

CIE Review of report on “The State of Deep Coral Communities of the United States”

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Executive Summary

This report thoroughly reviews the state of knowledge of U. S. deep-water corals and their associated communities in such a way as to allow for proper management and conservation. The authors of all seven regional chapters closely adhere to the very detailed regional chapter outline, which gives cohesiveness and uniformity to the report; but, having been written by seven sets of authors, there is sometimes an unevenness in the coverage of some of the subtopics. For instance, chapter 2 has great maps but does poorly on the history of the coral taxa; chapter 3 is very good on the biology of the corals, but also does not give an adequate history of the coral taxa; chapter 5 has excellent geological and biological sections; chapter 6 has perhaps the best historical setting; chapter 7 has extensive geological and spatial distribution sections but is poor on the biological history; and chapter 8 has marvelous historical and associated organisms sections. I have given comments to improve some of these deficiencies in the chapter reviews. This unevenness is to be expected, as the authors were chosen for their knowledge of the subject matter, and not for their ability to be consistent with other reports that they may not have even read. I applaud the choice of authors for this report, all of them being experts on their particular region. If I had to choose a best chapter I would list chapters 5 and 8; conversely, chapter 4 had a major omission (the Appendix listing the taxa) and thus I could not complete its review. Likewise, I, as a reviewer, have my strengths and weaknesses. I was most attentive to the introduction (especially the history of taxonomic research), the oceanographic section, the list and discussion of the structure forming taxa, the species associations, and the conclusion; I am not well versed on the stressors on deep water corals or management of fisheries resources.

I address three general points. Throughout the account of the seven marine regions of the U. S. EEZ, there is a tendency to stress information obtained within the last 20 years, primarily as the result of submersible activity. But, deep-water corals have been collected off the US ever since Pourtalès in 1867. Indeed, he named 59 new species by the time he died in 1880, and Moseley (1881), who wrote the Challenger report, laid the foundation for deep coral taxonomy and zoogeography. My point is that one should not forget to mention the standard taxonomic revisions for these regions, most based on historical collections made by trawling efforts of vessels over the last 150 years. Also, one should consult museum records and living taxonomists, if possible.

Second, the word “hermatypic” is used by many of the authors, however, despite an article written by Zibrowius (1985) entitled “What is hermatypic”, most people do not understand or agree on what this word means. According to Zibrowius, hermatypic should be used only for shallow-water reef corals, and the word “constructional” used for structure-forming

deep species. Most usage in this report to this type of coral community is as “structure forming” corals, so I would urge the use of that phrase and not the controversial and often misunderstood term hermatypic.

Third, the chapter outline lists stoloniferans as structure forming corals (category IV1f), so all authors dutifully addressed that taxon, but stoloniferans are never structure forming. The same might be said for pennatulaceans (IV 1e).

In summary, I think this is a very good report, but I have made a number of constructive criticisms as well as corrections of fact (including many misspellings) and interpretation, all of which I hope the authors will have a chance to rectify before the report is submitted.

Preface, Chapter 1: Introduction

I would like to begin by making a general comment that pertains to the entire report, but most specifically to Chapter 1 and the Preface. The report clearly addresses the “structure-forming” deep-water corals in the U. S. EEZ, the authors on page 3 referring to these as a functional group in contrast to the taxonomic group of all corals. I fully understand and appreciate why this subset was selected (i.e., for ecological and conservation reasons, and because they are large), but one should not lose sight of the fact that these species represent a very small part of the whole. Concerning the stony corals (Scleractinia), the group that I know best, there are at most 14 species of structure-forming species in the world, 13 of which occur in the U. S. EEZ, but there are 615 species of deep-water Scleractinia (Cairns, 1999, in press); thus the structure-forming species constitute only 2.3% of the total number of species. The other 97.7% of the species are for the most part small (some as small as 2 mm adult size) and solitary (74% are solitary, Cairns, 2001), but they undoubtedly occur in communities - species rarely, if ever, exist in a vacuum unassociated with other organisms. Furthermore, sometimes 15-20 species are collected in the same trawl, arguing for spatial proximity. My point is that perhaps the title should read: “The State of **Structure-Forming** Deep Coral Communities of the U. S.”, as the title currently is too inclusive. Page 42 of chapter 1 suggests that this is only the first of a planned series of reports on deep coral communities - perhaps the next one could be on the other 98%.

In general, I believe that the introductory chapter is excellent, providing a guide and foundation for the remaining chapters. Definitions are important at this point, and the authors provide them for all the necessary, reoccurring terms, including the concept of “coral”, “deep water”, and “structure-forming”, as well as explaining the rationale for limiting the report to the functional group of structure-forming species, not the taxonomic group of all deep-water corals. Their classification of the different types of corals (box 1.2) is good and the various examples they give of the key species are largely accurate and nicely illustrated. The seven threats to deep-water coral communities are succinctly summarized (I was personally unaware of the threat of sand and gravel mining). Finally, the seven geographic regions within the U. S. EEZ are briefly introduced as are the eight sections about needs and research priorities. I cannot comment on “Conservation and Management Measures”.

My constructive criticism on this chapter, and probably on all of the chapters, will be on the details, which I hope will result in a better product or at least one that is more internally

consistent. I will list them by page number:

Page 4: Zibrowius (1985) could be quoted here as an excellent paper for the distinction of structure-forming (hermatypic) and non-structure-forming (ahermatypic) deep-corals and the terminology that has been applied to them. For instance, the title of Table 1.1 compares “tropical and deep hermatypic stony corals”. I would suggest “shallow-water and deep-water structure-forming stony corals”. The report should avoid the word hermatypic, as this has not been explained anywhere and is potentially confusing (see executive summary). Also, deep corals can occur in the tropics. Also, deep stony corals are global, not just potentially so.

Page 6: Don’t forget that CITES II protects corals in a big way at the international level.

Page 7 (Box 1.2): A more complete list is given in Appendix 1.2 - so this is somewhat of an overlap. It is hard to believe that a stoloniferan can be a structure-forming coral. I recommend deleting that taxon. The same is true for the Pennatulacea. Finally, the classification of the Hydrozoa is incorrect. It should read:

Class Hydrozoa

Order Anthoathecatae

Suborder Filifera (Stylasteridae: stylasterids, lace corals)

Suborder Capitata (Milleporidae: fire corals)

This information should be applied to page 18.

Page 8: The word cnidarians should be used over the word coelenterates. The paragraph under Scleractinia is confusing. The first sentence says that most scleractinians are colonial, later it says most deep water scleractinians are solitary. Indeed, most (74%, Cairns 2001) of deep water corals are solitary and because they constitute 47% of the Scleractinia, the Scleractinia have a healthy percentage as solitary - perhaps 35%. So, the authors might want to rephrase sentence 2. There are no parentheses around Vaughan and Wells, 1943.

Page 9: *Lophelia pertusa* is not pseudocolonial, but forms true colonies by intratentacular budding; the polyps are indeed connected.

Page 10: *Solenosmilia variabilis* Duncan, 1873: Duncan 1873 is not in parentheses because Duncan described *variabilis* in the genus *Solenosmilia* in 1873. In contrast *Enallopsammia profunda* (Pourtalès, 1867) is in parentheses because in 1867 Portalès placed that species in a different genus and it was subsequently transferred to the genus *Enallopsammia*. That is why the name and date are in parentheses - because of the later generic transfer. It actually has a nomenclatural significance. Change “I it occurs” to “It occurs”.

Page 11: Linnaeus, 1758 is *not* in parentheses, and it is traditional to place a comma between author and date. Zig-zag is also called sympodial branching

Page 12: *Oculina varicosa* requires author and date: i.e., Lesueur, 1821. The first sentence of *Oculina* paragraph implies that the genus *Oculina* occurs only in Gulf Stream and South Atlantic, but this genus is found throughout the Pacific. The authors mean *O. varicosa* is found at those places.

Page 13: “I.A.3.Order family Antipathidae” (remove word Order), although the report is really talking about all families here. First sentence under Antipatharia implies that all spp are branched, but many are unbranched whips.

Page 14: Under Octocorallia: place (pinnate) after word feathered, not after outward, as the tentacles are pinnate not the radiation. Lower down, one might mention that some octocorals form large calcareous axes (e.g., isidids, *Corallium*) in addition to having sclerites.

Page 15: As mentioned previously, stoloniferans should not be included in this report. Isidids can be up to 2 m in height, not just 1. The deepest isidid was collected at 4,851 m, not 3,880 m: *Echinisis persephone* Bayer & Stefani, 1987.

Page 16: Change “but is now these corals” to “but now these corals”. *Corallium* has also been found in the Straits of Florida by Bayer (1964).

Page 17: As mentioned before and implied here, pennatulids are probably not structure formers.

Page 18: Under the lace coral section: Stylasterids are known to occur to 2,700 m (Cairns, 1992a); their zooids are all interconnected by a fine reticulum of canals; they do not occur in all 7 regions, as they do not occur in the northern Gulf of Mexico; they avoid continental margins (Cairns, 1992b). See also comment on page 7 for correcting the classification: Milleporacea is not an order or a word.

Page 23: Sand mining: It is stated that most corals are found on hard substrates, but in fact 47% of the deep-water Scleractinia are unattached (i.e., free living) (Cairns, 2004) and thus are capable of living on muddy, sandy, or otherwise unconsolidated substrate. A few species, such as some turbinoliids (e.g., *Sphenotrochus*), live interstitially among sand grains. So, this paragraph should be restructured.

Page 25: A subhead equivalent to “Ocean Acidification” should be added just under Climate Change called “Ocean Warming”.

Page 26: At the end of 1st paragraph, the reference of Guinotte et al. (2006) should be cited here.

Pages 29-31: Throughout the account of the seven marine regions of the U. S. EEZ there is a tendency to stress information obtained within the last 20 years, primarily as the result of submersible activity. But, deep-water corals have been collected off the US ever since Pourtalès collected them in 1867. Indeed, he named 59 new species by the time he died in 1880, almost half of the known fauna for the eastern U. S. My point is that one should not forget to mention the standard taxonomic revisions for these regions, most based on historical collections made by

the Albatross and other vessels, e.g., Alaska (Fisher, 1938), West Coast (Cairns, 1994), Hawaii (Vaughan 1907, Cairns, 1984, 2006), Northeast coast (Deichmann, 1936, Cairns, 1981), Southeast coast (Cairns, 1979), northern Gulf of Mexico (Cairns et al., 1994), US Caribbean (Cairns, 1979).

Page 30: The endemic rate of deep-water Scleractinia in Hawaii is 48% (Cairns, 1984) and lowered to 21% by Cairns (2006). Why talk about shallow water corals here at all?

Page 31: The *Primnoa* off New England were revised by Cairns & Bayer (2005).

Pages 32-37: I am not conversant with conservation matters and therefore cannot comment on this section.

Page 40: Genetic studies could be amplified by citing some of the papers by Baco Taylor and Scott France on octocoral gene flow.

Pages 43, et seq.: The Reference section is somewhat sloppy. The journals are sometimes abbreviated, other times not. *Coral Reefs* abbreviates all journals. Some references are unfinished, or lacking pagination or other pieces of information. For instance: Baco & Cairns (contains 3 misspellings); Cairns 1979: volume 57: 341 pp., also there is no word "A" at the beginning of the title; where is pagination for Ostarello, Pourtalès, 1874 and Veron 2000; and volume and pages for Zibrowius. There are others.

Appendices 1.1, 2: Perhaps this was meant to be in color, since the hard copy I have gives the same symbol (a black dot) to denote coral species identified by regional authors and those not identified by regional authors.

Appendix 1.2: Another species, *Coenosmilia arbuscula*, is listed on page 312.

Misspellings: pages 7, 15, 16, 20 (Coralliidae); page 9 (been, as bee); page 10 (Dendrophylliidae); page 11 (Caryophylliidae); page 15 (Fabricius); p. 20 Gerardiidae; Appendix 1.1 (Nephtheidae, Enallopsammia).

To reiterate, although there are some technical issues to resolve, I think this was a fine introduction.

Chapter 2: Alaska Region

This report closely follows the regional chapter outline and provides a good foundation for assessing the deep-water coral fauna of this region. Splitting the region into five smaller subregions is a good idea, allowing for a more detailed analysis. I am impressed with the 30 distributional maps (6 taxa x 5 subregions); this represents a great deal of effort. The choice of author (Bob Stone) for this chapter is perfect, as I cannot think of anyone more qualified to

discuss or knowledgeable about this region, particularly the fauna of the seamounts in the Gulf of Alaska, which virtually no one has sampled. Their list of taxa (Table 2.1) is exhaustive, even including many as yet unidentified species, although in the cases of unidentified species one should probably put an authority or some kind of documentation. It is extraordinary that this region contains 70% of the nation's continental shelf, and good that they highlighted this in the first sentence.

My constructive criticism is mainly on the details.

Page 54: The coral diversity of the Aleutian Islands is indeed high, but it is still a fraction of that of New Caledonia or the Philippines - certainly not the highest in the world.

Page 54: The authors state that most information on coral distribution in Alaska is based on fisheries bycatch and stock assessment surveys, but this seems to ignore the taxonomic (and distributional) data reported over the last century, much of which was collected by the USFWS Albatross. This includes the seminal work on Alaskan octocorals (Nutting, 1912), and subsequent work by Bayer (1952, 1982, 1996); and on hydrocorals (Fisher, 1938); and the synthesis on scleractinian corals by Cairns (1994), as well as the general field guide by Wing & Barnard (2004). These all should at least be mentioned in the history section, if only as historical notes. Then there is the distributional resource of museum collections, which seems to be ignored as well. Their list and history of the region depends heavily on a paper by Heifetz, et al. (2005), and not the original source material and papers. Ironically Heifetz relies heavily on yet another source (Wing and Barnard, 2004), as well as museum records and the literature.

Table 2.1 (page 61): There is a line after *Clavularia* sp. A, which seems strange, and then after Order Gorgonacea there is only one dot for Seamounts, whereas surely there should be five dots for all regions as indicated for the next species *Acanella* sp. A. Was there a line shift error about here?

Page 65: Table 2.2: *Primnoa* and *Paragorgia* should be indented under Gorgonacea.

Pages 57, 65, 76: Scleractinian corals do not occur as deep as 6,328 m in the Alaskan region. This is a misinterpretation of the distribution of *Fungiacyathus marenzelleri* given in Cairns (1994: 16), who gave that depth as a worldwide depth range, 6,328 m being found in the Kurile-Kamchatka Trench. The deepest Alaskan scleractinian record is 4,620 m from the Alaskan Trench (Keller, 1976).

Page 65: Table 2.3: *Stolonifera* really should not be included as it does not form structure.

Page 66: a. Stony corals: Indeed, they are all solitary and do not form structure.

Pages 66-67: I can't help but think that the authors mean to say "contiguously distributed" instead of "contagiously distributed"?

Pages 60-77: The organization of this section of the report is a little confusing. Five subregions

are clearly distinguished and mapped (fig. 2.2), then those subregions are discussed individually but two subregions are added: Alaska Arctic and Seamounts. But the 5 categories in Table 2.1 do not correlate with either of those two organizations: 3 are the same as the original five, but both east and west Aleutians are combined, and seamounts is used as a separate category. So, whereas I am happy with the data presented, I am simply saying that it is difficult to follow the continuity of the discussion. It is interesting to note that Heifetz et al. uses 10 regions.

Page 71-72: I am also very surprised that no stylasterids were found in this region, as that would seem to be an ideal environment for this taxon (Cairns, 1992b).

Page 73: The sidehead requires the word East: “The **East** Aleutian Islands.” Then the next paragraph should be labeled “The West Aleutian Islands”.

Page 76: I cannot imagine what two scleractinian species are found in the Bering Sea, even though page 60 lists *Javania borealis* and *J. cailetti*, I don’t think those occur in the Bering. Please check.

Page 79: Commensal ophiuroids are common on primnoid octocorals.

Page 80: Sidehead “Fishing effects” should be boldface to correspond to “Non-fishing effects” on page 88.

Fig. 2.8-2.11: A black and white hard copy does not do justice to the color coded scale bars.

Page 84: 619/541,350 is 0.1%, so perhaps they can say that.

Page 88: Need a sidehead saying “scallop dredging”.

Page 89: Would algal blooms have any effect on deep water corals?

Page 100: Attempts have been made to preserve deep water corals from the bycatch of NOAA fisheries expeditions, but with little success. There seems to be little time onboard to do this. I wish that a program could be developed to keep the deep corals and preserve them at some museum for taxonomic study.

Misspellings: page 63 (petrograpta, alaskanus), page 67 (petrograpta), page 79 (actinarians).

Chapter 3: Hawaii, etc.

The chapter follows the regional chapter outline and is a useful review of the status of deep-water corals in the Hawaiian Island region. Although this EEZ includes a variety of other territories and states, the authors are correct in stating that virtually nothing is known about the deep-water corals of these other regions, and thus this report is reduced to the description of the

corals known from Hawaii. Indeed, the first recommendation (page 130) is a call for baseline surveys of the remote areas. The report has a strong biological underpinning, telling me that the authors know both the corals and fish from this region, and I know that both have enormous field experience throughout the archipelago, allowing them to make many “unpublished” observations on ecology and associated organisms. The choice of these authors to write this chapter was fortunate. Their list of species is thorough, including many undescribed species, which is another bonus of their extensive fieldwork. Their descriptions of the commercially harvested deep-water precious corals are well documented. Their conclusion is that although there are several structure-forming species in this region, there are no reef building species (Table 3.1).

My detailed comments follow:

Page 109, 116: The authors do not do much of an historical background of the Hawaiian deep-water corals, as evidenced by their statement that the earliest description of deep-water octocorals were from the 1950's. Actually the earliest octocoral reported from Hawaii was in 1846 (Dana) and Nutting (1908) reported 68 species. The unpublished dissertation of Muzik (1979) should also be mentioned as well as the listing of Grigg and Bayer (1976). As for Scleractinia, Vaughan (1907) was the basis for this taxon, and Cairns (1984, 2006) should be mentioned, as well as Wells (1954) for the Marshall Islands. As for stylasterids, please refer to Cairns, 2005. Our knowledge of deep coral biology and taxonomy did not begin with the advent of submersibles; much useful information can be obtained from the older taxonomic work that depended on trawling to collect.

Page 111: Grigg (1988) should be cited in the geological setting section.

Page 112: It would be helpful to have a figure of the surface currents.

Page 112: After three new species of stylasterids, cite Cairns, 2005.

Page 113: I think *Madrepora kauaiensis* and *M. oculata* might qualify as potential structure forming species.

Page 114: In the second paragraph, submersible observations are not the only way to obtain a true determination of coral distribution. The traditional way has been by trawling and dredging. Although this may be banned now, perhaps for scientific purposes it may be allowed some day.

Page 114: The use of the abbreviation *cf.* means *confer* (Latin for compare to), it is not *c. f.*

Page 115: None of the true soft corals are structure forming.

Page 116: Again, cite Cairns 2005 for this stylasterid information.

Page 118: *Leiopathes* n. sp., not n. Sp.

Page 133- : Journal names are not always abbreviated.

Page 138 (Appendix 3.1): The title should be changed to read ... “from the U. S. Pacific Islands” (insert U. S.), as many species are known from non-U.S. Pacific Islands. I would also recommend that the authors indicate in some way which of these species are potential structure formers.

Page 138: *A. macrolobata* depth range: 369 m ***

Page 139: *Tr. patelliformis* depth range: 1,020 m ***

Page 139: *Tr. rhombocolumna* depth range 110-530 m*

Page 139: *B. gigas* depth range 90-640 m *

Page 140: *T. coccinea* is not a deep-water species, so it should be deleted..

Page 140: *Javania exserta*: the reference is Cairns, 2006

Page 140: *Placotrochides minuta* depth range 119-291 m ***

Page 140: *Polymyces wellsii*: reference is Cairns 2006

Page 141: Delete: “(*Gardineria HI Islansensis*)”

Page 141: *M. kauaiensis* depth range: 362-538 m **

Page 141: *M. oculata*, HI, depth range 627-750 m**, (Cairns, 1984)

Page 141: *C. rachelfitzhardingae* is shallow water and should be deleted.

Pages 138-152 (Appendix 3.1): Many of the references from this appendix are not in the literature cited.

Misspellings: Pages 113, 119 (*Enallopsammia*), Page 115 (Coralliidae), Page 145 (Stefani), Page 150 (helminthophora)

Chapter 4: Northeast region (California, Oregon, Washington)

I must confess that I cannot give this chapter a thorough review, as the authors have not included a list of deep-water species from the region, as most chapters do. Furthermore, their list of structure-forming species (Table 4.2) is not complete. An Appendix is referred to many times throughout the text, always with two question marks following the word, but in my copy I do not have this Appendix. As this is one of the main things I comment on, I find it difficult to complete the review. For instance, on page 157 the authors say that 8 scleractinian species occur in this region, but Cairns (1994: Table 4) lists about 22 species from the Californian (their San Diegoan)

and Oregonian regions. Three more of these I think qualify as potential structure forming species: *Dendrophyllia oldroydae*, *D. californica*, and *Oculina profunda*. I think the authors need to check the literature more carefully. This also applies to the introductory historical paragraph where all effort prior to 1970 is summarized on one undocumented sentence. In such an historical section the seminal works of Durham & Barnard (1952), Fisher (1938), Ostarello (1973), and Cairns (1994) should be mentioned. And dates should be given for the important papers of Gray, Verrill, and Dall.

Some other details:

Page 159 (Table 4.2): *Lophelia pertusa* is listed twice. Three others should be listed (see above).

Page 160: Gorgonian section: The 25 species need to be documented in some way. Also, *Primnoa* does occur off this coast; see Cairns & Bayer (2005). It would be a potential structure forming species.

Page 160: Likewise, the lace coral species need some form of documentation (e.g., Dall, 1884).

Page 163-166: The maps of deep-water coral families are based primarily on Etnoyer and Morgan (2003), which in turn were based on uncritical museum records. In other words, the primary taxonomic sources were not consulted to make these maps.

Page 165: Change “it’s” to “its”.

Page 173 (Coral Harvest): I thought that the purple *Stylaster californica* was harvested to some extent, in that it can be bought in almost any marine curio shop for about \$50 a colony.

Page 182: The article title is missing from DeVogelaere, et al.

Page 182: The correct title of Fisher (1938) is: Hydrocorals of the North Pacific Ocean, not Lace corals...

The appendix is missing that lists the species.

Chapter 5: Northeast U. S.

This chapter follows the regional chapter outline and gives an excellent account of what we know about deep-sea corals from this region. Of all seven chapters, this is perhaps the best written and most logically presented. Their historical account of the taxonomy of the region is remarkably complete, and cites several web pages for distributional information. Not only do the authors employ the classical literature for their taxonomy, but they have also consulted several museums, and other unpublished web sites. Their breakdown into three subregions is logical, and I appreciate the extra considerations of the submarine canyons and New England Seamounts. Although they say their geological setting review is brief, I think it is the longest and most

thorough of all seven accounts. The maps are legible and meaningful. Admittedly there are not many structure forming corals in this region, and there is ample literature on the taxonomy and distribution of the species of this region; nonetheless this chapter was a pleasure to read (there are even few misspellings, which indicates a high level of care and attention to detail) .

Still, there is room for improvement. Here is my detailed constructive criticism:

Page 189: Either on this page or page 193, they should cite Cairns (1981), which gives a \ list and illustrated key of the scleractinian species that occur in this precise region. Also, here or on page 193, the citation of Cairns & Bayer (2005) should be used on the worldwide revision of the genus *Primnoa*.

Page 193: Need a year for the Hecker references. I am very glad that they dug up those Hecker reports, who did a lot of good work.

Page 194-195 (Tables 5.1-2): It would be helpful to indicate in some way which of these species are potentially structure forming - four in the case of the Scleractinia.

Page 195 (Table 5.2): *Thouarella* n. sp. is now *Th. grasshoffi* Cairns, 2006; *Gunnerus* is misspelled.

Page 196: The authors should recall that Moore et al. published another paper on the Bear Seamount in 2004, which has a lot more information.

Page 196: Cite Cairns (1992b) to support that no stylasterids occur in this region.

Pages 198-200: These maps are not labeled A and B, which is confusing because in two cases (Fig. 5.2 and 5.4) it would appear that they are presented in reverse order, B being to the left of A!

Page 204 (Table 5.4): *F. angularis* is *F. angulare*; for *Lophelia prolifera*, it should state that “it is the same as *L. pertusa*”, not “could be”.

Page 208: I am 99% sure that *Primnoa* does *not* occur on Bear Seamount. This record was taken from Houghton, et al. (1977), which is in error.

Chapter 6: Southeast U. S.

This chapter closely follows the regional chapter outline and is well written. This region contains the best developed and most extensive deep water corals in the U. S. EEZ, so the authors' task was significant. Of all seven accounts, they had the best historical introduction to previous work; the literature they consulted was broad and covered both older history as well as recent developments. Their list of species (Table 6.1) is thorough and informative and their second list of structure-forming species (Table 6.2) is a good summary. There is really little I

can criticize about this report, other than some minor inconsistencies, primarily in the list of species.

Page 226: It should state “menzies”, not “enzies”.

Page 229: They mention 52 species of “soft and horny corals”, with a total of 109 species. I think they should just say that there are 58 scleractinians (including 10 colonial), 1 zoanthid, 4 antipatharians, 7 stylasterids, 1 pennatulids, and 43 octocorals, for a total of 114. I could not get my total count to agree with theirs. This may have been due to the fact that in Table 6.1 they insert about 50 extraneous horizontal lines, which break up much of the information associated with various species. This makes the table hard to read and difficult to count as well. They may consider breaking up the extra horizontal lines.

Page 232: *Astrangia poculata* is not a solitary coral, nor is it a deep-water coral, so it really should be deleted from the list altogether.

Page 233: Date for Deichmann is 1936.

Page 235: Date of Wright & Studer is 1889.

Page 237: Although technically correct, the word “hermatypic”, used in the first line under stony corals, should probably be replaced with the phrase “structure-forming”, as most people still associate hermatypic with shallow water corals, and the focus of this entire report appears to be on structure-forming deep-water corals.

Page 243 (Table 6.2): I think *Solenosmilia variabilis* should be added as a potential structure forming coral species from this region.

Page 253: Although corals do not fall into the Endangered Species Act (ESA), they are covered by CITES II, which has an effect of protecting them from exploitation.

Page 254: Certainly deep corals from this region need more study, but in relation to the other six areas of the U. S. EEZ they are well known, and some groups better than others. For instance, deep scleractinian and stylasterids are fairly well known taxonomically, whereas octocorals and antipatharians still need a lot of attention.

Chapter 7: Northern Gulf of Mexico and Florida Keys

This chapter follows the regional chapter outline and gives a good background for the deep corals of the northern Gulf of Mexico. The chapter logically divides the region into three discrete subregions. The strong point of this chapter is the geological setting, with which the authors describe the complex geography and past history of this area. This is one of the most biologically diverse regions within the U. S. EEZ, so the authors’ task of enumerating the deep corals present (Table 7.1) was formidable; I have many comments on that list. Their biological history of the region was good but did omit some important papers, to be listed below. Finally,

their knowledge of the spatial distribution of the deep corals, providing detailed accounts of regions such as Viosca Knoll, the canyons, and even shipwrecks, is impressive and speaks to their deep experience in this region. Although I am an “authority” on this region, I learned from this report. My detailed comments follow:

Page 265 (first sentence): The authors should always qualify Gulf of Mexico with the word “northern”, as they are not reporting on the entire Gulf.

Page 271: Although correctly used, I would avoid the word “hermatypic” and use instead “structure-forming”.

Page 272-273: In a discussion of Scleractinia from the Gulf one should cite the checklist by Cairns, Opresko, Hopkins & Schroeder (1994), the authors of this report should know that paper.

Pages 274-278 (Table 7.1): This table is extremely difficult to read across the page, as various columns have been misaligned as well as running into the words from below and above. If possible, I would ask the authors to put a space between each species; that might help in the alignment.

Page 274: The title of the table should read: “... in the northern Gulf of Mexico and Straits of Florida”; the author of *C. parvula* is Cairns, 1979; *Deltocyathus hexagonus* does not occur in the Gulf, what they mean is *D. eccentricus* Cairns, 1979; *Desmophyllum cristagalli* is no more, the senior synonym is *D. dianthus* Esper, 1794.

Page 275: *Fungiacyathus crispus* is not in the family Fungiidae, rather Fungiacyathidae; *Funiculina quad.* is a pennatulid and thus misplaced in the Scleractinia.

Page 277: *Nicella flagellum* does not occur in the Gulf. This is a mistake from Giamonna (1978); year for *R. paniculata* is 1860; *K. flexibilis* (Pourtalès, 1868); *Nidalia occidentalis* Gray, 1835; Deichmann is always 1936; *Caliacis nutans* is D & M, 1864; *Echinomuricea atlantica* Johnson, 1862; *H. pendula* D & M, 1864; *P. multispina* is Deichmann, 1936; *Placogorgia tenuis* (Verrill, 1883); *Pliobothrus echinatus* is a stylasterid and thus misplaced in the octocorals; *S. guadaloupensis* (D & M, 1860).

Page 278: The authors of *C. americana delta* and *americana* are Cairns & Bayer, 2002; *Callo. verticellata* is not in Gulf, and what is most likely meant is *C. gracilis* (ME & H, 1857) - see Cairns & Bayer, 2002; *U. guntheri* Kölliker, 1880; *U. lindahlia* K., 1874; *S. laevigatus* Cairns, 1986; *S. aurantiacus* Cairns, 1986; *S. gemmascens* does not occur in the Gulf; *C. glossopoma* Cairns, 1986; *Stylaster miniatus* (Pourtalès, 1868)

Page 279: I would include *Pourtaloesmilia conferta* as a potential structure forming scleractinian species. It certainly provides habitat for other invertebrates.

Page 279: How can one review the octocorals from the Gulf without mentioning the unpublished

dissertation of Giamonna (1978)?

Page 280: Stylasterina is not a suborder, simply a family Stylasteridae. One should mention the revision of Cairns (1986) in this context.

Page 285: '*formosa*' is not capitalized.

Misspellings: page 274 (Caryophylliidae), page 276 (abietina, not abletina), page 277 (Leptogorgia); page 277 (pourtalesi); Page 278 (miniatus)

Chapter 8: U. S. Caribbean

This chapter closely follows the regional chapter outline and provides a good foundation for assessing the deep-water coral fauna of this region. This is by far the smallest of the 7 U. S. EEZ regions (Puerto Rico and Navassa) and thus the authors have reviewed what they call the “wider Caribbean region”, which may have been unnecessary, but does provide a better basis for understanding the smaller region, and by implication includes species and habitats that may yet be found in those smaller regions. This report is also the most “biological” of the seven, the authors having gone to great extent to understand and illustrate many of the species involved. Their Table 8.2 is a nicely presented descriptive and illustrative account of the structure-forming scleractinian corals. It is also refreshing to see pictures of the other types of corals on pages 319-324. It is clear that the authors have visited museums and talked to taxonomists. They have not only reviewed the historical literature, but found unpublished deck logs in order to document associated species. This was going the extra mile. Although their geological section was quite short, I think they make up for that in a nice explanation of the difference between lithoherms and deep coral mounds. I also thought that the oceanographic setting section was well done, with Table 8.1 being very informative. With the limited data available on these two small regions, I think the authors have produced a very thorough document.

My detailed comments follow:

Page 306: There is a typo in the first paragraph: “...interactions; and. Deep-sea...”.

Page 311 (Fig. 8.4-5): The labeling is too small to read on my hard copy.

Page 312: “...with a maximum reported height...” It seems that either maximum or minimum works equally well here?

Page 312: Appendix 1 should read Table 8.2.

Pages 313, 315, 376: Never capitalize species name: e.g., *Madrepora carolina*, not *M. Carolina*.

Page 314: are regarded as major... (insert word as).

Page 315: LeGoff-Vitry is not cited in the literature; Gorgonians should be labelled as b. Then on page 322 b becomes c, etc...

Page 315, 320 (Fig. 8.16): *Nicella* does not occur in the Puerto Rico Trench at 7956 m. This was a labeling error on a specimen at the Smithsonian.

Page 320 (Fig. 8.16): As mentioned before, not from this depth.

Page 322: There is a typo: height of a 25 cm (delete word a).

Page 323: Lithotelestids would never be structure forming, so this section should be deleted.

Page 323-4: They have two figures labelled as 8.27. The sequence will have to be renumbered.

Page 325 (Fig. 8.30): Captions only goes to 22, but images go to 34.

Page 326: There is a typo: “eastern siwestern side...” ?

Page 327: In my hard copy Fig. 8.31 did not print.

Page 342: Cairns 1977 is listed twice, and in both cases, misspelling Caryophylliidae.

Page 351 (Appendix 8.1): In the caption, it should say the species are alphabetically arranged; also, I recommend placing the footnotes up front.

Page 351 (Appendix 8.1): The authors should check Cairns & Chapman (2001), which has a detailed listing of the scleractinian species for this region.

Page 364: I would suggest that *Candidella imbricata* is a structure forming species.

Page 368: Therefore remove #85 from the list (see comment on page 315 above).

Page 369: Add *P. pourtalesii* var. *obtusa* as a structure former.

Page 379: Asteroidea and Asteroids are the same taxon.

Misspellings: Pages 312, 319 (*alternata*); Page 322 (*D. sulcata*); Page 326 (antipatharian); Page 354 (*pusillus*, *pharensis*); Page 364 (Windward); Page 364 (*C. elegans*); Page 365: *thrysiiformis*); Page 366 (*Junceella*); Page 372 (*tenuiseptata*, *cochleata*); Page 373 (*clavigera*); Page 374 (*erubescens*, *miniatus*).

Literature Cited

- Bayer, F. M. 1952. Descriptions and redescriptions of the Hawaiian octocorals collected by the U. S. Fish Commission Steamer "Albatross" (1. Alcyonacea, Stolonifera, and Telestacea). *Pac. Sci.* 6(2): 126-136.
- Bayer, F. M. 1964. The genus *Corallium* in the western North Atlantic Ocean. *Bull. Mar. Sci.* 14(3): 465-478.
- Bayer, F. M. 1982. Some new and old species of the primnoid genus *Callogorgia* Gray, with a revalidation of the related genus *Fanellia* Gray. *Proc. Biol. Soc. Wash.* 95(1): 116-160.
- Bayer, F. M. 1996. The gorgonacean genus *Arthrogorgia*. *Proc. Biol. Soc. Wash.* 109(4): 605-628.
- Cairns, S. D. 1979. The Deep-Water Scleractinia of the Caribbean and adjacent waters. *Stud. Fauna Curaçao Other Caribb. Isl.* 57:(180): 341 pages, 40 plates, 60 maps.
- Cairns, S. D. 1981. Marine Flora and Fauna of the Northeastern United States. Scleractinia. NOAA Tech. Rep NMFS Circ. 438: 14 pages, 16 figures.
- Cairns, S. D. 1984. New records of ahermatypic corals (Scleractinia) from the Hawaiian and Line islands. *Occas. Pap. Bernice Pauahi Bishop Mus.* 25:(10): 30 pages, including 5 plates.
- Cairns, S. D. 1986. A revision of the Northwest Atlantic Stylasteridae. *Smithsonian Cont. Zool.* 418: 131 pp.
- Cairns, S. D. 1992a. A generic revision of the Stylasteridae. Part 3. Keys to the genera. *Bull. Mar. Sci.* 49: 538-545.
- Cairns, S. D. 1992b. Worldwide distribution of the Stylasteridae. *Sci. Mar.* 56: 125-130.
- Cairns, S. D. 1994. Scleractinia of the Temperate North Pacific. *Smithsonian Cont. Zool.* 557: 150 pages, 42 plates, 3 figures.
- Cairns, S. D. 1999. Species Richness of Recent Scleractinia. *Atoll Res. Bull.* 459: 12 pages, 1 figure.
- Cairns, S. D. 2001. A Brief History of taxonomic research on azooxanthellate Scleractinia (Cnidaria: Anthozoa). *Bull. Biol. Soc. Wash.* 10: 191-203, 2 figures.
- Cairns, S. D. 2004. The azooxanthellate Scleractinia (Coelenterata: Anthozoa) of Australia. *Rec. Australian Mus.* 56: 259-329, 12 pls.
- Cairns, S. D. 2005. Revision of the Hawaiian Stylasteridae. *Pac. Sci.* 59: 439-451.
- Cairns, S. D. 2006. New records of azooxanthellate Scleractinia from the Hawaiian Islands. *Occas. Pap. Bishop Mus.* 87: 45-53.
- Cairns, S. D. in press. Deep-Water corals: an overview with special reference to diversity and distribution of deep-water Scleractinia. *Bull. Mar. Sci.*
- Cairns, S. D. and F. M. Bayer. 2005. A review of the genus *Primnoa*, with the description of two new species. *Bull. Mar. Sci.* 77(2): 225-256.
- Cairns, S. D., D. M. Opresko, T. S. Hopkins & W. W. Schroeder 1993. New records of deep-water Cnidaria (Scleractinia & Antipatharia) from the Gulf of Mexico. *Northeast Gulf Sci.* 13:(1): 11 pages.
- Dana, J. D. 1846. Zoophytes. Lea & Blanchard, Philadelphia, 7:vi + 740 pages.
- Deichmann, E. 1936. The Alcyonaria of the western part of the Atlantic Ocean. *Mem. Mus. comp. Zool., Harvard*, 53: 317 pp.

- Durham, J. W. & J. L. Barnard 1952. Stony corals of the eastern Pacific collected by the *Velero III* and *Velero IV*. Allan Hancock Pacific Exped. 16:(1): 110 pages, 16 pls.
- Fisher, W. K. 1938. Hydrocorals of the North Pacific Ocean. Proc. U. S. nat. Mus. 84: 493-554.
- Giamonna, C. P. 1978. Octocorals in the Gulf of Mexico – their taxonomy and distribution with remarks on their paleontology. PhD Dissertation, Texas A & M University, Texas, 212 pp.
- Grigg, R. W. 1988. Paleooceanography of the coral reefs in the Hawaiian-Emperor Chain. Science 240: 1737-1743.
- Grigg, R. W. and F. M. Bayer. 1976. Present knowledge of the systematics and zoogeography of the order Scleractinia in Hawaii. Pac. Sci. 30: 167-175.
- Houghton, R. L., J. R. Heirtzler, R. D. Ballard, and P. T. Taylor. 1977. Submersible observations of the New England Seamounts. Naturwissenschaften 64: 348-355.
- Keller, N. B. 1976. The Deep-Sea Madreporarian Corals of the Genus *Fungiacyathus* from the Kurile-Kamchatka, Aleutian Trenches and Other Regions of the World Oceans. Trudy Instit. Okeanol. 99: 31-44, 3 plates [in Russian, English translation deposited at Smithsonian].
- Moore, J. A, Vecchione, Collette, Gibbons, Hartel. 2004. Selected fauna of Bear Seamount, and the presence of “natural invader” species. Arch. Fish. Mar. Res. 51: 241-250.
- Moseley, H. N. 1881. Report on certain ... madreporarian corals procured by the Challenger. Rept. Challenger Exped. 2: 248 pp.
- Muzik, K. M. 1979. A systematic revision of the Hawaiian Paramuriceidae and Plexauridae. PhD Dissertation, University of Miami, 227 pp.
- Nutting, C. C. 1908. Descriptions of the Alcyonaria collected by the U. S. Bureau of Fisheries Steamer Albatross in the vicinity of the Hawaiian Islands in 1902. Proc. U. S. Nat. Mus. 34: 543-601.
- Nutting, C. C. 1912. Descriptions of the Alcyonaria collected by the U. S. Fisheries steamer Albatross, mainly from Japanese waters, during 1906. Proc. U. S. Nat. Mus. 43: 104 pp.
- Ostarello, G. L. 1973. Natural history of the hydrocoral *Allopora californica*. Biol. Bull. Mar. Biol. Lab, Woods Hole, 145: 548-564.
- Vaughan, T. W. 1907. Recent Madreporaria of the Hawaiian Islands and Laysan. Bull. U. S. Nat. Mus. 59: ix + 427 pages, including 96 plates.
- Wells, J. W. 1954. Recent Corals of the Marshall Islands: Bikini and Nearby Atolls, Part 2, Oceanography (Biologic). Geol. Surv. Prof. Pap. 260-I: 382-486, plates 94-185.
- Wing, B. L. and D. R. Barnard. 2004. A field guide to Alaskan corals. NOAA Tech. Mem. NMFS-AFSC-146: 67 pp.
- Zibrowius, H. 1985. What is hermatypic? Coral Reefs 4: 1-9.

Appendix I: Statement of Work

Subcontract Between the University of Miami and the Smithsonian Institute (Stephen Cairns) Statement of Work

CIE Review of report on “The State of Deep Coral Communities of the United States”

The NOAA Coral Reef Conservation Program has developed a draft report on the status of deep coral resources found within U.S. waters. The review by the CIE of this report is in partial fulfillment of the requirements set out in the Information Quality Act (IQA). The IQA requires independent review of influential Federal documents. The goals of the review are to evaluate whether the document presents a thorough review of the state of our knowledge regarding deep corals and their associated communities in U.S. waters that can support future deep coral management and conservation action, and to provide recommendations for improving the report. The document consists of an introductory chapter with a national summary, and seven regional chapters prepared by authors knowledgeable of deep coral communities. The report is approximately 240 pages in length, of which approximately 190 pages is 12 point, single spaced text, including references. The remaining 50 pages are photos, figures and tables.

Background

The *First International Symposium on Deep Sea Corals* was held July 30 - August 3, 2000, in Halifax, Canada. Participants in the symposium identified several major points: 1) deepwater corals comprise significant habitat for commercial fishes; 2) biodiversity levels are higher in deepwater coral aggregations than in adjacent areas; 3) fishing gear, especially trawls, are damaging deepwater corals; 4) more research is needed on the distribution, life history (especially larvae), and taxonomy of deepwater corals; 5) individual deepwater corals reach ages measurable in centuries, and certain species, such as *Lophelia*, form reef-like structures that can reach ages measurable in millennia; and 6) these ecosystems are in need of conservation through the establishment of marine protected areas, and the curtailment of trawl fishing on coral aggregations. Since this first symposium, there has been a rapid increase in both the number of studies aimed at understanding deep corals and the calls for their protection.

The President’s Ocean Action Plan calls upon NOAA to produce a report detailing the state of our knowledge of deep coral communities in the U.S. Exclusive Economic Zone and to further the President’s agenda to research, survey and protect deep coral communities. As fisheries and other human activities move into deep waters, it is important to understand the location of potentially vulnerable deep coral habitats, their importance to biological diversity and potential role as essential fish habitat. In U.S. waters deep corals primarily occur in Federal waters rather than in state waters. As fisheries in Federal waters require permits, NOAA has an obligation to protect trust resources from overexploitation and base decisions regarding permitting on the best available science. The report on “**The State of Deep Coral Communities of the United States**” is designed to review current understanding of deep coral communities in U.S. waters and their

role in ocean ecosystems, as well as serve as a baseline for future research and management activities.

CIE Review

The CIE shall provide three reviewers with nationally and internationally recognized expertise in the following fields.

- Deep coral biology/taxonomy - Expertise in the distribution, biology, taxonomy or ecology of deep-water (cold-water) corals (e.g., deep-water stony corals, octocorals, black corals and stylasterid corals).
- Biogeography – Expertise in the biogeography of deep coral communities as well as associated fauna and flora.
- Fish ecology/deep sea biology - Expertise in the distribution, abundance and biology of deep sea fishes or other deep sea marine organisms and their interaction with the environment.
- Marine conservation biology - Expertise in the protection, restoration and sustainability of marine biological diversity, and the science necessary to achieve such goals.
- Fisheries management - Expertise in the conservation and management of marine fisheries species, especially deeper-water demersal fishes and the impacts of fishing gear on marine habitats.

Knowledge of marine ecology, taxonomy and deep coral biology, as well as a familiarity with the mandates governing deep coral conservation are highly desirable. All of the reviewers must have a common thread of expertise in the field of deep corals.

Each reviewer's duties shall occupy a maximum of 6 workdays (i.e., a few days for document review and a few days to prepare a Review Report). The reviewers shall review the report and deliver recommendations for individual chapters and the overall report. Each reviewer shall develop an individual review report that addresses all the terms of reference. See Appendix 1 for further details on report contents.

By January 22, 2007, the reviewers shall submit their individual reports to the CIE for review^a. The CIE reports shall be sent to Dr. David Die, via e-mail to ddie@rsmas.miami.edu and to Mr. Manoj Shivlani via e-mail to mshivlani@rsmas.miami.edu.

Terms of Reference

The review is being conducted under the auspices of the Information Quality Act as required for a document deemed "Influential". The resulting reviews, including the names and affiliations of the reviewers, will be posted at www.doc.gov in compliance with the Information Quality Act.

^a All reports will undergo an internal CIE review before they are considered final.

The reviewers shall address all of the terms of reference listed below.

Overall:

- Is the report a cohesive document, or does it read as separate, individual, papers? If the latter, provide recommendations to make it more cohesive.
- Are the chapters balanced and the levels of information presented relatively consistent among chapters? If not, provide recommendations for improvement or areas where more detail is needed if it is available.
- Is the taxonomic information correct and complete with respect to current American Fisheries Society guidelines and current taxonomic understanding?
- Is the biogeographic information thorough and accurate? If not, report key gaps and provide key references.

Introduction and National Overview:

- Does the introductory chapter provide adequate background and context for understanding the regional chapters?
- Does the introduction accurately summarize the major threats to deep coral communities?
- Does the introductory chapter's "National Overview" synthesize major trends and conclusions from the regional chapters that follow? Are important pieces missing from the overview?

Regional Chapters:

- Evaluate the completeness of the information. Does each of the regional chapters reflect the most current data? Identify any major gaps or weaknesses in the reported information.
 - Are major known areas of deep corals in each region identified?
 - Does each chapter accurately characterize the state of research and knowledge to date? If not, provide specific recommendations for strengthening the information and associated references.
 - Are the maps and tables in each chapter clear, accurate and complete? Identify gaps and omissions in the maps and tables and provide key references for the missing information.
- Are the conclusions supported by the available evidence? If not, provide a detailed explanation and key recommended revisions.
- Evaluate the continuity of the regional chapters. Do they contain similar levels of information? Did the authors of the regional chapters follow the provided outline (see Appendix 2)?

Submission and Acceptance of Reviewers' Reports

The CIE shall provide via e-mail the final reports of all reviewers by February 5, 2007 to the COTR, Dr. Stephen K. Brown (Stephen.K.Brown@noaa.gov), for review and approval, based on compliance with the requirements of this Statement of Work. The COTR shall notify the CIE via e-mail regarding acceptance of these reports. Following the COTR's approval, the CIE shall provide the COTR with pdf versions of the final reports.

Appendix 1: Contents of Reviewer Reports

1. The reports shall be prefaced with an executive summary of findings and/or recommendations.
2. The main body of the reports shall consist of a background, description of review activities, summary of findings, conclusions/recommendations, and references.
3. The reports shall also include as separate appendices the bibliography of all materials provided and any papers cited in the Reviewer's Report, along with a copy of the statement of work.

Please refer to the following website for additional information on report generation:
http://www.rsmas.miami.edu/groups/cimas/Report_Standard_Format.html

Appendix 2: Regional Chapter Outline

I. Introduction

1. Summary of regions covered by this chapter
2. Historical information
3. What is in chapter

II. Geological Setting

1. Brief general description of major geological features of importance to deep corals (e.g., shelf and slope, geomorphology, canyons, seamounts etc.)
2. Brief identification of geological or biogeographical subregions as applicable

III. Oceanographic Setting

1. Brief general intro of oceanographic features of importance to deep corals
2. Subheadings by geological or biogeographical subregions discussing oceanography in each region

IV. Structure-forming deep corals and the spatial distribution of deep coral communities

1. General Introduction - If a particular class is not known to be in the region then state but do not remove the heading. Include unique information about the corals in the region, including number of species, only one ever found. If something unique is known about the biology in the region then include:
 - a. *Stony corals* (Class Anthozoa, Order Scleractinia)
 - b. *Black corals* (Class Anthozoa, Order Antipatharia, Families Cladopathidae and Schizopathidae)
 - c. *Gorgonians* (Class Anthozoa, Order Gorgonacea)
 - d. *True soft corals* (Class Anthozoa, Order Alcyonacea)
 - e. *Pennatulaceans* (Class Anthozoa, Order Pennatulacea)
 - f. *Stoloniferans* (Class Anthozoa, Order Stolonifera)
 - g. *Gold Corals* (Class Anthozoa, Order Zoanthidea)
 - h. *Hydrocorals* (Class Hydrozoa, Order Anthothecatae, Suborder Filifera)
2. Spatial Distribution of Coral Species and Habitat
 - a. Introductory sentences
 - b. Organize subregions by geological setting if applicable

V. Species Associations with Deep Coral Communities

3. General intro sentence
4. Separate into regional geological sections as appropriate, then discuss fish then invertebrates.
5. Comment on critical habitat as possible.

VI. Stressors on Deep Coral Communities

6. Introduction

7. Fishing effects
 - a. Bottom trawling
 - b. Scallop dredges
 - c. Deep Gill Nets
 - d. Bottom Long-lines
 - e. Other (e.g. traps)
8. Non-Fishing Effects
 - a. Oil and Gas Exploration and Extraction
 - b. Deployment of Gas Pipelines and Communication Cables
 - c. Sedimentation
 - d. Pollution
 - e. Coral Harvest (e.g. black or precious corals)
 - f. Mineral Mining
 - g. Climate Change
 - h. Invasive Species

VII. Management of Fishery Resources and Habitats

1. Introduction
2. Management of Fishery Resources and Habitats
3. Mapping and Research
4. Directed Harvest
5. Minerals Management Service
6. Fishery Management Councils
7. National Marine Sanctuaries
8. Planned or anticipated activities

VIII. Regional Priorities to Understand and Conserve Deep Coral Communities

1. Introductory sentences – Given limited funds these will help develop strategic plans.
2. Mapping? Name specific areas
3. Research? Be specific about gaps

IX. Conclusion

1. General statement on how much deep coral habitat may be found in the region.
2. What factor is most important in the region for deep coral development?
3. What are the unique features in the region?
4. Specific statements (re: fish or inverts) that rely on DSC or are they opportunistic structures
5. Are there specific areas impacted by the threats – known coral areas
6. Condition of areas examined
7. Unique assemblages
8. Areas in critical need of protection

X. References

1. References are in the Coral Reefs format. Please use this format for any additional included references.