

**The Center for Independent Experts (CIE) review of the draft NOAA
Technical Memorandum “The State of Deep Coral Communities of
the United States”**

Dr. Pål B. Mortensen
Benthic Habitat Research Group
Institute of Marine Research
PO Box 1870 Nordnes
N-5817 Bergen
Norway

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Executive summary

The compiled manuscript represents a much needed overview of the status of cold-water coral habitats and research on these habitats in the United States (US), and it aims to review the knowledge on cold-water corals in the US focusing on the following five themes:

- Presentation of taxonomic composition of cold-water corals present in the US.
- Description of the distribution of cold-water corals in the US.
- Description of cold-water coral habitats and associated communities in the US.
- Identification and assessment of stressors to cold-water corals in the US.
- Recommendations for prioritized research on cold-water corals in the US.

The text is generally well written in a language which is not too technically specialized, while not being overly popular either. Most chapters are to the point and present relevant information. One exception to this, however, is the first chapter (Introduction and National Overview). This is also where I have most specific comments. To make the report more coherent, I recommend that the common information for all regional chapters be moved to the Introduction and National Overview chapter.

The main topics of the report are covered well by the different chapters. The taxonomic overview of cold-water corals that this report gives is highly useful. That information should be compiled and presented in a single table (maybe as an appendix) with references to authors and with columns for the different regions as presented in chapters 2-8.

A presentation of the geographical distribution of cold-water corals cannot give the same attention to all species without becoming too voluminous. I think the report gives a good overview of the distribution of either higher coral taxa or selected dominant species.

The knowledge on corals as habitat for other species is still limited. There have been few directed investigations, and most of the species that are found within cold-water coral habitats are facultative commensalists, which may result in communities to a large degree reflecting what locally represents the hard bottom epifauna. Some of the chapters could stress this fact and point to the lack of knowledge from their regions.

The report demonstrates that there has been an increased awareness of the threats (both potential and present) to cold-water corals. As evident from the published literature, the destructive effects of bottom trawling have been pointed out in different parts of the world. Surprisingly, only one chapter cites the work by Mortensen et al (2005), which is the only paper focusing on the effects of long-lining, and which also suggests indirect effects (colonisation by parasitic zooanthids) through coral tissue damage.

The paragraphs on regional priorities to understand and conserve cold-water communities are basically addressing the following needs as summarized in first chapter:

- Habitat mapping;
- Modelling the distribution;
- Data mining and data management;
- Monitoring;
- Understanding the taxonomy, biology and ecology;
- Biodiversity and ecology;
- Effects of climate change;
- Information on anthropogenic stressors.

This list only partly synthesizes the need addressed by the regional chapters. There is no guidance or advice offered on how to monitor the corals, and there is very little understanding of knowledge needed to give general but precise advice to managers (i.e. how much total sedimentation (and at what frequency) can a coral stand , without showing significant effects on their survival, growth, reproduction, etc.?). The importance of modeling of cold-water coral distribution should not be over-sold. Such modelling can only aid in the mapping (e.g., identify areas that should be prioritized for mapping)

Background

“Coral” is a taxonomically heterogeneous group comprising both Octocorallia and Hexacorallia species. At high latitudes they occur from the upper bathyal zone down into the abyssal at depths of around 6,000 m. In deep-water, Octocorallia has richer species diversity than does Hexacorallia. The taxonomic order Gorgonacea (horny corals) comprises the richest Octocorallia group. In some arctic areas, such as off the Aleutian Islands and certain areas on the Norwegian shelf they occur in stands often called “coral forests”.

Most deep, or cold-water, corals occur in temperatures between 4° and 12° C, but a few species are confined to the deeper, cold (subzero) waters, and others may occur in a wide range of temperatures. Many corals are habitat-forming species, hosting diverse faunas with representatives from most marine invertebrate phyla. Some fish species occur in greater densities in coral habitats than within the surrounding seabed. It is not known exactly what role the corals play for the life-history of these fishes, but their role as shelters, feeding grounds, and possible nurseries have all been suggested.

Reef-building corals are comprised of a few species of stone corals, and these occur from the Barents Sea off Norway in the Northern Hemisphere to the Scotia Sea off the Antarctic continent in the Southern Hemisphere. Given their wide distribution (semi-cosmopolitan for many of the species), knowledge on cold-water corals is available in papers from around the globe.

The discovery of large cold-water coral reefs in deep water in the Atlantic Ocean as late as the mid 1960’s, is remarkable since such species were first described and depicted by Linné and Gunnerus already in the 18th century (Linné 1758, Gunnerus 1768). Although research on corals has been carried out for more than two centuries, it was only recently that the technological development allowed for an extensive

visual investigation of the deep sea. In the 1980s and 1990s, awareness of sensitivity of cold-water coral reefs arose among fishermen and scientists around the world (Norway, Canada USA), and among survey engineers in the offshore petroleum industry. By means of new technology, colourful footage from reefs was brought up from the deep and made available for scientists as well as the general public.

The cold-water coral reefs represent biodiversity hotspots, and they serve as complex habitats that may function as shelter, feeding grounds and nurseries for a number of commercially important fish species. Their significance as grazers on the zooplankton community is poorly known, as also is the case for their ability of permanently storing carbon dioxide. There are many arguments to why it is important to protect the slow-growing deep-water coral reefs. Research on cold-water corals should focus not only on meeting the demands for management advice, but also to increase the basic scientific knowledge.

Description of review activities

I participated in this review with the intent to provide recommendations that could improve the quality of the report. I accepted the invitation from the Center for Independent Experts (CIE) to review the report 31 December 2006, and started reading and reviewing it on 5 February 2007. After submitting a draft report on 9 February, 2007, I completed the work on 14 February, 2007, after being provided comments. Much of the work has been to compare the information provided by the different chapters of the report, and I address the terms of reference for the report in the following sections.

General comments on the manuscript and terms of reference

This manuscript represents a much needed overview of the status of cold-water coral habitats and research on these habitats in the United States. The text is generally well written in a language which is not too technically specialized, but not too popular. Most chapters are to the point and present relevant information. One exception to this, however, is the first chapter (Introduction and National Overview). Below, I provide my comments to the specific terms of reference.

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.

The report is partly a cohesive document, but it reads mostly as a set of separate, individual, papers (i.e., a collection of chapters appearing more or less as independent articles). What holds the report together is its geographical coverage and the predefined structure with common headings. The manuscript contains a huge amount of information, which could be better structured (and condensed). I recommend that the report is re-organised so that the Introduction and National Overview gives the necessary background and provides general information, which currently is repeated

several times throughout the draft report. The changes needed to the language are few and easily fixed, but the reorganization of the report would require editors with a good overview/understanding of the topic (e.g., some of the senior, US cold-water coral researchers).

- 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.

The chapters are relatively well balanced in their presentation of geographical distribution and overview of current research. My major comment to the structure of the chapters and their contents is that the repetition of general information should be avoided. One way to improve the report is to give more responsibilities/leeway to editors to change the text and to communicate directly with the authors.

- Is the taxonomic information correct and complete with respect to current American Fisheries Society guidelines and current taxonomic understanding?

The taxonomic information is mainly correct and complete with respect to current taxonomic understanding. One exception, as far as I understand the current taxonomy, is that which concerns lace corals. The taxonomy used here (*Anthothecatae*) is new to me and is not yet established at major web-based taxonomic check lists (e.g., ERMS Taxon list, www.marbef.org; IT IS, www.itis.gov). It is not a problem that the report uses this new taxonomy, only that it should be implemented consistently throughout the report.

- Is the biogeographic information thorough and accurate? If not, report key gaps and provide key references.

The biogeographic information appears thorough and accurate.

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?

The introductory chapter provides adequate background and context for understanding the regional chapters. However, I have some comments on how to improve this chapter in the "specific comments" section.

The introductory chapter contains a very good summary of the major threats to deep coral communities, and it also synthesizes major trends and conclusions from the regional chapters under the “National 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)?

The information seems to be complete for the different regions. The regional chapters reflect the most current data for their region, but the chapters often lack the overview of current knowledge from other parts of the world (e.g., Europe).

To my knowledge, the major known areas of cold-water corals in each region are identified.

The chapters characterize the state of research and knowledge to date fairly accurately. However, non-American literature is clearly less well implemented in the text. This is a pity since this literature is important and could give good ideas on how to direct further research. Furthermore, McCloskey (1970) should be included in relevant parts discussing associated fauna of scleractinians. References that should add significant knowledge are listed below:

Burdon-Jones C, Tambs-Lyche H (1960) Observations on the fauna of the North Brattholmen stone-coral reef near Bergen. Årbok for Universitetet i Bergen. Mat.-naturv. Serie. 1960 (4):1-24.

Duineveld GCA, Lavaleye MSS, Berghuis EM (2004) Particle flux and food supply to a seamount cold-water coral community (Galicia Bank, nw Spain). Marine Ecology Progress Series 277:13–23.

Frederiksen, R, Jensen A, Westerberg H (1992) The distribution of the scleractinian coral *Lophelia pertusa* around the Faroe islands and the relation to internal mixing. *Sarsia* 77:157-171.

Jonsson LG, Nilsson PG, Floruta F, Lundälv T (2004) Distributional patterns of macro- and megafauna associated with a reef of the cold-water coral *Lophelia pertusa* on the Swedish west coast. *Marine Ecology Progress Series* 284: 163-171.

McCloskey LR (1970) The dynamics of the community associated with a marine Scleractinian coral. *International Revue der gesamten Hydrobiologie* 55: 13-81.

Mortensen, PB, Fosså JH (2006) Species diversity and spatial distribution of invertebrates on *Lophelia* reefs in Norway. - *Proceedings of the 10th International Coral Reef Symposium*. Okinawa, Japan, pp 1849-1868

To my knowledge, the maps and tables are accurate and complete, and the conclusions are supported by available evidence.

The regional chapters, with few exceptions, contain similar levels of information. One thing that stands clearly out is the new information about cold-water coral reproduction, mostly referring to unpublished work or work in progress. I cannot find any appendix providing an outline for the chapters, but the chapter structures are similar and thus help the reader to compare between the regions.

Specific comments on the manuscript chapters

Page 1

- Preface: Well written to the point.

Chapter 1

Page 2

- In general, the language used is too popular.
- The content of the first two lines are repeated below (delete).
- “Deep coral” is too popular a term (and should not be sued). The corals are not deep, but the water is. It is acceptable to use such terms in the public mass media, but not in a NOAA technical memorandum.
- What is meant by “northern latitudes”?

Page 3

- Structure forming corals: I don’t know any reason to why “structure-forming” should be used as a term rather than “habitat-forming”. I would not recommend using this term because it is not precise (structure can be physical, abstract, or ecological, whereas habitat is more what is described in this chapter).
- Box 1.1: See comments above, but also, what is the vertical structure above the seafloor”?
- has been known to science for over a century, ...”. Actually, they have been known to science since 1758, when Carl von Linné wrote the *Systema Naturae*.

- The knowledge about these corals is NOT strikingly limited anymore. At the end of the document is a list of publications (in peer reviewed international journals) that I have contributed; these are just some very few of the numerous publications that has come out the last 12 years. The work by members of the EU projects ACES and Hermes should indeed also be considered.

Page 4

- In general, this chapter lacks references. One such example concerns where the vast reef complexes occur, and who has published this information.
- Table 1.1: “*Oculine varicose*” should be “*Oculina varicosa*”. Climate change is maybe too broad a term. I would suggest a term that is more to the point (e.g: ocean acidification, temperature stress, storm intensity, etc.).

Page 5

- 1,300 species associated with *Lophelia* reefs. This number should be understood as associated with coral mounds (L.A. Henry. Pers comm). A more recent review (Mortensen, P.B. & J.H. Fosså 2006) of the *Lophelia* fauna reveals lower numbers.
- “.....both fascinating in its own right, as well as ...” It is very weak to say that except from bioprospecting potential, the only value of high biodiversity in cold-water coral communities is “fascinating”. This reflects very limited understanding of nature conservation and management.
- The authors should include Costello et al. (2005) when reviewing the importance of cold-water corals for fish.

Page 6

- Here, “cold-water corals” is used as a term again. I believe that this is the best term for these corals.
- “As fisheries expand into deeper waters (Roberts 2002) ...”. I wonder why this statement needed a reference and most other facts about the corals don’t have any references. Delete this and include some few words describing what have been done world-wide to protect these corals.

Page 8:

- “It has been recorded as shallow as 39 meters in the Norwegian Fjords”. Cairns (1979) is the wrong reference to this, and fjords should not be capitalized. I believe that the UNEP report (Freiwald et al. 2004) is a better reference to the shallow occurrence.

Page 9:

- *Lophelia* is pseudocolonial (because the polyps do not have a common fast speed nerve net and they do not share the food through any gastrovascular systems), but the “mucus that covers the skeleton” is not mucus, but coenosarc.
- The well-documented association is not well documented if it is not possible to tell which species is involved. Most examples in the literature are of *Eunice norvegica* being involved, but *E. pennata* has also been identified.
- The mentioning of separate sexes in *Lophelia* without reference is strange. In the next set of sentences the authors talk about time of year for maturation and spawning-time, referring to unpublished results. This is not good. Later

readers will refer to this report without being able to critically judge the original results. I suggest omitting this information until it has been through a peer review round. This important new information is also a great contrast to what the authors have said earlier (page 3) about the lack of such knowledge.

- “*Lophelia pertusa* is often associated with *Enallopsammia profunda*....” Where in the world does this occur? A reference is required here.
- Figure 1.3, and elsewhere: Remember to write species’ names in italics.

Page 10:

- *Solenosmilia variabilis* has a wide distribution but is not a cosmopolitan species. The authors should include Arctic waters as one of the areas that it does not occur (it is also absent from the Norwegian Sea).
- Figure 1.4: Delete “coral”. Only species’ name should be in italics.
- Replace “structure-constructing” with “habitat-forming”.
- Why abbreviate *Lophelia* and *Madrepora*, but not *Solenosmilia* within the same sentence, especially as all have been mentioned few lines earlier?
- “*E. profunda* significantly contributes to the structure of deep-water coral banks...”. This is a vague sentence that does not tell much. Proportionally, on average, how much of the reef surface is covered with this species? One example of why I think this kind of sentence is unclear can be illustrated by this sentence (which I constructed as a means of illustration): “Due to its great size, *Paragorgia* contributes significantly to the reef structure even though it occurs at low densities”. This gets to my earlier point that “structure” is not a good term here.

Page 11

- *Madrepora oculata* is claimed as a cosmopolitan species. Maybe I am wrong, but since this species does not occur in polar areas, it can not be termed “cosmopolitan”; it is “semi-cosmopolitan” at best.

Page 12

- The new information on reproduction does not have any references.

Page 14/15

- Surprisingly little is written about true soft corals. What about the great taxonomical problems within the very common group Nephtheidae? What about the very common genera such as *Gersemia* or *Duva*?

Page 15

- “And several species are known to attain massive size.” This sentence can be deleted.

Page 16

- “Mortensen and Mortensen 2005” should be “Mortensen and Buhl-Mortensen 2005”. It is not among the reference list.
- Again, what is cosmopolitan? Precious corals are not present in the Northeast Atlantic and many other waters.
- *Paragorgia* is not the “largest seafloor organism on the planet”, as there are large plants such as macrocystis. *Paragorgia* is a sessile colonial animal, so, it would be better stated that it is the “largest sessile colonial animal...”

- A 10 meter high Paragorgia is much higher than the fragment I have read about. The big fragment I know of is supposed to originally have been much higher, but there is no record of a 10 meter tall Paragorgia, to my knowledge. Smith (2001) is not in the reference list, so I can not verify the statement.

Overall, this chapter needs major reworking, in terms of the words selected. The themes are acceptable, but their logic of presentation and documentation need improvement. This background chapter should really be strongly written. It is important to set the stage in a convincing way. As it stands now, this chapter is not convincing.

Chapter 2

Compared to the previous chapter, Chapter 2 is much more readable. It is concise and to the point, and it avoids popular expressions or the overselling of science.

Page 58

- “Structure-forming”, again, here and elsewhere.. This term is not precise, and I strongly argue that it should be replaced with a term that is more appropriate . The authors are really not talking about structure because structure is not necessarily elevated from a surface. A canvas has a certain structure, etc. But here, small solitary corals such as *Flabellum* are not defined as providing any “structure”, but certainly, they represent a structure. As I stated previously, my preference is still “habitat”. It is unclear why this word is not used and perhaps it is no longer popular in the US.
- The term “deep coral” is inaccurate and should be changed.

Page 79

- Non-commercial species associations: This is the weakest of the paragraphs in the chapter. “Few obligatory associations have been described to date...”: I wonder whether the authors refer to the general literature or solely to Alaskan waters. This should be spelled out and in case this refers to Alaskan waters, the “few” obligate associations should be prioritised in the description.

Page 80

- I wonder why scallop dredges are regarded as having a lower negative effect on coral habitats in Alaska compared to longlines. It should be discussed/explained in the text.

Page 88

- “Non-fishing effects”: A better title could be “Effects of other human activities”.

Overall, this is a good chapter that needs minimal revisions.

Chapter 3

Page 109

- There is a great deal of listing of island names in this first paragraph. This could be saved for a later table.

Overall, this is a good chapter that needs minimal revisions.

Chapter 4

Page 160

- Sort out the uncertainty with the numbering of the Appendix (Referred to as “Appendix”).

Page 172

- “Stony corals....have the ability to clean sediments from the polyps, thus withstanding considerable deposition (Fosså et al 2002)”. As one of the co-authors, I can verify that this is not a good use of the reference. There is no indication that corals can withstand considerable deposition. In addition I would request some more information be added about the sources of increased sedimentation (e.g., re-suspension from trawling, ploughing pipelines down into the bottom, etc.).

Chapter 6

Page 239

- Fig 6.2: One of the images here has been shown earlier.
- Table 6.3: Keep species names in italic.

Chapter 7

Page 272

- Fig 7.5: These images have been shown earlier in the report.

Page 279

- Fig 7.6: Species names in italics (this comment applies for a number of places in the draft report). I have looked and looked, but cannot find the anomoran (*Munidopsis* is not a brachyuran), and if such a crustacean is present in the picture, it should be pointed out by an arrow.

Page 280 (and elsewhere in this chapter)

- Hydrocorals, Stylasterina: Ensure that the taxonomy follows what is used elsewhere in the document (Anthothecatae).

Page 286

- I am pretty sure that “*Trachimuricea*” should be spelled “*Trachymuricea*”, but more importantly, the genus should be revised to *Muriceides*, which is the valid genus name for this coral.

Page 291

- The discussion of effects of oil and gas exploration and extraction is interesting and has valuable information. However, I believe that reference to previous work on this could add further to the substance of the discussion. See, for instance:

Thompson, J.H., E.A. Shinn and T.J. Bright. 1980. Effects of drilling mud on seven species of reef-building corals as measured in the field and laboratory. Pp. 433–453 in R.A. Geyer, ed., *Marine Environmental Pollution*, Vol. 1—Hydrocarbons. Elsevier, Amsterdam, The Netherlands.

Even though this paper concerns shallow water corals, it provides information on the possible effects of drilling muds.

Page 296

- With the increasing effort in offshore petroleum related activities, it is important to gain more knowledge about corals in order to provide sound advice. This is especially the case when evaluating how the safe distance for corals from seabed operations that create increased levels of sedimentation. In my opinion, the only way to find out how vulnerable the corals are to increased sedimentation is by performing experiments, either in the field or in the lab, or both.

Chapter 8

Page 311

- Here, “structure-forming” is defined again. If this is the preferred term, then it need not be defined in each and every chapter. The Background chapter would be the right place to define this and other terms.
- The terms “banks, bioherms and lithoherms” should also be defined, as well as the difference (if any) between the terms. Also, the term “reef” should be mentioned in the Background chapter.

Page 312

- When I read Table 8.2, I realized that there is much repetition throughout the draft report. For instance, the basic information about *Lophelia* is found several places in the document. This basic information differs in the document (i.e. deepest occurrence of *Lophelia* is listed as 2.170 meters on page 8, but as 3,383 meters on page 313. There is no need to keep on repeating this kind of information, and if one does, it should of course be consistent.

Page 321/322

- Figure 8.17: Don't capitalize species' names (“*N. Pauciflora*”).
- Figure 8.18: Replace “crab” with “crustacean” or “anumuran”
- Figure 8.19 and 8.21: Replace “profinda” with “profunda”.
- Figure 8.22: Replace “Keratosiis” with “Keratoisii”
- Figure 8.23 and 8.24: Replace “stylastrid” with “stylasterid” or “lace coral”.

Page 322

- Hydrocorals, Stylasterina: Ensure that the taxonomy follows what is used elsewhere in the document (Anthothecatae).
- Here and many places on the following page, replace “stylastrids” with “stylasterids” or “lace corals”.

Page 325

- These pages (325-326) contain much background information that is more general than just applicable to the Caribbean. I suggest that this information is moved to, and merged with, the Background chapter.

Page 217

- Figure 8.31: The image in the figure is missing

Page 333

- “Freiwall” is spelled “Freiwald”.

Page 372-374

- Appendix 8.1: Hydrocorals, Stylasterina: make sure that the taxonomy follows what is used elsewhere in the document (Anthothecatae).

Page 376

- Appendix 8.2: I am not sure that this table is needed. If it should be included it should contain information about which of the major structure-forming corals the species are found on.

Finally, I have added the following list of references of my publications as they relate to coral literature; these serve mainly as an example of research findings that are available on cold-water corals:

- Buhl-Mortensen, L. & P.B. Mortensen 2004a. Crustaceans associated with the deep-water gorgonian corals *Paragorgia arborea* (L., 1758) and *Primnoa resedaeformis* (Gunnerus 1763). – *Journal of Natural History* 38: 1233-1247.
- Buhl-Mortensen, L. & Mortensen, P.B. 2004b. *Gorgonophilus canadensis* n. gen., n. sp. (Copepoda: Lamippidae), a gall forming endoparasite in the octocoral *Paragorgia arborea* (L., 1758) from the Northwest Atlantic. - *Symbiosis* vol. 37: 155-168.
- Buhl-Mortensen, L. & Mortensen P.B. 2004c. Symbiosis in deep-water corals. - *Symbiosis* 37: 33-61.
- Buhl-Mortensen, L. & P.B. Mortensen 2005. Distribution and diversity of species Associated with Deep-sea gorgonian corals off Atlantic Canada. Pp 849-879 in Freiwald A, Roberts JM (eds). *Cold-water Corals and Ecosystems*. Springer-Verlag Berlin Heidelberg, 1244pp.
- Fosså, J.H., P.B. Mortensen, D.M. Furevik 2002. The deep-water coral *Lophelia pertusa* in Norwegian waters: Distribution and fishery impacts. - *Hydrobiologia* 471: 1-12.
- Fosså, J.H., B. Lindberg, O. Christensen, T. Lundälv, I. Svellingen, P.B. Mortensen, J. Alvsvåg 2005. Mapping of *Lophelia* reefs in Norway: experiences and survey methods. Pp 359-391 in Freiwald A. and J.M. Roberts (Eds), *Cold-water Corals and Ecosystems*. Springer-Verlag Berlin Heidelberg, 1244pp.

- Freiwald, A. & P.B. Mortensen 2000. The first record of the deep-water coral *Stenocyathus vermiformis* (Pourtales, 1868) (Scleractinia: Guyniidae) from Norwegian waters. - *Sarsia* 85: 275-276.
- Hovland, M., R. Farestveit & P.B. Mortensen 1994. Large cold-water coral reefs off mid-Norway - a problem for pipe-laying? - *Oceanology International, Conference Proceedings* Vol. 3. Brighton, UK, 8. - 11. March 1994.
- Hovland, M., P. B. Mortensen, E. Thomsen & T. Brattegard 1997. Substratum related ahermatypic corals on the Norwegian continental shelf. - *Proceedings of the 8th International coral reef symposium*. Vol. 2, Panama 1996, pp 1203-1206.
- Hovland, M., P.B. Mortensen, T. Brattegard, P. Strass & K. Rokoengen 1998. Ahermatypic Coral Banks off Mid-Norway: Evidence for a Link with Seepage of Light Hydrocarbons. - *Palaios* 13:198-200.
- Mortensen, P.B., M. Hovland, T. Brattegard & R. Farestveit 1995. Deep water bioherms of the scleractinian coral *Lophelia pertusa* (L.) at 64° N on the Norwegian shelf: structure and associated megafauna. - *Sarsia* 80: 145-158.
- Mortensen, P.B. & H.T. Rapp 1998. Oxygen- and carbon isotope ratios related to growth line patterns in skeletons of *Lophelia pertusa* (L.) (Anthozoa: Scleractinia): Implications for determination of linear extension rates. - *Sarsia* 83:433-446.
- Mortensen P.B., J.M. Roberts & R.C. Sundt 2000. Video-assisted grabbing: a minimally destructive method of sampling azooxanthellate coral banks. - *Journal of the Marine Biological Association of the UK* 80: 365-366.
- Mortensen P.B. 2001. Aquarium observations on the deep-water coral *Lophelia pertusa* (L., 1758) (Scleractinia) and selected associated invertebrates. - *Ophelia* 54 (2):83-104.
- Mortensen, P.B., M.T. Hovland, J.H. Fosså & D.M. Furevik 2001. Distribution, abundance and size of *Lophelia pertusa* coral reefs in mid-Norway in relation to seabed characteristics. - *Journal of the Marine Biological Association of the UK* 81:581-597.
- Mortensen, P.B. & L. Buhl-Mortensen 2004. Distribution of deep-water gorgonian corals in relation to benthic habitat features in the Northeast Channel (Atlantic Canada). - *Marine Biology* 144: 1223-1238.
- Mortensen, P.B. & L. Buhl-Mortensen 2005a. Coral habitats in The Gully, a submarine canyon off Atlantic Canada. Pp 247-277 in Freiwald A. and J.M. Roberts (Eds), *Cold-water Corals and Ecosystems*. Springer-Verlag Berlin Heidelberg, 1244pp.
- Mortensen, P.B. & L. Buhl-Mortensen 2005b. Morphology and growth of the deep-water gorgonians *Primnoa resedaeformis* and *Paragorgia arborea*. - *Marine Biology* 147: 775-788.
- Mortensen, P.B. & J.H. Fosså 2006. Species diversity and spatial distribution of invertebrates on *Lophelia* reefs in Norway. - *Proceedings of the 10th International Coral Reef Symposium*. 28.06.-02.07.04, Okinawa, Japan pp 1849-1868.
- Mortensen, P.B., L. Buhl-Mortensen, & D.C. Gordon Jr 2006. Distribution of deep-water corals in Atlantic Canada. - *Proceedings of the 10th International Coral Reef Symposium*. 28.06.-02.07.04, Okinawa, Japan, pp 1849-1868.
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Appendix 1: Statement of Work

Consulting Agreement Between the University of Miami and Dr. Pat Buhl Mortensen

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 review¹. The CIE reports shall be sent to Dr. David Die, via e-mail to ddie@rsmas.miami.edu and to Mr. Manoj Shivilani via e-mail to mshivilani@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.

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

¹ All reports will undergo an internal CIE review before they are considered final.

Overall:

1. Is the report a cohesive document, or does it read as separate, individual, papers? If the latter, provide recommendations to make it more cohesive.
2. 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.
3. Is the taxonomic information correct and complete with respect to current American Fisheries Society guidelines and current taxonomic understanding?
4. Is the biogeographic information thorough and accurate? If not, report key gaps and provide key references.

Introduction and National Overview:

5. Does the introductory chapter provide adequate background and context for understanding the regional chapters?
6. Does the introduction accurately summarize the major threats to deep coral communities?
7. 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:

8. 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.
9. Are the conclusions supported by the available evidence? If not, provide a detailed explanation and key recommended revisions.
10. 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.