Habitat-forming deep-sea corals in the Northeast Pacific Ocean

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Abstract. We define habitat-forming deep-sea corals as those families of octocorals, hexacorals, and stylasterids with species that live deeper than 200 m, with a majority of species exhibiting complex branching morphology and a sufficient size to provide substrata or refugia to associated species. We present 2,649 records (name, geoposition, depth, and data quality) from eleven institutions on eight habitat-forming deep-sea coral families, including octocorals in the families Coralliidae, Isididae, Paragorgiidae and Primnoidae, hexacorals in the families Antipathidae, Oculinidae and Caryophylliidae, and stylasterids in the family Stylasteridae. The data are ranked according to record quality. We compare family range and distribution as predicted by historical records to the family extent as informed by recent collections aboard the National Oceanic of Atmospheric Administration (NOAA) Office of Ocean Exploration 2002 Gulf of Alaska Seamount Expedition (GOASEX). We present a map of one of these families, the Primnoidae.

We find that these habitat-forming families are widespread throughout the Northeast Pacific, save Caryophylliidae (*Lophelia* sp.) and Oculinidae (*Madrepora* sp.), which are limited in occurrence. Most coral records fall on the continental shelves, in Alaska, or Hawaii, likely reflecting research effort. The vertical range of these families, based on large samples (*N* >200), is impressive. Four families have maximum-recorded depths deeper than 1500 m, and minimum depths shallower than 40 m. Isidid, primnoid, and antipatharian records all exceed 2500 m depth. GOASEX collections are made from each of seven seamounts surveyed, extending the known range of Coralliidae 2500 km northward and the known limits of Isididae 450 km seaward, beyond the continental shelf, to seamounts in the Gulf of Alaska.

Keywords. Deep-sea coral, Northeast Pacific, distribution, mapping, data base

Introduction

Deep-sea coral records in the Northeast Pacific date to the late 19th century (Verrill 1869). Dall (1884), Fisher (1938), and Ostarello (1973) described the stylasterids

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of California and Alaska. Nutting (1909) documented isidids (Bamboo corals) and primnoids (Red tree corals) in California and Southeast Alaska during the Albatross stations 4766 - 4787 (see Cimberg 1981). Heifetz (2002) described the distribution of several different polypoid Cnidarian orders in Alaskan waters in great detail. However, none of these studies examined the horizontal and vertical ranges of deep-sea coral families over the Northeast Pacific extent. Contemporary concerns about commercial fishery sustainability and the benthic impacts of commercial fishing gear have renewed interest in habitat forming deep-sea corals and their areas of occurrence. In 1996, the United States Congress revised the Magnuson-Stevens Fishery Conservation and Management Act to include new habitat conservation provisions for U.S. marine fisheries. One candidate for a Habitat Area of Particular Concern (HAPC) under these provisions is “coral” areas. The *Oculina* Banks off Florida were destroyed by trawling over 25 years ago and are now designated HAPC. These banks were important habitats and spawning areas for commercially important snappers and groupers (Koenig et al. 2000). Proposals for similar HAPC designations are being developed for corals in the North Pacific.

In the tropics, reef fish species richness is less associated with coral species richness than it is with “rugosity”, a measure of three-dimensional complexity (Connell and Jones 1991; Friedlander and Parrish 1998). Complex habitats, such as seagrass beds and branching corals, are known to provide more refuge to prey species than less rugose habitats. Risk (1972) stated for tropical coral reefs, “there exists a striking positive correlation between fish species diversity and degree of substrate topographic complexity.” Complex habitats also provide more vertical relief, more surface area for settlement, and more microhabitat variability than simpler habitats. Habitat-forming deep-sea corals are defined here as those families of octocorals, hexacorals and stylasterids that have a majority of species able to grow deeper than 200 m, with a complex branching morphology, and a size sufficient to provide substrate or refuge to associated species. The depth cutoff of 200 m reflects a colloquial definition of deep-sea, deeper than the continental shelf, generally regarded as 200 m. This figure was a loose guideline. Ultimately, we find that all these families prosper deeper than 400 m. In this manuscript, we use the term deep-sea coral to refer to most of the families of hexacorals, octocorals, and stylasterids we know to thrive beyond the traditional sunlit tropical boundaries commonly attributed to zooxanthellate shallow-water tropical scleractinian corals.

Habitat-forming deep-sea corals often occur on rocky habitats in deep-water with strong water currents, similar to habitats preferred by shallow-water gorgonians. These currents may facilitate settlement onto clean swept surfaces, increase food availability and capture and, therefore, growth rate and survivorship (Patterson 1984; Sponaugle and LaBarbera 1991). Octocorals have been used as indicators of flow velocity on seamount peaks (Genin et al. 1986), but small differences in relief (<1 m) also accommodate deep-sea corals. Octocorals can be found in abundance in current swept muddy and mixed substrates of low relief (Lissner 1989; Lissner et al. 1991). Strong currents can benefit suspension feeders but challenge smaller marine life, such as juvenile fish. Deep coral reefs are important habitat for adult fishes, juvenile fish, crustaceans, sea stars, brittle stars, anemones and sponges because they provide protection from these currents and from predators. Clusters of biodiversity around deep-sea corals were recently documented by submersible craft in missions to the Gulf of Alaska, the Gulf of Maine, in Europe, Japan, and Australia by the National Oceanic and Atmospheric Administration, International Council for Exploration of the Sea, and International Oceanographic Committee. Scientists document 300 reef associated invertebrate species in the Faroe Islands alone (Jensen and Frederiksen 1992). A variety of fishes and sharks also rely on coral areas for food, protection, and a place to lay their eggs. *In situ* evidence of habitat functions for deep-sea corals is currently limited to video and photographic observations (e.g., an egg case attached to a *Paragorgia*, crabs perched atop *Isidella*, snail fish resting in the polyps of *Isidella*). Research is expanding into the deep-sea. More quantifiable results of habitat function are forthcoming from cooperative programs in both Europe and America.

Commercially important fish species are also found in association with these reefs, such as Atka mackerel, *Pleurogrammus monopterygius,* and shortspine thornyhead, *Sebastolobus alascanus,* in Alaska (Heifetz 2002). Krieger and Wing (2002) reported rockfish associated with *Primnoa* octocorals in the Gulf of Alaska. Fosså et al. (2002) showed a dense aggregation of *Sebastes* sp. associated with *Lophelia* corals off the coast of Norway. Elsewhere, Husebø et al. (2002) found that fish in coral habitats tended to be larger than in non-coral habitat. Endangered species are also known to frequent coral beds. Surveys with Hawaii Undersea Research Laboratory (HURL) submersibles found deep-sea coral colonies may aggregate conger eels, and attract foraging monk seals to *Gerardia* sp. and *Corallium* sp. reefs at depths over 500 m (Parrish et al. 2000).

Commercial fishing is the most obvious threat to these complex habitats (Koslow et al. 2001; Hall-Spencer et al. 2002). Deep-sea trawling is expanding globally, with more than 5000 km^2 of the Northeast Pacific seabed trawled more than once annually for Atka mackerel and other species (NRC 2002). Trawl nets and longline gear frequently remove octocoral colonies from the rocks and boulders they grow upon. The benthic impacts of this mobile fishing gear have been likened to clear-cutting techniques in old growth forests (Watling and Norse 1998). Other anthropogenic activities, such as ocean dumping and seafloor mining also threaten deep-sea corals (Rogers 1999).

Based on limited knowledge of deep-sea corals and their growing conservation significance, NOAA's Office of Protected Resources commissioned Marine Conservation Biology Institute to document the known occurrences of habitat-forming deep-sea corals for the Northeast Pacific and the adjacent Bering Sea.

Methods

The goals of this project were to map Northeast Pacific occurrences of selected deep-sea corals suspected of being important formers of biogenic habitat, as well as to construct a ranked database of the accumulated records that informed these maps.

Our definition of deep-sea, habitat-forming coral excludes deep-sea scleractinian solitary corals. Our investigation of the families Caryophylliidae and Oculinidae were limited to *Lophelia* sp. and *Madrepora* sp., but Antipathidae, Coralliidae, Isididae, Paragorgiidae, Primnoidae, and Stylasteridae were not limited to any particular species.

Our initial data gathering efforts focused on records of a few well-documented species, e.g., *Paragorgia arborea* and *Primnoa resedaeformis,* in the Northeast Pacific. However, record reviews of database outputs from participating institutions revealed that species-specific searching often resulted in record loss due to species name changes and spelling changes over time spans sometimes exceeding 100 years. For example, records from the Smithsonian Institution for the family Isididae revealed that the name *Ceratoisis* has been revised to *Keratoisis*. Likewise, in the family Stylasteridae, *Allopora californica* has been revised to *Stylaster californicus* (Cairns 1983). Deep-sea coral systematics are still poorly resolved due to the diversity and scarcity of the material, despite the monumental efforts of a limited number of experts around the world. Unfortunately, few researchers are qualified to make genus level distinctions between octocorals, and even then, this distinction might be revised later (e.g., Cairns 1983; Alderslade 1998).

Drs. Frederick Bayer and Stephen Cairns of the Smithsonian Institution, (leading taxonomic authorities on octocorals and deep-sea scleractinian corals respectively), suggested that searches should be conducted by family name rather than species name to minimize the impacts of taxonomic revision and misidentification at the species level. This approach alleviated issues related to misspelling and synonymy, but also speeded search time, limited institutional effort, incorporated lesser-known species names with similar morphology. This study seeks to take advantage of data that ranges in quality without sacrificing validity. We assume that family level descriptions are likely correct for trained observers, while genus and species levels might be incorrect. Drs. Bayer and Cairns identified 8 families as habitat-formers in the Northeast Pacific Ocean: hexacorals in the families Antipathidae, Oculinidae and Caryophylliidae; octocorals in the families Coralliidae, Isididae, Paragorgiidae and Primnoidae; and stylasterids in the family Stylasteridae.

Based upon this list of families, we contacted deep-sea coral researchers through a series of networked contacts that resulted from the First International Symposium on Deep-sea Corals held in Halifax, Canada, July 30-August 3, 2000. Of these contacts, a limited number maintained deep-sea coral records, and of those, a further reduced number maintained geo-positional records and were willing or able to distribute these records due to staffing constraints or other institutional limitations. A total of eleven different organizations supplied range and distribution records, including the California Academy of Sciences (CAS), Canadian Museum of Nature, Canadian Department of Fisheries and Oceans (combined here to CMN-DFO), the Monterey Bay Aquarium Research Institute (MBARI), the National Museum of Natural History at the Smithsonian Institution (NMNH), National Oceanic and Atmospheric Administration Office of Ocean Exploration (NOAA-OE), NOAA Fisheries Resource Assessment and Conservation Engineering (RACE) Division, the Santa Barbara Museum of Natural History (SBMNH), the REEF Foundation (REEF), the Scripps Institution of Oceanography (SIO) and a study performed by the late Dr. Robert Cimberg for VTN Oregon (Cimberg 1981).

The record selection methodology varied only slightly between institutions. Generally, we selected only those records that included a field for taxonomic identification. RACEBASE includes many records identified as "coral", but these were not included in this effort. Our NOAA-OE records represent the results of a single expedition to the Gulf of Alaska. Each organization maintained different information, so all database records were subset to five common fields: latitude, longitude, family, species name, and depth in meters. Additional fields were added to these records in order to facilitate potential researcher follow up. These fields include an institution name, an institution specific identification number, a "coordinates code", and a rank. Not all records included depth information.

The "coordinates code" is a measure of accuracy for the latitude and longitude information. If a given record included coordinate information, it was assigned a value of 1, if that record included a place name only it was assigned the value of 2, and we assigned approximate coordinates to that place name. If a record lacked either of these qualities, or if the place name was too general (e.g., Alaska) it was dropped from the database. Most often, these records were duplicated by other more specific records (e.g., Alaska, Aleutian Islands, Unimak Pass).

"Rank" is a relative measure of record quality based upon two factors: 1) whether a physical sample is associated with that record and 2) the identifiers level of expertise. The ranking system is as such:

1 = sample collected, expert identification
2 = sample collected, non-expert identification
3 = no sample collected, expert identification
4 = no sample collected, non-expert identification

This ranking system is consistent with ongoing efforts at the Hawaiian Undersea Research Laboratory, where a fleet of manned submersibles makes frequent deep-water dives, but takes few samples, relying instead on video and photo identification. This ranking is also consistent with a need to conserve slow growing deep-sea coral resources, and to limit the impact of scientific collections.

Results

The families Isididae, Paragorgiidae and Primnoidae are reported to occur throughout the Northeast Pacific from the Bering Sea south to the Equator and west to the Hawaiian Islands. Antipathidae likewise appear widespread, but are documented only as far south as Baja California. Coralliidae, Caryophylliidae, Oculinidae, and Stylasteridae are not documented north of the Aleutian Islands chain.

Bamboo corals, in the family Isididae, have the deepest coral record, listed as an *Isidella* sp. at 3880 m off the coast of Southern California from Scripps Institution. Cimberg (1981) documents a specimen of *Keratoisis profunda* at 3532 m in the Aleutian Islands. Specimens of Primnoidae and Antipathidae are also documented at depths nearing 3000 m. Isididae, Antipathidae, Primnoidae, and Paragorgiidae are the deepest occurring deep-sea coral families, respectively. Paragorgiidae and Primnoidae have maximum depths of approximately 2500 m. Each of these families is also represented by species records shallower than 220 m, suggesting a wide vertical distribution. Depth ranges for the families of interest are detailed in Table 1, and the frequency of occurrence is shown in Figure 1.

Table 1 Deep-sea coral families exhibit a range of species richness and depth distributions. Isididae and Antipathidae are documented at the greatest depths

Taxa	Species listed	N	Mean Depth (m)	Min Depth (m)	Max Depth (m)
Isididae	21	335	1262	107	3880
Antipathidae	3	208	924	9	2957
Primnoidae	63	925	324	25.5	2600
Coralliidae	8	130	539	215	2116
Paragorgiidae	4	257	406	19	1925
Stylasteridae	11	7	265	79	823
Oculinidae	2	2	278	40	556
Caryophylliidae	1	10	301	115	486

A total of 2649 records from eleven participating organizations in the United States and Canada documents 105 species of habitat-forming deep-sea corals in Northeast Pacific. The family Primnoidae had the most listed species (63), with 14 species names for Isididae, 9 for Stylasteridae, 10 for Coralliidae, 4 for Paragorgiidae, 3 for Antipathidae, and one each for Caryophylliidae and Oculinidae. The species

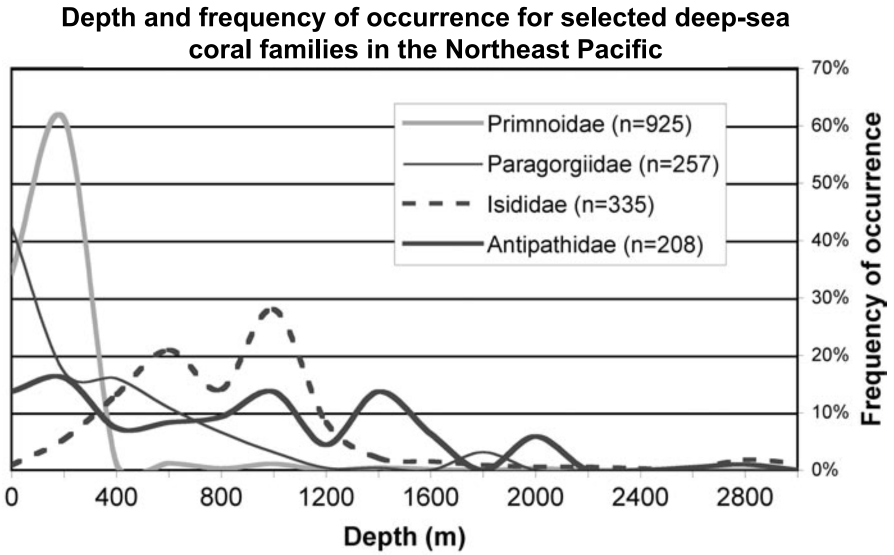

Fig. 1 The majority of records for families Primnoidae and Paragorgiidae are shallower than 500 m, while more than half of all isidid and antipatharian records occur deeper than 800 m

names associated with each family are detailed in Appendix 1. This database is publicly available through Marine Conservation Biology Institute's Baja California to Bering Sea 1.1 (B2B) CD-ROM (Etnoyer et al. 2002). An example map for the family Primnoidae is presented in Figure 2. Maps of all families are available in the NOAA report on this database (Etnoyer and Morgan 2003) available for download at www.mcbi.org.

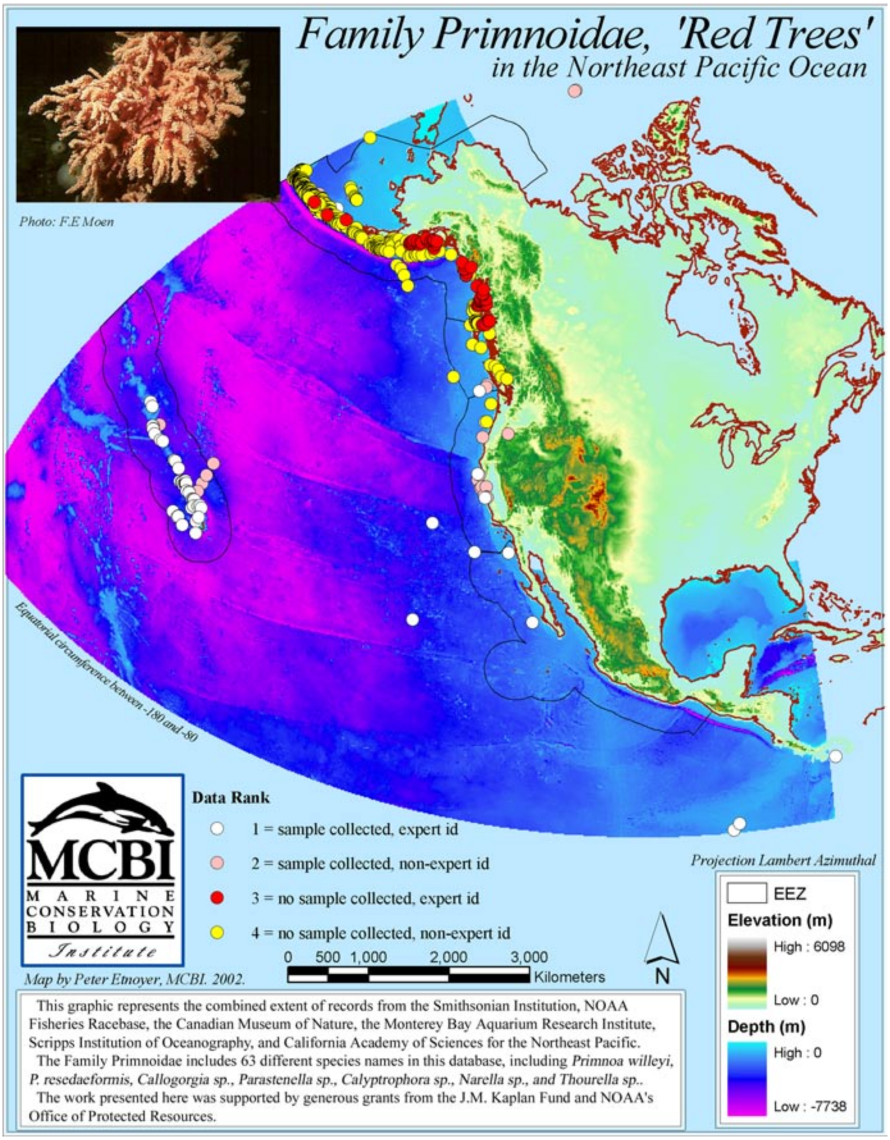

Fig. 2 An example map of Northeast Pacific occurrences for family Primnoidae, symbolized by data rank

The National Marine Fisheries Service's RACEBASE was the largest contributor with 1540 records on five families, followed by the Smithsonian Institution, the most comprehensive contributor, with 423 records in seven of the eight families. MBARI was a substantial contributor for a very specific locale, namely Monterey Bay, where "easy" access to deep-water and remotely operated vehicles (ROVs) facilitates almost daily expeditions to the Monterey Canyon. Video archivists at MBARI meticulously document most of those species familiar to them. Canadian Museum of Nature and Department of Fisheries and Oceans (CMN-DFO) records were restricted to waters around British Columbia. CAS also worked closely with this study to accommodate numerous data requests, and their high quality, very comprehensive information based on Dr. Gary Williams' identification was an important supplement to this study. Records from NOAA-OE are derived from the 2002 Gulf of Alaska Seamount expedition aboard the R/V Atlantis with the Alvin submersible. Though the NOAA-OE contribution was small in number, this remote expedition to seamounts in the Gulf documented several habitat-forming corals where none were known before, extending the known range of Isididae and Coralliidae into the Gulf of Alaska.

Accessing institutional databases by family name (Table 2) resulted in a 13 % increase in data records for Isididae across all institutions. For Paragorgiidae, searching by family increased CAS records from 6 to 18, and NMNH records from 16 to 39. *Primnoa* records increased from 1 record for *Primnoa willeyi* to 53 records for *Primnoa* sp. A review of the taxonomic methods practiced by each of the participating institutions indicated that CAS, NMNH and SIO records ranked "1" (see Table 2). CMN-DFO, NOAA-OE, and SBMNH ranked "2". Each of these institutions maintains physical samples associated with their records. MBARI and Cimberg's Report ranked "3", while REEF and RACE ranked "4", as these records failed to maintain a physical sample. RACE represents data gathered by fisheries observers with minimal training in taxonomic identification, and REEF records are gathered by volunteer scuba divers with a similar cursory training and background. As an example, in order to the identify octocorals to the species level, one often requires a high powered microscope to identify sclerites in the preserved tissue. Thus, even a physical sample of a calcified skeleton may be insufficient to satisfy the highest-level criterion.

The specimen collection dates are not included as a field in the database presented here, but the history of the largest collections may be of some interest to readers. *Paragorgia* and primnoid collections from RACEBASE date from the mid-80's, while isidids date from the mid-90's. This observer based program sets a formidable precedent. Paragorgidae and Isididae records in the Aleutian Islands from NMNH date back to the Albatross expeditions of 1890 and 1906 but Coralliidae records do not appear in the Northeast Pacific until a Scripps Pelagic Area Studies cruise in 1954. The early 1970's produced a dramatic increase in records for many families of deep-sea corals in Hawaii, attributed largely to Dr. Richard Grigg of the Sango Expeditions. Those contributions were not matched until the mid-1990's, when the crew and scientists of manned submersible expeditions aboard ALVIN and PISCES DSR/Vs introduced many new specimens to NMNH collections.

Table 2 Details of 2649 records from eleven institutions are shown here for eight habitat-forming deep-sea coral families in the Northeast Pacific

Taxa	NMNH	CAS	SIO	NOAA-OE	SBMNH	MBARI	Cimberg	CMN- DFO	RACE	REEF	Total
Antipathidae	29	8		3		101			102		243
Oculinidae	2										2
Caryophilliidae	8		1		1						10
Coralliidae	128			2							130
Isididae	60	17	5	4		237	2		19		344
Paragorgiidae	38	12		2		51	9	11	143		266
Primnoidae	158	53		5			73	15	1012		1316
Stylasteridae		58							264	16	338
Total	423	148	6	16	1	389	84	26	1540	16	2649
Data rank	1			2		3			4		

Discussion

While a few deep-sea coral records in the Northeast Pacific are more than a hundred years old, the majority of our understanding about deep-sea coral biogeography is founded in records less than fifty years old, and most of those are less than fifteen years old. Though deep-sea coral occurrences are most abundant on Pacific North American continental shelves in Hawaii, and Alaska's Aleutian Islands, GOASEX shows that all of these habitat forming deep-sea coral families have records on one or more seamounts in the Gulf of Alaska. Deep-sea corals are likely widespread, occurring on all seamounts, shelves, and banks that provide sufficient relief and substrate (Bayer pers. comm.). This database benefited greatly from a groundtruthing exercise that looked for corals where none were known before. The distribution map in Figure 2 would look different without recent manned submersible records (rank 2, central Gulf of Alaska in pink), but even more different without a ranking system to incorporate observer data (in yellow).

The maps generated by the database most likely represent maps of research effort rather than maps of the true extent of deep-sea coral occurrences in the Northeast Pacific. This is evidenced by two GOASEX collections, a Corallid specimen that extends the known range of that family 2500 km north, and an Isidid specimen that extends the known range of that species 500 km seaward, from the continental shelf, onto several seamounts in the Northeast Pacific. A map of historical records of the family Coralliidae would have shown the northernmost extent for this precious ornamental coral as *Corallium imperiale* USNM 85082 from 600 m depth on Fieberling Seamount off Baja California. Recently, GOASEX scientists aboard ALVIN 3802 collected a colony or *Corallium* sp. from 1652 m depth on Patton Seamount, south of the Aleutian Islands. Though we present an unprecedented collection of deep-sea coral records, it is well informed by continued exploration.

Stylasteridae is best documented along the continental shelf on relatively shallow banks within 25 miles of shore. *Stylaster californicus* of the family Stylasteridae has a maximum recorded depth of 823 m (2700 ft), from CAS. Several northeast Pacific seamounts reach beyond that depth, and may provide habitat for stylasteriids. Alternatively, stylasteriids may actually be restricted to the nearshore. They are widely distributed in nearshore habitats of California (Fisher 1931) and most of the records reported here are from SCUBA surveys (REEF). The southern extent of Stylasterid records along the mainland of North America is the northern tip of Baja California. However, since this family is present at lower latitudes in the Hawaiian Islands, its southern range limit along the North America margin might be an artifact of the geographic extent of our national databases.

Similarly, the distribution map for Antipathidae suggests that any apparent geographic limit for deep-sea corals is most likely an artifact of sampling effort and expertise. Antipatharians are best documented in the islands of Hawaii, partly due to collaborations between scientists there and a manned submersible fishery (Grigg and Opresko 1977). Antipatharians are likely to be present in seamounts off western Mexico at latitudes similar to those from Hawaii. Isididae, Paragorgiidae, and Primnoidae occur north and south of Pacific Mexico with an absence of records in Mexico, and west of Baja California (Fig. 2).

Future data gathering might concentrate on building collaborations with Mexican benthic ecologists to test these southern range limits. Future submersible research might focus on the Islas Revillagigedo and the Mathematician Seamounts off the coast of western Mexico to better understand the southern extent of these deep-sea coral species in the Northeast Pacific. The volcanic origin of the Islas Revillagigedo and their proximity to the highly productive Gulf of California make these impressive seamounts prime candidates for abundant coral forests.

Madrepora oculata in the family Oculinidae and *Lophelia* sp. in the family Caryophylliidae are well documented in the Atlantic but poorly documented here. This may be due to some oceanographic conditions that bias against hermatypic scleractinian reefs, or this may be the fault of the authors. Recent findings suggest that some *potentially* hermatypic scleractinians, e.g., *Dendrophyllia* spp., may have been overlooked in the Northeast Pacific. Future investigations of the biogeography of deep hermatypic Scleractinia in North America could alleviate some of the confusion surrounding these deep hermatypic species. Also, the family list used in this study is likely a subset of those that satisfy the habitat forming criteria at this basin scale. Some genera in the family Zooanthidae, and some in the family Gorgoniidae should be considered for future study.

Clear patterns are evident in the frequency distribution chart in Figure 1. Primnoid occurrences appear to be bracketed entirely by the 0-400 m bins. These charts should be appreciated as shadows of reality, biased by the question "where have we looked?". Based upon 900 primnoid records, sixty percent fall within 200-400 m, yet we recorded an unusually dense field of *Parastenella* sp. (ALVIN dive no. 3808) at 2200 m on Warwick Seamount, suggesting primnoids thrive at these extremes. It is evident that reports of *Paragorgia* sp. tail off with increasing depth with relatively few reports deeper than 1200 m. Again, a small number of the 200+ reports from that family are between 1600 m and 1800 m. Clearly, isidid and antipatharian deep-sea corals are the habitat-formers best adapted to life at these profound depths. More than half of the records from those families are from depths greater than 800 m. Sampling effort can only be partly responsible for this distribution.

It is important to note that this data ranking exercise was a relative one, and that a low data rank does not necessarily indicate poor quality. A low data rank in this case indicates that the researcher failed to preserve an intact sample, and that the researcher lacks scientific expertise in systematics. Neither of these conditions is surprising or rare. Research vessels may have limited human resources available, with few specialists dedicated to benthic invertebrates, limited quantities of ethanol preservative, and/or limited storage facilities. Also, the global number of researchers that can claim systematic expertise with deep-sea stony corals and gorgonians is less than a dozen (S. Cairns pers. comm.). The number of researchers that may claim this expertise in the Northeast Pacific accounts for less than half that number.

The data ranking exercise suggests that the waters around Hawaii and Southern California have the largest numbers of high quality records. This is most likely due to the efforts of particular researchers in those regions to collect samples and submit them to the proper authorities for species level identification. However, Alaskan waters exhibit the greatest number of data points. This can be largely attributed to the RACEBASE program, as evidenced by Table 1. The RACEBASE program is as strong candidate for data quality improvement in the near future. Capacity-building training in deep-sea coral systematics should be a high priority for these observers and record keepers.

The occurrences of the habitat-forming deep-sea coral families presented here suggest they have a large depth range throughout the Northeast Pacific. Frederick Bayer (pers. comm.) supports the conclusion that these families are widespread throughout their depth range (9-3880 m) along the Pacific rim. Too few data points and too little effort have been focused on seamounts in the Gulf of Alaska, and in the Northeast Pacific. Sampling effort in the Gulf of Alaska and the Bering Sea, however, is unfortunately defined as “bycatch” to the commercial bottom trawl industry. While some of these records represent first occurrences, most of these records are dated, and may represent deep-sea coral reefs that are no longer. With the expansion of trawl fleets into deeper waters and seamounts, deep-sea corals are certain to suffer greater risk in the future (Roberts 2002). These animals form habitat for diverse assemblages uniquely adapted to extreme environments, and must be protected from fishing gears which destroy seafloor habitat (Watling and Norse 1998; Koslow et al. 2001; Hall-Spencer et al. 2002; Morgan and Chuenpagdee 2003).

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