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Mesh size effects on assessments of planktonic hydrozoan abundance and assemblage structure

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ABSTRACT

The choice of appropriate mesh-size is paramount to accurately quantify planktonic assemblages, however there is no such information available for hydrozoans. Here planktonic hydrozoan abundance and assemblage structure were compared using 200 and 500 μm meshes at Babitonga estuary (S Brazil), throughout a year cycle. Species richness and Shannon–Wiener diversity were higher in the 200 μm mesh, while evenness was typically higher in the 500 μm. Assemblage structure was significantly different between meshes (PERMANOVA, $P < 0.05$; $n = 72$ pairs of samples) both regarding taxa and size composition. These discrepancies are due to significant underestimation of small hydromedusae by the coarse mesh, like *Obelia* spp., young *Liriope tetraphylla*, *Podocoryna loyola* and others. Yet, larger taxa like *Eucheilota maculata* and adult *L. tetraphylla* were more abundant in the coarse mesh on some occasions and others such as *Blackfordia virginica* and *Muggiaea kochi* were similarly represented in both meshes. Overall collection efficiency of the coarse mesh (CE_{500}) was 14.4%, with monthly averages between 1.6% and 43.0%, in July (winter) and January (summer) respectively. Differences between the meshes were size-dependent; CE_{500} was ~0.3% for hydrozoans sizing <0.5 mm, ~21% for those between 1 and 2 mm, ~56% for those between 2 and 4 mm, and nearly 100% for larger ones, reaching up to 312% for hydrozoans >8 mm in October. These results suggest that both meshes have their drawbacks and the best choice would depend on the objectives of each study. Nevertheless species richness, total abundances and most taxa were better represented by the 200 μm mesh, suggesting that it is more appropriate to quantitatively sample planktonic hydrozoan assemblages.

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1. Introduction

Zooplankton communities are paramount to food web structure and energy transfer and consequently to the functioning of marine ecosystems. Therefore quantitative assessments are necessary to properly evaluate their role, and to accomplish so with reliability the choice of appropriate sampler is a key issue. Among the many variables that may influence the accuracy of zooplankton sampling – such as shape and size of the net, towing speed, filtration performance, and so on – mesh size selectivity is commonly regarded among the major sources of error when estimating zooplankton abundance and community structure (Riccardi, 2010; Sameoto et al., 2000; Skjoldal et al., 2013; Vannucci, 1968). Although many studies attempted to evaluate mesh size effects since late XIX century, the subject is still troublesome since no single mesh properly sample all taxa and/or developmental stages in all areas and under different conditions (Hopcroft et al., 2001; Miloslavic et al., 2014; Skjoldal et al., 2013).

Mesh size selectivity is relatively well known for copepods, and many authors have shown that 200 μm meshes underestimate adults of small species, and copepodites and nauplii of all species due to extrusion. Losses are significant and may exceed 90% in abundance and 50% in biomass and production (Bernhard et al., 1973; Di Mauro et al., 2009; Favareto et al., 2009; Hopcroft et al., 1998; Hwang et al., 2007; Krsinic and Lucic, 1994; Riccardi, 2010; Wu et al., 2011). In contrast, larger copepods may not be well sampled by fine meshes due to the bow wave effect and reduced filtering efficiency (Favareto et al., 2009; UNESCO, 1968). Hopcroft et al. (2001) concluded that among 64, 200, and 500–600 μm meshes, each is more efficient for a specific copepod size range. However this seems not to be always the case, since many other authors did not find differences for larger copepods (Almeida Prado, 1962; Antacli et al., 2010; Miloslavic et al., 2014; Vidjak, 1998; Wu et al., 2011).

Among other marine invertebrate taxa, studies are considerably fewer. Bivalve larvae and the pteropod *Limacina* spp. are highly underestimated by 200 μm mesh (Miloslavic et al., 2014). Decapod larvae and ostracods are equally sampled by 125 and 250–333 μm meshes

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(Krsinic and Lucic, 1994; Vidjak, 1998). The same may be true for chaetognaths (Almeida Prado, 1962; Vidjak, 1998) but the issue is disputable; small slender species such as *Parasagitta setosa* may be underestimated in more than 50% by 200–250 μm meshes (Krsinic and Lucic, 1994; Miloslavic et al., 2014), but Skjoldal et al. (2013) concluded that 330 μm is more efficient than 180 μm mesh for chaetognaths. Cladocerans are equally sampled by 125 and 250 μm meshes in Adriatic (Krsinic and Lucic, 1994; Miloslavic et al., 2014), but *Evadne nordmanni* and *Podon* sp. from Norway are better sampled by 200 μm in comparison with 400, 100 or 55 μm meshes (Skjoldal et al., 2013). Losses of 35–98% of *Oikopleura dioica* <1 mm in trunk length abundance and between 60–90% of biomass of animals <400 μm have been reported in 220 μm mesh. Conversely, 67 μm mesh may underestimate in 50–80% biomass of larger animals, and completely missed appendicularians >1 mm (Di Mauro et al., 2009). All developmental stages of three other species of *Oikopleura* were similarly sampled by 53 and 200 μm meshes (Esnal et al., 1997).

From the data depicted above particularities for each taxon are clear, which are typically related to their size, morphology, flexibility and behavior (Vannucci, 1968). Therefore, the effectiveness of a given mesh size depends on taxonomic composition and size–structure of the assemblage to be sampled (Hopcroft et al., 2001; Riccardi, 2010; Skjoldal et al., 2013; Vannucci, 1968). Moreover, retention efficiency of a given mesh size may change seasonally (Riccardi, 2010) and in different environments (Hopcroft et al., 2001; Miloslavic et al., 2014) further complicating the topic. Consequently, detailed evaluations of effects of mesh size, including different seasons and environments, are critical for proper quantitative sampling of any taxonomic group.

Planktonic hydrozoans are common, abundant, and diversified in marine systems. They are typically carnivores with high feeding rates, playing a significant role in pelagic food webs (e.g. Mills, 1995; Pagès et al., 2001). Therefore, accurately quantifying them is essential for detailed understanding of ecological processes and energy flow in water column. Most authors use meshes with pore sizing between 200 and 500 μm when attempting to quantify planktonic hydrozoans, but both finer and coarser meshes have also been employed (Mesquita et al., 2006; Pagès and Kurbjeweit, 1994; Pagès et al., 1996; Palma, 1985; Palma et al., 2007; Panasiuk-Chodnicka and Zmijewska, 2010; Persad et al., 2003; Pestoric et al., 2012; Petrova et al., 2011; Sabatés et al., 2010; Suárez-Morales et al., 2002). Notwithstanding the wide range of mesh sizes employed, there has been no effort to test the effects of different meshes on such estimates. Bouillon (1999) suggested that meshes larger than 200 μm may lose smaller hydromedusae however this hypothesis has not been tested yet. The lack of this knowledge complicates both the choice of appropriate mesh size and direct comparisons of samples – or studies – made with different meshes. Aiming to improve the knowledge of quantification of planktonic hydrozoans, in the present study we tested the hypothesis that meshes with pores sizing 200 and 500 μm provide different results regarding abundance and assemblage structure.

2. Material and methods

2.1. Study site and sampling methods

Babitonga Bay is a subtropical estuary located in the state of Santa Catarina, south Brazil (26.3°S; 48.7°W). The estuary has an area of ~130 km^2, average depth of 6 m, and is bordered by extensive mangroves (Cremer et al., 2006). Its high biological productivity sustains a high abundance and diversity of phytoplankton and zooplankton (Brandini et al., 2006; Nogueira Júnior, 2012). Eight surveys were done on a seasonal basis between October 2007 and August 2008. On each cruise nine stations were sampled along the estuary (Fig. 1), totalizing 72 stations. On each station, two conical plankton nets were simultaneously obliquely hauled side-by-side between 2 and 5 min integrating most of the water column, one with 200 and other with 500 μm mesh–pore, 40 and 50 cm in mouth diameter respectively. The hauls were all made during daylight (between 9 a.m. and 3 p.m.) and speed was kept low, around 1.5 knots. Both nets were fitted with a calibrated mechanic flowmeter, and samples were fixed in 4% formaldehyde seawater solution.

2.2. Analysis of samples

In laboratory whole samples were analyzed under stereomicroscope and the hydrozoans sorted, identified and quantified. Voucher specimens of most species were deposited at the Zoology Museum from São Paulo University (Museu de Zoologia da Universidade de São Paulo; MZUSP 1578–1582, 1584–1632), and their taxonomy discussed in a previous study (Nogueira Júnior, 2012). The abundant hydromedusa *Liriope tetraphylla* was further classified as juvenile or adult. The former was characterized by the absence of gonads and undeveloped gastric peduncle (Nagata et al., 2014). Siphonophores calycophoran colonies were quantified as anterior nectophores and bracts. The unique physonect species sampled, *Nanomia bijuga*, was not included in the present analysis due to the well-known difficulties in accurate quantifying physonects from net samples. Medusae's bell diameter and siphonophore's largest width (both for polygastrics and eudoxids) were measured.

2.3. Data analysis

Community indexes such as Pielou's evenness (J) and Shannon–Wiener diversity (H′) were calculated for each sample (n = 72 for each mesh). Species richness, ecological indexes, and abundances of individual taxa estimated with both meshes were compared using a paired t test (Zar, 2010). A permutational multivariate analysis of variance (PERMANOVA) was used to test whether taxonomic and size structure of hydrozoan assemblage changed according to mesh size, sampling months, sampling sites and possible interactions between these factors. Both analyses were based on a Bray–Curtis similarity matrix constructed on the log (x + 1) transformed densities of each taxa or size class from all samples (n = 72 with each mesh). Significance of PERMANOVAs was evaluated by the pseudo-F statistic (Anderson et al, 2008) after 999 permutations. In case of significant differences ($P < 0.05$) the taxa and/or size classes most contributing to the differences were recognized using a similarity percentage analysis (SIMPER, Clarke and Warwick, 2001). The collection efficiency of the 500 μm mesh (CE_{500}, %) in relation to the 200 μm mesh was calculated as follows: $CE_{500} = (Ab_{500} * 100)/Ab_{200}$; where Ab_{500} and Ab_{200} are abundance estimated by 500 and 200 μm meshes respectively. To estimate monthly CE_{500} we used the monthly average abundance estimated with each mesh.

3. Results

3.1. Taxonomic and size class composition

A total of 31 hydromedusae and three calicophoran species were sampled, beyond actinula larvae (online supplementary Table 1). Among these 35 taxa, *Laodicea minuscula* (n = 8 individuals), *Corymorpha forbesi* (n = 9), *Amphinema dinema* (n = 1), and *Hydractinia* sp.2 (n = 1) were exclusively sampled by the 200 μm mesh, while *Eirene* sp. (n = 2) and *Stauridiosarsia reesi* (n = 6) were exclusively sampled by the 500 μm mesh. Although total number of species was similar in both meshes (33 and 31 species in 200 and 500 μm meshes respectively), the coarse mesh underestimated species richness in smaller size classes, particularly those <0.5 mm (7 against 17 species), and retrieved slightly more species than the 200 μm mesh in size classes >1 mm (Fig. 2a). Hydrozoan size composition and abundance were markedly different in the two meshes employed. Most hydrozoans retrieved by the 200 μm mesh were smaller than 1 mm,

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