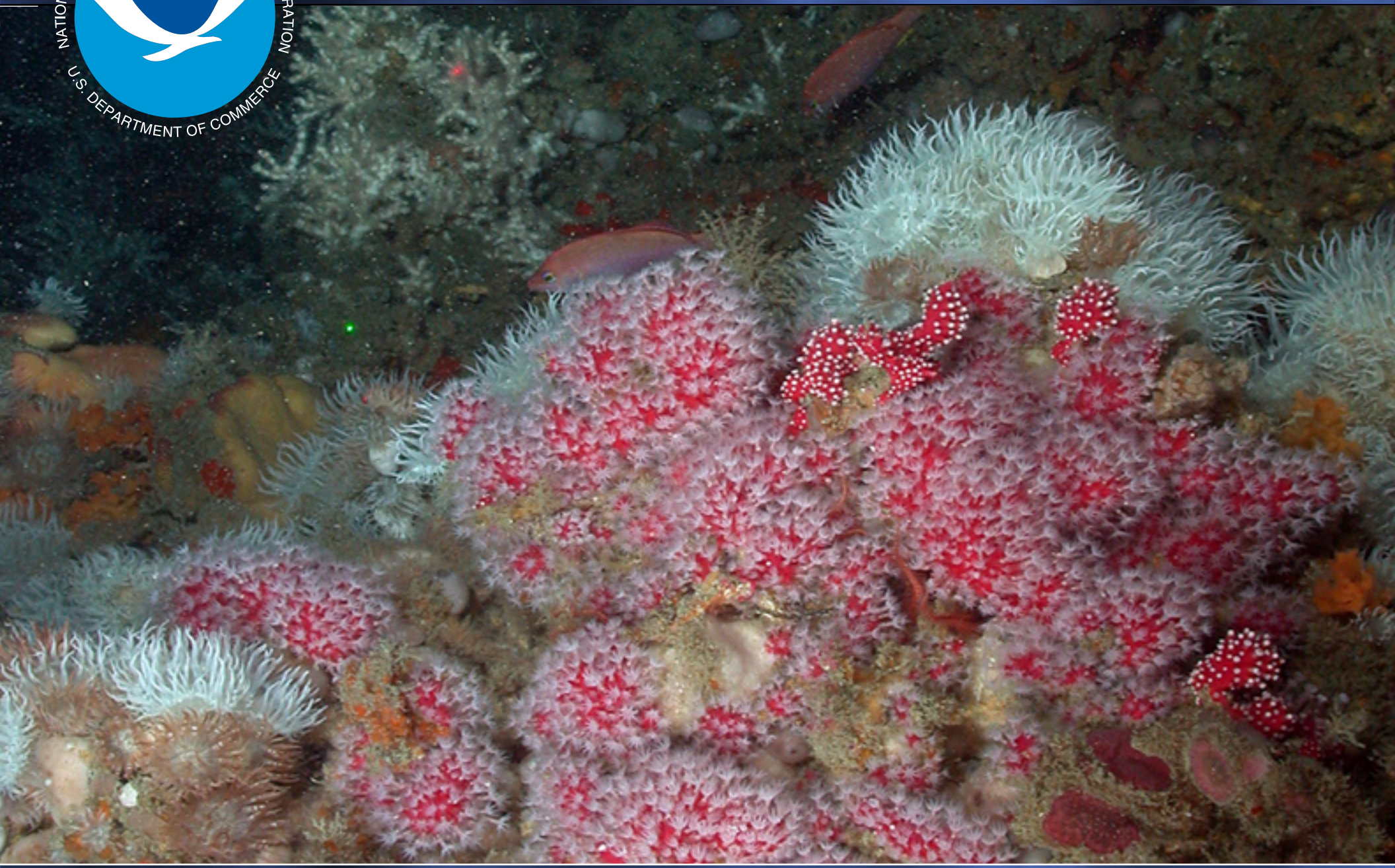
Deep Sea Coral Research and Technology Program
2012 Report to Congress



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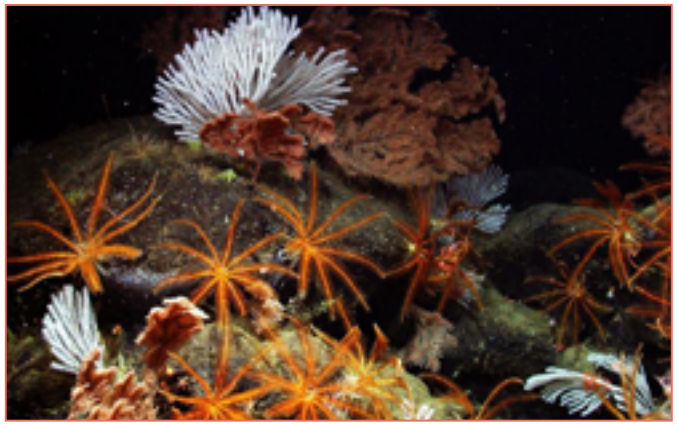
About This Report

The Deep Sea Coral Research and Technology Program was established under the authority of Section 408 of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as reauthorized in 2006. This MSA-required biennial report to Congress and the public summarizes the steps taken by the National Oceanic and Atmospheric Administration (NOAA) in fiscal years (FY) 2010 and 2011 to identify, monitor, and protect deep-sea coral areas, including the program's research activities and results. This report was developed in consultation with the Regional Fishery Management Councils. This report is supplemented by further descriptions of program-funded activities available at **www.habitat.noaa.gov/deepseacorals**.

The Deep Sea Coral Research and Technology Program ("program") collaborates with other NOAA programs and offices, such as National Marine Sanctuaries, Ocean Exploration and Research, Fisheries Science Centers, Fisheries Regional Offices, and the National Centers for Coastal Ocean Science. These programs and offices support exploration, research and management activities critical to understanding and managing deep-sea corals and other trust resources. Additionally, the program's work is enhanced by the research and ongoing collaborations with the Regional Fishery Management Councils, other federal agencies, international partners, and non-governmental and academic scientists. Accomplishments of these partner programs and agencies, while important to the program, will not be specifically discussed as they are outside the scope of this report.



MSA Section 408. Deep Sea Coral Research and Technology Program

(a) IN GENERAL - The Secretary, in consultation with appropriate regional fishery management Councils and in coordination with other Federal agencies and educational institutions, shall, subject to the availability of appropriations, establish a program--

(1) to identify existing research on, and known locations of, deep-sea corals and submit such information to the appropriate Councils;

(2) to locate and map locations of deep-sea corals and submit such information to the Councils;

(3) to monitor activity in locations where deep-sea corals are known or likely to occur, based on best scientific information available, including through underwater or remote sensing technologies and submit such information to the appropriate Councils;

(4) to conduct research, including cooperative research with fishing industry participants, on deep-sea corals and related species, and on survey methods;

(5) to develop technologies or methods designed to assist fishing industry participants in reducing interactions between fishing gear and deep-sea corals; and

(6) to prioritize program activities in areas where deep-sea corals are known to occur, and in areas where scientific modeling or other methods predict deep-sea corals are likely to be present.

(b) REPORTING - Beginning 1 year after the date of enactment of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006, the Secretary, in consultation with the Councils, shall submit biennial reports to Congress and the public on steps taken by the Secretary to identify, monitor, and protect deep-sea coral areas, including summaries of the results of mapping, research, and data collection performed under the program.

Executive Summary

Deep-sea corals form large, complex structures in all U.S. regions, providing habitats for myriad marine species. The Deep Sea Coral Research and Technology Program is the nation's only federal research program dedicated to increasing scientific understanding of deep-sea coral ecosystems and is designed to provide ocean resource managers with scientific studies to inform conservation actions. Begun in 2009, and funded at $2.5M annually in FY 2010 and 2011, the program focuses its resources on priority regions and targeted analyses to maximize its conservation impact while partnering with other programs and organizations to enhance cost-effectiveness.

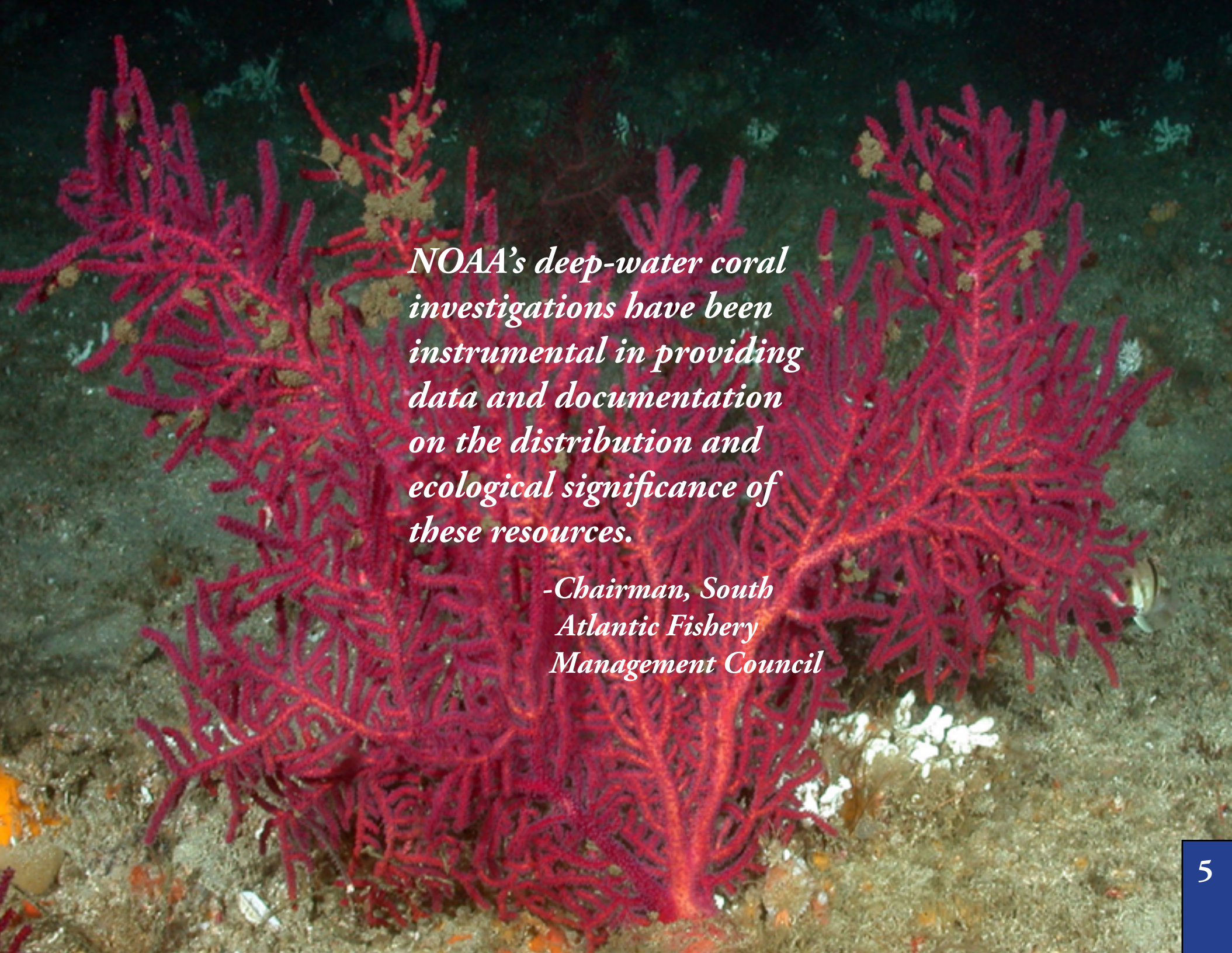
In the 2010-2011 reporting period, the program completed a three-year field study off the southeastern United States. The study revealed deep-sea coral communities never before seen off the eastern and southern coasts of Florida. Protecting deep-sea coral habitats like these is important to the South Atlantic Fishery Management Council, which has authority for fisheries in federal waters off North Carolina, South Carolina, Georgia, and eastern Florida. The Council and its Coral Advisory Panel partnered with the program in planning and implementing the study, and the program's research findings will enable the Council to refine its coral protection actions while allowing sustainable fisheries to thrive. The program is currently analyzing the data and biological samples collected from the research cruises and will present the final results in 2012 to provide the best available science to the Council in a timely manner.

On the west coast, the program is contributing to the Pacific Fishery Management Council's work to review the designation of groundfish essential fish habitats—areas important to the survival and reproduction of commercially-caught, seafloor-dwelling fish—and management actions associated with these habitats.

To support this review, a coordinated suite of studies funded by the program brought forward new descriptions of where deep-sea coral communities are, how fish use them as habitat, and where interactions between fishing gear and corals could be reduced. As the Council considers ways to safeguard the habitats crucial to the region's fisheries, this knowledge is fundamental to effective conservation. Furthermore, the program's findings will be used by multiple National Marine Sanctuaries to refine sanctuary management actions.

In 2010 and 2011, the program began planning for three-year field studies in additional regions of the United States. The program's first research expedition in Alaska is scheduled to depart in 2012, and a northeast field study (Maine to Virginia) is slated to begin in 2013. To guide these regional research efforts, the program reached out to the fishing industry, the Regional Fishery Management Councils, state agencies, academia, and conservation groups to identify the key research topics that are important for making management decisions.

In spite of these recent efforts by the program and more than a decade of research by other partners, much about deep-sea coral ecosystems in the United States remains unknown. Even after three successful years of thoughtfully planned, intensive field research by the program and partners, most of the area managed by the South Atlantic Fishery Management Council is still unexplored. The South Atlantic Council has taken conservation action based on the available science and recognizes the need for further research, and it has encouraged NOAA to continue the deep-sea coral research. NOAA is committed to producing quality scientific information to support all Regional Fishery Management Councils and other ocean management initiatives.



NOAA's deep-water coral investigations have been instrumental in providing data and documentation on the distribution and ecological significance of these resources.

-Chairman, South Atlantic Fishery Management Council

About Deep-Sea Corals

Black corals often resemble bushes or trees, and may include the oldest living marine organisms. This black coral off Hawaii was estimated to be over 4,000 years old.

Deep-sea **stony corals** range from small individual cup corals to a few species, like this *Lophelia pertusa* colony off Eastern Florida, that contribute to extensive deep-water reefs.

Gold corals, which belong to a single genus, *Gerardia*, are sometimes collected for jewelry. They are unique in that they appear to grow on the skeletons of other deep-sea corals and can live for thousands of years.

Gorgonians, like this fan-shaped colony of **red coral** (*Corallium* sp.) on Davidson Seamount, are among the most diverse deep-sea corals.

Sea pens, like these off Alaska, are related to **gorgonians**, but unlike most other deep-sea corals they live in soft sediments where they can form large fields.

Lace corals, like these off California, are actually hydroids and only distantly related to other corals.

Deep-sea corals can live for hundreds or thousands of years, creating remarkably complex communities in the depths of the oceans from where the light is dim to more than 10,000 feet below. In the United States, deep-sea coral habitats have been discovered in all regions on continental shelves and slopes, canyons, and seamounts. Their full geographic extent is still unknown because most areas have yet to be adequately surveyed.

Some deep-sea coral species form reefs that, over millennia, can grow more than 300 feet tall. Other species shaped like bushes or trees can form assemblages similar to groves or forests on the seafloor.

Nationwide, these complex structures provide habitat for many fish and invertebrate species, including certain commercially important ones like grouper, snapper, sea bass, rockfish, shrimp, and crab. Moreover, organisms that live in deep-sea coral habitats produce chemicals with great potential for biomedical uses, and some deep-sea coral species have commercial value as jewelry and art objects.

Most deep-sea corals grow extremely slowly. Once damaged, the corals and the communities they support may take centuries to recover, if they recover at all. Deep-sea corals are vulnerable to disturbance caused by fishing gears such as bottom trawls that contact the seafloor. They can also be damaged by activities associated with energy exploration and development, cable deployment, and other activities that disturb the seafloor. Additionally, ocean acidification—a result of the ocean absorbing increased carbon dioxide—can adversely affect corals' ability to grow or maintain their structures.

Unveiling Deep-Sea Coral Ecosystems

Beneath the ocean surface, America's marine waters hold rich treasures of ecosystems full of life supported by the complex structures of deep-sea corals. Sustainable management of these resources requires knowledge of their extent and condition. NOAA's Deep Sea Coral Research and Technology Program provides this knowledge.

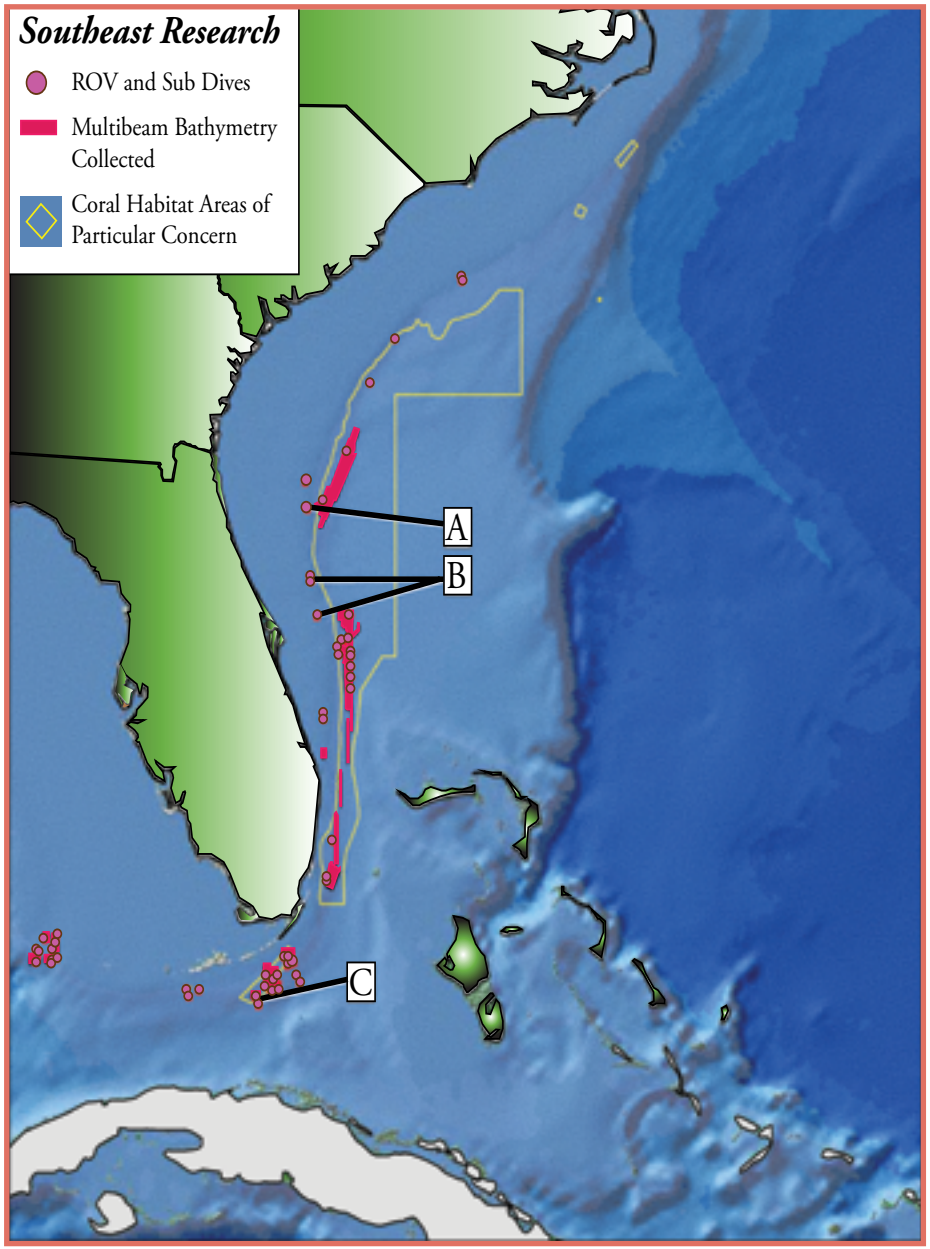
In FY 2010 and 2011, NOAA received $2.5 million each year to implement the program. Through the research studies summarized in Appendix I, the program expanded our nation's collective knowledge of deep-sea coral distribution and biology, as well as our understanding of the marine life that uses the corals as shelter, feeding platforms, and breeding grounds. A focus during this reporting period was the southeastern United States, where significant discoveries of deep-sea coral communities occurred.

Studying the Deep Reefs of the Southeast

In waters off the southeastern United States, NOAA concluded a three-year field study of deep-sea coral ecosystems from North Carolina to Florida, with the final research cruise returning to shore in fall 2011. Over the last three years, NOAA and partners used a wide range of high-tech tools on seven research cruises to find and study deep-sea coral reefs. Five cruises used a sonar technology called multibeam to discover areas where the seafloor has the particular size, shape, and texture that indicate probable locations of deep-sea corals. This resulted in 1,480 square miles of high-resolution seafloor maps. On five expeditions, scientists sent a submersible or an unmanned research vehicle—known as a remotely operated vehicle, or ROV—to the bottom of the ocean to visually survey the deep-sea coral communities. Fifty-eight ROV and submersible dives brought back biological specimens, hundreds of hours of video, and thousands of photos, documenting the myriad species—corals, fishes, crabs, and more—at sites more than 2,000 feet deep (Figure 1).

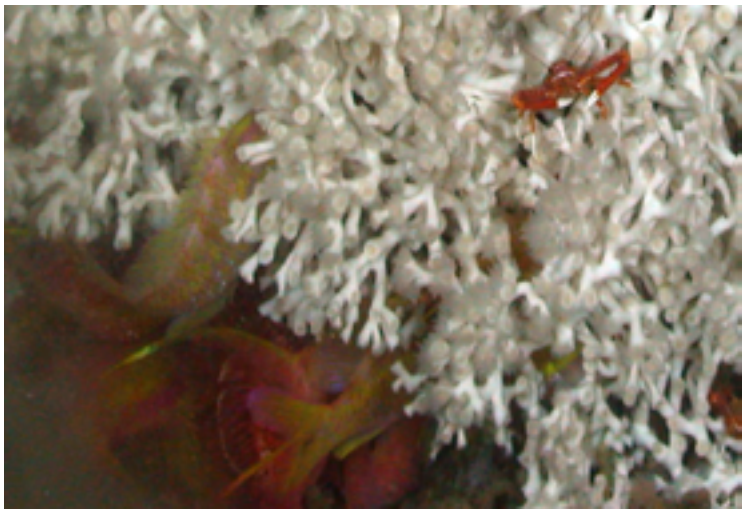
The videos, photos, and over 1,000 biological samples collected over these three years are undergoing analysis. Scientists are reviewing them to quantify the abundance of fishes and invertebrates living in deep-sea coral communities, identify the species encountered, estimate the corals' ages and growth rates, and understand their population structure by examining their DNA. These results are puzzle pieces that, when fit together, will tell us more about what functions deep-sea corals serve for the ocean ecosystem, how vulnerable or resilient deep-sea corals are to disturbance, what environmental conditions are most suitable for deep-sea corals to thrive and, based on that, where additional deep-sea corals might be found.

Fig 1: The Deep Sea Coral Research and Technology Program unveiled deep-sea coral ecosystems in the Southeast

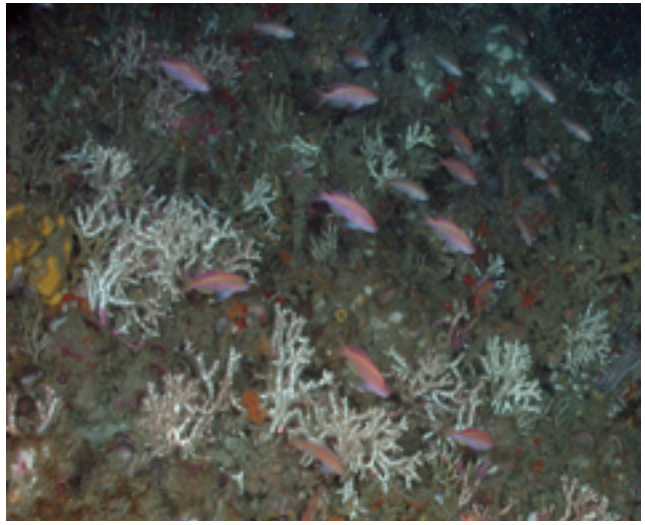


NOAA and partners used a wide range of high-tech tools to find and study deep-sea coral reef ecosystems off the southeastern United States in 2009-2011 with support from the Deep Sea Coral Research and Technology Program. The study consisted of seven research cruises and post-cruise analyses of the videos, photos and biological samples collected.

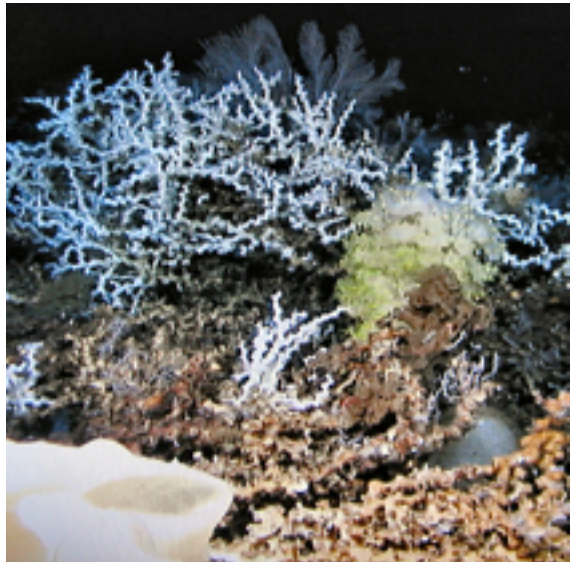
Locations where the program conducted 58 ROV and submersible dives are in pink. Areas where the program mapped the seafloor with multibeam, totaling 1,480 square miles, are in red. The highlights of the preliminary findings to date are:



A. Off **Jacksonville, Florida**, scientists discovered the shallowest *Lophelia pertusa* coral habitat in the United States to date, at approximately 660 ft (200 m) depth. Occurring globally, *Lophelia pertusa* is an important reef-forming deep-sea coral.

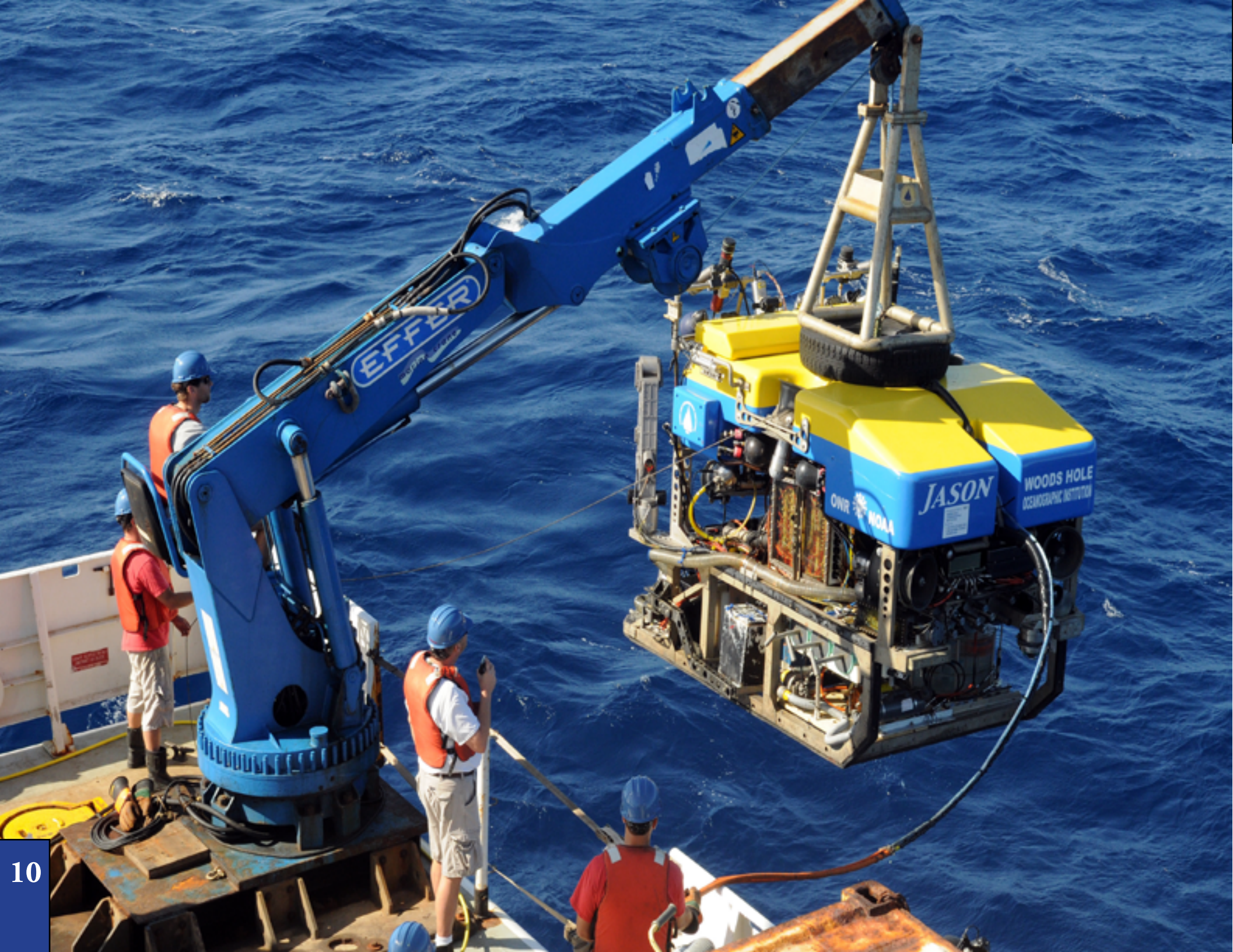


B. Off **Daytona Beach, Florida**, researchers documented 75 unprotected and previously unknown mounds of the reef-forming ivory tree coral, *Oculina varicosa*. The only place in the world where this species is known to form reefs is in U.S. waters off Florida, and it has been listed by NOAA as a Species of Concern based on well-documented population declines in the *Oculina* Banks area.



C. Just south of the **Florida Keys**, at a site called Pourtalès Terrace, our research cruise found the southernmost *Lophelia* reefs in the United States.

Our researchers are reviewing the videos recorded during the cruises to describe how fishes and invertebrates use deep-sea corals as habitat. They are also examining and identifying the invertebrates collected from these habitats. Some species could be new to science.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WOODS HOLE
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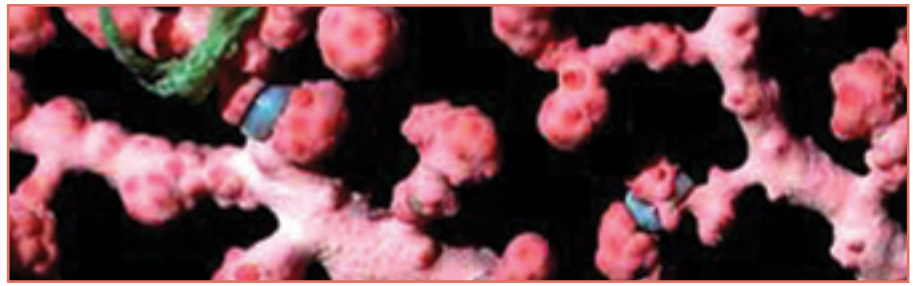
Safeguarding America's Secret Gardens

Deep-sea corals are fragile and tend to grow slowly. Therefore, they are vulnerable to physical damage and are slow to recover from it. Thus, thoughtful actions are required to avoid damage while allowing compatible human uses of ocean resources, such as sustainable fisheries, to continue. As the Deep Sea Coral Research and Technology Program studies the "coral gardens" hidden in the depths of America's oceans, the program's research findings are used in ocean management decisions to enable actions that safeguard these vulnerable ecosystems. An example is unfolding on the west coast:

Examining Deep-Sea Corals as Fish Habitat on the West Coast

NOAA and the Pacific Fishery Management Council manage fishing activities in federal waters off Washington, Oregon, and California, and co-manage the fisheries resources off Washington with the Pacific Northwest coastal treaty tribes. In 2011 the Council began reviewing the 2006 designation of groundfish essential fish habitats (EFH)—areas important to the survival and reproduction of commercially-caught, seafloor-dwelling fish—and management actions associated with these habitats. Some groundfish EFH encompass deep-sea coral and sponge communities, which, like corals, can form complex habitats for fishes and invertebrates.

Among the research funded by the Deep Sea Coral Research and Technology Program, a coordinated suite of studies on the west coast support the Council's work describing, identifying, and conserving groundfish EFH. By locating where deep-sea corals and sponges occur, documenting the species associated with them, and clarifying their importance as habitat to groundfish, these studies will assist the Council in determining EFH boundaries. The designation of deep-sea coral and sponge areas as groundfish EFH, if warranted, would require the Council to consider management actions to protect the areas from disturbance caused by fishing gear. Such measures would be expected to help support a healthy groundfish population. Such designation also allows NOAA to



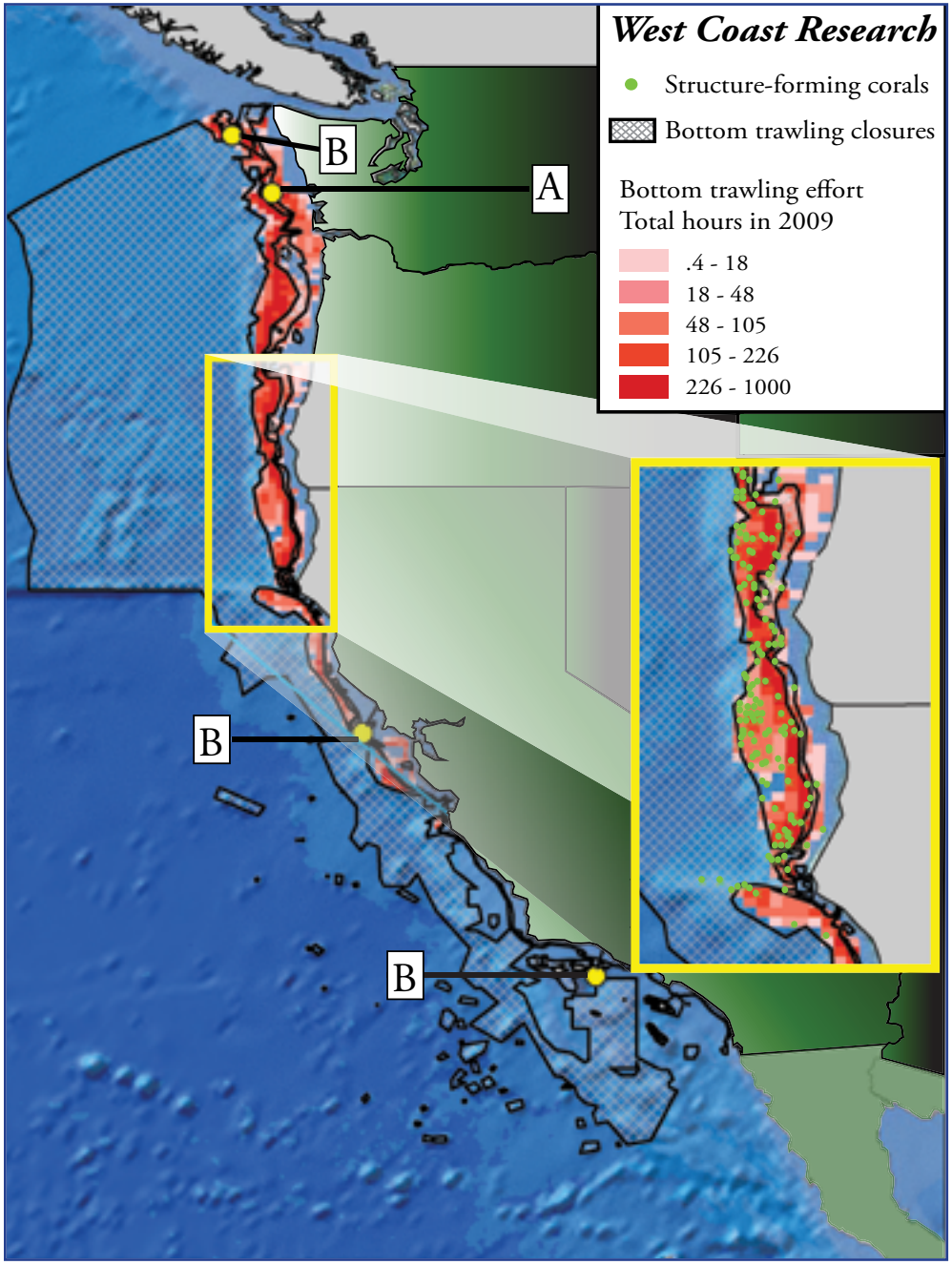
provide recommendations to other federal agencies to help them protect these sensitive habitats from the impacts of activities like cable-laying and dredging.

Scientists involved in these studies are preparing the following spatial data products to submit to the Council's EFH Review Committee (Figure 2).

- Detailed descriptions of deep-sea coral and sponge communities at sites off California and Washington, including associated fishes, invertebrates, and habitats
- Results of visual surveys of glass sponge habitats and their associated groundfish species
- A compilation of thousands of deep-sea coral locations known to date
- Predictive maps of areas where deep-sea corals are likely to occur
- The geographic extent of bottom trawling
- The amount and distribution of deep-sea coral bycatch in commercial fisheries

Some of these products came from one-year studies that concluded in 2010 and 2011 listed in Figure 1. Others are interim products of the program's three-year field study that started in 2010 to locate deep-sea coral and sponge habitats and to document fish associated with these habitats along the West Coast. The three-year study comprises multibeam, autonomous underwater vehicle (AUV), ROV, and manned submersible surveys and subsequent analyses of the images and samples collected. Although the study is still ongoing, scientists have accelerated their analyses to meet the Council's EFH review schedule.

Figure 2: The Deep Sea Coral Research and Technology Program informs deep-sea coral management on the West Coast

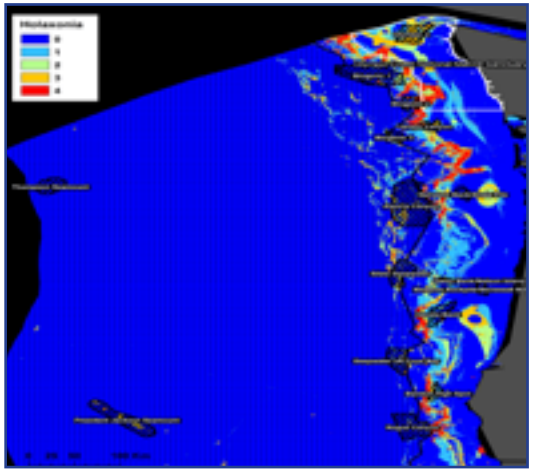


Findings from studies funded by the program are submitted to the Pacific Fishery Management Council to help the Council make informed decisions in describing, identifying, and conserving groundfish EFH.

The following products have been submitted to, or are being prepared for, the Council's EFH Review Committee:

A. Results of visual surveys of a glass sponge habitat forming "gardens" off southern Washington. This picture shows sponges with rockfish at a site near Grays Canyon.

B. Detailed descriptions of deep-sea coral and sponge communities, including the fish and invertebrates associated with them, at sites such as coral areas off Washington, Cordell Bank off central California, and Piggy Bank off southern California. The picture shows a deep-sea coral (*Plumarella longispina*) on a large boulder at 1,000 ft (318 m) depth at Piggy Bank.



A compilation of structure-forming deep-sea coral locations known to date, shown in light green on the map. See Appendix II for a more detailed deep-sea coral distribution map.

Predictive maps of areas where deep-sea corals are likely to occur.

The amount and distribution of deep-sea coral bycatch, and the geographic extent of bottom trawling. The 2009 extent of bottom trawling is shown on the map as 10 km x 10 km grids. The grid color indicates the trawling intensity measured in cumulative hours over the year. The trawling intensity data can be found at the Pacific Coast Ocean Observing System (PaCOOS) West Coast Habitat Server (http://pacoos.coas.oregonstate.edu). The bycatch and trawling data can help the Council assess the risk of interactions between fishing gear and corals. It can also help guide the Deep Sea Coral Research and Technology Program's selection of future survey sites to better understand the relationships between corals, fish, and fishing.

(Notes: 1. Grids fished by fewer than three bottom-trawling vessels are not shown. 2. Coral presence in a colored grid does not necessarily imply interaction between trawling and corals; it only means that trawling occurred in 2009 in the same grid where a coral has been documented. 3. Crosshatched are the areas closed to bottom trawling year-round to protect EFH or for the purpose of reducing incidental take of overfished rockfish.)

Regional Highlights

South Atlantic Region

The three-year field study to investigate deep-sea coral ecosystems in the southeast, as previously described on page page 7, serves the needs of the South Atlantic Fishery Management Council, which has authority over fisheries in federal waters from North Carolina to Key West.

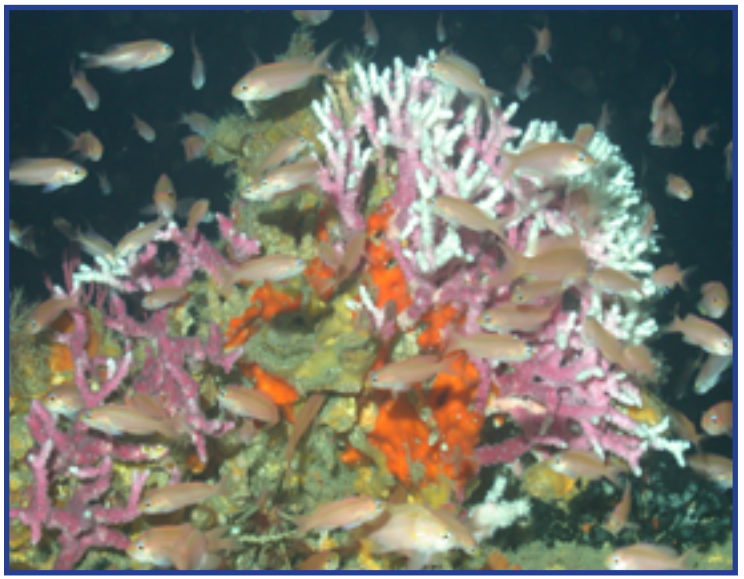
The Council and NOAA have been proactive in protecting deep-sea coral reefs by establishing five deepwater Coral Habitat Areas of Particular Concern (C-HAPCs) totaling 24,215 square miles in 2010, where fishing gears that contact the seafloor are prohibited and coral habitat is protected. Within the C-HAPCs, there are areas where small-scale traditional fisheries that use bottom-contact gear to catch golden crab and royal red shrimp are allowed. As the Council continues to find ways to best conserve coral habitats while preserving fishing interests, it is looking to the Deep Sea Coral Research and Technology Program and other NOAA programs and offices to determine the precise locations and ecological importance of the coral habitats so the boundaries of the C-HAPCs and allowable fishing areas can be refined.

To align the program's three-year study with the Council's needs, the program not only involved the Council representatives in the initial design of the study but also partnered with members of the Council's Coral Advisory Panel in five of the program's seven research cruises. Furthermore, as the study entered the final analysis phase in late 2011, NOAA presented the preliminary findings to the advisory panel to keep the Council informed (Figure 2). Final results are scheduled to be released in a report in late 2012.

In recognition of the value of the preliminary findings provided by the program, the South Atlantic Fishery Management Council chairman thanked NOAA for its research in the region over the last three years, referring to the preliminary results as "instrumental in providing data and documentation on the distribution and ecological significance of these resources." In a letter to NOAA Assistant Administrator for Fisheries, the chairman summarized the areas where the new findings can help with the Council's adaptive management to protect deep-sea coral communities. As much of the South Atlantic region has yet to be explored to determine the true extent of deep-sea coral ecosystems, the chairman recognized the large suite of remaining science needs and called for continued research.

Gulf of Mexico Region

In the southeast region, the program also works in the Gulf of Mexico. The program compiled spatial records of structure-forming deep-sea coral locations in the Gulf, and has increased the compilation from less than 100 records to over 1,800. The program provided maps of these deep-sea coral locations to help guide efforts for the response and Natural Resource Damage Assessment following the Deepwater Horizon MC252 oil spill. Building on this knowledge of deep-sea coral locations, in 2011 the program initiated a study to use computer models to predict additional habitat areas in the Gulf of Mexico that may be suitable for deep-sea corals.



Regional Highlights

West Coast Region

The Deep Sea Coral Research and Technology Program is conducting a three-year field study (from 2010 to 2012) along the west coast, as described on page 11. This study benefits from strong collaborations with many partners. The coastal treaty tribes that co-manage federal fisheries with NOAA participated in the initial research priority-setting workshop, and a fishery biologist from the Makah Tribe was on the research team that surveyed coral sites off Washington with an AUV and ROV in 2010. Moreover, a research cruise off southern California in 2010 was contracted on the private fishing vessel Velero IV. The program also engaged academic scientists and other government agencies in this research. These

academic, agency, tribal, and industry partnerships enhance the program's ability in conducting scientific studies in response to management needs. Along with the Pacific Fishery Management Council, the National Marine Sanctuaries also utilize the newly generated deep-sea coral science to develop their management actions. There are five sanctuaries on the west coast, and they all encompass deep-sea coral communities. The program's research aids all these sanctuaries in the identification of deep-sea coral habitats and subsequent management of coral communities. The findings will also strengthen the sanctuaries' ongoing collaborations with the Pacific Fishery Management Council and the tribes to manage fishing activities in key habitats in sanctuary waters.

Alaska Region

The Deep Sea Coral Research and Technology Program will begin a three-year field study in the Alaska region in 2012. To that end, the program organized a research priorities workshop in 2010, where participants from the fishing industry, the North Pacific Fishery Management Council, other federal and state agencies, academia, and conservation groups shared their research ideas and management needs with NOAA. The program is analyzing archived underwater videos and multibeam maps so the upcoming fieldwork can build on a solid understanding of previous scientific observations. The program also supported the production of a deep-sea sponge identification guide that documents the Aleutian Islands' rich sponge fauna and will help fishery observers better document the types and amounts of incidentally caught sponges. Sponges, like corals, can form complex habitat for commercially valuable fish and crabs, and are a significant component of bycatch in certain Alaskan bottom-trawl fisheries.

Regional Highlights

Northeast Region

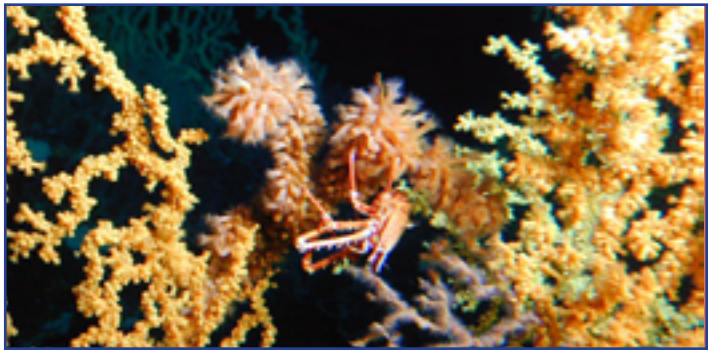
The Deep Sea Coral Research and Technology Program is planning a three-year field study in the Northeast region (Maine to Virginia) starting in 2013. To support this effort, the program organized a research priorities workshop in 2011, where representatives from the New England and Mid-Atlantic Fishery Management Councils, other federal agencies, academia, and conservation groups shared their research ideas and management needs with NOAA. As has been done for other regions, the program is developing computer models to predict the location of potential suitable habitat of deep-sea corals in this region, so the fieldwork can be targeted at locations where corals are likely to be.

The New England Council is considering a suite of alternatives to designate deep-sea coral protection zones using its discretionary authority provided in MSA Section 303(b)(2)(B). This would be the first use by a Council of this authority provided in the 2006 MSA reauthorization. In this process, the New England Council's Habitat Plan Development Team has an ongoing collaboration with the program to refine, audit, and add coral location records for the northeast region. The Mid-Atlantic Council is a strong partner in this effort too as its representatives serve on the New England Council's Habitat Committee and Habitat Plan Development Team. NOAA supports the Councils' efforts to advance the management of known coral ecosystems of the northeast, particularly in submarine canyons, on seamounts, and on select high-relief areas in the Gulf of Maine (see Figure 3).

The program has also supplied information on deep-sea coral locations to regional planning efforts by states that are members of the Mid-Atlantic Regional Council on the Ocean.

Pacific Islands Region

In the 2010-2011 period, the program supported a study in the Main Hawaiian Islands to identify suitable habitat of pink coral (*Corallium secundum*) and gold coral (*Gerardia* sp.) – species of deep-sea corals with colored skeletons that can be made into jewelry. They are also the primary species of interest in a currently inactive commercial fishery and, as a result, more data are available than for other species of deep-sea coral in the Pacific Islands region. This study integrates 1,227 observations of the species of interest, from more than 1,100 submersible dives, with data on ocean current velocity, depth, and substrate type, to develop a



predictive map of locations with a high probability of occurrences of these deep-sea coral species. Findings from the study will be submitted to the Western Pacific Fishery Management Council, which has authority over the precious coral fishery. Findings can also be used to guide activities such as route planning for subsea communications or power cables, dredge disposal sites, and future research on deep-water environments in the Main Hawaiian Islands. Fieldwork to groundtruth the predictive map will, in turn, enhance the prediction technique.

Regional Highlights

National Geodatabase of Deep-Sea Coral Locations

The Deep Sea Coral Research and Technology Program is building a national geodatabase that houses spatial records of deep-sea corals. Regional Fishery Management Councils could use records in the geodatabase to "protect deep sea corals from physical damage of fishing gear or to prevent loss or damage to such fishing gear from interactions with deep sea corals" under their discretionary authorities provided by MSA Section 303 (b)(2)(B).

The records in the geodatabase are derived from the research funded by the program, results of other NOAA programs that study the deep sea, and data voluntarily contributed by other federal agencies, research institutions and international organizations. The geodatabase has grown from 1,700 records from the East Coast and the Gulf of Mexico in 2010, to over 85,000 records from around the United States by 2011. Information from the national geodatabase, the first of its kind, has been provided to the New England and Pacific Fishery Management Councils for their use in designing habitat conservation measures.

Using innovative tools to advance deep-sea coral science

The Deep Sea Coral Research and Technology Program applies innovative research tools to answer key science questions. One such tool is the autonomous underwater vehicle (AUV), a robot that can be programmed to independently travel underwater along a set route at a certain height above the ocean bottom, photographing what lives on the seafloor. It can also measure water quality and map the seafloor with sonar. An AUV was used in the program's research off the west coast and captured thousands of photos revealing the deep-sea ecosystems formed on a foundation of corals and sponges. See page page 11 for research progress.

Complementing the use of multibeam, AUVs, ROVs, and submersibles, the program employs other innovative and cost-effective methods, such as analyzing archived deep-sea images and fisheries bycatch data, and developing predictive models, to identify where deep-sea corals are likely to be. Additionally, in the southeast region and off the west coast, the program also maps the degree of geographic overlap between bottom fishing and deep-sea corals so that the Regional Fishery Management Councils and NOAA can make informed decisions to reduce the interactions between fishing gear and the corals.

Looking to the Future

Building on the Deep Sea Coral Research and Technology Program's progress in 2010 and 2011, NOAA plans to take the following steps to advance deep-sea coral science and management in alignment with NOAA's 10-year Strategic Plan for Deep-Sea Coral and Sponge Ecosystems.

Advancing Deep-Sea Coral Science

The program is planning to begin three-year field studies in Alaska and the northeast, in 2012 and 2013 respectively. Meanwhile, the program will also complete the three-year field studies and data analysis on the west coast and in the southeast, and submit the results to the appropriate Regional Fishery Management Councils.

Parallel to the fieldwork studies, the program will continue to support smaller-scale, targeted analyses throughout the nation to bring forward deep-sea coral information that lies in archived images and fisheries data, monitor fishing activities in deep-sea coral areas, and develop predictive models of where deep-sea corals are likely to occur.

The program will integrate the new information into its national deep-sea coral geodatabase, and strengthen partnerships with other agencies and institutions to collect voluntarily contributed deep-sea coral records. The geodatabase will be peer-reviewed and made available to the public and the research community.

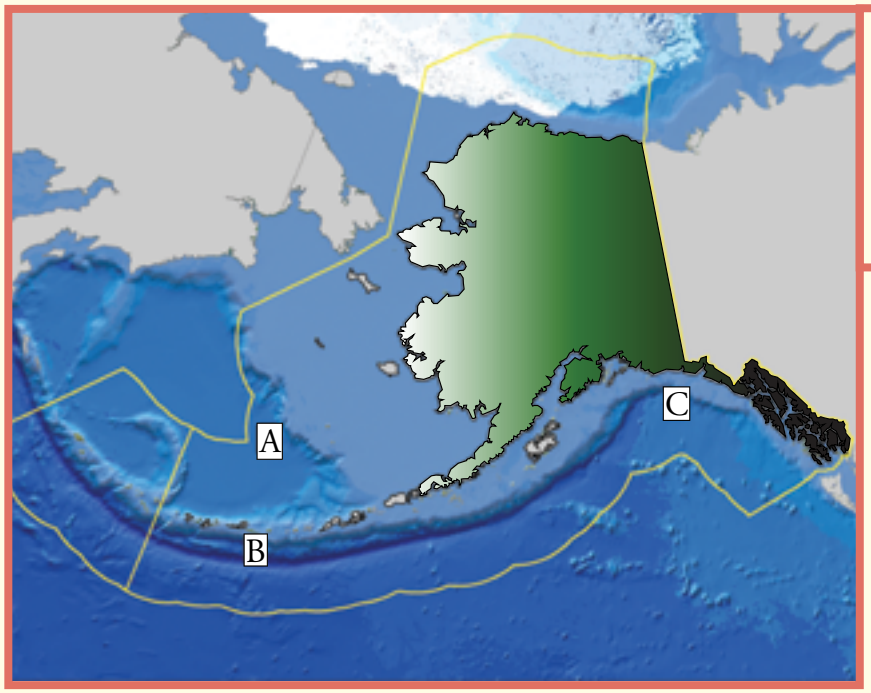
Advancing Deep-Sea Coral Management

Around the nation, the Regional Fishery Management Councils are increasingly interested in protecting deep-sea coral ecosystems. The South Atlantic, New England, Mid-Atlantic, and Pacific Fishery Management Councils in particular have advisory groups actively considering deep-sea coral science in the context of conserving habitats that are important to fisheries. Known deep-sea coral habitats that could benefit from enhanced protection in these and other regions are summarized in Figure 3.

As evidenced by the South Atlantic Fishery Management Council's positive recognition of the fieldwork results the program has provided to date, the program contributes information that is timely and useful to ocean resource managers for ecosystem-based management. Looking to the future, the program will continue to support all the Councils with the best available science to conserve essential and vulnerable habitats. It will also look to expand its role in assisting with other ocean management initiatives by delivering high-quality scientific information that will help protect, maintain, and restore the health and biological diversity of the oceans.

Figure 3: Looking to the Future

The Deep Sea Coral Research and Technology Program, through a review of its funded research and other scientific literature, has identified several locations where deep-sea coral habitats are in areas open to bottom fishing with gears that can damage corals. The program is committed to helping resource managers evaluate the need for protection at these locations, including:



Alaska

A. Parts of the Bering Sea Slope

B. Some of the Aleutian Island coral areas not currently protected

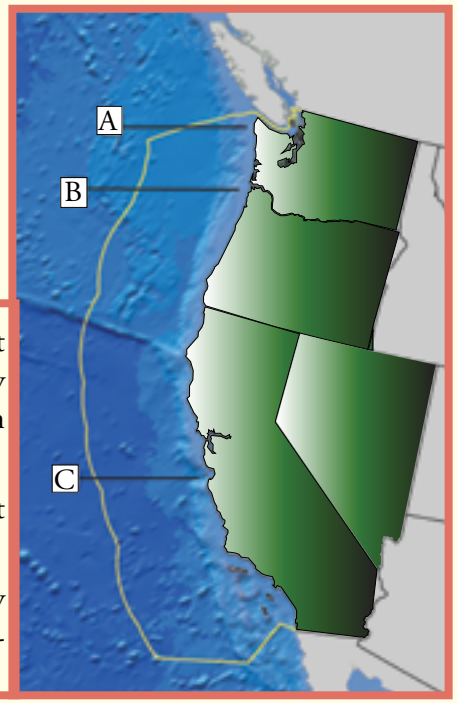
C. Gulf of Alaska *Primnoa* coral habitats outside the protected areas

West Coast

A. Areas in the Olympic Coast National Marine Sanctuary where deep-sea corals have been documented

B. Parts of Astoria Canyon that have no special protections

C. Certain areas of Monterey Canyon with no special protections

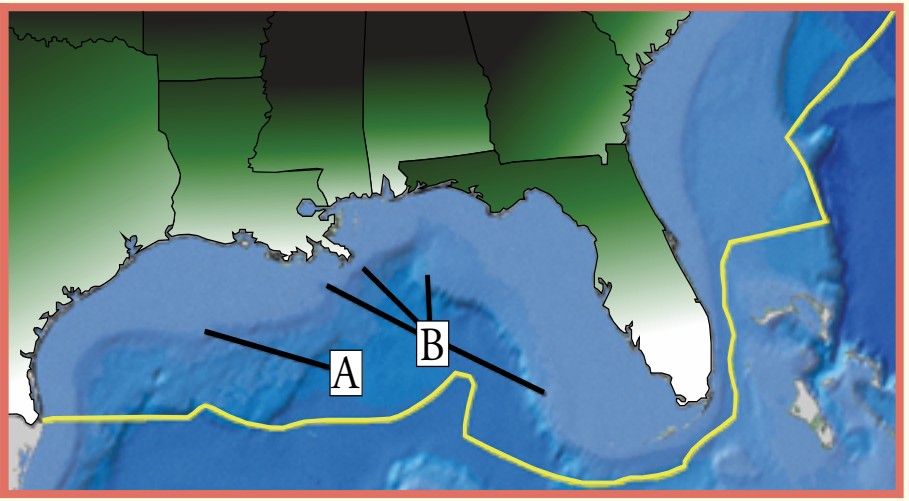


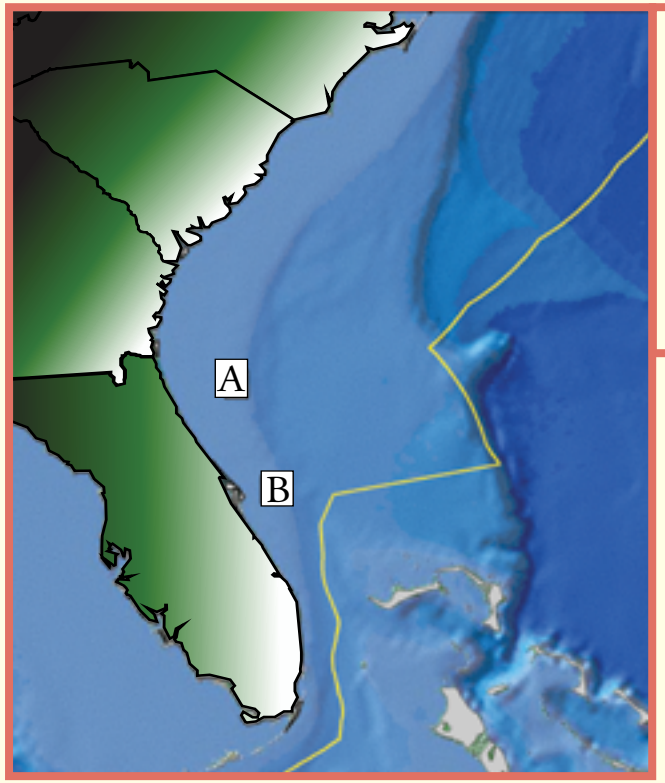
Denotes U.S. Exclusive Economic Zone

Gulf of Mexico

A. Numerous banks in the northwest Gulf of Mexico that harbor significant populations of deep-sea corals have been identified as Habitat Areas of Particular Concern, but some of them do not carry any protection measures against the impacts of bottom fishing, including 29 Fathom, Sonnier, MacNeil and Rankin Bright Banks.

B. Other areas observed to contain deep-sea corals, but have no special protections, such as Green Canyon, Mississippi Canyon, Viosca Knoll, Mississippi–Alabama Pinnacles, and southwest Florida Slope reefs





South Atlantic

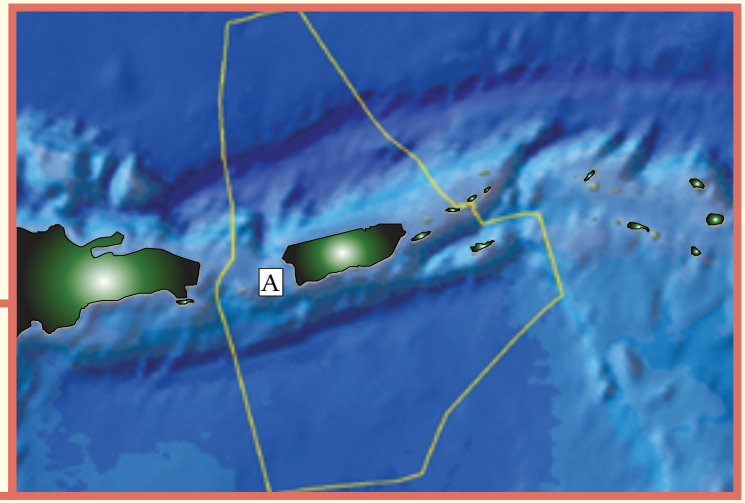
A. The recently discovered shallow *Lophelia* coral habitat off Jacksonville, FL

B. The recently discovered *Oculina* mounds outside the current *Oculina* Habitat Areas of Particular Concern boundaries, off Daytona Beach, FL

Northeast

A. Deep-sea corals are known to occur in several areas, including Bear and Retriever seamounts; Heezen, Toms, Carteret, Hendrickson and Baltimore canyons; and the slope near Alvin Canyon. The New England Fishery Management Council's Habitat Plan Development Team is reviewing the management needs for these and other canyon and slope areas in the region.

B. Two areas in the Gulf of Maine—Western Jordan Basin and Mount Desert Rock—are known to contain assemblages of deep-sea corals, but are not protected from fishing.



Caribbean

A. Mona Passage, off the west coast of Puerto Rico, where deep-sea corals have been documented

References for Figure 3:

Alaska A: Miller, R. J., Hocevar, J., Stone, R., & Federov, D. (In review). Structure-forming corals and sponges and their use as fish habitat in Bering Sea submarine canyons. PLos ONE.

Alaska B: Stone, R. P., & Alcorn, D. J. (In preparation). The ecology of deep-sea coral and sponge habitats of the central Aleutian Islands. NOAA Professional Paper.

Alaska C: Stone, R. P., Karinen, J. F., & Masuda, M. M. (In preparation). An assessment of red tree coral ecosystems of the eastern Gulf of Alaska.

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Hecker, B., Logan, D. T., Gandarillas, F. E., & Gibson, P. R. (1983). Megafaunal assemblages in Lydonia Canyon, Baltimore Canyon, and selected slope areas. In Canyon and slope processes study: Vol. III, biological processes. Final report for U.S. Department of Interior, Minerals Management Service (pp. 1-140). Washington, DC: Mineral Management Service.

Northeast B: Auster, P. J. (2005). Are deep-water corals important habitats for fishes? In A. Freiwald, & J. M. Roberts (Eds.), Cold-water Corals and Ecosystems (pp. 747-760). Berlin: Springer.

Watling et al., (2003), as above.

South Atlantic A and B: David, A. W. (2011). Southeast Deep-Sea Coral Research and Technology Program (SE-DSC) 2009-2011, presentation to the South Atlantic Fishery Management Council Coral Advisory Panel on October 25. North Charleston, SC.

Caribbean A: Lutz, S. J., & Ginsburg, R. N. (2007). State of deep coral ecosystems in the Caribbean Region: Puerto Rico and the U.S. Virgin Islands. In S. E. Lumsden, T. F. Hourigan, A. W. Bruckner, & G. Dorr (Eds.), The State of Deep Coral Ecosystems of the United States (pp. 307-365). Silver Spring, MD: NOAA.

Gulf of Mexico A: Rezak, R., Bright, T. J., & McGrail, D. W. (1985). Reefs and Banks of the Northwestern Gulf of Mexico: Their Geological, Biological, and Physical Dynamics. New York: Wiley.

Etnoyer, P. (2009). Distribution and Diversity of Octocorals in the Gulf of Mexico, PhD Dissertation. Corpus Christi: Texas A&M University. 187 pp.

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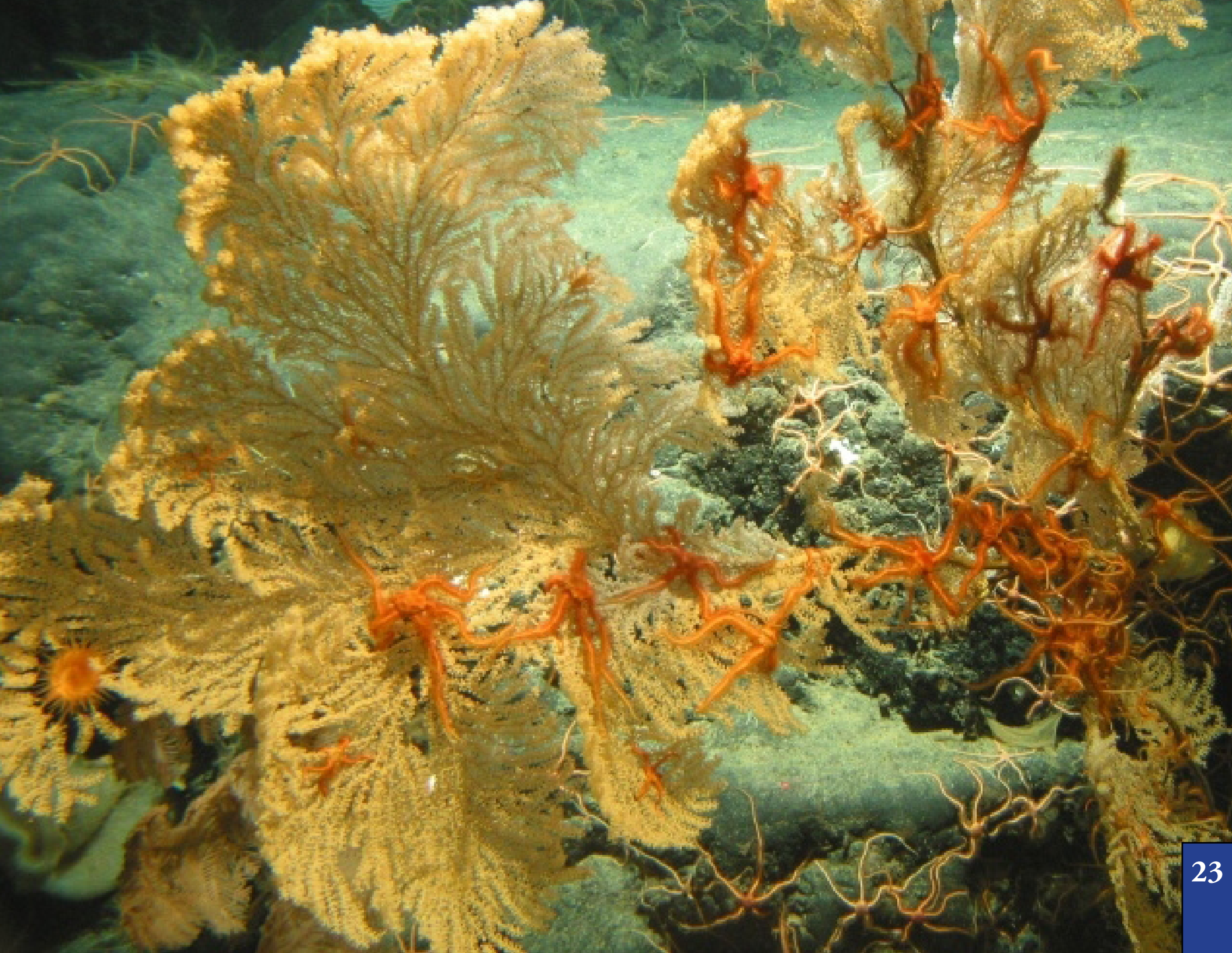
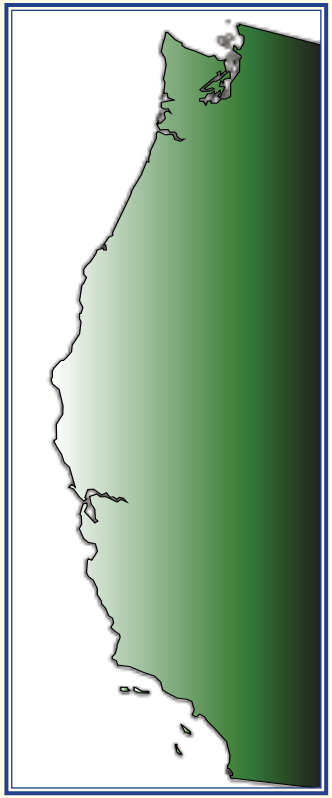
Gittings, S. R., Bright, T. J., Schroeder, W. W., Sager, W. W., Laswell, J. S., Rezak, R. (1992). Invertebrate assemblages and ecological controls on topographic features in the Northeast Gulf of Mexico. Bulletin of Marine Science 50(3): 435-455.



Appendix I: The Deep Sea Coral Research and Technology Program supports research nationwide in 2010-2011

Research projects that the program initiated in FY2010 and 2011 are listed here. Also shown here are the projects with FY2009 funding that concluded in 2010-2011; their funding amounts were reported in the program's 2010 Report to Congress. Find more details on these projects at **www.habitat.noaa.gov/deepseacorals**.



West Coast

Three-year field study: $810,000 in FY2010; $945,000 in FY2011

FY2011

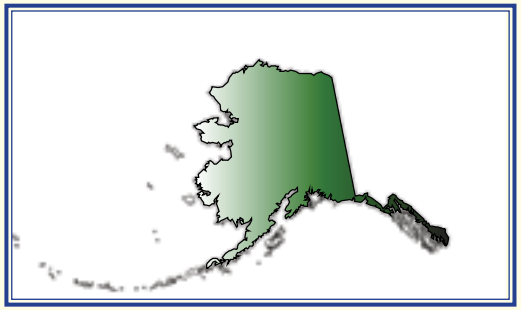
- $50,000 for analysis and visualization of deep-sea coral and commercial fishing interactions in Southern California
- $49,800 for relating distribution and abundance of deep-sea corals and sponges to habitats using predictive models and broad-scale seafloor maps
- $44,686 for taxonomic and genetic identification of fisheries bycatch of deep-sea corals
- $15,889 for analyzing coral bycatch information in the context of bottom trawling intensity off the West Coast

FY2010

- $50,000 for assessing deep-sea coral communities from archived video surveys off California
- $40,000 for habitat suitability modeling for deep-sea corals off the West Coast
- $40,000 for evaluation of predicted coral and sponge habitat within Olympic Coast National Marine Sanctuary
- $39,741 for taxonomic and genetic identification of fisheries bycatch of deep-sea corals

FY2009

- Enhancing the West Coast Regional Deep-Sea Coral Database
- Deep-sea coral community research off California
- Using Cordell Bank as a model to conduct fine-scale deep-sea coral predictive habitat modeling
- Mapping the distribution and intensity of bottom trawling efforts along the California coast from 1997 to 2008, with impacts to deep-sea corals
- Taxonomic and genetic identification of fisheries bycatch of deep-sea corals



Alaska

FY2011

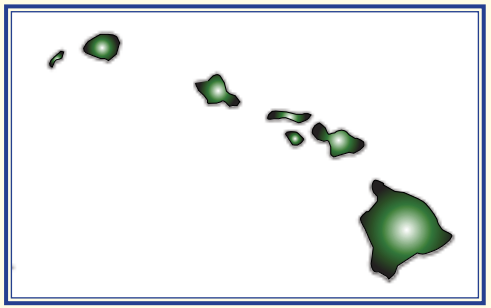
- $100,000 for identifying the location of Aleutian Island corals from archived video footage
- $32,500 for assessing the effectiveness of the Aleutian Islands Habitat Conservation Area in protecting deep-sea coral and sponge habitat

FY2010

- $20,000 Alaska research priorities workshop

FY2009

- A Field Guide to the Deepwater Sponges of the Aleutian Islands Archipelago



Pacific Islands

FY2010

- $47,610 for predictive modeling of the distribution of deep-sea corals in the main Hawaiian Islands

Multi-Region

Ongoing

- National deep-sea coral geodatabase $170,000 in FY2010; $170,000 in FY2011
- Program coordination $175,879 in FY2010; $189,500 in FY2011

FY2011

- $22,825 for State of Deep-Sea Coral and Sponge Ecosystems Report
- $5,800 for igniting a discourse on deep-sea sponge science and conservation

Northeast

FY2011

- $46,500 for modeling of suitable habitats for deep-sea corals in the Northwest Atlantic
- $20,000 for Northeast field study priorities workshop

FY2010

- $36,480 for creation of ultra-high resolution multibeam sonar images targeting deep-sea coral habitats in Hudson Canyon

FY2009

- Deriving deep-sea coral and sponge distribution data from archived video records in Northeast
- Mapping the intensity of fishing in the Northeast using gears that may damage deep-sea corals

Gulf of Mexico

FY2011

- $50,000 for habitat suitability modeling for deep-sea corals in the Northern Gulf of Mexico

FY2010

- $36,000 for Cold-Water Coral Geographic Database update for the Gulf of Mexico

FY2009

- Flower Garden Banks National Marine Sanctuary deep-sea coral investigations

South Atlantic

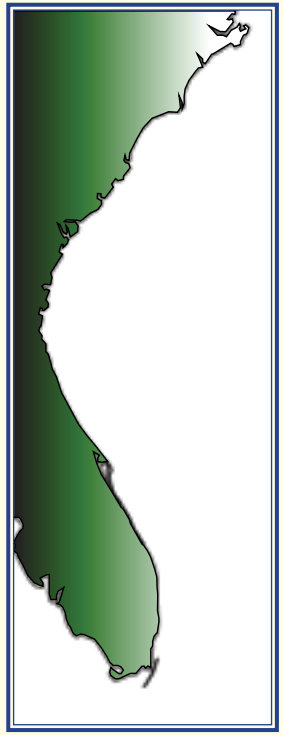
Three-year field study: $1,013,500 in FY2009; $790,000 in FY2010; $620,728 in FY2011

FY2010

- $50,000 for growth rates in deep-sea stylasterid corals off the southeastern U.S.
- $38,500 for integration of South Atlantic and Gulf of Mexico fishing intensity data sets into a spatially explicit data warehouse
- $37,750 for protecting deep reefs: correlating deep coral loc ations with VMS data on fishing locations
- $31,040 for mapping of hook and line fishing efforts relative to deep coral ecosystems in the South Atlantic Bight

FY2009

- Analysis of autonomous underwater vehicle (AUV) sonar data from deepwater coral habitats
- Analysis and distribution of deepwater commercial fisheries species in deepwater coral habitats off eastern Florida
- Integrating mapping and fisheries data for deep-sea coral habitats off South Carolina and Georgia
- Analysis of fishing intensity and potential deep-sea coral impacts in the U.S. South Atlantic and Gulf of Mexico

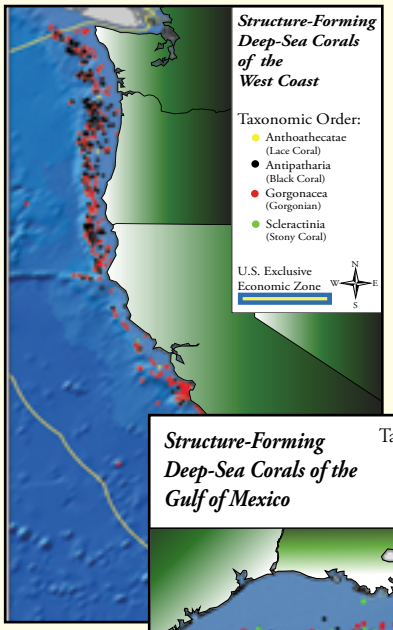


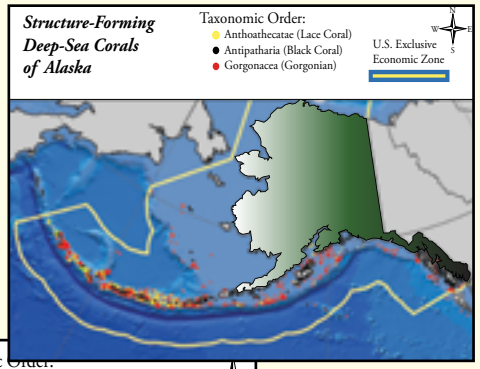
Appendix II: Deep-sea coral distribution maps by taxon and region

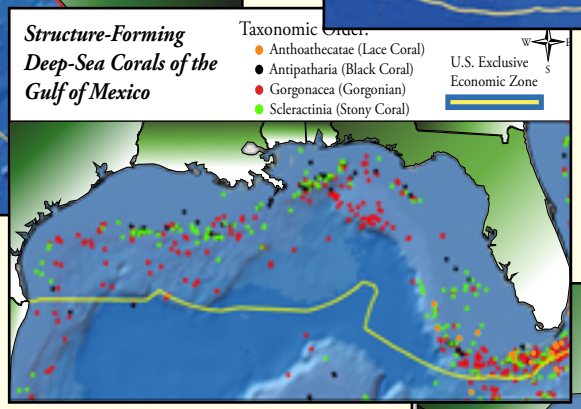
This appendix includes maps showing known locations of structure-forming deep-sea corals in selected U.S. regions. These maps represent the coral records in the Deep Sea Coral Research and Technology Program's national geodatabase. The maps are for illustrative purposes and are not meant to be used for management purposes. Due to the resolution of these maps, a single point may include more than one record.

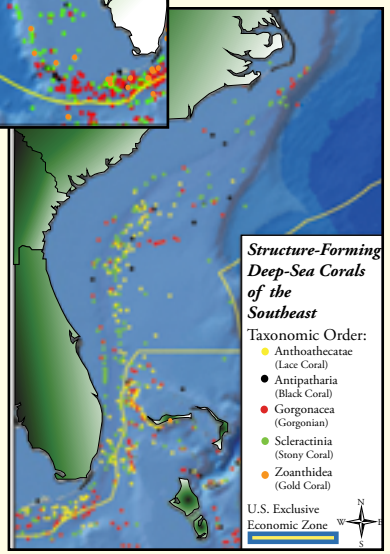
The data do not represent density of coral cover but rather known locations of corals that have been compiled by the program to date and reported by taxonomic orders. Compilation of existing data is ongoing, and information on some orders may be incomplete. Reported coral locations are limited to where fishing or research has occurred. Thus, areas where no corals are shown on a map may reflect either an absence of corals or an absence of sampling. The data sources can be found on page 33 and include NOAA Fisheries bottom trawl survey and fisheries observer program databases, fishery management council databases, research cruise results, museum collections, and literature citations.

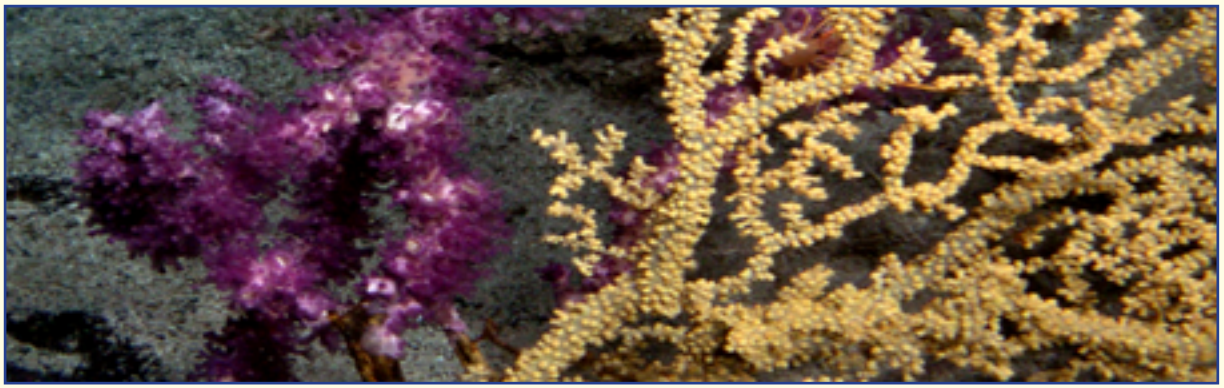
The boundaries for the U.S. Exclusive Economic Zone (EEZ) shown on the maps are for illustrative purposes only and are not intended to reflect areas claimed by the United States.

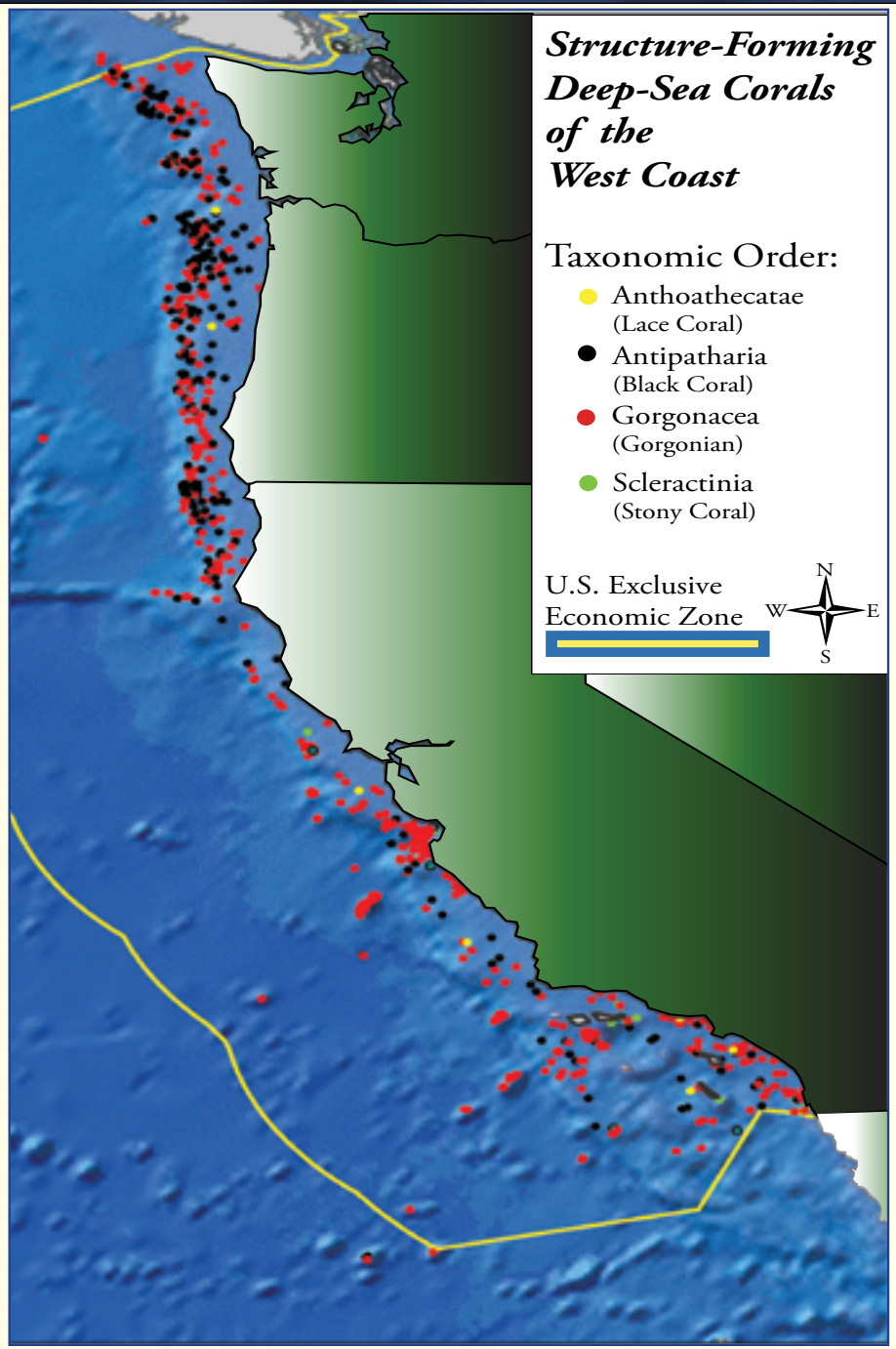


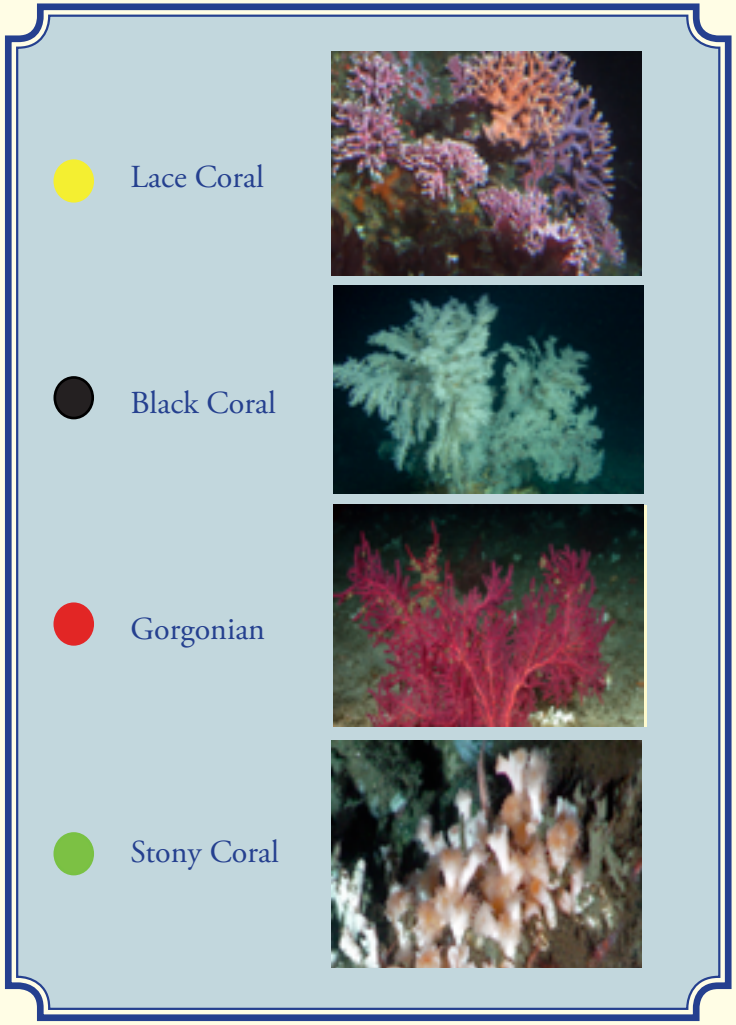




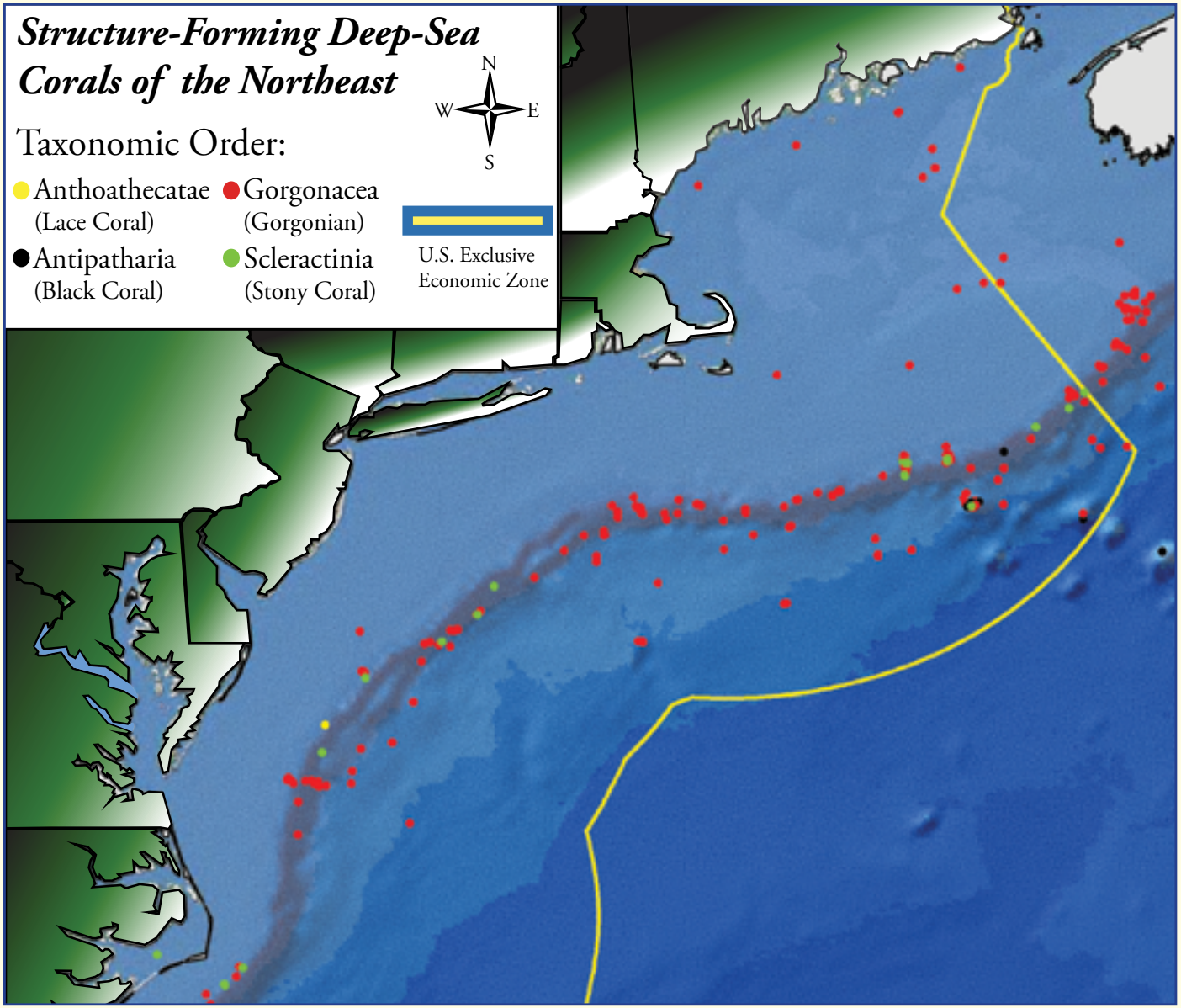


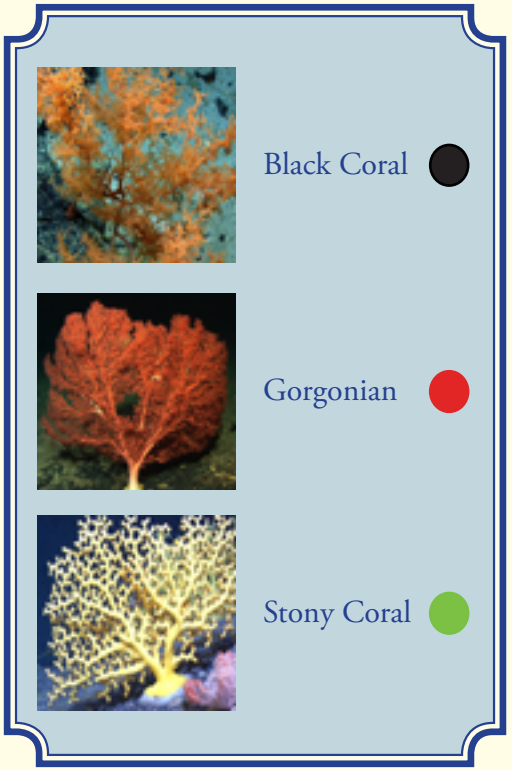




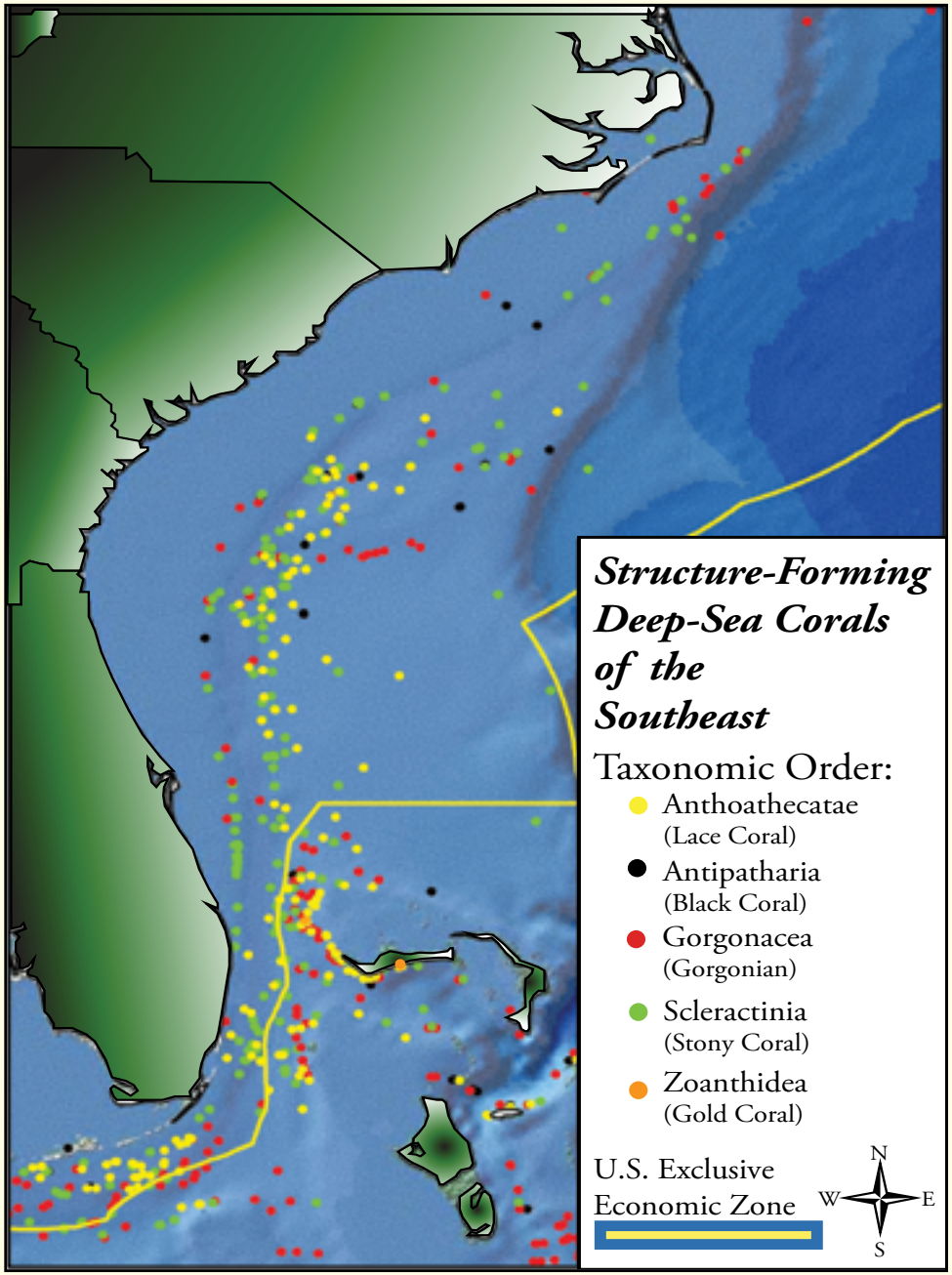


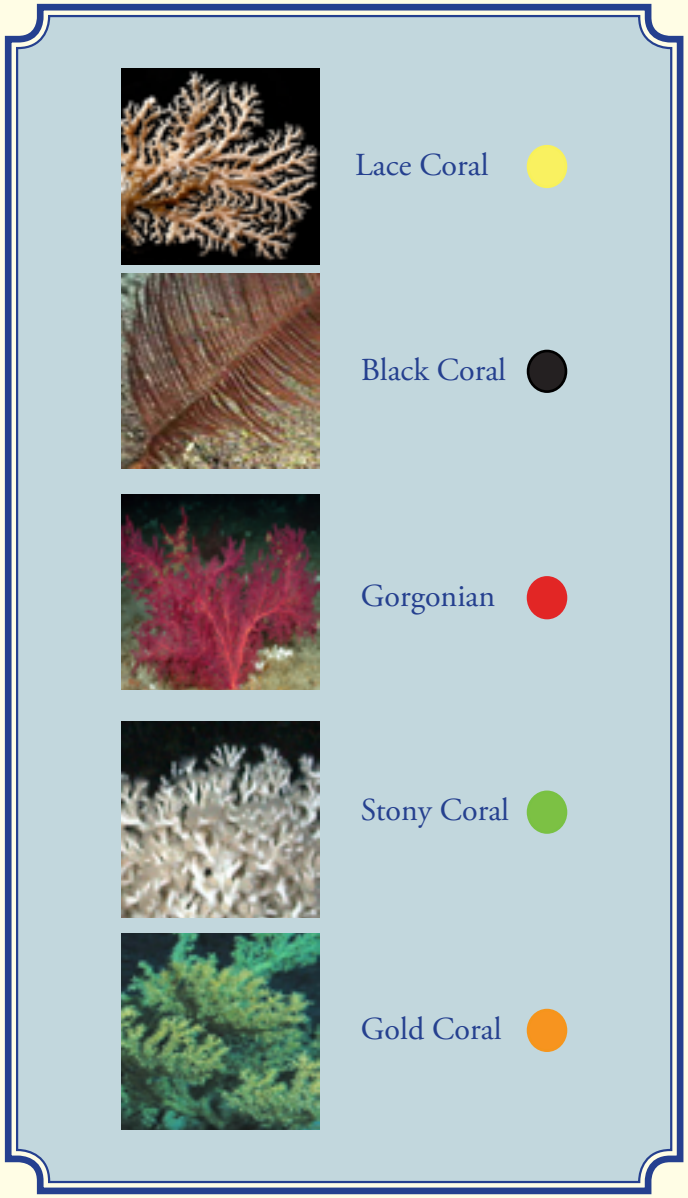
Known locations of major structure-forming species of lace corals, black corals, gorgonian corals, and colonial stony corals off the West Coast.



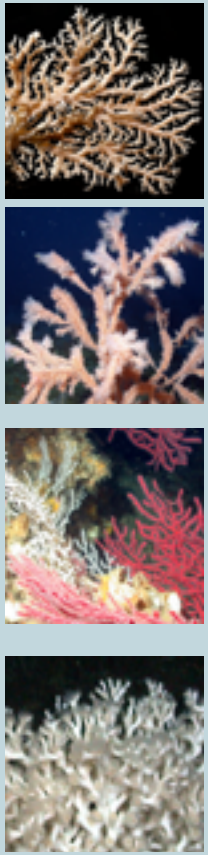


Known locations of major structure-forming species of lace corals, black corals, gorgonian corals, and colonial stony corals off the Northeast.





Known locations of major structure-forming species of lace corals, black corals, gorgonian corals, gold corals, and colonial stony corals off the Southeast.

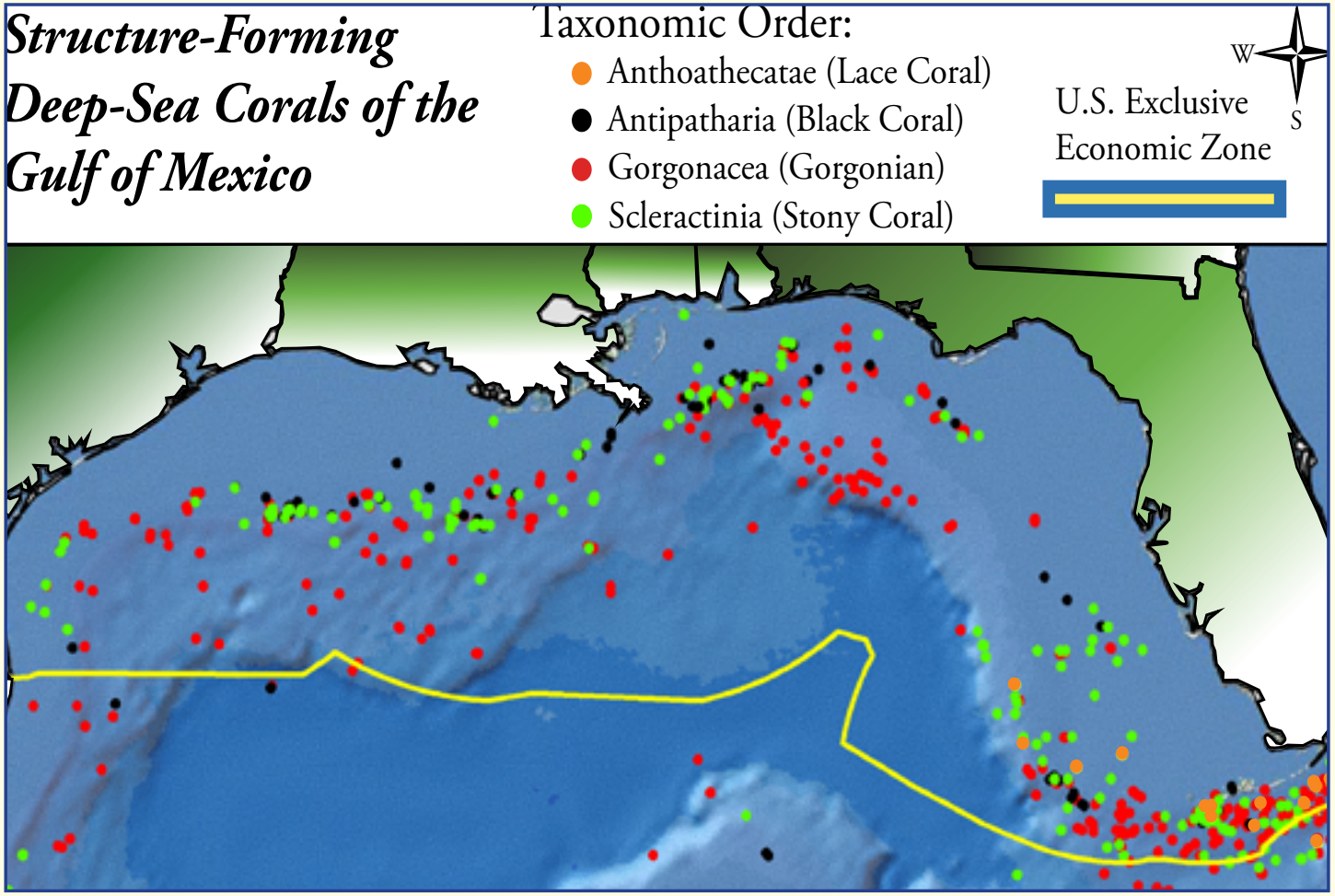


Lace Coral

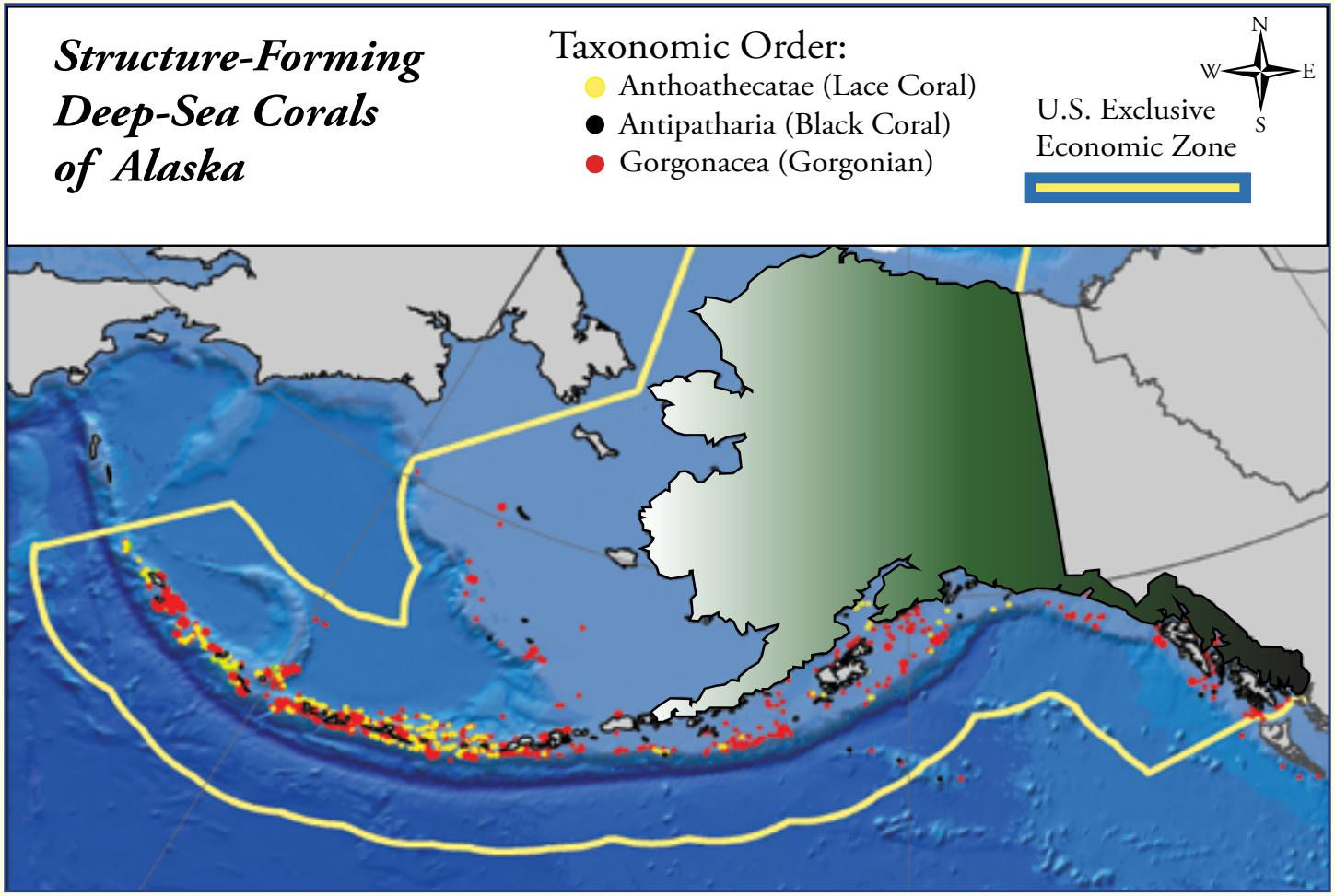
Black Coral

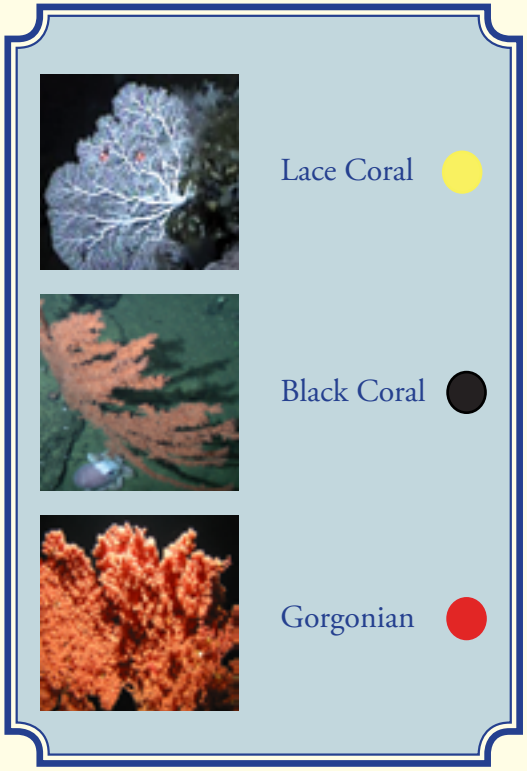
Gorgonian

Stony Coral



Known locations of major structure-forming species of lace corals, black corals, gorgonian corals, and colonial stony corals in the Gulf of Mexico.



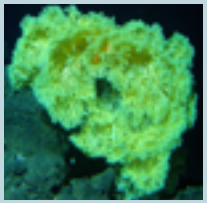


Known locations of major structure-forming species of lace corals, black corals, and gorgonian corals off Alaska.

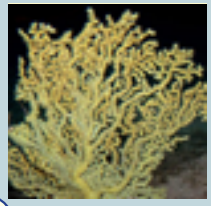
Lace Coral

Black Coral

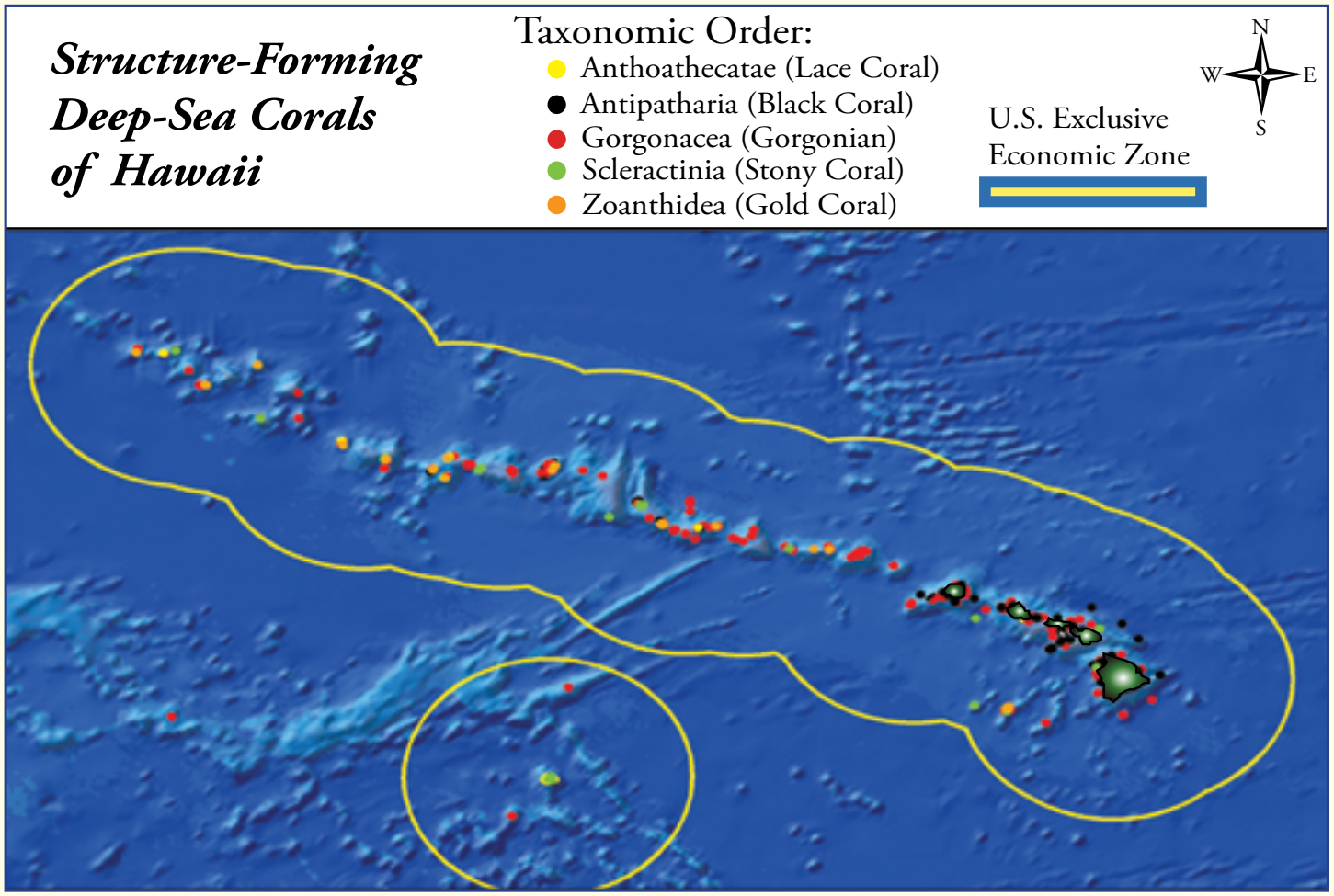
Gorgonian



Stony Coral



Gold Coral



Known locations of major structure-forming species of lace corals, black corals, gorgonian corals, colonial stony corals, and gold corals in waters around the Hawaiian Archipelago.

Data Sources of Deep-Sea Coral Distribution Maps:

Southeast:
National Museum of Natural History
US Geological Survey, Cold-Water Coral Geographic Database (Scanlon et al., 2010)
Reed et al., 2005, 2006
Messing et al., 1990
Marine Conservation Institute
Yale Peabody Museum

Northeast:
US Geological Survey, Cold-Water Coral Geographic Database (Scanlon et al., 2010)
National Museum of Natural History
NOAA Northeast Fisheries Science Center
Hecker et al., 1980
Watling et al., 2003
Theroux and Wigley, 1998
National Undersea Research Center, University of Connecticut
Yale Peabody Museum

Hawaii:
Hawaii Undersea Research Laboratory; University of Hawaii
California Academy of Sciences
Marine Conservation Institute
Monterey Bay Aquarium Research Institute
National Museum of Natural History

Alaska:
NOAA Alaska Fisheries Science Center
Marine Conservation Institute
Monterey Bay Aquarium Research Institute
California Academy of Sciences
National Museum of Natural History
NOAA Office of Ocean Exploration

West Coast:
NOAA Alaska Fisheries Science Center
NOAA Northwest Fisheries Science Center
NOAA Southwest Fishery Science Center
National Museum of Natural History
Monterey Bay Aquarium Research Institute
NOAA Olympic Coast National Marine Sanctuary
NOAA Cordell Bank National Marine Sanctuary
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Environmental Protection Agency's EMAP Database
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Gulf of Mexico:
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National Museum of Natural History
Bureau of Ocean Energy Management
NOAA Flower Garden Banks National Marine Sanctuary
Yale Peabody Museum
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Harbor Branch Oceanographic Institute
Marine Conservation Institute
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Photo Captions and Credits

Cover Photo: Deep-sea coral habitat off the coast of Florida as documented by the NOAA Deep Sea Coral Research and Technology Program.

Page 3 top right: Gorgonian coral off of Alaska.
bottom left: A diversity of deep-sea corals—including primnoid coral (*Narella* sp.), black coral (*Trissopathes pseudtristicha*)—and crinoids (*Florometra serratissima*)—flourish 8,757 feet deep on Davidson Seamount off the coast of California. Credit: NOAA/MBARI

Page 5 Gorgonian coral off the coast of Florida as documented by the NOAA Deep Sea Coral Research and Technology Program.

Page 7 Coral off the coast of Florida as documented by the NOAA Deep Sea Coral Research and Technology Program.

Page 10 The Woods Hole Oceanographic Institution team maneuvers the *Jason II* ROV for launch on a dive to investigate deep coral reefs off the east coast of Florida. Credit: Andrew David, NOAA-SEFSC

Page 11 Close-up of bubblegum corals in the genus *Paragorgia,* which grow to 8 feet tall on Davidson Seamount. Credit: MBARI/NOAA

Page 14 Coral community in the Gulf of Mexico

Page 15 left: The fishing vessel *Velero IV* was the platform from which NOAA scientists used the red *Dual Deepworker* submersible to study the southern California deep-sea corals.
bottom right: Soft coral landscape in AK
top right: Gorgonian coral and sponge in AK

Page 16 left: A coral landscape in Oceanographer Canyon off of New England. Credit: NOAA/Ocean Explorer
right: Galatheid crab on gold coral off Hawaii

Page 17 Bamboo coral off Hawaii

Page 18 Crab on *Primnoa* coral off Alaska

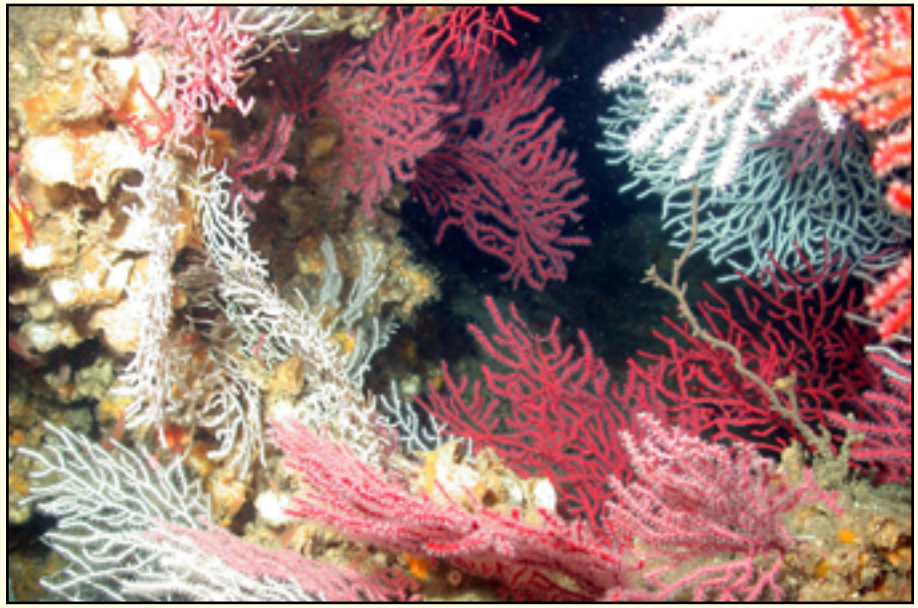
Page 19 Gorgonian coral off Alaska

Page 23 *Primnoa* coral off Alaska

Page 26 Corals off Hawaii

Page 32 Coral photos courtesy NOAA and HURL

Below: Coral garden in Madison Swanson Marine Protected Area in the Gulf of Mexico.



Biennial Report to Congress on the
Deep Sea Coral Research and Technology Program

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John Bryson

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