

Testimony of
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Before the
Subcommittee on Insular Affairs, Oceans and Wildlife
Committee on Natural Resources
U.S. House of Representatives
Hearing on
Ocean Science and Data Limits in a Time of Crisis:
Do NOAA and the Fish and Wildlife Service (FWS) have the Resources to Respond?
June 15, 2010

Thank you Chairwoman Bordallo and distinguished members of the Subcommittee for the opportunity to provide testimony today. My name is Jonathan Coddington. I am the Associate Director of Research and Collections at the National Museum of Natural History, Smithsonian Institution. I have a PhD in Invertebrate Zoology and have published frequently on design and analysis of biological inventories and inventory design theory. As Associate Director I oversee about 90 scientists and 240 technical staff at the National Museum of Natural History in Washington, D.C., at the Museum Support Center in Suitland, Maryland, and at the Smithsonian Marine Station at Fort Pierce, Florida. Collectively we care for an estimated 126 million specimens, approximately 94% of all Smithsonian collections. About one third of our collections and staff focus on the marine realm.

Introduction:

The National Museum of Natural History (NMNH, previously the US National Museum, in part) has, since its beginning, been linked to the collection activities of the U. S. Government. The 1846 legislation that created the Smithsonian Institution identified the U.S. National Museum as the repository for natural history specimens belonging to the United States, “All collections of rocks, minerals, soils, fossils, and objects of natural history, archaeology, and ethnology, made by the National Ocean Survey, the United States Geological Survey, or by any other parties for the Government of the United States, when no longer needed for investigations in progress shall be deposited in the National Museum” (20 U.S.C. § 59). In fact, it was research in the marine environment, the 1838-1842 U.S. Exploring Expedition that made clear the national need for such a repository. The role of the Smithsonian as the primary repository for federally funded collections has been repeatedly affirmed by Congress by legislation in 1879, 1965, 1970, and 1991.

Scientific collections are an essential and irreplaceable component of the national scientific infrastructure, as documented in the 2009 report of the *Interagency Working Group on Scientific Collections* (OSTP, 2009). Speaking just for the Smithsonian, we collaborate with the Federal Aviation Administration, the U.S. Air Force, and the U.S. Navy to identify birds involved in over 5,000 collisions with airplanes annually. Last summer, a number of Canada geese famously forced US Airways Flight 1549 to land in the Hudson River, luckily with no loss of life. Knowing the species of bird in each collision allows humans, as far as possible, to design systems to minimize collisions. We collaborate with the United States Department of Agriculture

(USDA) by hosting 40 USDA entomology staff at NMNH because the collections are critical to their mission of protecting U.S. Agriculture. When the citrus leaf miner invaded the U.S. in 1993, the NMNH collections contained the only identified material in the country. Our scientists rapidly identified the pest, which enabled targeted control programs throughout citrus agriculture regions. Smithsonian collections also played a crucial role in the identification and control of many other invasive species, for example, the veined rapa whelk that damages Chesapeake oyster populations, or the Asian longhorned beetle, on track to cause billions of dollars of damage to urban trees. Our unique database on volcanic eruptions is the international standard for basic science in this area, supporting plans to mitigate threats to human life near volcanoes, as well as threats to aviation. We also support our armed forces by hosting the Walter Reed Biosystematics Unit, a component of the Walter Reed Army Institute of Research. Mosquitoes, in particular, spread some of the most deadly and debilitating diseases, and NMNH therefore supports the largest and most comprehensive mosquito collection in the world. Another recent example is *Hyalomma* ticks, which are particularly common and diverse in Iraq. They transmit viral hemorrhagic fevers. Luckily, we have the world's best reference collection of *Hyalomma* ticks. Wherever our soldiers are, the ability to rapidly identify disease vectors in their environment is crucial to mitigating risk. Our collections have been used repeatedly to answer basic and historical questions regarding many diseases: Lyme disease, influenza, and hemorrhagic fevers, to name a few.

In the near future our collections may play crucial roles in two areas: climate change and ocean acidification. Since 1963 we have archived the results of environmental monitoring in the Antarctic, a partnership with the U.S. Antarctic Program (USAP). Climate models predict that the climate change may be particularly evident at the North and South Poles. The density and scope of our historical collections can provide the “before” to climate change’s “after.” Ocean acidification, itself caused by climate change, threatens keystone species—reef builders—of many marine ecosystems. Clams and corals, for example, record growth rates in their skeletons. Those growth rates depend on the availability of calcium carbonate, and that depends on ocean acidification. Growth rates as reflected in the skeletons of marine organisms are an important record of environmental change.

Regarding the Deepwater Horizon oil spill, knowing what the conditions were like before the event is essential. The Smithsonian is committed to long-term studies of ecosystems and biodiversity, and the data and collections that have resulted can play a crucial role in situations such as that posed by the gulf oil spill. For example, in 1986 more than 50,000 barrels of oil impacted the coast of Panama, including the habitats adjacent to the Galeta Marine Laboratory of the Smithsonian Tropical Research Institute. Because the Smithsonian had already studied this site for many years, the Minerals Management Service (MMS) chose the Smithsonian to assess the impact of the spill. This study was one of the first to clearly document the long term effects of oil on soft bottom marine habitats such as are found along the U.S. Gulf Coast. Collections documenting this study (see below) are archived at NMNH. Throughout history, scientific collections have helped to resolve the issues of the day.

My testimony today focuses on the assistance the National Museum of Natural History can provide to a coordinated national response to the Deepwater Horizon oil spill. This spill already

has been described by many experts as the worst man-made ecological disaster in U.S. history. The extent of the ecological impact, its geographic extent, and possibilities for remediation at this point are only estimates, not known facts. Given the likely economic impacts of the spill and future costs, the accuracy of before and after comparisons are important. Assembling an accurate and detailed description of the Gulf of Mexico marine ecosystem as it existed prior to the spill is the chief topic I will address today.

NMNH Collections, MMS, and the Gulf of Mexico:

Since 1979, NMNH has collaborated with the Environmental Division of the Minerals Management Service to archive the collections generated by their Environmental Studies Program. The Minerals Management Service (MMS) has been conducting intensive environmental studies on the Outer Continental Shelf (OCS) for more than 30 years to support information needs for managing oil and gas development on the continental shelf and slope. Through its initial design, and during the first four years of program activity, the MMS Environmental Studies Program established baseline environmental conditions based on a large number of biological, chemical, and physical parameters. With these baseline conditions, future monitoring studies during and after development would, presumably, have allowed an assessment of the long-term effects of development. After a review and recommendations from the National Academy of Sciences, this program design was revised in 1978. Subsequently, a new program of directed studies has provided data to inform critical decisions before they are required. These baseline surveys took place from 1974 to 1978, and the Smithsonian has all or most of the specimens they generated in our collections. Specimens from numerous additional MMS-directed studies are also in our collections. Data from these studies, including site and collecting event specific physico-chemical, oceanographic, sedimentary and biodiversity data are available in the various technical reports prepared by program contractors. These reports, available on-line at the [MMS Environmental Studies Program Information System](https://www.gomr.mms.gov/homepg/espis/espisfront.asp), (<https://www.gomr.mms.gov/homepg/espis/espisfront.asp>), provide information that document not only the biodiversity of these sites, but the population characteristics and environmental conditions at the time the samples were collected. For the Gulf of Mexico alone, from 1974-2010, this site provides 109 "baseline" reports, 252 "biology" reports, 86 "fate & effects" reports, and 340 "technical summaries." The availability of this extensive supporting data in conjunction with the specimens themselves makes these collections an irreplaceable research resource for comparative studies on the invertebrate biodiversity (animals without backbones) of the Gulf of Mexico.

These specimens represent one of the most extensive collections of marine organisms from U.S. continental shelves and slopes, in terms of geographic coverage, sampling density (spatial and temporal), number of phyla represented, and associated data collected concomitantly (other organisms, chemical, hydrographic, geologic). The MMS therefore established a system for the archiving of, and access to, these specimens. Through a series of contracts, MMS has partnered with the Smithsonian's NMNH-Department of Invertebrate Zoology (in its role as the repository for federally-funded collections) to ensure the long term maintenance of and access to invertebrates collected during these studies. The MMS Environmental Studies Program deserves praise for the foresight and initiative shown in conducting and preserving the results, especially the collections, from these surveys.

Details of MMS surveys as represented in NMNH Collections:

NMNH to date has received material from 21 continental shelf, slope and canyon surveys as well as two special oil spill surveys. These are: the Atlantic Slope and Rise Program (ASLAR); George's Bank Benthic Infauna Monitoring Program (BIMP); Central Atlantic Benchmark Program (CABP); California Monitoring Program (CAMP); Central and Northern California Reconnaissance Program (CARP); the Canyon and Slope Process Study (CASPS); Central Gulf Platform Study (CGPS); Gulf of Mexico Chemosynthetic Communities (CHEMO); Deep Gulf Shipwrecks of World War II (Deep Wrecks); Northern Gulf of Mexico Continental Shelf Habitats and Benthic Ecology (DGoMB); the special Ixtoc oil spill survey in the Gulf of Mexico (IXTOC); the South Atlantic Outer Continental Shelf Area Living Marine Resources Study (LMRS); Gulf Of Mexico Hard Bottom Communities (Lophelia); Mississippi, Alabama, Florida Benchmark Program (MAFLA); Mississippi-Alabama Marine Ecosystem Program (MAMES); Mississippi/Alabama Pinnacle Trend Ecosystem Monitoring Program (MAPTEM); the New England Environmental Benchmark Program (NEEB); the Northern Gulf of Mexico Continental Slope Study (NGOMCS); the special Panama Oil Spill Study (POSP); the South Atlantic Benchmark Program (SABP); the Southern California Baseline Study (SOCAL); the Southwest Florida Shelf Ecosystems Study (SOFLA); and the South Texas Outer Continental Shelf Program (STOCS). In addition to the biological material, more than 200 color slides of animals *in situ* were received from the MAPTEM program.

During the 30+-year tenure of the contracts between MMS and the Smithsonian, more than 337,012 lots of sorted and identified material and 20,000 lots of unprocessed samples or mixed taxa have been received. "Lot" means a single jar or vial of specimens that have identical collecting data. One lot may comprise one or dozens or thousands of specimens. Therefore lot statistics always underestimate the actual number of specimens involved. Of this number more than 93,000 lots originated from studies in the U.S. Gulf of Mexico and more than 18,000 lots originated from the studies following the oil spill in Panama. In that case, Smithsonian marine scientists also led a scientific study (funded by MMS, see above) of the ecological consequences of the oil. It remains a benchmark study in the field.

In the aggregate these collections document at least 4,000 species of marine invertebrates from 602 families from 22 phyla. Recent scientific publications document that the Gulf as a whole contains roughly 15,000 species, with perhaps another 3,000 species still undiscovered. These represent everything from ecological keystone species to economically important species to potentially threatened or endangered species. "Keystone" species are those on which most of the rest of the ecosystem depends. The North Atlantic cold water coral (*Lophelia pertusa* (Linnaeus, 1758) is a keystone species because it is one of the most important deep water reef-builders, and thus fundamental to deep marine ecosystems. It occurs within 20 or so miles of the Deepwater Horizon well-head, as documented by trawl samples from 1984 and direct observation from submersibles during MMS-funded studies between 2004 and as recently as September of last year. Economically important species are the focus of the National Oceanic and Atmospheric Agency's National Marine Fisheries Service. Examples are the three commercially important

Gulf shrimp species (pink and brown shrimps, *Farfantepenaeus duorarum* and *F. aztecus*, and the white shrimp, *Litopenaeus setiferus*), all of which are well-represented in NMNH collections. Endangered or “at risk” species include several populations of genetically distinct bottlenose dolphins, and the Florida manatee, which is particularly vulnerable to oil fouling of the plants on which they feed. Finally, many of the species collected through these surveys were entirely new: between 300 and 400 new species were described based on these collections and many more await description.

As many as six persons have been employed at any one time on the joint Smithsonian-MMS project with responsibilities for inventorying the material as it was received, cataloging the identified specimens, sorting and identifying additional specimens from unprocessed lots, and other curatorial tasks necessary to meet NMNH curatorial standards. However, approximately one third of MMS collections deposited at the Smithsonian need further work in order to optimally support research related to the oil spill.

Importance of Collections:

To give the committee some idea of the importance of these collections, my staff recently estimated that fully 58% of publicly available specimen-based records from the Gulf of Mexico represent Smithsonian collections. I would like to emphasize that many marine research institutions around the Gulf and elsewhere will play key roles in assessing damage and measuring remediation and recovery in the years ahead. The Smithsonian is ready to collaborate and support that work in any way it can. It is also likely that many scientists and institutions have data or collections that are not publically available (i.e. accessible via on-line databases) that are highly relevant to the Deepwater Horizon oil spill. However, the massive size and quality of the MMS survey collections at the Smithsonian will surely continue to be an important resource.

These collections, therefore, represent a unique and now irreplaceable resource to describe quantitatively the pre-spill Gulf of Mexico ecosystem. The depth range of these collections is enormous, ranging from five to nearly 3,000 meters (nearly two miles). From the label data I calculated that specimens were accessed at 459 distinct depths. The deep collections are especially valuable because survey work at such depths is extremely expensive and limited. Given the depth of the Deepwater Horizon well-head, data on abyssal communities are especially important. A Gulf-wide MMS-funded deepwater study listed above as DGoMB was recently published and includes a number of these deep stations very near the spill site in its database. The total number of distinct geographic points sampled is roughly 1,000. In short, by the standards of biological sampling in general, and especially considering the rarity of deep-water samples, these collections are truly impressive.

Distinct Roles of Smithsonian and MMS:

The Smithsonian role in this partnership has been the archiving of the collections that support these technical studies, the improvement of the scientific quality of the collections as resources permitted, and making them publicly available in digital form through our website. MMS conducted the surveys, received reports from the scientists and contractors involved, and is therefore the final authority on data and analyses extracted from the collections. The Smithsonian enhances the value of the collections by meticulously creating digital records for

each sample of specimens, including precise georeferenced locality data and other important ecological aspects. Few other museums have the resources to create so many records of such high quality. The quality and quantity of digitally available data will make these collections in particular extremely valuable to scientists seeking information on the pre-spill ecosystem.

Future Work:

Ideally, the scientists that will carry out inventories and surveys of the post-spill environment will want exactly comparable pre-spill surveys, using the same methods, and designed for the same analytical protocols. There is one ongoing MMS and NOAA-funded study of deep corals in the vicinity that is ideally suited to this task. We cannot say at this time to what extent the 1974-1978 baseline surveys, and most surveys since then, fulfill these stringent requirements. While such surveys may be in retrospect imperfect, or imperfectly archived in some ways, they certainly provide one of the most comprehensive available resources on biodiversity and abundance data prior to the spill. Even if the background raw data are not available, it is possible that such data could be regenerated directly from NMNH collections. Although it is already obvious that NMNH collections have had, and will have, an important role to play in describing the pre-spill ecosystem, we must wait until post-spill questions are more precisely formulated before we can assess their role more specifically.

In addition to the more than 333,000 lots of invertebrates originating from MMS studies in the Gulf of Mexico, the NMNH Invertebrate Zoology collections also include 39,000 lots of invertebrates that have been at least partially inventoried (have a corresponding record in our catalog database). Of the 39,000 lots represented in our database, the majority were collected between 1951-2010. Our collection also includes an estimated 75,000-120,000 lots that have not been inventoried at all. We have, however, completed an initial digitization assessment in which collections have been prioritized for improvements in curation. In order to make these high-priority collections available to researchers we would need to inventory and digitize them. Direct digitization is the most efficient way to make the information widely available. Although these collections are not as extensively documented as the MMS specimens, many were collected from shallow near-shore and in-shore areas, and are an important source of comparative material from Gulf of Mexico locations not sampled by the MMS programs.

Recommendations:

1. The MMS baseline surveys in the 1970's, and special applied project studies conducted thereafter, are now a unique and irreplaceable resource to provide factual and objective data on the Gulf of Mexico pre-spill environment.
2. Precise assessment of the ability of these collections and associated data to support quantitative comparisons of pre- and post-spill conditions will require additional work, contingent on the exact questions to be answered.
3. Survey work in the Gulf region in advance of oil damage has commenced already, but it needs to be well-organized and quantitative. We have a short window of time to increase our baseline knowledge of these ecosystems before damage occurs.

4. Post-spill ecological research would be enhanced by working up and making publicly available Gulf of Mexico pre-spill collections that are not yet publicly available.
5. Gathering baseline ecological data (similar to the MMS Environmental Program) is a proactive and precautionary step wherever offshore drilling may take place. The Gulf of Mexico MMS baseline surveys were refocused in 1978, yet today, 32 years later, they are suddenly of national importance and significance. All stakeholders benefit from objective and factual information. Advances since then in the ability to archive and exploit such data now make such activities both economical and routine.

Thank you for the opportunity to testify today and I look forward to answering any questions you may have.