, gerando valores de similaridade baseada no Índice de Sørensen superiores a 80%. A análise de correspondência (CA) baseada no recobrimento percentual não mostrou diferenças significativas entre os valores encontrados para os Eixos I, II, III e IV (correspondentes a 42,8% da variabilidade dos dados) quando comprados por ANOVA (P respectivamente igual a 0,963; 0,975; 0,867; 0,894). Os resultados apresentados aqui indicam que a etapa quantitativa do Método de Caracterização Fisionômica de Comunidades Marinhas Bentônicas é pouco pesquisador-dependente, possibilitando com isso a cooperação entre diferentes pesquisadores para descrever grandes áreas.

Palavras-Chave: Comunidades bentônicas, precisão, abordagem quantitativa e amostragem fisionômico.

INTRODUCTION

Coastal zones are dynamic environments even without the interference of man (Baily & Nowell 1996). The increase in the rate of environmental alterations caused by human activities has stressed the need for methodologies that can rapidly describe biological communities before great changes in their original structure occurs. Such descriptions are many times the base of management and conservation programs (Sabino & Villaça 1999).

However, choosing the descriptive methodologies has been mostly based on tradition, disregarding each specific community characteristics, while ignoring the obstacle for sampling in the field and blurring the research objectives (Greig-Smith 1983).

This has also been the case with of hard bottom marine community studies in Brazil. Most papers describe sampling methodologies based on rectangular sampling units distributed along transects, which are used to calculate coverage areas (*e.g*. Figueiredo *et al*. 2004) and biomass (*e.g*. Silva *et al*. 1987, Guimaraens & Coutinho 1995, Amado Filho *et al*. 2003, Paula *et al*. 2003, Marins-Rosa et al. 2005) of species as the operational units.

Using species as the operational unit demands considerable expertise of the researchers and time for the correct identification in the field and/or at the lab. Furthermore, identification to species level is frequently impossible or difficult, *e.g.* when essential reproductive structures are missing or special techniques are needed, or if there are no specialists available. Consequently, there have been attempts to substitute species with other operational units, such as higher taxonomic categories, functional groups, or even species associations (Murray *et al*. 2006).

Berchez *et al.* (2005) proposed the use of landscape ecology concepts as an alternative for the study of marine benthic communities. Their proposal included operational units called "settlements": visually homogeneous landscape units characterized by one or a few structuring species. The method is based on four complementary approaches: I) settlement identification and description; II) the determination of horizontal and vertical distribution of each settlement; III) the quantification of each settlement percent cover based on photographs; and IV) settlement detailing at a specific level, either qualitatively or quantitatively.

Photographic sampling for studying marine benthic communities has been employed since the 70's (Lundälv 1971). Furthermore, this technique has been the required standard for studies contracted by the U. S. Department of the Interior since the 80's (Littler & Littler 1985).

From comparing different percent cover evaluation methods, Meese & Tomich (1992) observed that the photographic method is the fastest in the field and the most precise. The same has been observed by Macedo *et al*. (2006), who compared photographic sampling with the point quadrat method. In a similar comparison, Foster *et al.* (1991) showed that photographic sampling is more precise than point quadrat estimates. Nevertheless, it is impossible to state the species of most organisms based on photographs, especially in multilayered assemblages.

The quantitative approach of the "Physiognomic Assessment of Hard Bottom Marine Benthic Communities Method" (PCM) suggests the use of photographic samples taken at random in association with settlements as operational units. It thus suppresses the main drawbacks of sampling based on images, since settlements, contrary to species, are easily identified in the images.

The results obtained by any method are products of the interaction between researcher and the object being researched, and thus are subject to factors that influence human performance (fatigue, stress and negligence). Knowledge about the interference of these factors is essential for establishing a reliable research method.

The aim of this study was to test the precision, defined as the degree of concordance among repeated estimates (Meese & Tomich 1992), of the PCM quantitative approach, when subject to: a) different researchers and b) a different time analysis carried out by the same researcher.

MATERIAL AND METHODS

Thirty digital images were taken in February, 2005 (with a Cybershot W5 Sony camera in a marine case) within two areas: 15 were taken in Moela Island (24º 03' 00.90"S 46º 15' 58.58"W) and 15 were taken in Ponta do Munduba (24º 02' 30.15"S 46º 17' 18.33"W), Santos, São Paulo state, both on the Brazilian southeastern coast (Figure 1), at depths from zero to five meters.

The images were analyzed with the aid of a digitizing pad, which allowed the researchers to manually delineate each settlement on the image. The software used was Adobe Photoshop v. 7.0, and the number of pixels inside each delineated area was determined with UTSHSCA Image Tool v. 3.0. The percent cover of each settlement was calculated by the formula: Ri(%) = Ni/Nt x 100 - where Ri is the i settlement percent cover; Ni is the number of pixels represented by the i settlement and Nt is the total number of pixels in the image.

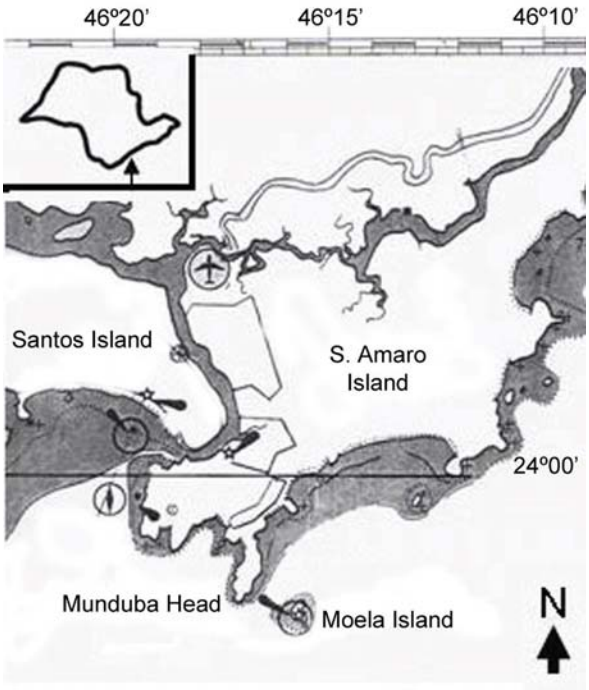

Figure 1. Location of the study area on the São Paulo coast: Moela Island and Ponta do Munduba.

Three researchers were selected to analyze the images. The results obtained by two of them were used to compare the degree of concordance among repeated estimates done by different researchers, and also by the same researcher on two different occasions. The data from third researcher, unaware of taking part in the experiment, were also compared with those of the other two, thus to guarantee that prior knowledge was affecting neither the procedures nor the results, and especially not the `researchers` performance.

With this intent, one researcher repeated the task on two different occasions, six months apart (termed P1 and P1(2), respectively), while the other two (P2 and P3) did only once. Researcher P2 was the only one unaware of the comparison objectives, being told that the aim of the analysis was to obtain a description of the community.

Community descriptors used in the analysis were Settlement Richness and Percent Cover. A cluster analysis was performed between each researcher, based on a Sørensen Qualitative Similarity Index, taking into consideration the presence and absence of settlements found by each observer, and by using the nearest neighbour grouping strategy.

To test the hypothesis of statistical differences among the percent cover values of the various observations, correspondence analysis (CA) using MVSP v.3.1 software was performed. The different values obtained for Axes I, II, III and IV, and for each researcher, were tested by ANOVA with the aid of SPSS v.13.0 software.

RESULTS

Settlement Richness was found to be different in all the observations. The first researcher found 13 settlements on the first observation (P1) and 15 on the second (P1(2)), whereas P2 found 19 and P3 found 13. Three settlements were delineated in only

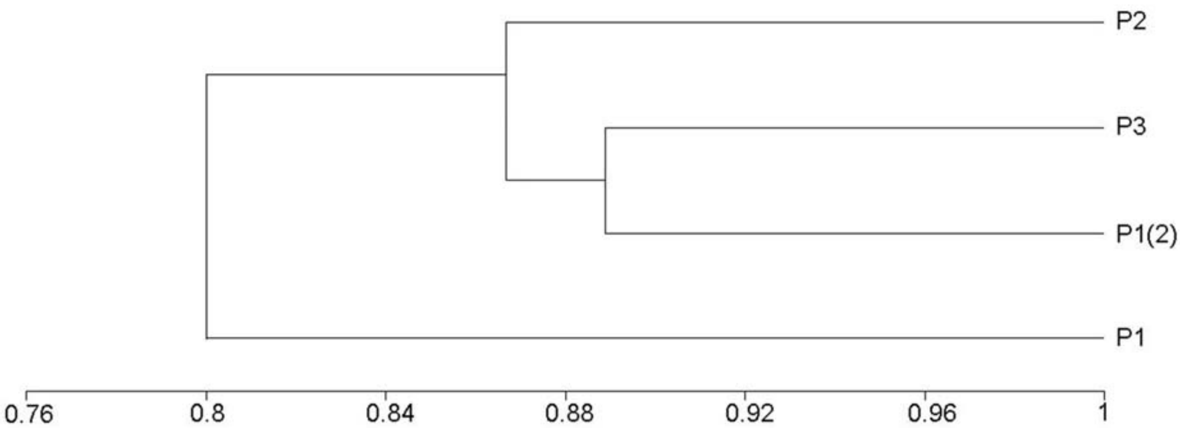

Figure 2. Sørensen Similarity between the researchers, based on the presence or absence of settlements and grouped by the nearest neighbour method. P1 – First observation carried out by researcher 1; P1(2) – Second observation carried out by researcer 1; P2 – observation carried out by an unaware researcher; and P3 – observation carried out by researcher 3.

Table 1. Settlements delineated in each observation. P1 – First observation carried out by researcher 1; P1(2) – second observation carried by researcher 1; P2 – observation carried by the unaware researcher and P3 – observation carried by researcher 3. + = presence; - = absence.

	RESEARCHERS			
SETTLEMENTS	**P1**	**P1(2)**	**P2**	**P3**
Amphiroa and *Jania* Turf with *Isognomon*	+	+	+	+
Amphiroa and *Jania* Turf	+	+	+	+
Asparagopsis Bed	+	+	+	+
Bryopsis Turf	+	-	-	-
Chthamalus Bed	-	+	-	+
Corallinaceae Crust with *Echinometra*	+	+	+	+
Crassostrea Bed	-	+	-	+
Didemnidae Colony	-	+	+	+
Didemnum Colony	-	+	+	+
Ectocarpaceae Turf	+	+	+	+
Ectoprocta Turf with *Polysiphonia*	+	+	+	+
Hydrozoa Turf	+	+	+	+
Mycale Crust	-	-	-	+
Phallusia Bed	+	-	-	+
Polysiphonia Turf	+	+	+	+
Porifera Crust	+	+	-	+
Schizoporella Colony	-	-	+	+
Tedania Crust	+	+	+	+
Tropiometra Bed	+	+	+	+
Unconsolidate Substrate Region	-	-	-	+
Settlement Richness	**13**	**15**	**13**	**19**

Table 2. ANOVA results between the values of each researcher for Axes I, II, III and IV obtained by Correspondence Analysis of percent cover data. SS = Sum of Square; Df = Degree of Freedom; MS = Mean Square; F = F value.

		SS	Df	MS	F	P.
Axis I	Between Groups	0.27	3	0.090	0.094	0.963
	Within Groups	107.317	112	0.958		
	Total	107.589	115			
Axis II	Between Groups	0.227	3	0.076	0.072	0.975
	Within Groups	118.269	112	1.056		
	Total	118.497	115			
Axis III	Between Groups	0.783	3	0.261	0.242	0.867
	Within Groups	120.565	112	1.076		
	Total	121.348	115			
Axis IV	Between Groups	0.513	3	0.171	0.203	0.894
	Within Groups	94.315	112	0.842		
	Total	94.828	115			

one observation: a *Mycale* Crust, an Unconsolidated Substrate Region and a *Bryopsis* Turf. However, their average percent cover was always less than 1.7% (Table 1), indicating that they are of low importance to the evaluation of this community parameter. The qualitative Sørensen similarities among different observations showed that these observations were close, being always higher than 0.8 (Figure 2).

The settlement presenting the highest mean percent cover, always superior to 50% (Figure 3) was *Amphiroa* and *Jania* Turf with *Isognomon* and it was found in all observations. The other settlements revealed a mean percent cover of less than 20%.

Quantitative comparison was based on the values found by the correspondence analysis of axes I, II, III and IV, which together correspond to 42.8% of the data variability. When these values were compared by Variance Analysis, no statistical difference was detected among the observers in any of the axes (P = 0.963; P = 0.975; P = 0.867; P = 0.894 respectively for Axes I, II, III and IV values - Table 2), indicating that qualitative results were not observer-influenced.

The Pearson correlation obtained for the values of Axis I, between the two observations carried out by the same researcher (P1 and P1(2)), was less than the correlation obtained between the second observation (P1(2)) and the one by the researcher 3 (P3). However, this correlation was higher than 0.8 in all cases, the smallest values being obtained by the unaware researcher (P2) in relation to the other two researchers (Table 3), thus showing that little influence was caused by the former.

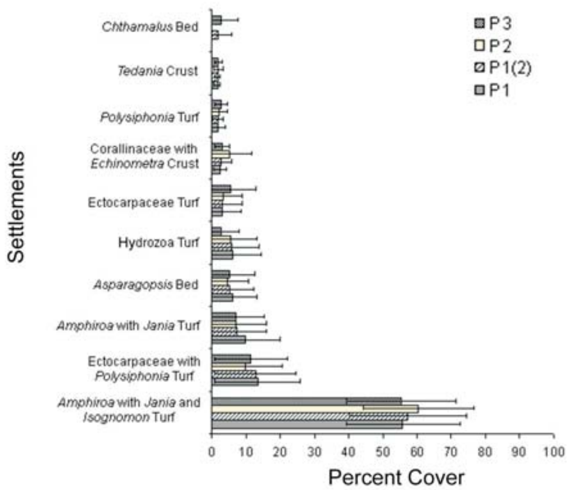

Figure 3. Mean Percent Cover of the main settlements for each observer (P1, P1(2), P2 and P3), and their respective confidence interval (95%). P1 – First observation carried out by researcher 1; P1(2) – second observation carried out by researcher 1; P2 – observation carried out by the unaware researcher; and P3 – observation carried out by researcher 3.

Table 3. Pearson Correlation obtained from Axis I values, obtained from a Correspondence Analysis, for each observer. P1 – first observation carried out by researcher 1; P1(2) – second observation carried out by researcher 1; P2 – observation carried out by the unaware researcher; and P3 – observation carried out by researcher 3.

	P1	P1(2)	P2	P3
P1	1.000			
P1(2)	0.932	1.000		
P2	0.823	0.860	1.000	
P3	0.903	0.987	0.879	1.000

DISCUSSION

The previously mentioned factors that affect research methods are more or less influential in each different method, generating individual advantages and disadvantages (Dethier *et al*. 1993, Sabino & Villaça 1999, Bernhardt & Griffing 2001). For example, describing benthic marine communities from photographs is quite fast (Lundälv 1971, Foster 1991, Meese & Tomich 1992, Pech *et al*. 2004). However, there are also disadvantages in the method. For instance, identifying certain organisms from the images is difficult (Meese & Tomich 1992, Macedo *et al*. 2006) and it is impossible to quantify the different community strata, while the complexity is underestimated (Foster *et al.* 1991). Yet, it should be noted that the mentioned authors used species as operational units.

In the present study, which used settlements as operational units, all the three researchers tested found similar Settlement Richness values. Moreover, qualitative similarity among their analyses was always superior to 0.80, this being related to the low sensitivity of researchers to rare settlements. These finds agree with the observations related with rare species in photographs made by Foster *et al.* (1991).

The quantitative analysis of settlement percent cover proved not significantly different among the tested observers, neither between the first and second observations of the same tested researcher, this indicating high precision under the given conditions. Moysés *et al.* (2007) attributed the high precision of photographic sampling to the absence of adverse field conditions, which permits devoting more attention onto the analysis.

Using a different approach, Meese & Tomich (1992) and Foster *et al.* (1991) concluded that the photographic method is the most precise in comparison with visual estimation and intersection points. Foster *et al*. (1991) also found that the latter technique is more accurate (yielding values closer to reality), as it considers the three-dimensional structure of the community, which is disregarded in photographic sampling.

However, in addition to the quantitative approach, the "Physiognomic Assessment Method" (Berchez *et al.* 2005) includes other two complementary approaches, which allow for the detection of rare settlements and thus increase the description accuracy, counteracting the deficiency pointed out by Foster *et al.* (1991).

In conclusion, the results herein presented indicate that the quantitative approach of the "Physiognomic Assessment Method" is not much researcher-dependent and therefore makes the cooperation among different researchers to describe large areas possible with minimum loss of methodological rigor.

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