

DOCUMENTING THE MARINE BIODIVERSITY OF BELIZE THROUGH FISHBASE AND SEALIFEBASE¹

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ABSTRACT

There is a large body of published material available on the marine biodiversity of Belize, including well over 1,000 scientific papers and other documents available online, notably through the Biodiversity and Environment Data System of Belize (BERDS). A large fraction of these publications were based on work done by the Smithsonian Institution in Belize, especially in Carrie Bow Cay. We briefly review the nature of these documents, which were used to enhance the contents of FishBase (www.fishbase.org) and SeaLifeBase (www.sealifebase.org) on fish and other metazoans, respectively. Jointly, these databases not only allow for a near complete inventory of the marine biodiversity of Belize (especially if completed by AlgaeBase; www.algaebase.org), but also will support detailed reviews and impact assessments, via the biological data that these databases make readily accessible.

INTRODUCTION

The Belize Barrier Reef, a UNESCO World Heritage Site, is the longest in the Atlantic (Gibson, this volume), comprising a major part of the world's second largest barrier reef, i.e., the Mesoamerican Reef (Cherrington *et al.*, 2010), which is one of the 43 marine priority ecoregions identified in Olson and Dinerstein (2002). Belize, which ranked 46th of 103 countries assessed for fish biodiversity by Baer (2001), is in the Western Caribbean (ranked 12th in terms of number of species and 9th in terms of endemism of 18 biodiversity hotspots worldwide; Roberts *et al.*, 2002; see also Myers *et al.*, 2000).

The region has been the object of marine biology studies, mainly by the continued efforts of the Smithsonian Institution for over 37 years (see Ruetzler, 2009). The various papers in this volume attest to the science and the wealth of knowledge that has been gathered on Belize marine biodiversity.

Meerman (2005) documented, through the Biodiversity and Environmental Resource Data System for Belize (BERDS; <http://www.biodiversity.bz>), 7,000 profiles of terrestrial and aquatic species, the best known being vertebrates and vascular plants. BERDS assembled this comprehensive account of Belizean biodiversity from several source databases, including FishBase as the source of all fish data (freshwater, brackish and marine). Meerman (2005) does not provide information on marine invertebrates. Miloslavich *et al.* (2010), though with a regional focus, provides some estimates of the number of species occurring in Belize for some groups of marine invertebrates. However, there is still not one authoritative list of the marine fauna of Belize, one of the important food and economic resource, if not the first, on which many Belizeans depend (see, e.g., Cisneros and Sumaila, Harper *et al.*, and Kirkwood and Matura-Shepherd, this volume).

This contribution aims to compliment the results of Meerman (2005), which mainly covers terrestrial organisms, with an improved coverage of marine life in Belize, from marine mammals to invertebrates, through FishBase and SeaLifeBase and with reference to AlgaeBase (www.algaebase.org) which provides a list of the algae found in Belize.

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MATERIALS AND METHODS

The BERDS online version was consulted to obtain a preliminary list of the marine biodiversity of Belize as well as a preliminary bibliography of the scientific literature. This also gave us an idea of what the BERDS is missing in terms of large marine invertebrate groups, on which we can perform subsequent targeted searches. We then focused on large repositories of scientific literature notably that of the online archives of the Smithsonian Institution, the Biodiversity Heritage Library, the Aquatic Science and Fisheries Abstracts, Google Scholar and Web of Science, which we combed through using 'Belize' or 'British Honduras' and 'marine' as general keywords. We also made a general Google search for magazine, newspaper and blog articles that matched these keywords. Later, more targeted searches using the scientific names of taxa coupled with 'Belize' or 'British Honduras' were made, notably for the groups which were not particularly well covered by BERDS. Once these searches were exhausted, a regional search using keywords 'Caribbean' and 'Meso-America' were performed. All available literature was downloaded in PDF format, while literature for which electronic copies were not available were noted in a bibliographic Excel worksheet.

Taxonomic data for non-fish metazoans were checked against WoRMS (www.marinespecies.org) and the Catalogue of Life (CoL; www.catalogueoflife.org). Valid species names (i.e., names stamped by a WoRMS or CoL taxonomic editor) and their related synonyms were encoded in SeaLifeBase. Literature on fish species were submitted to the FishBase team, where the same taxonomic validation process was followed using the Catalog of Fishes. Species specific ecological and biological data were extracted after the valid species name has been cleared.

RESULTS AND DISCUSSION

More than 1,000 references were found to match the search terms employed here, more than 600 of which contained the type of information that can be accommodated in FishBase and SeaLifeBase. Figure 1 summarizes the types of references used in this exercise, about half of which were published in peer-reviewed journals. This is probably an indication of their accessibility via the World Wide Web rather than of their relevance to the subject. Books, book chapters and reports accounted for about 40% of these references while the rest came from online databases and references (Figure 1). More than 400 references, not included in this analysis, but which are listed in the bibliographic list made available through the *Sea Around Us* home page (at www.seaaroundus.org, under 'Hot Topic', link to the 'Too Precious to Drill' conference website), contained more general information on geology, resource management and ecosystem functioning.

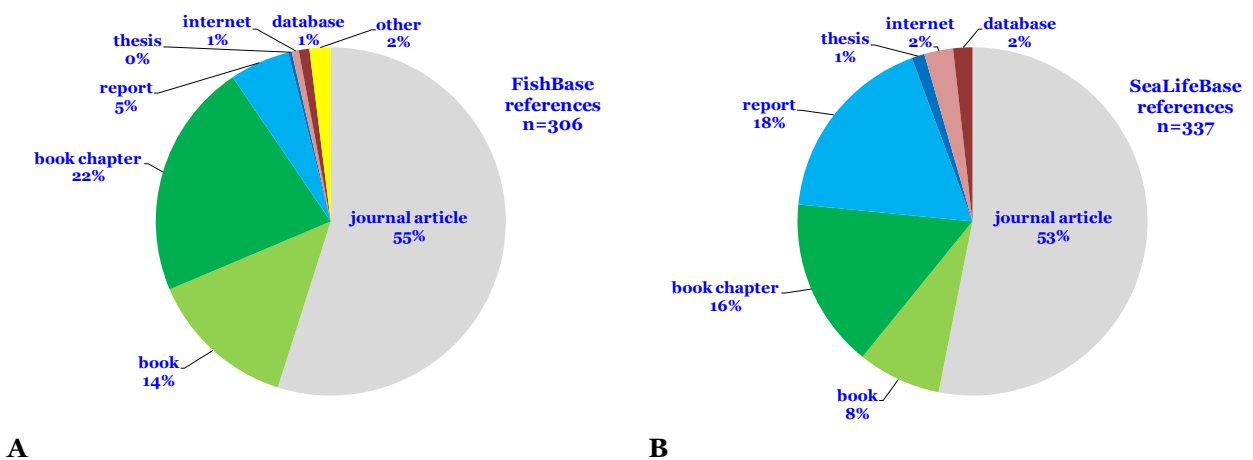


Figure 1. Types of references (total number=643) used in FishBase (A; for fish species) and in SeaLifeBase (B; for all other marine metazoans) for Belizean species (see detailed list in Appendices A and B, respectively). This does not include the more than 400 references which document geological, management and other policy issues in Belize, which are made available as a bibliographic list in the Conference website available through the *Sea Around Us* home page (see 'Hot Topic' at www.seaaroundus.org).

Four references used as 'Main Reference' for Belize in FishBase account for a third of the about 600 marine fish species currently available in FishBase, i.e., Claro (1994; 86 species), Acero (1985; 50 species), Greenfield and Thomerson (1997; 43 species), and Randall (1996; 36 species). Following these, are 13 references each of which document between 10-21 species representing over 28% and another 120 references each documenting between 1-9 species representing 38% of the Belizean fish species documented in FishBase. A detailed list of these references is included in Appendix A.

Three references used as 'Main Reference' for Belize in SeaLifeBase account for about half of the about 2,300 Belize non-fish species currently included in SeaLifeBase, i.e., Miloslavich *et al.* (2010; 667 species), Bright (2010; 206 species) and Guiry and Guiry (2009; 137 species). Following these are, *viz.*: 5 references documenting 40-70 species each which account for 12%, i.e., Hendler and Pawson (2000), Diaz and Ruetzler (2009), Rocha *et al.* (2005), Diaz and Erseus (1994) and Gischler and Ginsburg (1996); 33 references documenting between 10-38 species each, which make up 29%; and 117 references documenting between 1-9 species each, which make up the rest, i.e., 14% of Belizean non-fish species in SeaLifeBase. A detailed list of these references is included in Appendix B.

FishBase currently contains 552 bony fishes native to Belize (Pisces; Actinopterygii), 86% of which are found strictly in marine waters, 14% exist in marine and brackish waters, 9% are found in all aquatic environments (see Table 1), 1 is endemic and 1 exists only in brackish waters (see Table 2). FishBase has 28 species of Belizean sharks and rays (Pisces; Elasmobranchii), 13 occurring strictly in saltwater, 12 in marine and brackish waters and 3 in all aquatic environments (see Table 1). Meerman (2005) used the 2005 version of FishBase, which accounted for 669 marine and freshwater species of fish without identifying which ones are truly freshwater and truly marine species. In Table 1 we document, from the 2011 version of FishBase, 580 native and endemic fish species occurring in Belize marine waters, i.e., not including the truly freshwater species, after identifying and excluding misidentifications, erroneous and questionable species. Note that we cannot claim that this list is complete, notably since Chapman *et al.* (this volume) reports at least 18 species of sharks in Glover's Reef and Turneffe Atoll, and Lobel and Lobel (this volume) reports new species of gobies and wrasses waiting to be described. We can, however, claim that as of June 2011, FishBase contains the most authoritative list of fish species for Belize (go to www.fishbase.org, scroll down to 'Information by Country', choose Belize in the dropdown list, and click on the 'All Fishes' radio button).

SeaLifeBase, on the other hand, currently contains 2,272 species of native and endemic non-fish organisms from Belize, 86% of which are found strictly in marine waters, 12% in both marine and brackish waters, 5 are found in all aquatic environments, 1 in brackish waters only and 1 is endemic to Belize (see Table 2). The SeaLifeBase species counts presented in Table 1 compare fairly well with that of previous species counts for Amphipoda, Ascidiacea, Aves, Mammalia, Reptilia, Scleractinia, Echinodermata, and Mollusca. In addition, it is very close to those for Hydrozoa and Porifera. Again, we cannot claim that we have all of the marine organisms that can be found in Belize as we still have more than 400 references which we have not included in this analysis, i.e., because they deal with management issues, and the contributions in this volume, which may include a few species which have not yet been encoded, e.g., the deep-water corals in Henry (this volume). Note also the questionable species in Table 2, which though not included in the counts presented in Table 1, may become valid at some point in time. In the same manner as for fish species, recent sampling surveys may yet identify new species (see, e.g., the sea fan reported by Lobel and Lobel, this volume). However, we can claim that SeaLifeBase provides a first compendium of this kind for the marine non-fish metazoans of Belize comparable to that of BERDS for terrestrial organisms.

To get access to this list of species, go to www.sealifebase.org, scroll down to 'Information by Country', choose Belize in the dropdown list, and click on the 'All Species' radio button. The lists that the FishBase and SeaLifeBase web sites provide will include all species, i.e., native, endemic, introduced, questionable, error and misidentifications. Users are thus requested to carefully look at the list and to use only endemic and native species (and include with caution, introduced species) for checklist purposes.

This contribution demonstrated that published literature, if mined with care in a systematic and exhaustive manner, can lead to a preliminary authoritative list of marine and/or aquatic species in a country. We encourage experts on the marine biodiversity of Belize to validate the list that FishBase and SeaLifeBase has assembled. We also hope that this preliminary list will facilitate the efforts of the marine science and conservation community in Belize (and world wide) to build what is now a long overdue list of

marine flora and fauna of Belize, which can help, notably in efforts such as the ‘Too Precious to Drill’ campaign to inform Belizeans of what they stand to lose if oil drilling is permitted in their offshore and marine protected areas.

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Table 1. Number of native and endemic species occurring in Belize so far included in the July 2011 versions of FishBase (for Pisces) and SeaLifeBase (for all other groups) as compared with independent estimates by group. Phyla and Classes are here presented in alphabetical order (as opposed to phylogenetical order) documented using more than 600 references (see Figure 1). Note that though coverage of SeaLifeBase for certain groups, e.g., Scleractinia, appear sufficient, this list is not and will not be complete as the work on surveying and identifying, probably new and endemic species, continue (see, e.g., Lobel and Lobel, this volume).

Phylum	Class	marine	brackish	marine brackish	fresh, brackish marine	Total	Remarks
Annelida	Clitellata	50	–	1	–	51	
Annelida	Polychaeta	128	–	2	–	130	
Arthropoda	Malacostraca	190	1	14	1	206	24 species of Amphipoda in Miloslavich <i>et al.</i> (2010); SeaLifeBase documents 37 species of Amphipoda
Arthropoda	Maxillopoda	34	1	–	–	35	
Arthropoda	Ostracoda	3	–	–	–	3	
Arthropoda	Pycnogonida	33	–	–	–	33	
Bacillariophyta	Coscinodiscophyceae	1	–	–	–	1	
Bryozoa	Gymnolaemata	36	–	–	–	36	
Bryozoa	Stenolaemata	1	–	–	–	1	
Chlorophyta	Bryopsidophyceae	37	–	14	–	51	
Chlorophyta	Chlorophyceae	2	–	–	–	2	
Chlorophyta	Ulvophyceae	31	–	9	–	40	
Chordata	Amphibia	1	–	–	1	2	
Chordata	Ascidiacea	67	–	14	–	81	70 species in Goodbody (2000, cited in Gibson, this volume)
Chordata	Aves	33	–	–	–	33	21 historically occurring species in Jones and Balderamos (this volume); 37 in Paleczny (this volume)
Chordata	Mammalia	25	–	2	1	28	3 species of manatees in Auil-Gomez (this volume); 2 dolphins in Hines (this volume); 7 Cetacea and 1 Sirenia in Meerman (2005); SeaLifeBase documents 26 Cetacea, 2 Carnivora and 1 Sirenia
Chordata	Reptilia	4	1	4	1	10	7 species of Testudines, 2 Crocodylia and 111 Squamata (including terrestrials) in Meerman (2005); SeaLifeBase documents 4 sea turtles, 4 sea snakes and 2 crocodiles

Table 1. Continued.

Phylum	Class	marine	brackish	marine brackish	fresh, brackish marine	Total	Remarks
Ciliophora	Oligohymenophorea	–	–	1	–	1	
Cnidaria	Anthozoa	119	–	–	–	119	61 coral species in Fenner (1999, cited in Gibson, this volume); 51 Scleractinia in Miloslavich <i>et al.</i> (2010); 45 reef-building corals in Bright and Lang (2011, cited in Gibson, this volume); 6 cold-water species in Henry (this volume); SeaLifeBase documents 72 species of Scleractinia
Cnidaria	Cubozoa	1	–	–	–	1	
Cnidaria	Hydrozoa	32	1	70	–	103	117 Hydrozoa species in Henry (this volume)
Cnidaria	Scyphozoa	3	–	–	–	3	
Cyanobacteria	Not assigned	16	–	3	–	19	
Dinophyta	Dinophyceae	20	3	2	–	25	
Echinodermata	Asteroidea	19	–	–	–	19	134 species of Echinodermata in Miloslavich <i>et al.</i> (2010); SeaLifeBase documents 136 species (Asteroidea to Ophiuroidea)
Echinodermata	Crinoidea	5	–	–	–	5	
Echinodermata	Echinoidea	23	–	5	–	28	
Echinodermata	Holothuroidea	26	–	–	–	26	
Echinodermata	Ophiuroidea	58	–	–	–	58	
Foraminifera	Polythalamia	27	–	–	–	27	
Gnathostomulida	Not assigned	21	–	–	–	21	
Kinorhyncha	Not assigned	6	1	11	–	18	
Mollusca	Bivalvia	148	2	2	–	152	580 species of Mollusca in Miloslavich <i>et al.</i> (2010); SeaLifeBase documents 672 species (Bivalvia to Scaphopoda)
Mollusca	Cephalopoda	23	–	1	–	24	
Mollusca	Gastropoda	492	–	1	–	493	
Mollusca	Polyplacophora	1	–	–	–	1	
Mollusca	Scaphopoda	2	–	–	–	2	
Nemertea	Anopla	3	–	–	–	3	
Ochrophyta	Phaeophyceae	28	–	8	–	36	
Pisces	Actinopterygii	434	1	72	45	552	
Pisces	Elasmobranchii	13	–	12	3	28	18 species of Elasmobranchii in Chapman <i>et al.</i> (this volume)
Platyhelminthes	Trematoda	2	–	–	–	2	
Platyhelminthes	Turbellaria	1	–	–	–	1	
Porifera	Calcarea	3	–	1	–	4	193 species of Porifera in Miloslavich <i>et al.</i> (2010); 189 in Diaz and Ruetzler (this volume); SeaLifeBase documents 166 species (Calcarea and Demospongiae)
Porifera	Demospongiae	44	21	97	–	162	
Pteridophyta	Filicopsida	–	–	–	1	1	

Table 1. Continued.

Phylum	Class	marine	brackish	marine brackish	fresh, brackish marine	Total	Remarks
Rhodophyta	Florideophyceae	124	1	8	–	133	
Rhodophyta	Rhodellophyceae	1	–	–	–	1	
Sagenista	Bicosoecophyceae	–	–	1	–	1	
Sipuncula	Phascolosomatidea	10	–	–	–	10	
Sipuncula	Sipunculidea	3	–	1	–	4	
Tracheophyta	Equisetopsida	3	–	–	–	3	
Tracheophyta	Magnoliopsida	2	–	1	–	3	
Sipuncula	Phascolosomatidea	10	–	–	–	10	
Sipuncula	Sipunculidea	4	–	–	–	4	
Tracheophyta	Equisetopsida	3	–	–	–	3	
Tracheophyta	Magnoliopsida	3	–	–	–	3	
Total		2409	33	354	53	2852	

Table 2. Endemic marine and native brackish species (included in Table 1) so far documented as occurring in Belize. Questionable fish and other metazoan species also included in the July 2011 versions of FishBase and SeaLifeBase, respectively, but not included in the list presented in Table 1. This list is not complete, notably since new, probably endemic, species are currently being described (see Lobel and Lobel, this volume).

Phylum	Class	Order	Family	Genus	Species	Status
Chordata	Asciacea	Enterogona	Didemnidae	<i>Trididemnum</i>	<i>hians</i>	endemic marine
Pisces	Actinopterygii	Perciformes	Labridae	<i>Halichoeres</i>	<i>socialis</i>	endemic marine
Pisces	Actinopterygii	Siluriformes	Ariidae	<i>Cathorops</i>	<i>belizensis</i>	native brackish
Arthropoda	Pycnogonida	Pantopoda	Ammonotheidae	<i>Ascorhynchus</i>	<i>serratus</i>	questionable marine
Mollusca	Gastropoda	Heterostropha	Omalogyridae	<i>Ammonicera</i>	<i>circumcirra</i>	questionable marine
Mollusca	Gastropoda	Neotaenioglossa	Rissoidae	<i>Alvania</i>	<i>moolenbeeki</i>	questionable marine
Pisces	Actinopterygii	Perciformes	Serranidae	<i>Alphestes</i>	<i>afer</i>	questionable marine
Pisces	Actinopterygii	Pleuronectiformes	Paralichthyidae	<i>Paralichthys</i>	<i>albigutta</i>	questionable marine
Pisces	Elasmobranchii	Torpediniformes	Narcinidae	<i>Narcine</i>	<i>brasiliensis</i>	questionable marine
Pisces	Actinopterygii	Perciformes	Serranidae	<i>Mycteroperca</i>	<i>microlepis</i>	questionable marine & brackish
Porifera	Demospongiae	Haplosclerida	Petrosiidae	<i>Neopetrosia</i>	<i>proxima</i>	questionable marine & brackish
Porifera	Demospongiae	Haplosclerida	Petrosiidae	<i>Neopetrosia</i>	<i>subtriangularis</i>	questionable marine & brackish

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APPENDICES

Appendix A. FishBase references used in assigning fish species to Belize. The numbers at the beginning of each line refer to the reference code used in FishBase.

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