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Taxonomy and Zoogeography of Cold Water Corals in Explored Areas of Coastal British Columbia

Taxinomie et zoogéographie des coraux d'eaux froides présents dans les aires cotières explorées de la Colombie-Britannique

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ABSTRACT

The current state of knowledge about the cold water corals in British Columbia is summarised. Pacific Canada has a more diverse coral community than does Atlantic Canada, as is the case for most taxonomic groups. A list of Pacific Canada's known coral species and potential species based on records from adjacent jurisdictions is presented, along with maps derived from existing records showing all currently known locations of corals in British Columbia. To date, five Orders, 24 Families and 61 species of corals are documented from British Columbian waters, but an additional Order, three Families and 50 species may also occur in British Columbia, as these species have been documented from areas adjacent to British Columbia, i.e., south-east Alaska, Gulf of Alaska sea mounts and Washington/Oregon.

RÉSUMÉ

Ce rapport fait le point sur l'état actuel des connaissances relatives aux coraux d'eaux froides de la Colombie-Britannique. Dans les eaux canadiennes du Pacifique, on trouve une communauté de coraux plus diversifiée que celle présente dans les eaux canadiennes de l'Atlantique, comme c'est d'ailleurs le cas pour la plupart des groupes taxinomiques. Ce rapport contient une liste des espèces de coraux connues des eaux canadiennes du Pacifique ainsi qu'une liste d'autres espèces possibles établie à partir de relevés effectués dans les eaux avoisinantes aux eaux canadiennes. Il contient également des cartes établies grâce aux relevés actuels et montrant tous les emplacements connus de coraux en Colombie-Britannique. À ce jour, on a répertorié 5 ordres, 24 familles et 61 espèces de coraux dans les eaux de la Colombie-Britannique, mais à ceci pourraient s'ajouter 1 ordre, 3 familles et 50 espèces qui ont été répertoriés dans des zones adjacentes à la Colombie-Britannique (c'est-à-dire au sud-est de l'Alaska, sur le mont sous-marin du golfe de l'Alaska et dans les eaux au large des États de Washington et de l'Oregon).

INTRODUCTION

Cold water corals are distributed throughout all the world's oceans, from the Antarctic to the Arctic and within the Mediterranean Sea. Typically, these corals are mostly found in the bathyal zone (on the continental shelf at a depth range of 200 - 2,000 m), which covers approximately 20 per cent of the total ocean bottom (Keller and Pasternak 2001), including canyons along the shelf edge, deep channels between fishing banks (MacIsaac et al 2001), and on fjord walls (J. Marliave, Vancouver Aquarium, Vancouver, BC, pers. comm.). Large scale patterns of distribution may be influenced by depth, currents and/or productivity, and sediment transport (Etnoyer and Morgan 2003). Keller and Pasternak (2001) claim that diversity of coral fauna is greater in the northern hemisphere then in the southern hemisphere, and that the age of the coral fauna is a key factor in determining its latitudinal distribution. Coral depth distribution within an ocean basin can be variable, as shown by depth ranges of the same species from the eastern and western Atlantic (Cairns and Chapman 2001). The depth range for cold water corals is vast, from intertidal to 6000 m, with the majority of species found between 500 m and 2000 m (Adkins et al 1998).

It is first important to clearly define the general term "coral", a generic term that is used for many different species. Here, we use this term with respect to Class Anthozoa, Subclasses Alcyonaria (soft corals and sea fans) (see Appendix A), Ceriantipatharia (black corals), and Hexacorallia (stony and cup corals); and Class Hydrozoa, Order Filifera (fire corals). We also distinguish between the octocorals (Subclass Alcyonaria, Orders Helioporacea, Alcyonacea, and Penntulacea) and hexacorals (Subclass Hexacorallia, Order Scleractinia), not only because of their different evolutionary histories, biology and ecology, but also because only the scleractinians, and even here not all, are able to build reef structures. The octocorals form communities that are typically referred to as 'forests'.

While the classification of scleractinian corals and black corals is relatively accepted, there is still considerable debate concerning the classification of octocorals, i.e., Subclass Alcyonaria. I base my octocoral classification on Williams and Cairns (last revised January 2006), which is a system of Higher Taxa after Bayer (1981) for Helioporacea and Alcyonacea, and Kükenthal (1915) and Williams (1995) for Pennatulacea. Because it is quite recent, this classification is not always in agreement with current Integrated Taxonomic Information System (ITIS) data on the web, such as with the Order Gorgonacea, whose species have been included in the Order Alcyonacea by Williams and Cairns (2006) but which is still shown as a separate order in ITIS (Appendix A).

In Canada, cold water corals have been reported from both Atlantic (Breeze et al 1997) and Pacific waters (McAllister and Alfonso 2001, Lamb and Hanby 2005). Distributions are limited by both geography and bathymetry (Gass 2003), and off Nova Scotia, highest diversity of corals has so far been observed at the 'Gully' and the 'Stone Fence' (Breeze et al 1997, MacIsaac et al 2001). In the Pacific, cold water coral distributions have been documented along the western waters of the Americas (Reyes-Bonilla and Pinon 2002), with the northeast Pacific dominated by large octocorals (Gass 2003). Reyes-Bonilla and Pinon (2002) suggested there were about 79 species of azooxanthellate corals along the western coast of the Americas, representing ten families; only 29 species from six families are believed to have an average depth distribution greater than 200 metres. The most extensive regional surveys to date have been conducted in Alaska and seamounts in the Gulf of Alaska (Heifetz, J. 2002; Etnoyer and Morgan 2003; Bob Stone, NOAA, Juneau, AK, USA, pers. comm.).

Published data on cold water corals in British Columbia (BC) is relatively minimal. Levings and McDaniel (1974) noted corals as one of many benthic organisms found on an underwater cable in the Strait of Georgia and Westrheim (1974) reported no coral bycatch from trawling grounds in the Strait of Georgia. Austin (1985) provided an extensive list of marine invertebrates for the Pacific Northeast, and McAllister and Alfonso (2001) provided a preliminary assessment of the cold water corals in British Columbia, listing 21 species. Most recently, Canessa et al (2003) reported corals in the ecosystem overview report of Bowie Seamount, Ardron (2005) summarised and mapped coral occurrences in bycatch analyses of groundfish trawl data, and Conway et al. (2005a,b) reported corals from their ROV surveys.

Increased awareness of concentrations of cold water corals and their high vulnerability to damage from human activities such as benthic fishing gears, coupled with the introduction of new legislation (e.g. Canada's *Oceans Act*) requiring an ecosystem-based approach to management, is providing a new impetus for describing coral occurrence and distribution off British Columbia. Better conservation of biogenic marine habitats is high on the agenda of environmental non-governmental organisations (e.g., Ardron 2005), and this includes the minimisation of impacts from fishing gear on benthic habitats (MacIssac et al 2001). Cold water corals can form an extensive structural habitat, but their spatial occurrence, biology and ecosystem significance are relatively poorly known due to their predominance in deep waters. While their role in the marine benthic ecosystem has yet to be fully defined, these animals are often found in association with numerous other species (Cimberg et al 1981; Etnoyer and Morgan 2003; Gass 2003; Hyland et al. 2004; Koslow et al 2001; Witherell and Coon 2001), leading to the suggestion that coral concentrations in particular may have an important ecosystem role and thus should be particularly conserved.

Octocorals and scleractinian corals can be either zooxanthellate (symbiotic with algae) or azooxanthellate (non-symbiotic), and scleractinian corals can also be hermatypic (reef-building) or ahermatypic (non reef-building). Corals occurring in the photic zone are typically warm water, are often hermatypic, and coexist in a symbiotic relationship with photosynthetic organisms called zooxanthellae, which are unicellular yellow-brown (dinoflagellate) algae that live symbiotically in the gastroderm of many shallow-water corals. Unlike warm water corals, most cold water corals that commonly exist below the photic zone do not form symbiotic associations and are thus azooxanthellate. The majority of cold water corals are considered to be ahermatypic, but some hermatypic, azooxanthellate cold water coral species (e.g., *Lophelia* and *Dendrophyllia*) exist. It should be noted that the idea of exclusive symbiont algal nutrition for shallow water zooxanthellate corals is likely a myth, and all corals, even perhaps all cnidarians, should be recognised as predators, not filter feeders per se or detrital feeders. Nematocysts are evolved for capturing living prey and cultured corals require live food with the fatty acid balance of crustacean zooplankton to thrive (J. Marliave, pers. comm.).

The zooxanthellae (dinoflagellate) were once thought to be the same species, *Symbiodinium microadriaticum*, but its now known (Baker 2003) that zooxanthellae of various reef-building corals belong to at least ten different symbiont taxa in four clades of *Symbiodinium* (A, B, C and D). Finally, while a vast majority of tropical shallow-water scleractinian reef-building corals are 'colonial' (each colony may have tens to thousands of polyps, each of which is a separate coral animal), the vast majority of cold-water scleractinian corals are solitary (i.e., one polyp). Sizes of solitary scleractinians vary from a few millimetres to a few centimetres in diameter.

There is also a need to explain what we actually mean by the term "reef", as the terms reef vs. bioherms vs. communities are sometimes confused. In tropical settings, a coral reef is a biogenic structure build by both reef-building scleractinian corals and coralline algae, each having a key "cementing" function in the development of the reef. In contrast, cold-water, deep-water scleractinian coral reefs (e.g., *Lophelia* reefs) are built mainly by the corals themselves without any functional input from algae. However, shallow-water, cold-water coral reefs have been poorly studied, so this generalization may not be true for all cold-water corals. We also distinguish between true scleractinian coral reefs and octocoral 'forests', i.e. concentrations of octocorals, which seem to be more common in BC waters than are true scleractinian coral reefs.

Bioherms are a mound-like accumulation of fossil remains on the site where the organisms lived, and this can consist of either coral skeletons which have been built on and added to by successive coral generations, or in the case of sponges, accumulations of living and dead sponges in a fine sediment matrix. The terms reefs and bioherm can thus be used interchangeably if there is an accumulation of structural species remains.

Coral or sponge "communities" around reefs and bioherms simply refer to the mix of benthic and demersal species, including corals and sponges if present, in close proximity to either the reefs or bioherms.

To date, there has been no summary of available data on the cold water corals of British Columbia, as has been presented for cold water corals on the Scotian Shelf of Nova Scotia (Breeze et al. 1997). Objectives here are thus to list both observed corals from Pacific Canadian waters and potential corals based on records of occurrence from adjacent areas, and to identify and map locations of corals from existing records and anecdotal information in British Columbia. Most data presented here are from deeper water areas, and specifically from either commercial fishing data or research surveys. It is recognised that scuba diving observations are inadequately represented here. Modern sport divers can dive within the depth ranges of some coldwater coral species in coastal nearshore regions, and valuable added information is known to be available from interested citizens. For example, Pacific Marine Life Surveys list for sale a summary of 2017 sightings of 17 coral species from 487 B.C. locations from 1967-2006, along with relevant GIS metadata (J. Marliave, Vancouver Aquarium, pers. comm.). This company has all of Andy Lamb's and his partners' dive log data in electronic form. The abundance of corals in BC's coastal fjords also needs better documentation, as rocky walls in particular in these areas have been poorly surveyed.

FIELD TAXONOMIC IDENTIFICATION CHALLENGES

Generally, coral genera (and species) are distinguished by their morphology (body shape) and the presence or absence and structure of sclerites (small calcareous structures in the tissue of the polyps and coenenchyme) (Etnoyer and Morgan 2003). However, while identification of scleractinian corals relies mostly on the skeletal morphology of coral colonies and the corallites (i.e., the complex skeletal structure secreted by individual polyps), the identification of octocorals is more difficult. While general colony morphology is still used, the taxonomy of scleritic (sclerite secreting) octocorals is based largely on sclerite morphology. Also, while the presence and identification of sclerites appears to be the preferred morphological method of identification, it can require tissue preparation and a microscope, an approach that takes time and cannot be implemented at sea by at-sea observers reporting commercial fishing bycatches. These observers, if present, can retain some reference specimens for later identification, but they, like fishers, have time and space constraints when working on commercial fishing vessels. The result is that precise taxonomic identification in the field on commercial vessels is unlikely to occur except for the most common species. To date, observers in British Columbia have not had convenient field identification guides for even common species, so observer reported data has not been usable taxonomically. Efforts are now underway to make such coral identification information available.

Coral taxonomy is a rapidly evolving field, so the following references have been used to determine taxonomic hierarchy: Orders Alcyonacea and Pennatulacea (Williams and Cairns 2006), Order Antipatharia (Opresko 2005, ITIS Taxonomic Report, November 2005), Order Scleractinia (Cairns 1994), and Order Filifera (ITIS Taxonomic Report, November 2005). Cairns et al. (2002) was also utilised.

CORAL HABITAT

Cold water coral structures range from small, solitary individuals to massive reef habitats, often in relatively barren surroundings. Habitat-forming cold water corals include octocorals, hexacorals and hydrocorals (Etnoyer and Morgan 2003). Live and dead portions of a coral's matrix or lattice framework can create substratum and shelter for other corals, sponges, brachiopods, bivalves, crustaceans, bryozoans, crinoids and tunicates (Hall-Spencer et al 2001; Koslow et al 2001). The complex branching morphology of many cold water corals may create structures of sufficient size to provide substrate or refuge for other species (Etnoyer and Morgan 2003).

The majority of cold water corals exhibit preference for rocky substrate or hard surfaces with moderate to strong currents, although Pennatulaceans prefer soft, sandy or muddy bottoms. Coral substrate ranges from fine, well-sorted sand, gravel areas and shell deposits, to slump deposits with rock outcrops, boulders, crevices, rock pinnacles, over-hangs, living habitat and sheer cliffs, and iceberg furrows (MacIsaac et al 2001).

Hard bottom biological communities can often be distinguished by localized differences in relief height (Etnoyer and Morgan 2003). Low relief is often characterized by high levels of sedimentation, favouring relatively short lived, smaller organisms. In contrast, high relief environments have generally lower levels of sedimentation, and often support longer lived and larger species, particularly for corals (*Lophelia, Paracyathus, Desmophyllum* and *Caryophyllia*) and sponges (Etnoyer and Morgan 2003). However, sponge bioherms with relatively long-lived species have been found in British Columbia in strong current areas having a significant sediment load (Conway et al. 1991, 2001; Krautter et al. 2006), indicating that it may be the balance between current strength and sediment load rather than sediment load per se that is most relevant, at least for sponges.

Seamounts provide opportunity for patchy, wide-scale occurrence of benthic species in a primarily homogeneous environment. Habitats there are characterized by having good currents, and sessile feeders are often relatively abundant (Canessa et al. 2003; Gass 2003). Corals typically found on shallower seamounts may be hermatypic such as *Solenosmilia variabilis* Duncan, 1873, but also include octocoral and antipatharian corals (Gass 2003).

Canada's Pacific Bowie Seamount has been recently surveyed, with research efforts targeted on a limited number of species (primarily rockfish and sablefish) (Canessa et al 2003). Corals from the Orders Alcyonacea and Scleractinia were observed there by Lynn Yamanaka (Fisheries and Oceans Canada (DFO), Pacific Biological Station, Nanaimo, British Columbia) and reported in Canessa et al (2003). In 2002, seven seamounts (Patton, Murray, Chirikof, Marchand, Campbell, Scott and Warwick) from the Cobb Hotspot in the Gulf of Alaska were explored using submersibles and multibeam bathymetric surveys (Etnoyer and Morgan 2003).

Conway et al. (2005a, b) documented the remains of a large dead coral reef in the Strait of Georgia at 255 m depth on the side of a knoll near Halibut Bank. Initially reported as a *Solenosmilia variabilis* reef (Conway et al. 2005a), the coral remains have now been identified as *Lophelia pertusa* (S. Cairns, Smithsonian National Museum of Natural History, Washington, DC, pers. comm. to K. Conway). The reef remains measured about 200 by 150 m; no living corals were found, and it is not presently known why the corals died. Conway et al (2005a) suggested this was likely due to natural factors rather than fishing gear impact, as surface oxide staining of the corals suggested it was not recent and the coral fragment spatial distribution suggested reef collapse rather than disturbance. While this particular reef did not contain live corals, its presence in BC waters strongly suggests that other as-of-yet undiscovered *Lophelia* reefs likely exist in BC waters. Austin (1985) reported this species, again initially incorrectly identified as *Solenosmilia variabilis*, from Alberni Inlet.

METHODS

Scientific knowledge was obtained from survey data, by-catch data and personal and museum collections. For reporting consistency, corals were mapped by Orders due to identification inconsistencies. Mapped data points include areas where identified corals were collected during research surveys and/or fishing activities.

Published Literature: As mentioned above, published literature on cold water corals in British Columbia is limited. Bibliographic databases investigated included those of Fisheries and Oceans (WAVES), museum libraries and scientific journals. Literature requests from cold water coral researchers were also made and on-line resources were utilized when available from reliable sources.

Personal and Museum Collections: Cold water coral records from museums are listed in Table 1. All data were included in the maps presented in this paper. These data, along with species listed in the published literature or from private collections where specimens were identified by recognised experts, are the only data used at this time to determine coral species occurring in British Columbia, as taxonomic identification in other databases were not at the species level. Where records for British Columbia could not be identified to species, that record was included in the list as "sp." only if no other species of that Genus was recorded from British Columbia. Using Occam's razor, it is assumed that when identified, the species will be one already known to occur in British Columbia. Whether this was done for species lists obtained from other jurisdictions is uncertain, so again species listed as “sp.” have not been included as potential species in British Columbia unless no other species of that Genus are listed in any of the columns shaded in Table 2.

Observer and Scientific Survey Data: Fisheries and Oceans Canada’s trawl observer database is a major source of British Columbian fisheries data including by-catch records. Prior to the establishment of observer coverage, only two occurrences of coral encounters were recorded in fishermen’s logbooks between the years 1954 and 1995. Since the onset of observer coverage in 1996, recording of data has greatly improved, although by-catch species identification remains an issue. All records of corals in DFO’s ‘PacHarvTrawl’ (groundfish trawl) and ‘PacHarvSable’ (sablefish trap) databases represent species (or groups of organisms) observed during fishing events. The databases include a total of 860 coral by-catch records between the first quarter of 1996 and the fourth quarter of 2003. International Pacific Halibut Commission (IPHC) annual stock assessment surveys provided an additional 15 records (Tracee Geernaert, IPHC, Seattle, WA., pers. comm).

Spatial data from the available fishery databases contained ‘rolled-up’ records (to protect the privacy of an individual’s records) representing information from three or more vessels within a defined spatial area. To optimize the number of records within the smallest data area, records were rolled-up into 16 km^2 bins by year. The centres of each spatially referenced bin (latitude and longitude) containing coral records identifiable to order were plotted and represented as point records.

Only a few DFO scientific research surveys contain records of cold water corals. Groundfish, shrimp and tanner crab surveys prior to 2004 contained 301 records of observed corals as incidental catch. The latitude and longitude of these locations were mapped and represent the mid-point of each set line. To date, there have been no directed research initiatives on deep-water corals in British Columbia.

Mapping: The limited literature on British Columbian cold water corals includes a taxonomic list by Austin (1985) and a report by McAllister and Alfonso (2001). Since cold water marine environments are generally similar in adjacent waters, species presence and distribution can, to some extent, be inferred from literature on corals from nearby northeast Pacific regions, notably Washington and south-east Alaska, and to some extent from global observations. Maps were produced to complement the earlier maps produced by McAllister and Alfonso (2001) and more recently produced maps by Ardron and Jamieson (submitted) for coral records in British Columbia. All available coral data within the Canadian Exclusive Economic Zone (EEZ) were mapped. This encompasses all of British Columbia’s territorial waters. Maps were produced in ArcGIS (9.0) with base map bathymetric intervals of 500m.

RESULTS

Taxonomic classification of the cold water corals found to date in Canadian Pacific waters includes representation from five Orders, 24 Families and 61 species of corals are documented from British Columbian waters (Table 2, Appendix A). Including potential species in south-east Alaska, Gulf of Alaska sea mounts and Washington/Oregon, there are at least five Orders, 27 Families and 111 species. To date, 53 species of corals have been reported from south-eastern Alaskan waters and Gulf of Alaska seamounts ((Table 2; Bob Stone, NOAA, Juneau, Alaska, USA, pers. comm.) and 27 species from Washington/Oregon (Curt E. Whitmire and M. Elizabeth Clarke, NOAA, Seattle, Washington, USA, pers. comm.).

A total of 1,826 British Columbia cold water coral records were mapped. Table 1 presents their data source, years of data collection and the number of records containing geospatial information. The maps presented here identify areas where corals have been encountered and expand on those of McAllister and Alfonso (2001). The distribution of cold water coral encounters for all coral orders documented in British Columbia are illustrated in Figure 1.

DISCUSSION

The reported locations of coral orders in British Columbia presented in this paper only relate to the spatial locations of past sampling effort, commercial fishing grounds and known dive sites. Corals likely occur in other areas as well. The available data on the distribution of corals on British Columbia's coast are presently at too large a scale (e.g. groundfish trawl tows average about 10 km in length, and tow midpoints were the locations mapped) to define discrete locations of corals, although Ardron (2005) and Ardron and Jamieson (2006) suggest general areas of higher coral/sponge abundance from analyses of groundfish trawl bycatch data. Surveys utilizing video equipment are needed for ground-truthing and identifying coral species and other vulnerable benthic organisms at an acceptable resolution. Such surveys would also allow coral abundance assessments in areas with relatively low disturbance to date or in areas not well suited for present fishing methods due to potential gear damage or loss.

Given the relative lack of surveys for corals in the Pacific Northeast, and the relatively large number of species that exist in areas adjacent to British Columbia but which have yet to be documented in Canada, it is expected that many new coral species will be documented from Pacific Canada in forthcoming years. Cold water coral concentrations are now generally recognised as important and worth conserving by the general public, and future research and management efforts to survey their presence and abundance and to minimise human impacts on them are presently being developed.

a) Indirect Value of Corals

In general, greater structural habitat complexity results in greater biological diversity. Relatively little is known about the role of cold-water coral concentrations as habitat for other species or their connection to shallower shelf ecosystems where the majority of commercial fisheries take place (MacIsaac et al 2001). Corals can provide high relief diverse habitats, and may be important habitat for some life stages of commercially exploited species. Numerous commercial and non-commercial species have been observed among cold water corals in the northeast Pacific, either by video, direct observations or from by-catch data.

Corals provide a habitat in which fish and invertebrates can forage, survive, seek refuge, grow and reproduce (Andrews et al 2002; Jensen and Frederiksen 1992; Rogers 1999; Fossa et al 2002; Willison 2002; Huesbo et al 2002; Gass 2003; Krieger 2001; Etnoyer and Morgan 2003; Heifetz 2002; Krieger and Wing 2002). Size and densities of coral aggregations in warm waters directly influence the structural complexity of hard-bottom habitats and consequently, the attractiveness of such areas to both fish and invertebrate species (Van Dolah et al 1987). In a Norwegian cold-water study, significantly more fish were caught in coral reef habitats (e.g., *Lophelia*) then in non-coral habitats (Husebo et al 2002). As a refuge, it has been suggested that corals may help stabilize predator-prey interactions by allowing a greater abundance of prey to occur (Gass 2003). Fish found in coral habitat (e.g., *Lophelia*) have also been larger in size then those found in non-coral habitat (Husebo et al. 2002). The use of SCUBA (recreational dive limits of <30 metres depth) has allowed the documentation of diverse associations of fish and invertebrates among shallow cold-water corals (Krieger 2001).

MacIsaac et al. (2001) reported redfish (*Sebastes* spp.) as consistently co-occurring with the majority of coral species in Atlantic Canada. In Alaska, Atka mackerel (*Pleurogrammus* *monopterygius*) and shortspine thornyhead (*Sebastolobus alascanus*) have been noted to be associated with corals (Heifetz 2002). The affinity of some planktivorous *Sebastes* with corals has been suggested as possibly relating to the physical structure of corals (Husebo et al. 2002), but no direct interaction has yet to be observed (MacIsaac et al 2001). *In situ* evidence of corals providing habitat for some species is documented in video and photographic observations (e.g., egg casings on *Paragorgia*, crabs perched on *Isidella* and snail fish resting on polyps of *Isidella*) (Etnoyer and Morgan 2003). Submersible photos taken show juvenile rockfish among *Paragorgia* sp. and lingcod within close proximity to hydrocorals (Etnoyer and Morgan 2003).

A number of authors have tried to explain the lack of direct association, as opposed to general co-occurrence, between commercial fish and corals. For example, the absence of juvenile *Sebastes* among Atlantic corals was noted by MacIsaac et al (2001), who suggested this may be the result of low video resolution, inadequate sampling technique or other disturbances caused by observers. MacIsaac et al (2001) also suggest the height of the biological habitat provided by many cold water corals may not be optimum for the survival of juvenile Atlantic cod. We suggest that trying to detect a direct association between a significant coral concentration and fish may in fact be missing the main issues, which are the circumstances that allow a very high abundance of deep-water plankton feeders to occur at a specific benthic location at depth, and the relevance this might have in our understanding of the general spatial pattern of deepwater productivity and its importance to exploited fish.

We suggest the following hypothesis: just as seabirds often congregate over areas of high surface water plankton abundance (convergence zones, upwellings, etc.) and indicate where these higher productivity areas are, concentrations of deep-water micro-organism feeders such as corals, that rely on plankton feeding on food coming from surface waters, can similarly show where benthic currents are concentrating food. Seabirds are recognised indicators for surface feeding fish concentrations, and coral concentrations may similarly be indicators for deep-water fish concentrations, or vice versa. Fish concentrations don't have to necessarily be in direct association with corals to benefit from localised higher food availability, but could be in the general vicinity around corals, i.e., indirectly associated with coral concentrations. As an example, Whitney et al. (submitted) suggest that canyons containing the sponge reefs provide a means of concentrating the particulate matter (sediment and food items) that large colonies of sponges require.

Fish species typically not associated with cold water corals but numerous in non-coral habitats include skates (Rajidae) and rays (Torpedinidae) (Husebo et al 2002), relatively large benthic species that would not be expected to occur in abundance in a structurally complex habitat.

Invertebrates, unlike fish species, have been noted to have a direct interaction with various species of cold water corals (MacIsaac et al (2001). It has been speculated that cold water azooxanthellate corals may have a commensal relationship with fish and invertebrate species similar to that found among warm, shallower water zooxanthellate corals (Krieger 2001). In British Columbia, McAllister and Alfonso (2001) noted numerous fish (warbonnets and rockfish) and invertebrate (sponges, hydroids, scallops, octopuses, shrimps, bryozoans and basket stars) species in association with cold water corals.

b) Human and natural threats to corals

Human activities constitute the most serious threat to corals and other sessile, benthic organisms. Coral vulnerability is a result of their biology: slow growth rates, longevity, and the fact that their structure allows them to be easily and rapidly destroyed physically by many human activities (McDonough and Puglise 2003; Witherell and Coon 2001; Laist et al 1986; NOAA 2004; Etnoyer and Morgan 2003). The extent of vulnerability is dependent on the type, duration and magnitude of an activity, as well as the coral's susceptibility to damage based on its physical characteristics (e.g., relative rigidity and large size of *Paragorgia*, *Primnoa* and *Lophelia*) (Heifetz 2002; Gass 2003). In general, fauna are adapted to natural physical disturbances but in the deep oceans, human-caused disturbances have been hypothesised to take decades or centuries to recover from because of slow growth resulting from low temperatures and relatively limited food availability (Gass 2003). Concern about the status of Canada's cold water corals has increased with better knowledge about destructive fishing techniques, better spatial mapping of coral concentrations, and realization that corals represent a relatively rare, vulnerable, and in some areas, an abundant resource.

In Atlantic Canada, activities identified with the potential to impact corals include fishing, petroleum exploration and extraction, cable laying, sand and gravel extraction and the dumping of munitions (Butler and Gass 2001). In British Columbia, advances in technology are allowing human activities to move into unexplored deeper water marine regions and resource managers have allowed grounds to be utilized prior to them being modelled or surveyed for coral concentration presence.

i) Fishing gear effects

Fishers try to catch targeted fishes most efficiently; destroying or modifying habitat per se is usually not an objective (McAllister and Alfonso 2001). Nevertheless, fishing gear impacts on corals have been documented since the mid-1900s by de Groot (1984) and over the past decade published literature and expressed concerns on this subject have increased (Koslow et al 2001; Chuenpagdee et al. 2003; Roberts 2002; Etnoyer and Morgan 2003). In some areas, chains between otter boards have been dragged across coral areas to flatten them and make them less damaging to trawl activity (Breeze et al. 1997). During recent decades, development of new and more robust fishing gear has allowed fisheries to expand into ever deeper waters (Roberts 2002; Husebo et al 2002), extending the depth at which habitat impacts from fishing may now occur. As a result, previously undisturbed, potentially biologically rich habitats are increasingly being impacted by bottom trawls, longlines, pots and dredges (Roberts 2002). In British Columbia, trawling is now occasionally occurring as deep as 1200 m (3-4 tows each year have been deeper) on the continental slope for slope rockfish, i.e., thornyheads (*Sebastolobus* spp.) (D. Rutherford, DFO, Nanaimo, pers. comm.), and tanner crab (*Chionoecetes* spp.) exploratory trap fishing has occurred from 450-2100 m (G. Gillespie, DFO, Nanaimo, pers. comm.). Commercial groundfish trawling targets mobile species and the same successful track area is often fished numerous times, partly to minimize gear damage or loss of gear since that location had been shown by previous fishing to be both devoid of obstructions and having the targeted species. In contrast, exploratory trawling, such as with research trawls, is less frequent and typically involves only a single tow over an area. Damage can still occur, but the lower frequency of such tows means they may have a lesser impact than the more frequent commercial trawling (Van Dolah et al 1987). However, this does not justify trawling as an exploratory tool to assess coral presence or abundance, as other non-destructive assessment options (e.g. drop cameras, ROVs, etc.) exist.

All dragged benthic types of fishing gear have the potential to cause harm to benthic environments but the nature and extent of this harm is dependant on gear type and the level or intensity of fishing (Butler and Gass 2001; Gass 2003). Chuenpagdee et al (2003) described gear-specific by-catch and habitat impacts. Destructive fishing practices have destroyed coral concentrations, leaving rubble and possibly, a less-valued fish habitat in their place (McDonough and Puglise 2003). Habitat degradation may consist of damage to living seafloor structures (e.g., corals, sponges, sea grass, etc.) as well as the physical disturbance of geologic structures (e.g., rolled boulders, cobbles, gravel, sand, mud, etc.) (Chuenpagdee et al 2003). Fishers on Canada's east coast indicate that areas where the ocean floor has been altered (e.g. the dragging of chains strung horizontally over the ground to remove obstacles causing damage to fishing gear) show a reduction in the quantity of living cold water corals later caught as bycatch (Breeze et al 1997). The removal or reduction of corals can reduce the availability of habitat and potentially affect the recruitment or survival of exploited species (Freese el al 1999).

On the east coast of Canada, fishers reported risking the loss or entanglement of their gear in corals in order to obtain 'good' fish catches (Gass 2003). Fishermen have set gear close to corals to obtain catches, while hopefully not damaging or losing gear (Gass 2003). Halibut have been noted to be found in areas with cold water corals and these areas have been described as 'good fishing grounds' (Gass 2003). This tendency suggests that to ensure functional protection, no-take buffer zones are needed around the specific boundaries of known coral concentrations to ensure that accidental intrusion by fishing gear does not occur. Dragged gear does not precisely follow the track of its towing surface vessels, and there is always an element of uncertainty as to where the trawl exactly is.

Kreiger (2001) reported on two 1990 trawl path catches of corals (*Primnoa*) in the Gulf of Alaska, with catches of 1,000 kg over 2.72 km in one and 60 kg over 1.32 km in the other. Seven years later, the trawl paths were still evident, with many corals in the paths missing a significant portion of their branches and polyps; no young corals appeared to have yet repopulated the damaged areas. He also documented that longline gear can damage corals but provided no estimate of the scale of damage, only noting that sturdy flexible corals appeared to be relatively unharmed by longline gear. However, colonies attached to small boulders could be pulled over when longline gear snagged them.

ii) *Offshore Oil and Gas Exploration*

Advances in technology and improved knowledge of the marine environment are enabling various industries to explore and carry out activities at ever greater depths (Gass 2003). Oil and gas exploration and development has the potential to cause physical and biological damage to corals, from initial exploration and surveying to the placement of structures and during extraction activities (Cimberg et al 1981; Butler and Gass 2001; McAllister and Alfonso 2001; Grehan et al 2001; Gass 2003).

Initial exploration and surveying involves topographic mapping, sonar and seismic profiling. Impacts from these events are anticipated to be minimal on corals since detonations are often at a distance from benthic organisms (Cimberg et al 1981).

Physical damage or 'crushing' of corals may occur during pipe-laying and drilling (Cimberg et al 1981; Miller 2001; Butler and Gass 2001). Both localized and general impacts may result from structures (platforms, anchors, chains, pipelines and moorings (Cimberg et al 1981; Butler and Gass 2001)), but because such structures typically have a limited footprint, they can generally be sited to avoid corals. Platforms and structures provide large areas for sessile organisms with larval dispersal to settle and grow.

Oil and gas extraction activities can cause indirect effects over larger areas through the introduction of suspended or re-suspended sediment (Cimberg et al 1981; Raimondi et al 1997; Gass 2003; NOAA 2004; Miller 2001). Discharge of sediment (bottom sediment, drilling muds and/or drill cuttings) may smother corals growing in the vicinity or down current from the rigs (Butler and Gass 2001). Excess sediment can potentially interfere with corals physiology due to either its toxicity or potential to hinder feeding and respiration processes (Raimondi et al 1997; Butler and Gass 2001; Gass 2003). In contrast to most corals, scleractinian corals can actively clean sediment from their surface and better cope with sand deposition (Fossa et al 2002). The ecological effects of drilling wastes on benthic organisms are thus based on both particulate load and if relevant, its direct toxicity. Damage to *Lophelia* in the North Sea caused by oil and gas exploration structures and activities has been reported (NOAA 2004).

iii) Other Anthropogenic Threats

It is unknown at this time if persistent organic chemicals affect the growth and/or long-term survival of corals (McAllister and Alfonso 2001). Recent studies in Chile describe salmon farming as a potential threat to nearby shallow water coral aggregations (Forsterra and Haussermann 2003). Oil spills, ship wrecks and ballast-water dumping may impact surface planktonic and/or benthic coral life stages (McAllister and Alfonso 2001).

Aggregate extraction likely only directly impacts pennatulacean cold water corals since most others prefer stable hard substrates; extracted aggregates are typically found in shallow coastal waters or on the tops of offshore banks (Butler and Gass 2001). However, storage of log booms in deep-water areas with coral aggregations can cause habitat degradation and coral mortality from sinking bark debris, as observed in BC in Agamemnon Channel (Rick Harbo, DFO, Nanaimo, pers. comm.).

In general, corals exposed to disturbances, whether physical or chemical, react defensively by retracting their polyps and producing a hypersecretion of mucus (Gass 2003). Although such responses have been primarily documented with shallow, warm water corals, it is assumed a similar response is exhibited by cold water species. If this defence mechanism lasts for a prolonged period of time, effects can include decreased nutrient assimilation and production, altered biochemical composition, partial or complete inhibition of growth, bacterial infection and possible death from chronic exposure (Gass 2003).

c) Coral protection in Canada

At present, no coral species or coral areas are given any specific protection in British Columbia; there are no fishery closures or legislated marine protected areas established to specifically protect coral concentrations, as exist in eastern Canada. The latter areas to date are:

1) *Lophelia Conservation Area*: about 15 km^2 in size, closed to all bottom-impacting fishing gear, at the mouth of the Laurentian Channel (http://www.mar.dfo-mpo.gc.ca/communications/maritimes/news04e/NR-MAR-04-14E.html);
2) *Northeast Channel Coral Conservation Area*: about 424 square kilometres in size, with about 90 percent of the area closed to all bottom fishing gear used for groundfish or invertebrate fisheries (longline, gillnet, trap, mobile) (http://www.mar.dfo-mpo.gc.ca/communications/maritimes/back02e/B-MAR-02-(5E).html);
3) *The Gully Marine Protected Area*: the largest marine canyon in eastern North America, located off Nova Scotia near Sable Island, comprising an area of 2,364 square kilometres and includes the habitat of deep-sea corals and a variety of whale species, including the at-risk northern bottlenose whale. The MPA contains three management zones with varying levels of protection based on the conservation objectives and ecological vulnerability of each zone. Zone 1, the core deep-water portion of the canyon, provides full ecosystem protection with a complete restriction on extractive activities. Zone 2 imposes strict protection for the canyon head and sides, feeder canyons and the continental slope. The adjacent sand banks, which are prone to regular natural disturbance, comprise Zone 3 (http://www.dfo-mpo.gc.ca/media/backgrou/2004/hq-ac61a_e.htm).

Four groundfish trawl closures were established in 2002 in the Pacific North Coast Integrated Management Area (PNCIMA) to protect glass sponge bioherms, but the effectiveness of these fishery closures has yet to be assessed. Recent multibean surveys in PNCIMA in 2005 (K. Conway, NRCan, IOS, Sidney, BC, pers. comm.) have shown that about 93% of the reefs overall are within the closure boundaries, but that most of one reef lies outside the closure established in 2002 to protect it. Closure boundaries were modified on April 1, 2006, to reflect the revised sponge reef spatial distributions, but again, no buffer zones around the reefs were included in the closures. Few corals, if any, occur on the sponge bioherms because of their soft substrate. Analysis of coral bycatch in the groundfish fishery (Ardron and Jamieson, this meeting) has suggested high priority areas for coral conservation, and they proposed a precautionary management approach to achieve coral protection in the absence of known coral concentration locations on the BC coast.

Corals are known to occur off Atlantic Canada on the continental slope, in submarine canyons, and in channels between fishing banks; the same is presumed to occur in Pacific Canada. Until recently, most of the limited information available on deep-sea corals in Atlantic Canada was anecdotal, based primarily on observations made by the fishing industry (Breeze et al. 1997). However, since 1997, DFO in Atlantic Canada has been collecting video and photographic information of epibenthic communities on an opportunistic basis at prime coral habitat sites including the Northeast Channel, the Gully and Stone Fence. Corals there were also occasionally collected during DFO groundfish surveys. Similar video and photographic information on deep-water coral communities off British Columbia is lacking, with most current data being anecdotal or based primarily on observations made by the fishing industry (see Ardron and Jamieson, this meeting) and a few recent crab research surveys (J. Boutillier, DFO, Nanaimo, BC, pers. comm.). Until recently, there was no drop camera equipment available for deep-water benthic habitat photography in British Columbia, but NRCan now has such equipment and has offered to let DFO researchers use it when its not otherwise in use (Kim Conway, pers. comm.).

Existing fishery closures and marine protected areas in BC are mostly near-shore and in waters too shallow for deep-water corals. The exceptions are:

1) the proposed Gwaii Haanas National Marine Conservation Area Reserve (NMCA), which will extend about ten kilometres offshore from Gwaii Haanas National Park Reserve and Haida Heritage Site, and encompass approximately 3,400 km² of the Hecate Strait and Queen Charlotte Shelf Marine Regions (http://www.pc.gc.ca/pn-np/bc/gwaiihaanas/natcul/natcul4_E.asp). The continental shelf is very narrow on the outside of the Queen Charlotte Islands and the outer limit of the proposed NMCA boundary (Figure 2) could be as deep as about 1000 m, depth ranges where corals commonly occur (N. Sloan, Parks Canada, Queen Charlotte City, BC, pers. comm.). There are also a few deep areas within the proposed NMCA on the east side of the islands east and south of Ramsay Island which potentially also have deepwater corals. Three of the deepest are 285 m deep at N52º31’48’, W131º19’24”, 315 m deep at N52º31’56”, W131º16’30”, and 312 m deep at N52º31’44”, W131º17’20” (R. Hare, DFO, IOS, BC, pers. comm.). NMCA’s are not exclusively no-take conservation areas, and it remains to be determined what human activities will be regulated, and the spatial distribution of their potential regulation.
2) the experimental thornyhead (*Sebastolobus* spp.) closure off the west coast of Gwaii Haanas (Figure 3): this closure to groundfish trawling only functionally extends from about 200 fathoms (182 m) depth seaward to off the continental slope, and so while not established for corals, may in fact protect some corals from trawling. However, fishing with other gears (e.g. trap and longline) is still permitted. It partially overlaps the proposed Gwaii Haanas NMCA Reserve.

Recommedations

1. Initiate studies to identify and survey significant deepwater coral concentrations in Pacific Canadian waters;
2. Utilise whenever possible non-destructive technologies and methods (i.e. submersible, ROV, video, etc.) for studying biogenic structural species such as corals and sponges that are sensitive to physical damage in the marine benthic environment. There is need for non-invasive plankton sampling methods to determine the epibenthic food web (e.g., something like a pump-operated Hardy Continuous Plankton Recorder on the side of every ROV videotaping deepwater corals) at coral-bearing and non-coral areas of the continental shelf and slope;
3. Improve coral bycatch species identification and reporting in all relevant fishing activities and provide improved taxonomic guides to observers for coral species identification;
4. Initiate predictive coral habitat modelling utilising physical oceanographic and substrate parameters;
5. On completion of (5), groundtruth ‘predicted coral areas’ to assess model prediction accuracies;
6. Identify and prioritize short- and long-term coral survey and monitoring needs so as to achieve coral conservation as part of a regional coral/sponge conservation strategy;
7. Continue consultations and collaboration with First Nations, ENGOs, fisherman associations, staff from adjacent political jurisdictions and other marine stakeholders to achieve coral conservation;
8. Enhance public awareness about DFO’s coral research and management efforts to achieve cold-water coral conservation.

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Table 1: Number of cold water coral records mapped for British Columbia, their source and the years observations were made.

Data Source	Data Years	# Records Mapped
Royal British Columbia Museum	1965-2001	19
Canadian Museum of Nature	1900-1991	7
National Museum of Natural History – Smithsonian Institution	1888-2001	9
Centre for Marine Biodiversity and Parks Canada – Gwaii Haanas	1888-2000	262
GFBio Database – DFO Groundfish	1966-2002	152
Tanner Crab Database – DFO	1999-2003	29
Shrimp Database – DFO	1966-2003	114
International Pacific Halibut Commission – Stock Assessment Data	1995-2003	15
PacHarv Observer Trawl Database	1996-2003	1078

Table 2. Geographical distributions of coral records in Northeast Pacific waters. Families and Species likely to occur in British Columbia include those reported from Washington and Oregon, south-east Alaska and the seamounts (shaded columns). BS = Bering Sea, AI = Aleutian Islands, WG = western Gulf of Alaska, SM = seamounts, EG = eastern Gulf of Alaska, BC = British Columbia, WO = Washington and Oregon. ● = present. Alaskan records from Bob Stone, NOAA, Juneau, AK, USA, pers. comm., adapted by him from Heifetz et al. (in press); Washington and Oregon records from Curt E. Whitmire and M. Elizabeth Clarke, NOAA, Seattle, WA, USA, pers. comm., and Austin (1985).

Taxa	BS	AI	WG	EG	SM	BC	WO
Order Alcyonacea (gorgonians and true soft corals)							
Acanthogorgiidae							
cf. *Acanthogorgia*		●					
Calcigorgia beringi		●		●			
Calcigorgia spiculifera		●	●	●		●	●
Calcigorgia sp. A		●					
Calcigorgia sp.							●
Callogorgia sp.							●
Calcigorgia kinoshitae						●	
Alcyoniidae							
Alcyonium sp.						●	
Anthomastus cf. *glandiflora*						●	
Anthomastus japonicus	●	●					
Anthomastus cf. *japonicus*		●					
Anthomastus ritteri		●	●	●		●	●
Anthomastus sp. A		●					
Anthomastus sp.						●	●
Chrysogorgiidae							
cf. *Chrysogorgia*		●					●
Radicipes sp. A		●					
Clavulariidae							
Clavularia moresbii		●	●	●			
Clavularia sp						●	
Clavularia sp. A		●					
Sarcodictyon incrustans	●	●					
Coralliidae							
Corallium sp. A					●		
Isididae							
Acanella sp. A					●		
Isidella paucispinosa		●	●	●			
Isidella sp. A					●		
Isidella sp						●	●
Keratoisis profunda		●	●	●			
Keratoisis sp. A					●		
Keratoisis sp.						●	●
Lepidisis sp.						●	

Updated: November 2006 - Pages 21-25, Table 2: An error had occurred during the PDF conversion when released originally. Question marks from the earlier version were replaced by black dots (●).

<u>**Taxa**</u>	<u>**BS**</u>	<u>**AI**</u>	<u>**WG**</u>	<u>**EG**</u>	<u>**SM**</u>	<u>**BC**</u>	<u>**WO**</u>
Lepidisis sp. A			●	●			
Lepidisis sp. B					●		
Nephtheidae							
cf. *Eunephthea (Gersemia)*		●					
Eunephthea rubiformis	●	●	●	●		●	
Eunephthea sp. A		●					
Eunephthea sp.						●	●
Paragorgiidae							
Paragorgia arborea (syn. pacifica)		●	●	●		●	
Paragorgia yutlinux sp.nov.						●	
Paragorgia stephencairnsi sp. nov						●	
Paragorgia sp. A					●		
Paragorgia sp. B		●					
Paragorgia sp							●
Paramuriceidae							
Paramuricea sp. A		●					
Plexauridae							
Alaskagorgia aleutiana		●					
Euplexaura marki		●	●	●			●
Muriceides cylindrica.		●					
Muriceides cf. *cylindrica*		●					
Muriceides nigra		●					
Muriceides sp. A		●					
Swiftia (Psammogorgia) spauldingi						●	
Swiftia beringi		●					
Swiftia kofoidi							●
Swiftia pacifica		●				●	
Swiftia simplex		●			●	●	
Swiftia torreyi						●	
Swiftia sp. A		●					
Swiftia sp							●
Swiftia torreyi						●	
Euplexaura sp. A		●	●				
Primnoidae							
Amphilaphis sp. A		●					
Amphilaphis sp. B		●					
Amphilaphis sp. C		●					
Arthrogorgia kinoshitai	●	●	●	●			
Arthrogorgia otsukai	●	●					
Arthrogorgia utinomii		●					
Fanellia compressa	●	●					
Fanellia fraseri		●	●				
Narella sp. A		●					
Parastenella sp. A		●					
Parastenella cf. *doederieini*							●
Parastenella							●
Plumarella flabellata		●					

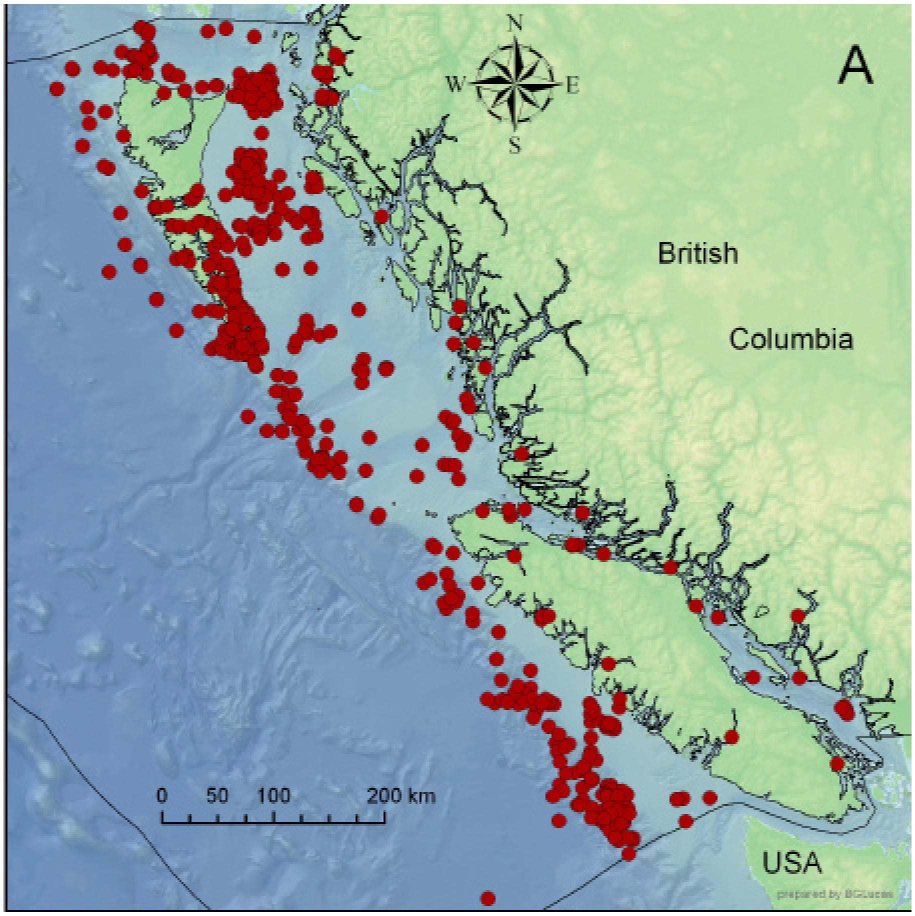
Taxa	BS	AI	WG	EG	SM	BC	WO
Plumarella longispina	●	●	●	●			
Plumarella spicata		●					
Plumarella spinosa		●					
Plumarella sp. A		●					
Primnoa pacifica	●	●	●	●			
Primnoa pacifica var. *willeyi*						●	
Primnoa wingi		●	●	●			
Thouarella hilgendorfi		●					
Thouarella striata		●					
Thouarella superba		●					
Thouarella sp. A		●					
Thouarella sp.							●
Order Pennatulacea (pennatulaceans)							
Anthoptilidae							
Anthoptilum grandiflorum	●					●	●
Anthoptilum murrayi	●						
Anthoptilum cf murrayi						●	
Funiculinidae							
Funiculina parkeri						●	●
Halipteridae							
Halipteris californica				●			
Halipteris cf californica						●	
Halipteris willemoesi	●	●	●	●			
Kophobelemnidae							
Kophobelemnon hispidum						●	
Kophobelemnon affine						●	●
Kophobelemnon biflorum							●
Pennatulidae							
Pennatula phosphorea				●		●	
Ptilosarcus gurneyi		●	●	●		●	●
Ptilosarcus sp.						●	
Protoptilidae							
Distichoptilum rigidum							●
Distichoptilum cf rigidum						●	
Protoptilum sp. A			●	●		●	
Scleroptilidae							
Scleroptilum sp.							●
Stachyptilidae							
Stachyptilum superbum						●	
Umbellulidae							
Umbellula lindahli	●	●	●	●		●	
Umbellula sp.							●
Virgulariidae							
Acanthoptilum gracile						●	
Balticina californica						●	
Balticina septentrionalis						●	

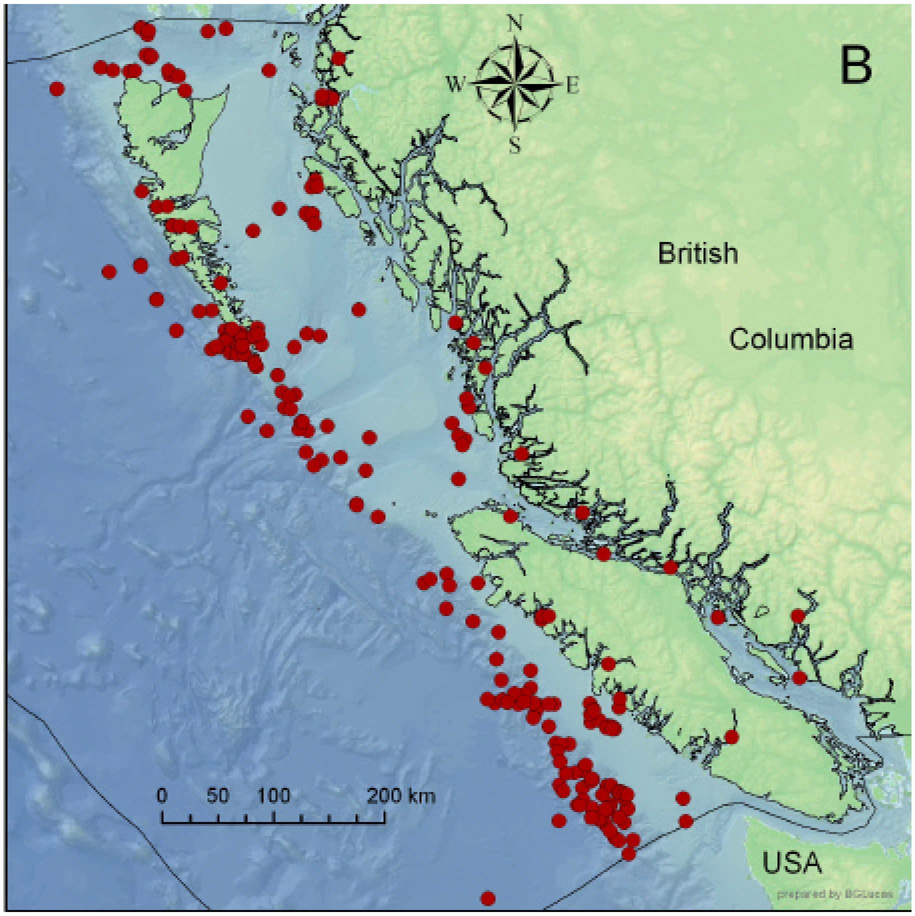
Taxa	BS	AI	WG	EG	SM	BC	WO
Stylaulta elongata						●	
Stylatula gracile							●
Stylatula sp.							●
Virgularia sp. A				●			
Virgularia sp.						●	●
Virgularia cystiferum						●	
Order Scleractinia (stony and cup corals)							
Caryophylliidae							
Caryophyllia alaskensis		●	●	●		●	
Caryophyllia arnoldi		●	●	●		●	
Caryophyllia sp. *A*		●					
Crispatotrochus foxi		●	●	●			
Labyrinthocyathus quaylei						●	
Desmophyllum dianthus (syn. cristagalli)						●	
Leptopenus discus		●					
Lophelia pertusa						●	●
Paracyathus caltha						●	
Paracyathus stearnsi				●		●	
Dendrophylliidae							
Balanophyllia elegans		●	●	●		●	
Flabellidae							
Flabellum sp.		●					
Javania borealis	●	●	●				
Fungiacyathidae							
Fungiacyathus marenzelleri		●					
Fungiacyathus sp. A					●		
Javania cailleti	●	●	●	●		●	
Order Antipatharia (black corals**)**							
Anthipathidae							
Antipathes sp.						●	●
Parantipathes sp.		●		●			●
Cladopathidae							
Chrysopathes formosa				●			
Chrysopathes speciosa				●		●	
Heliopathes pacifica					●		
Trissopathes pseudotristicha			●				
Schizopathidae							
Bathypathes alternata				●			
Bathypathes patula				●		●	
Bathypathes sp.				●			●
Dendrobathypathes boutillieri						●	
Dendrobathypathes n. sp. A		●		●			
Lillipathes lilliei				●			
Lillipathes wingi						●	
Lillipathes n. sp. A				●			

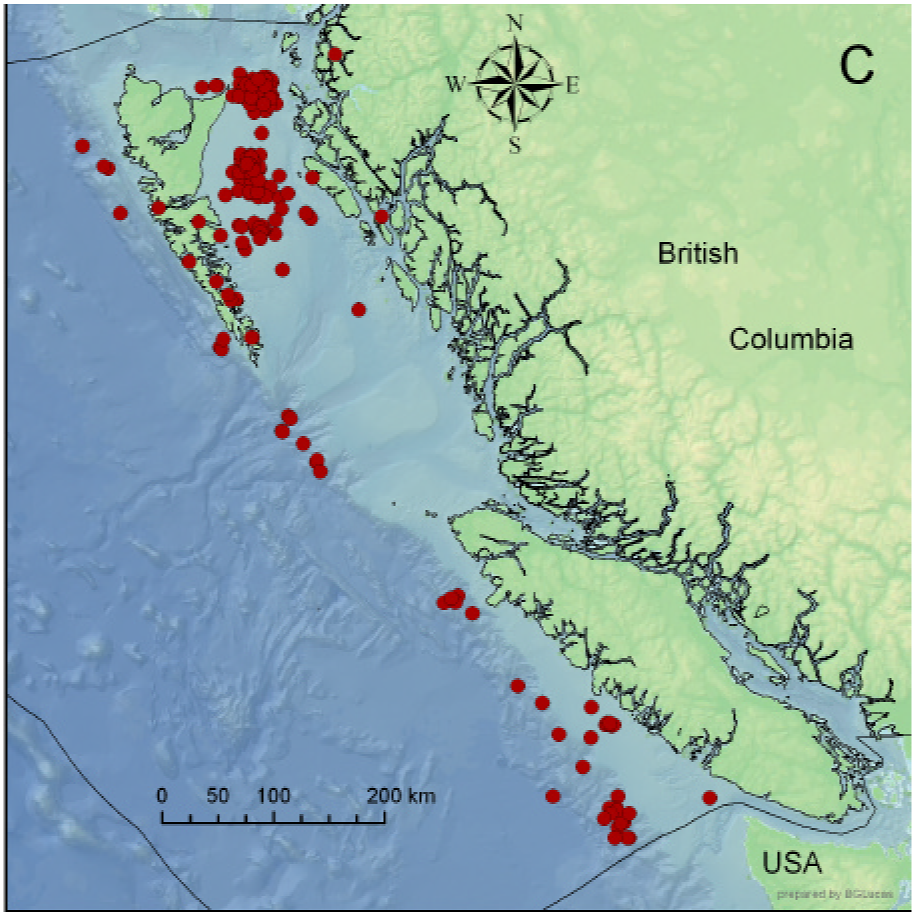
Updated: November 2006 - Pages 21-25, Table 2: An error had occurred during the PDF conversion when released originally. Question marks from the earlier version were replaced by black dots (●).

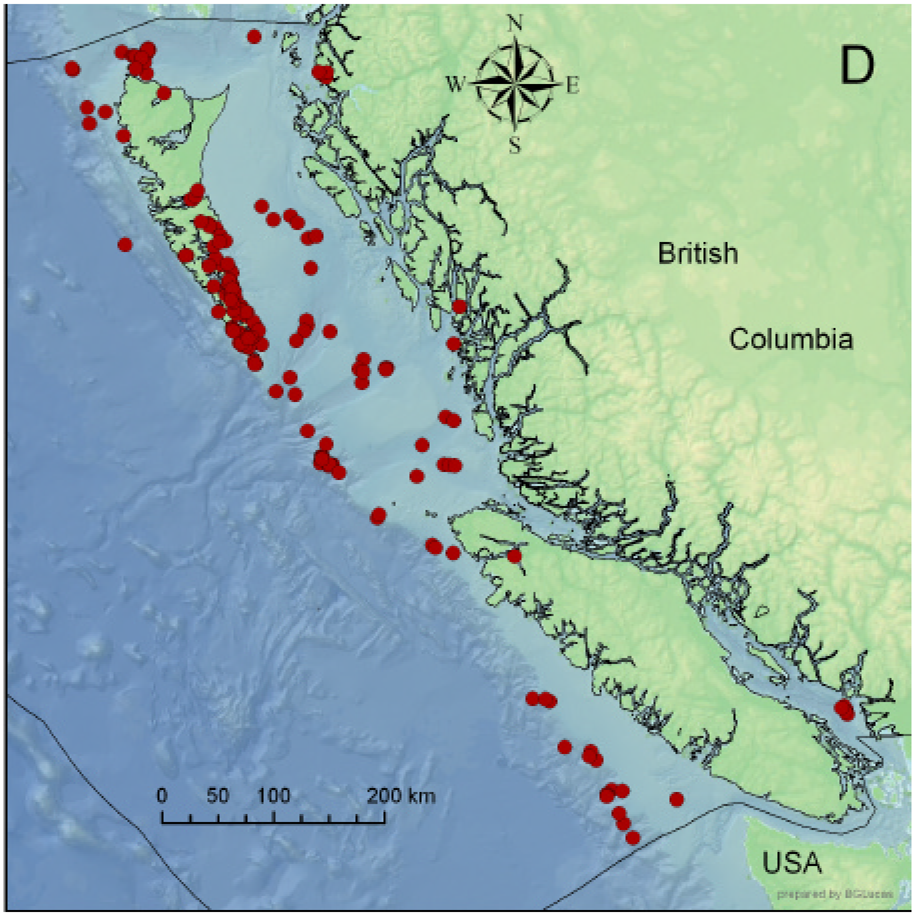
Taxa	BS	AI	WG	EG	SM	BC	WO
Umbellapathes helioanthes					●		
Umbellapathes sp. A						●	
Order Filifera (hydrocorals**)**							
Stylasteridae							
Crypthelia trophostega	●	●					
Cyclohelia lamellata	●	●					
Cyclohelia sp. A		●					
Distichopora borealis		●					
Distichopora sp. A		●					
Errinopora nanneca		●					
Errinopora poutalesii		●	●	●		●	
Errinopora stylifera		●					
Errinopora zarhyncha		●					
Errinopora sp. A		●					
cf. *Stenohelia*		●					
Stylantheca papillosa		●					
Stylantheca porphyra				●		●	
Stylantheca pterograpta		●		●		●	●
Stylaster alaskana		●					
Stylaster brochi		●					
Stylaster californicus							●
Stylaster campylecus campylecus		●	●	●			
Stylaster campylecus parageus				●			
Stylaster campylecus trachystomus		●					
Stylaster campylecus tylotus		●					
Stylaster cancellatus		●		●			
Stylaster elassotomus		●					
Stylaster moseleyanus		●					
Stylaster norvigicus						●	
Stylaster polyorchis		●					
Stylaster porphyra						●	
Stylaster stejnegeri	●	●					
Stylaster venustus				●		●	●
Stylaster verrillii		●		●			
Stylaster sp. A		●					

Figure 1: Locations of corals reported from British Columbia, Canada. A – All, B – Alcyonacea, C – Pennatulacea, D – Scleractinia, E – Filifera.




B
N
S
W
E
British
Columbia
0
50
100
200 km
USA
prepared by BGbases


C
N
W
E
S
British
Columbia
0 50 100 200 km
USA
prepared by BCbaces


D
N
W
E
S
British
Columbia
0 50 100 200 km
USA
prepared by BCbases

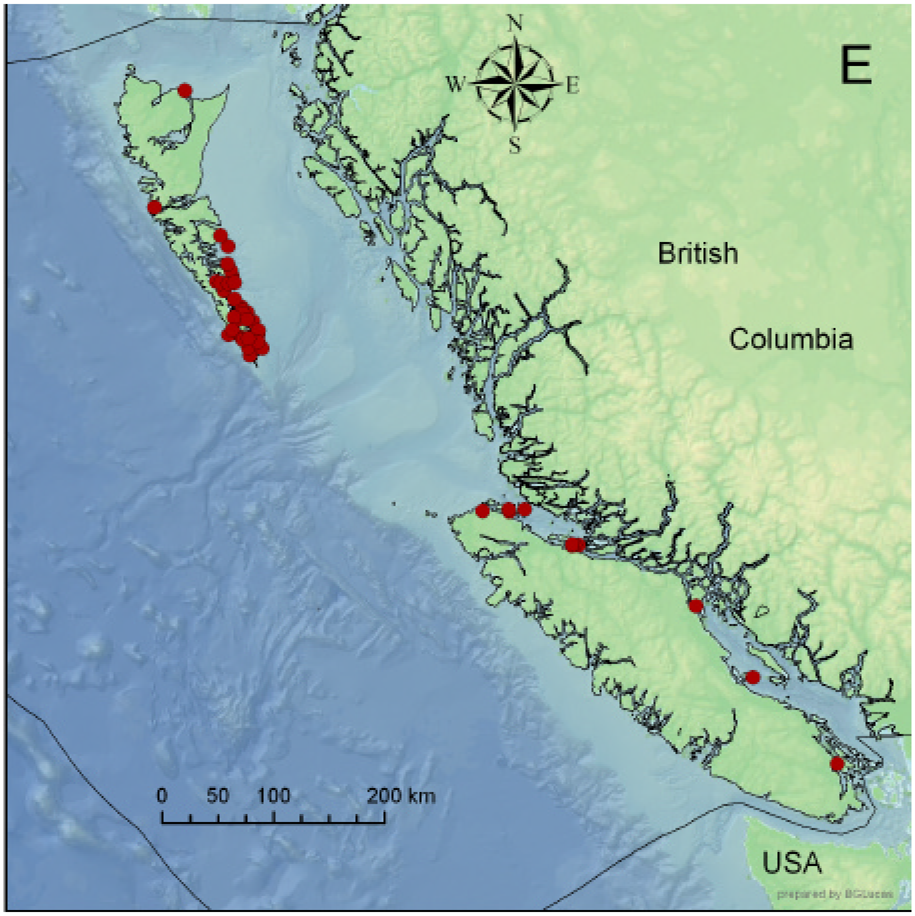

E
N
W
E
S
British
Columbia
0 50 100 200 km
USA

Figure 2: The boundary of the proposed Gwaii Haanas National Marine Conservation Area Reserve aro0unf Moresby Island, Queen Charlotte Islands (http://www.pc.gc.ca/pn-np/bc/gwaiihaanas/natcul/natcul4_E.asp).

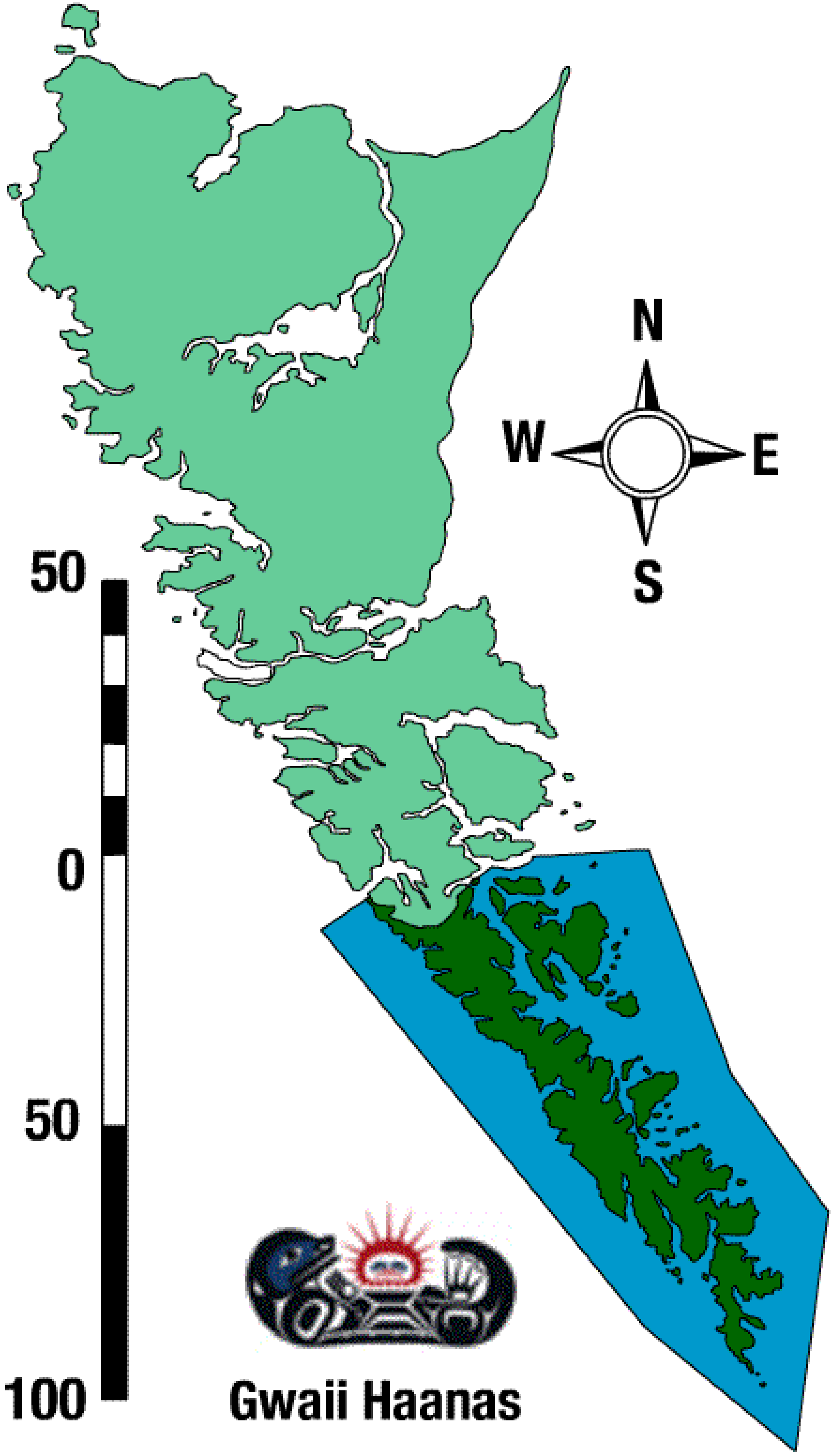
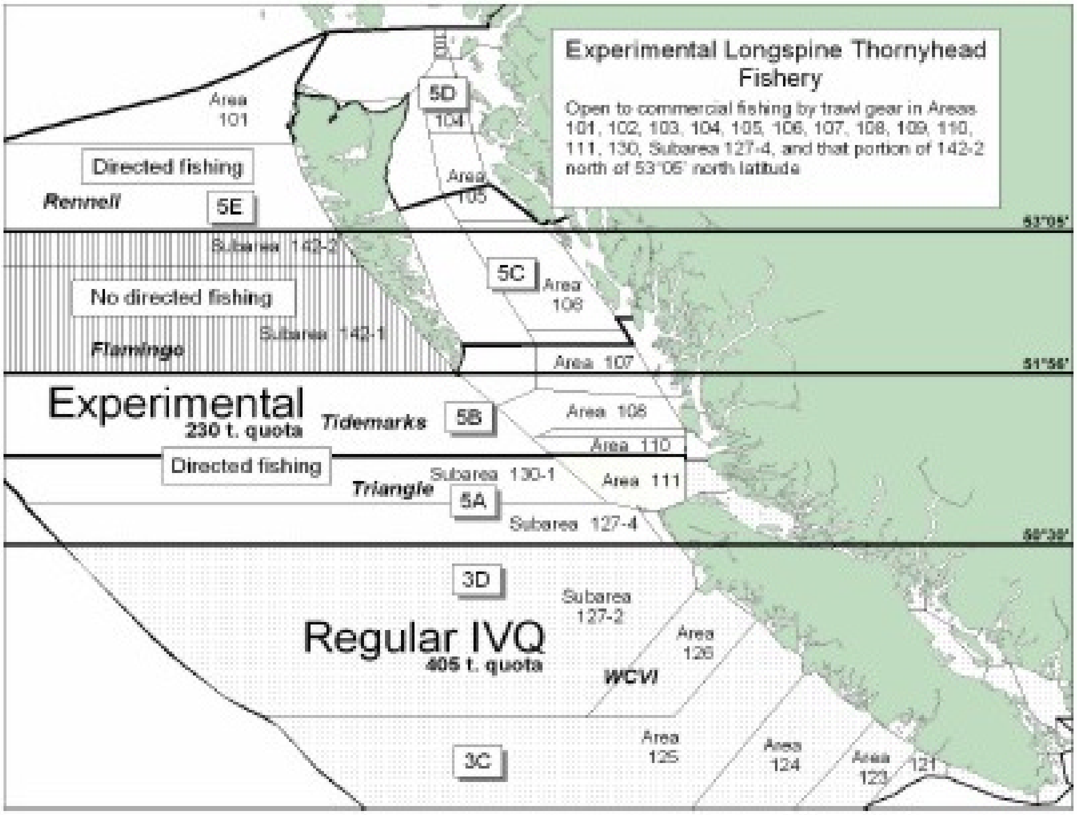


Figure 3: Location of the thornyhead groundfish trawl closure off the west coast of Gwaii Haanas (http://ops.info.pac.dfo.ca/fishman/Mgmt_plans/archive/2004/Trawl0405.pdf).



Appendix A. Contrasting classification schemes.

Williams and Cairns (2006)

Order	Family
HELIOPORACEA (blue corals)	
	Lithotelestidae
	Helioporidae
ALCYONACEA (soft corals and gorgonians)	
	Taiaroidae
	Haimeidae
	Cornulariidae
	Clavulariidae
	Tubiporidae
	Coelogorgiidae
	Pseudogorgiidae
	Paralcyoniidae
	Alcyoniidae
	Nephtheidae
	Nidaliidae
	Xeniidae
	Briareidae
	Anthothelidae
	Subergorgiidae
	Paragorgiidae
	Coralliidae
	Melithaeidae
	Parisididae
	Keroeididae
	Acanthogorgiidae
	Plexauridae
	Gorgoniidae
	Ellisellidae
	Ifalukellidae
	Chrysogorgiidae
	Primnoidae
	Isididae
	Dendrobrachiidae
PENNATULACEA (sea pens and sea whips)	
	Veretillidae
	Echinoptilidae
	Renillidae
	Kophobelemnidae
	Anthoptilidae
	Funiculinidae
	Protoptilidae
	Stachyptilidae
	Scleroptilidae

ITIS (May, 2006)

Order	Suborder	Family
HELIOPORACEA (blue corals)		
		Lithotelestidae
		Helioporidae
ALCYONACEA (soft corals)		
		Taiaroidae
		Haimeidae
		Cornulariidae
		Clavulariidae
		Tubiporidae
		Coelogorgiidae
		Pseudogorgiidae
		Paralcyoniidae
		Alcyoniidae
		Nephtheidae
		Nidaliidae
		Xeniidae
		Dendrobrachiidae
Gorgonacea (gorgonians)		
	Holaxonia	
		Acanthogorgiidae
		Ainigmaptilidae
		Chrysogorgiidae
		Ellisellidae
		Gorgoniidae
		Ifalukellidae
		Isididae
		Keroeididae
		Paramuriceidae
		Plexauridae
		Primnoidae
	Scleraxonia	
		Anthothelidae
		Briareidae
		Coralliidae
		Melithaeidae
		Paragorgiidae
		Parisididae
		Subergorgiidae
PENNATULACEA (sea pens and sea whips)		
		Veretillidae
		Echinoptilidae
		Renillidae

Chunellidae
Umbellulidae
Halipteridae
Virgulariidae
Pennatulidae

Kophobelemnidae
Anthoptilidae
Funiculinidae
Protoptilidae
Stachyptilidae
Scleroptilidae
Chunellidae
Umbellulidae
Halipteridae
Virgulariidae
Pennatulidae

Appendix B.

Taxonomic tree and references for cold water corals in British Columbia. Literature references are shown in square brackets. Bold: not now a recognised species; * - North Pacific record, unlikely from BC waters. [CMN] Canadian Museum of nature, Ottawa, ON, [RBCM] Royal BC Museum, Victoria, BC, [Smithsonian] Smithsonian Museum of Natural History, [Stone 2005] Bob Stone, , NOAA, Juneau, Alaska, USA, pers. comm., [Whitmire and Clarke 2005] Curt E. Whitmire and M. Elizabeth Clarke, NOAA, Seattle, Washington, USA, pers. comm., [Boutillier 2005] Jim Boutillier, DFO, Nanaimo, BC., pers. comm.

Phyllum Cnidaria,
Class Anthozoa
Subclass Alcyonaria Baltcina Gray, 1870
 Order Alcyonacea (based on Williams and Cairns 2002) (soft corals and sea fans)
 Alcyoniidae
  Alcyonium Linnaeus, 1758
   unknown sp.* [Heifetz 2002] [Lamb and Hanby 2005]
  Anthomastus Verrill, 1878
   unknown sp.* [Heifetz 2002]
   cf. glandiflora [Sloan et al. 2001]
   ritteri Nutting, 1909 [Smithsonian] [Sloan et al. 2001]
   sp. A (red)* [Heifetz 2002]
   sp. B (gray)* [Heifetz 2002]
 Nephtheidae
  *Eunephthea (*Gersemia) Marenzeller, 1878
   unknown sp. [Heifetz 2002] [Smithsonian]
   rubiformis* (Ehrenberg, 1834) [Heifetz 2002] [RBCM] [Sloan et al. 2001] [Stone 2005] [Lamb and Hanby 2005]
 Chrysogorgiidae
  Chrysogorgia Duchassaing and Michelotti, 1860
   unknown sp. [Austin 1985]
  Radicipes Stearns, 1883
   unknown sp. [Austin 1985]
 Paragorgiidae (bubblegum trees)
  Paragorgia Milne Edwards & Haime, 1857
   unknown sp.* [Heifetz 2002] [RBCM] [Sloan et al. 2001]
   arborea (Linnaeus, 1758) [Heifetz 2002, based on Cimberg et al. 1981; [Etnoyer and Morgan 2003] [Stone 2005]
   coralloides Bayer, 1993 [Etnoyer and Morgan 2003]
   dendroides Bayer, 1956 [Etnoyer and Morgan 2003]
   arborea var. pacifica (? Sanchez 2005) (Verrill, 1878) [Heifetz 2002, based on Cimberg et al. 1981; [Etnoyer and Morgan 2003] [RBCM] [Sloan et al. 2001], [Conway et al. 2005b] [Stone 2005] [Austin 1985] [Lamb and Hanby 2005]
   stephencairnsi sp. nov. [Boutillier 2005]
   yutlinux sp.nov. [Boutillier 2005]

Acanthogorgiidae

Calcigorgia sp. [Heifetz 2002]

spiculifera (Broch, 1935) [Heifetz 2002] [Smithsonian] [Austin 1985] [Lamb and Hanby 2005]

compressa (Verrill, 1865) [Heifetz 2002, based on Cimberg et al. 1981]

(as Leptogoriga) beringi [Stone 2005]

Plexauridae

Alaskagorgia Sanchez & Cairns, 2004

aleutiana Sanchez & Cairns, 2004 [Sanchez & Cairns 2004]

Euplexaura

marki Kukenthal 1913 [Stone 2005]

Muriceides Studer, 1887

unknown sp.* [Heifetz 2002]

cylindria (Nutting, 1912) [Heifetz 2002, based on Cimberg et al. 1981]

nigra (Nutting, 1912) [Heifetz 2002, based on Cimberg et al. 1981]

Swiftia Duchassaing & Michelotti, 1864 (syn. Psammogorgia)

beringi (Nutting, 1912) [Heifetz 2002, based on Cimberg et al. 1981]

kofoidi (Nutting, 1909) [Austin 1985]

pacifica (Nutting, 1812) [Heifetz 2002, based on Cimberg et al. 1981] [Smithsonian] [Sloan et al. 2001]

simplex [RBCM]

spauldingi Nutting, 1909 [RBCM] [Lamb and Hanby 2005]

torreyi [RBCM] [Lamb and Hanby 2005]

Paramuriceidae

Paramuricea

sp. A

Primnoidae (red trees)

Amphilaphis Wright & Studer, 1887

unknown sp. [Heifetz 2002; [Etnoyer and Morgan 2003]

sp. 1* [Heifetz 2002; [Etnoyer and Morgan 2003]

sp. 2* [Heifetz 2002; [Etnoyer and Morgan 2003]

sp. 3* [Heifetz 2002; [Etnoyer and Morgan 2003]

biserialis [Etnoyer and Morgan 2003]

Arthrogorgia Kükenthal, 1908

unknown sp. [Heifetz 2002; [Etnoyer and Morgan 2003]

kinoshitai (Bayer, 1952) [Heifetz 2002, based on Cimberg et al. 1981] [Stone 2005]

otsukai (Bayer, 1952) [Heifetz 2002, based on Cimberg et al. 1981]

utinomii [Etnoyer and Morgan 2003]

Caligorgia

cristata [Etnoyer and Morgan 2003]

gilberti [Etnoyer and Morgan 2003]

Callogorgia Gray, 1858

unknown sp. [Heifetz 2002; [Etnoyer and Morgan 2003]

flabellum [Etnoyer and Morgan 2003]

formosum [Etnoyer and Morgan 2003]

gilberti [Etnoyer and Morgan 2003]

gracilis [Etnoyer and Morgan 2003]
kinoshitae [Etnoyer and Morgan 2003] [Austin 1985]
Calyptrophora Gray, 1866
angularis [Etnoyer and Morgan 2003]
cf. versluysi [Etnoyer and Morgan 2003]
versluysi [Etnoyer and Morgan 2003]
wyvillei [Etnoyer and Morgan 2003]
Candidella Bayer, 1954 (= Stenella)
unknown sp. [Etnoyer and Morgan 2003]
helminthophora [Etnoyer and Morgan 2003]
<u>Fanellia</u> Gray, 1870
unknown sp.* [Heifetz 2002; [Etnoyer and Morgan 2003]
compressa (Verrill, 1865) [Heifetz 2002; [Etnoyer and Morgan 2003]
euthyeia [Etnoyer and Morgan 2003]
fraseri* (Hickson, 1915) [Heifetz 2002; [Etnoyer and Morgan 2003]
tuberculata [Etnoyer and Morgan 2003]
Narella Gray, 1870 (=(Stachyodes)
allmani [Etnoyer and Morgan 2003]
ambigua [Etnoyer and Morgan 2003]
bowersi [Etnoyer and Morgan 2003]
dichotoma [Etnoyer and Morgan 2003]
ornata [Etnoyer and Morgan 2003]
Narellai
bayer [Etnoyer and Morgan 2003]
Paracalyptrophora Kinoshita, 1908
unknown sp. [Etnoyer and Morgan 2003]
kerberti [Etnoyer and Morgan 2003]
Parastenella Versluys, 1906
unknown sp. [Etnoyer and Morgan 2003]
cf. doederieini [Etnoyer and Morgan 2003] [Whitmire and Clarke 2005] [Boutillier 2005]
<u>Plumarella</u> Gray, 1870
unknown sp. [Heifetz 2002, based on Cimberg et al. 1981] [Austin 1985]
sp. 1* [Heifetz 2002; [Etnoyer and Morgan 2003]
flabellata (Versluys, 1906) [Heifetz 2002, based on Cimberg et al. 1981; [Etnoyer and Morgan 2003]
longispina [Etnoyer and Morgan 2003] [Stone 2005]
spicata (Versluys, 1906) [Heifetz 2002, based on Cimberg et al. 1981]
spinosa (Versluys, 1906) [Heifetz 2002, based on Cimberg et al. 1981]
<u>Primnoa</u> Lamouroux, 1812
unknown sp. [Heifetz 2002; [Etnoyer and Morgan 2003] [Sloan et al. 2001]
pacifica [Stone 2005] [Lamb and Hanby 2005]
reseaeformis (Storm, 1901) [Heifetz 2002, based on Cimberg et al. 1981] [Lamb and Hanby 2005]

pacifica var. willeyi (Hickson, 1015) [Heifetz 2002] [RBCM] [Sloan et al. 2001] [Conway et al. 2005b] [Austin 1985] [Lamb and Hanby 2005] [Cairns and Bayer 2005]
wingi [Stone 2005]
Thouarella Gray, 1870
unknown sp.* [Heifetz 2002; Etnoyer and Morgan 2003] [Whitmire and Clarke 2005]
hilgendorfi (Studer, 1878) [Heifetz 2002, based on Cimberg et al. 1981]
reseda [Etnoyer and Morgan 2003]
resedaeformis [Etnoyer and Morgan 2003]
straita (Kukenthal, 1907) [Heifetz 2002, based on Cimberg et al. 1981; [Etnoyer and Morgan 2003]
regularis [Etnoyer and Morgan 2003]
willeyi [Etnoyer and Morgan 2003] [RBCM]
Isididae (bamboo corals)
Acanella Gray, 1870
eburnea (Pourtales, 1868) [Etnoyer and Morgan 2003]
dispar Bayer, 1990 [Etnoyer and Morgan 2003]
sp. A. [Stone 2005]
Ceratoisis
flabellum Nutting, 1908 [Etnoyer and Morgan 2003]
grandis Nutting, 1908 [Etnoyer and Morgan 2003'
Isidella Gray, 1857
sp. [Boutillier, pers. comm.]
sp. 3 [Etnoyer and Morgan 2003]
sp. 5 [Etnoyer and Morgan 2003]
paucispinosa [Stone 2005]
richotoma Bayer, 1990 [Etnoyer and Morgan 2003]
<u>Keratoisis</u> Wright, 1869
unknown sp.* [Heifetz 2002; Etnoyer and Morgan 2003] [Boutillier 2005]
paucispinosa Wright and Studer [Etnoyer and Morgan 2003]
philippinesis Wight and Studer [Etnoyer and Morgan 2003]
profunda (Wright and Studer, 1889) [Heifetz 2002, based on Cimberg et al. 1981; Etnoyer and Morgan 2003] [Stone 2005] [Lamb and Hanby 2005]

<u>Lepidisis</u> Verrill, 1883
<u>unknown sp.</u> [Etnoyer and Morgan 2003] [Smithsonian] [Sloan et al. 2001] [Stone 2005]
evelinaea Bayer, 1986 [Etnoyer and Morgan 2003]
longiflora Verrill [Etnoyer and Morgan 2003]
olapa Muzik, 1978 [Etnoyer and Morgan 2003]
paucispinosa (Wright and Studer, 1889) [Heifetz 2002, based on Cimberg et al. 1981]
Coralliidae (red or pink corals)
Corallium Cuvier, 1798
unknown sp. [Etnoyer and Morgan 2003]

abyssale* [Etnoyer and Morgan 2003]
ducale* [Etnoyer and Morgan 2003]
imperiale* [Etnoyer and Morgan 2003]
kishinouyei* [Etnoyer and Morgan 2003]
laauense* [Etnoyer and Morgan 2003]
niveum* [Etnoyer and Morgan 2003]
regale* [Etnoyer and Morgan 2003]
secundum* [Etnoyer and Morgan 2003]
tortuosum* [Etnoyer and Morgan 2003]

Clavulariidae (stoloniferans)

Clavularia Blainville, 1830

unknown sp. [Sloan et al. 2001]
unknown sp. A [Lamb and Hanby 2005]
unknown sp. B [Lamb and Hanby 2005]
moresbii Hickson, 1915 [Stone 2005]

Anthothela

pacifica [Lamb and Hanby 2005]

Order Pennatulacea (sea pens and sea whips)

Unknown sp. [Sloan et al. 2001]

Anthoptilidae

Anthoptilum

grandiflorum (Verrill, 1879) [Whitmire and Clarke 2005] [Austin 1985]
cf murrayi [Boutillier 2005]

Funiculinidae

Funiculina Lamarck, 1816

Parkeri Kükenthal 1913 [Austin 1985]

Halipteridae

Halipteris

californica (Moroff, 1902) [Stone 2005]
cf californica [Boutillier 2005]
willemoesi (Kölliker, 1870) [Stone 2005]

Kophobelemnidae

Kophobelemnon

hispidum Nutting, 1912 [Sloan et al. 2001]
affine Studer, 1894 [Austin 1985]
biflorum Pasternak 1960 [Austin 1985]

Pennatulidae

Pennatula

phosphorea Linnaeus, 1758 [Stone 2005] [Austin 1985]

Ptilosarcus

gurneyi Gray, 1860 [Kosloff 1974] [RBCM] [Stone 2005] [Whitmire and Clarke 2005] [Sloan et al. 2001] [Austin 1985] [Lamb and Hanby 2005]

Protoptilidae
Protoptilum
sp. A [Stone 2005] [Boutillier 2005]
Distichoptilum Verrill, 1882
rigidum Nutting 1912 [Austin 1985]
cf rigidum [Boutillier 2005]
Scleroptilidae
Scleroptilum
unknown sp. [Austin 1985]
Stachyptilidae
Stachyptilum Kölliker, 1880
superbum Studer 1894 [Austin 1985]
Umbellulidae
Umbellula
lindahli (Flores, 1999). [RBCM] [Stone 2005] [Austin 1985]
Virgulariidae
Acanthoptilum Kölliker, 1870
gracile (Gabb 1863) [Austin 1985]
Balticina Gray, 1870
californica [Sloan et al. 2001] [Austin 1985]
septentrionalis [Sloan et al. 2001] [Austin 1985]
Virgularia Lamarck, 1816
unknown sp. [Kosloff 1974] 9[RBCM] [Stone 2005] [Whitmire and Clarke 2005] [Lamb and Hanby 2005]
cystiferum (Nutting, 1909) [Sloan et al. 2001] [Austin 1985]
Stylatula
elongata (Gabb, 1863) [Kosloff 1974] [RBCM] [Sloan et al. 2001] [Austin 1985]
gracile [Whitmire and Clarke 2005]

Subclass Ceriantipatharia (ITIS)
Order Antipatharia (black corals)
Anthipathidae
Antipathes
unknown sp. [Etnoyer and Morgan 2003] [Austin 1985]
Parantipathes
unknown sp. [Etnoyer and Morgan 2003]
Cladopathidae
Chrysopathes
formosa Opresko, 2003 [Stone 2005]
speciosa Opresko, 2003 [Stone 2005]
Heliopathes Ospresko, 2005
pacifica Ospresko, 2005 [Ospresko, 2005]

Trissopathes

pseudotristicha Opresko, 2003 [Stone 2005]

Schizopathidae

Bathypathes

unknown sp. [Etnoyer and Morgan 2003]
patula Brock 1889 [Austin 1985] [Opresko 2005]

Dendrobathypathes Ospresko, 2002

sp. A [Stone 2005]

boutillieri Ospresko 2005 [Ospresko, 2005]

Lillipathes Ospresko, 2002

lilliei (Totton, 1923) [Stone 2005]

wingi Ospresko, 2005 [Ospresko, 2005]

sp. A [Stone 2005]

Umbellapathes Ospresko, 2005

helioanthes spec. nov. Laysan Seamount [Opresko 2005]

sp. A [Boutillier 2005]

Subclass Hexacorallia (ITIS)

Order Scleractinia (based on Cairns 1994) (“stony” and cup corals)

unidentified [Heifetz 2002]

Caryophylliidae

Caryophyllia Lamarck, 1816.

unknown sp*. [Heifetz 2002]
arnoldi Vaughan, 1900 [Smithsonian] [Sloan et al. 2001] [RBCM]
*alaskensis** Vaughan, 1941 [Heifetz 2002] [Sloan et al. 2001] [CMN] [Lamb and Hanby 2005]

Crispatotrochus Tension Woods, 1879

foxi (Durham & Barnard, 1952) [Stone 2005]

Labyrinthocyathus Cairns, 1979 syn. Cyathoceras

quaylei (Durham 1947) [Austin 1985]

Desmophyllum Ehrenberg, 1834

dianthus (Esper, 1794) syn. cristagalli Milne Edwarsa & Haime 1848 [Austin 1985]

Lophelia Milne-Edwards and Haime, 1849

prolifera (Pallas, 1766)
pertusa (Linnaeus, 1758) [Hyland et al. 2004; [Etnoyer and Morgan 2003], [Stone 2005] [Lamb and Hanby 2005] [Conway et al. 2005a,b]

Paracyathus Milne-Edwards and Haime, 1848

stearnsi Verrill, 1869 [Smithsonian] [Austin 1985] [Sloan et al. 2001] [IPHC], [Stone 2005] [Lamb and Hanby 2005] syn. caltha

Solenosmilia Duncan, 1873

variabilis Duncan, 1873 [Austin 1985]

Dendrophylliidae

Balanophyllia Wood, 1844

elegans (Verrill, 1864) [Heifetz 2002, based on Cimberg et al. 1981] [Smithosonian] [RBCM] [Lamb and Hanby 2005]

Flabellidae

- Javania Duncan, 1876
  - borealis (Cairns, 1994) [Heifetz 2002] [Stone 2005]
  - cailleti (Duchassaing & Michelotti, 1864) [Sloan et al. 2001]

Oculinidae

- Madrepora Linnaeus, 1758
  - oculata [Etnoyer and Morgan 2003]

Fungiacyathidae

- Fungiacyathus Sars, 1872
  - marenzelleri (Vaughan, 1906) [Stone 2005]
  - sp. *A* [Stone 2005]

Class Hydrozoa (ITIS)

Order Filifera

Stylasteridae (fire corals)

- Crypthelia Milne-Edwards and Haime, 1849
  - trophostega* Fisher, 1938 [Heifetz 2002]
- Cyclohelia Cairns, 1991
  - lamellata* Cairns, 1991 [Heifetz 2002]
- Distichopora Lamarck 1816
  - unknown sp.* [Heifetz 2002; Etnoyer and Morgan 2003]
  - borealis (Fisher, 1938) [Heifetz 2002, based on Cimberg et al. 1981]
- Errinopora Fisher, 1931
  - unknown sp.* [Heifetz 2002]
  - nanneca* Fisher, 1938 [Heifetz 2002]
  - pourtalesii (Dall, 1884) [Etnoyer and Morgan 2003] [Sloan et al. 2001]
  - zarhyncha* Fisher, 1938 [Heifetz 2002]
- Stylantheca Fisher, 1931
  - unknown sp. [Sloan et al. 2001] [Lamb and Hanby 2005]
  - papillosa (Dall, 1884) [Heifetz 2002, based on Cimberg et al. 1981]
  - petrograpta (Fisher, 1938) [Heifetz 2002, based on Cimberg et al. 1981; Etnoyer and Morgan 2003] [Sloan et al. 2001]
  - porphyra Fisher, 1931 [Etnoyer and Morgan 2003] [Sloan et al. 2001]
- Stylaster (Allopora) Gray, 1831
  - unknown sp.* [Heifetz 2002; Etnoyer and Morgan 2003] [Sloan et al. 2001]
  - brochi (Fisher, 1938) [Heifetz 2002]
  - californicus (Verrill, 1866) [Etnoyer and Morgan 2003]
  - campylecus (Fisher, 1938) [Heifetz 2002, based on Cimberg et al. 1981; Etnoyer and Morgan 2003] [Lamb and Hanby 2005]
  - cancellatus* Fisher, 1938 [Heifetz 2002; Etnoyer and Morgan 2003]
  - elassotomus Fisher, 1938 [Heifetz 2002, based on Cimberg et al. 1981]
  - gemmascens (Esper, 1794) [Heifetz 2002, based on Cimberg et al. 1981]

moseleyanus (Fisher, 1938) [Heifetz 2002, based on Cimberg et al. 1981]
norvigicus [Lamb and Hanby 2005]
polyorchis* (Fisher, 1938) [Heifetz 2002]
porphyra (Fisher, 1931) [Etnoyer and Morgan 2003] [Sloan et al. 2001]
venustus (Verrill, 1870) [Etnoyer and Morgan 2003] [Sloan et al. 2001]
verrillii* (Dall, 1884) [Heifetz 2002]

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