Regional Studies in Marine Science 9 (2017) 62–68

Contents lists available at ScienceDirect

Regional Studies in Marine Science

journal homepage: www.elsevier.com/locate/rsma

What do we know about soft-bottom elasmobranch species richness in the Colombian Caribbean and of its spatial distribution?

Camilo B. García

Departamento de Biología, Universidad Nacional de Colombia, Carrera 45 # 26-85, Bogotá D. C., Colombia

ARTICLE INFO

Article history:
Received 5 August 2016
Received in revised form
5 November 2016
Accepted 7 November 2016
Available online 21 November 2016

Keywords:
Soft-bottom
Elasmobranchs
Species richness
Colombian Caribbean

ABSTRACT

A spatial analysis of soft-bottom elasmobranch species richness in Colombian Caribbean waters is presented. A list of 90 species names was compiled of which for only 63 georeferenced occurrences could be located. Nevertheless, global richness completeness analysis suggests that the magnitude of total species richness is correct. In spatial terms, however, knowledge of richness is partial as none of the spatial units, in which the general area was divided, reached 100% completeness. Ecoregions Guajira, Magdalena (Golfo de Salamanca), Palomino and Darien concentrated spatial units with higher observed and predicted species richness than elsewhere. One additional spatial unit each with high species richness is predicted for ecoregion Arco and Palomino. These ecoregion and spatial units are then candidates for closer scrutiny as potential areas of protection and conservation of Colombian Caribbean elasmobranchs. Further exploration efforts are needed both in terms of georeferenced occurrences and with depth.

1. Introduction

Completing species lists for areas or regions is important in itself, but concerning management and conservation needs, lists just provide a partial picture of biodiversity. The spatial distribution of species richness (richness, from hereon) constitutes the macroecological trait that might translate the knowledge gained in species composition into effective action (management, conservation, etc.).

In the Colombian Caribbean biodiversity knowledge of elasmobranchs, the most speciose group among cartilaginous fishes (1139 Valid species according to Weigmann, 2016), is quite advanced. Elasmobranchs are alluded to in a variety of publications. Notably, Puentes et al. (2009, see contributions therein) seek to synthetize knowledge on elasmobranchs from several points of view while Mejía-Falla et al. (2011, see contribution there in) provide a guide for identification plus biological notes including general distribution (not georeferenced), for sharks, rays and chimeras in marine Colombian waters. Mapping marine richness, and in particular elasmobranchs richness, is, however, a new endeavour in Colombia. Identification of locations of conservation interest in terms of high species richness is paramount in the purpose of management and protection of biodiversity. It is well known that elasmobranch fishes are highly vulnerable to human activities, e.g. fishing, due to their life-history characteristics (large size, low fecundity, late reproduction, Ferretti et al., 2010; Field et al., 2009) hence the urgency of their protection.

In this work, I present and discuss, (1) a compiled list of demersal soft-bottom elasmobranchs (sharks and rays) based on relevant published work, and (2) based on the species for which georeferenced occurrences (occurrences, from hereon, implying availability of latitude and longitude) could be located, maps of (1) occurrences, (2) observed richness, (3) estimates of asymptotic (predicted) richness and (4) estimates of completeness of inventories in a number of spatial units or cells along the Caribbean coast of Colombia. This study, focused on the spatial distribution of demersal soft-bottom elasmobranchs richness, provides an assessment of areas well surveyed versus areas in need of further exploration and is therefore conceived as an objective input for management and conservation plans for Colombian Caribbean elasmobranchs.

2. Materials and methods

A list of Colombian Caribbean soft-bottom elasmobranchs was composed based on four sources: Mejía-Falla et al. (2007, 2011), Álvarez-León et al. (2013) and García and Armenteras (2015). In the case of the first three works mentioned above the status of species as belonging to the demersal soft-bottom assemblage was assigned according to the description of habitat for each species as found in FishBase (Froese and Pauly, 2015). As for García and Armenteras (2015), their work is based on demersal soft-bottom research surveys (historical and recent cruises and otherwise). Thus, by

E-mail address: cbgarciar@unal.edu.co.

http://dx.doi.org/10.1016/j.rsma.2016.11.006
2352-4855/

definition all the elasmobranchs listed there are demersal soft-bottom dwellers. It should be noted that García and Armenteras (2015) cover the time period from 1964 to 2010, depths from 0 to 1800 m and span the complete latitude gradient corresponding to the Colombian Caribbean Sea.

Occurrences for the species in the list were obtained from sources in García and Armenteras (2015, see their Table 1, p. 19, for details) and from GBIF database (Global Biodiversity Information Facility, http://www.gbif.org). GBIF data were obtained via the importing routine of the free software ModestR (http://www.ipez.es/ModestR; García-Roselló et al., 2013) and filtered as to exclude occurrences outside the Colombian Caribbean (also excluding San Andrés and Providencia archipelago). Further GBIF and García and Armenteras (2015) occurrence data were crosschecked in order to avoid duplicates. Two species in García and Armenteras (2015), hence with occurrences, where excluded from the compiled list and spatial analysis: *Atlantoraja cyclophora* because its distribution does not include the Western Tropical Atlantic, and *Pristis pectinata* because *Pristis* species are most likely exinct in Colombian Caribeean waters (Gómez-Rodríguez et al., 2014). In fact, occurrences for this species in García and Armenteras (2015) pertain to encounters in the late sixties.

Spatial distribution and completeness (percentage representing the observed versus the predicted number of species) analyses of richness were conducted via the KnobR application of the free software RWizard (http://www.ipez.es/RWizard). RWizard is an open source interface designed to facilitate the interaction with R (R Core Team, 2015), while KnobR is an R application specifically designed to work in the RWizard environment. KnobR uses the functions specpool, estimateR, specaccum of the package vegan (Oksanen et al., 2014) and the function ICE (Incidence Coverage-based estimator) of the package fossil (Vavrek, 2014).

A spatial unit size of 15 by 15 min was chosen as a good compromise to display results in maps. This resulted in 63 spatial units or cells. Further arguments were as follows: method = "incidence" (presence–absence data), cutoff (threshold representing the ratio between the number of database records and the number of species. If this ratio is lower than the selected threshold, the cell is considered non-informative) = 1, cutoffCompleteness (if the value of completeness is lower than this threshold, the cell is considered as non-informative) = 10.

The selection of estimator of asymptotic richness required some caveats. Runs with each one of the estimators offered in RWizard for incidence data (Chao, ICE, first order jackknife, second order jackknife and bootstrap; see Gotelli and Chao (2013) for a description of the estimators) were examined for pathological behaviour. The estimator ICE was then excluded from further consideration as its estimates were unrealistic. For instance, for a cell with 11 observed species it predicted as much as 366 species as asymptotic richness. The other estimators behaved within plausible numbers ranging an average of 8 (bootstrap) to 16 (Chao) predicted species per cell for an average of 7 observed species per cell. The performance of species richness estimators is dependent on assemblage attributes (species abundance distribution, spatial aggregation, species detection probability, etc.) and sampling design and effort (Reese et al., 2014). My data are heterogeneous in the sense that they include diverse surveys and cruises with different designs and different spatial and temporal coverage (García and Armenteras, 2015). Thus, as the appropriateness of any one estimator over the other cannot be evaluated, the estimation of asymptotic richness used per cell was chosen to be the mean value of the estimators except ICE.

Furthermore, global estimation of richness and hence completeness for the entire dataset was assessed via the free online software SpadeR (Chao et al., 2015). In this case, the data were treated as of the "species frequency" type, equating number of occurrences with frequency per species. In order to highlight localities along the Colombian Caribbean the ecoregions scheme proposed by INVEMAR (INVEMAR, 2000; see also Acero and Díaz, 2003) is used.

3. Results

A total of 90 elasmobranchs species names were found as present in the soft-bottom habitat of the Colombian Caribbean Sea (Table 1). General distributions as including Colombian Caribbean and/or neighbouring waters, be it Central America, Gulf of Mexico, Caribbean islands and/or north-east South America, i.e., tropical America (Western Tropical Atlantic), were corroborated in FishBase, GBIF, Chondrichthyan Tree of Life (http://sharksrays.org) and Shark References (http://shark-references.com). Of these 90 species names, occurrences were found for only 63 species (670 occurrences, Table 2).

As many as 22 species names were exclusively found in Álvarez-León et al. (2013) but for three of these species, occurrences were found in GBIF, which left 19 species names in need of georeferenced confirmation. However, the presence of these 19 species in Atlantic tropical America was checked as described above, thus their presence in Colombian Caribbean waters is not implausible (see Table 1).

Eight species names were found only in García and Armenteras (2015), thus with occurrences as defined above, while all the species names found in Mejía-Falla et al. (2007) and Mejía-Falla et al. (2011) were also found in one of the other sources or both. On the other hand, of the 20 species names common only to Álvarez-León et al. (2013) and Mejía-Falla et al. (2007) and Mejía-Falla et al. (2011) no occurrence was located for 11 species names, thus these species await georeferenced characterization of their distribution in Colombian Caribbean waters (see Table 1). As in the case above, the distribution of these 11 species in neighbouring waters or waters including Colombia was checked as described above.

Table 3 shows the estimated richness in the whole study area according to several indices. All indices covered the number of soft-bottom elasmobranchs species potentially inhabiting Colombian Caribbean waters (90) in their 95% confidence limits (Table 3), which at least confirms the magnitude of elasmobranchs richness in these waters.

Fig. 1 shows the distribution of occurrences that forms the base of this study. Figs. 2, 3, and 4 show the observed distribution, the predicted distribution and the spatialized completeness of richness, respectively, of soft-bottom elasmobranchs in the Colombian Caribbean Sea. Not surprisingly, spatialized observed and predicted richness coincide in general terms with high value cells in ecoregions Guajira, Palomino, Magdalena (Golfo de Salamanca), and Darién (one single cell, rather offshore, Figs. 2 and 3). Notice the appearing of a cell of high-predicted richness in ecoregion Arco (coralline archipelagos) and in ecoregion Palomino but offshore, respectively (Fig. 3).

Fig. 1 suggests that the central and northern part of Colombian Caribbean coast have received more attention than elsewhere. Significant positive correlations between latitude and occurrences (Spearman rank coefficient $= 0.30$, $n = 63$, $p < 0.05$) and latitude and observed richness (Spearman rank coefficient $= 0.28$, $n = 63$, $p < 0.05$) reinforces this impression. However, no significant correlation was found between latitude and predicted richness (Spearman rank coefficient $= 0.22$, $n = 63$, $p > 0.05$) or latitude and completeness (Spearman rank coefficient $= -0.01$, $n = 63$, $p > 0.05$). Inspection of the maps for predicted richness (Fig. 3) and completeness (Fig. 4) confirms the lack of a latitudinal gradient in this respect. Thus, the indices (their mean value, see