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Information on seamounts in the NAFO Convention Area

by

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ABSTRACT

In September 2006, NAFO Fisheries Commission passed a resolution to close four seamount zones within the NAFO Convention Area to demersal fishing activity. In response to a subsequent request for additional information, this paper presents a discussion of seamount research, with a focus on studies relevant to the four NAFO-defined seamount areas (Orphan Knoll, Newfoundland Seamounts, New England Seamounts, Corner Rising Seamounts).

Forty-three seamount peaks were identified in the NAFO area, thirty-eight of which were either contained within in or were very close to the four NAFO-defined closed areas. Of these 38 peaks, 12 had a minimum depth less than 2400 m, and only 4 were in depths less than 1800 m. Less than 0.5% of the area of the 43 seamounts examined was shallower than 1800 m.

Many of the seamounts have had little or no research conducted on them. Fishing has occurred on some of the seamounts in the Corner Rising and New England seamount zones, particularly in the shallowest seamounts in the Corner Rising, but there is no evidence of demersal fishing on the other two – Orphan Knoll and Newfoundland Seamounts. The main species fished is generally alfonsino (*Beryx splendens*), with catches of several thousand tons being reported in the 1970's, but much lower since then. There is evidence that fisheries which occurred in the past likely were not sustainable. The presence of corals has been noted in some of the seamount areas studied, but data are very limited.

1. Introduction

At its Annual Meeting in September 2006, NAFO Fisheries Commission passed a resolution to close four (4) seamount zones within the NAFO Convention Area to demersal fishing activity (see Appendix 1). These zones (Fig. 1), are large rectangular areas, covering approximately 125,000 square nautical miles, which encompass a number of individual seamounts. Fig 1 also shows location of individually numbered seamounts in these areas, as well as some other seamounts in the Convention Area. This paper summarizes available information on these seamounts, as well as some relevant information on the topic of seamounts and seamount fisheries in general. It is presented at Scientific Council to assist in addressing questions from FC, as referenced in the FC decision. The following is the text of those follow-up questions from FC to SC:

Regarding the precautionary closure to four seamount areas based on the ecosystem approach to fisheries (FC Doc. 06/5), using existing survey and commercial data from these seamount areas the Scientific Council is requested to provide the Fisheries Commission, at the 2007 Annual Meeting, recommendations on: 1) areas that could be fished on each seamount and, 2) a protocol for the collection of the data required to assess these seamounts, with a view to future recommendations on management measures for these areas.

2. Seamounts – General Information

It is widely believed that seamounts play an important role in marine biogeography. It was decided by participants at a Census of Marine Life seamount workshop in 2003 that seamounts represent important ecosystems for study that have not, to date, received scientific attention consistent with their biological and ecological value (Stocks et al. 2004).

As described in Stocks (2004) and Froese and Sampang (2004), many seamounts have assemblages of species not found in other deep-sea habitats, high levels of endemic species (species found only on one seamount or seamount range and nowhere else in the oceans to date), certain extremely long-lived and slow-growing species, and a few examples of 'living fossils' – species thought long extinct (Morato et al. 2004).

However, on a global scale, seamount biodiversity is largely unknown and an understanding of the way these ecosystems are likely to respond to perturbation is practically non-existent. According to CenSeam (2007) relatively few of the thousands of seamounts estimated or known to exist worldwide have been studied, with only about 350 having been sampled, and less than 100 in any detail.

2.1 Biodiversity

While a comprehensive assessment of seamount biodiversity is currently impossible due to the lack of data for many of the faunal groups living on seamounts, we do know that the distribution of organisms on seamounts is strongly influenced by the interaction between seamount topography and currents, where the high energy and advective nature of seamounts is capable of supporting large aggregations of fish and suspension-feeding benthic megafauna. Seamount benthos, in turn, provides vital habitat for many, often commercially and ecologically significant, fish species, the types of which vary from region to region and between seamounts (Rogers 1994).

The occurrence of hard substrata on seamounts means that, in contrast to the mostly soft sediments of the surrounding deep sea, seamount communities are often dominated by sessile, permanently attached organisms that feed on particles of food suspended in the water (Clark et al. 2006).

Corals are a prominent component of the suspension-feeding fauna on many seamounts, accompanied by barnacles, bryozoans, polychaete worms, molluscs, sponges, sea squirts and crinoids (Clark et al. 2006). Most deep-sea corals belong to the Hexacorallia, including stony corals (scleractinians) and black corals (antipatharians), or the Octocorallia, which include soft corals such as gorgonians (Clark et al. 2006). Notably, Scleractinian (e.g. *Lophelia; Desmophyllum*) corals may form massive reef matrices, which greatly increase habitat complexity and contribute to species diversity; their productivity may be related to their association with light hydrocarbon seeps (Koslow 2003). It has been suggested by some researchers that Orphan Knoll may contain the largest and deepest *Desmophyllum* reef in the world (see Section 3.2).

2.2 Fish stocks

Vinnichenko (1997) summarized 30 years of study, that began in the 60's-70's when large-scale fish scouting investigations were conducted by fishery researchers from the former Soviet Union around seamounts. Large aggregations of fish were rare, and fish stock sizes around seamounts were found to be generally low. The general biological productivity of each seamount varied based on factors such as size, relief, depth and circulation patterns.

The assumption of local groupings of fish species around seamounts, however, has been confirmed by genetic studies of common seamount species, including the grenadier. It has also been indirectly demonstrated by the fact that many areas that have been heavily fished have not regenerated. The highest catches were noted in the earliest years of the study and underline the vulnerability of many deepwater seamount populations.

2.3 Fishing

The species targeted by fisheries at seamounts generally have a very low overall abundance, but they aggregate at seamounts for various life processes. They are often long-lived, slow growing, late maturing (at about 30 years), and have low reproductive potential. (http://www.ices.dk/marineworld/seamounts.asp). However, alfonsino (Beryx splendens), which is often the main target of seamount fisheries in the NW Atlantic, is not a particularly slow-growing species.

Approximately 70 species are fished from seamounts worldwide and sharp boom-and-bust cycles and serial depletion generally characterize these fisheries, including many that are actively managed (Koslow *et al*. 2001). The vulnerability of fish populations on seamounts to fishing was also shown in Morato et al. (2004).

2.4 Endemism

Seamounts are particularly noted for their high rates of endemism: several recent studies (Parin *et al.* 1997; Richer de Forges *et al.* 2000; Koslow *et al.* 2001) have reported that > 30 % of the species found on seamounts were new to science and potential endemics (Stocks et al. 2004).

Recent faunal studies on Bear Seamount (one of the New England Seamounts) recognize that a small percentage of the fauna there is represented by “natural invader” species. Most of these species are more typically found in the eastern Atlantic, and are either rare or previously unknown from the western Atlantic (Moore et al. 2002).

2.5 Current Research

In 2005, a Census of Marine Life (CoML) field project was established to research and sample seamounts (Stocks et al. 2004; censeam.niwa.co.nz). This project, termed CenSeam (a Global Census of Marine Life on Seamounts), provides a framework to integrate, guide and expand seamount research efforts on a global scale. It has established a seamount researcher network of almost 200 people around the world, and is collating existing seamount information and expanding a database of seamount biodiversity. One of the key themes of CenSeam is to assess the impacts of fisheries on seamounts.

A recent report (Clark et al. 2006) produced by the Data Analysis Working Group of CenSeam provides insight into what is known about seamounts, deep-sea corals and fisheries, and uses the latest information to predict the existence and vulnerablility of seamount communities in areas for which we have insufficient or no information. Similarly, another recent report, Seamounts: Biodiversity and Fisheries (Morato and Pauly 2004), contains a collection of papers with topics ranging from the identification and distribution of seamounts in the world’s oceans, to a detailed documentation of their biodiversity and the potential and actual impact of fisheries thereon.

The Expert Consultation on Deep-Sea Fisheries, organized by the UN’s Food and Agriculture Organization (FAO), took place in Bangkok, Thailand from Nov. 21-23, 2006. That meeting was attended by experts from several countries, and included fisheries scientists and managers from various government organizations/agencies, academics, representatives from the fishing industry, as well as other non-governmental organizations. Several experts in attendance at that meeting had considerable experience with seamounts and seamount fisheries, and SC reviewed a number of their conclusions and recommendations in June 2007.

A common recommendation from scientists involved in much of the above research is the need to apply the precautionary approach to fisheries management of seamounts until considerably more knowledge and understanding of these habitats is available.

2.6 Corals

In the NAFO area the presence of deep sea corals is evident from both commercial and experimental trawls over the New England and Corner Rising seamounts. The presence of deep sea corals on the New England seamount chains has been noted in bottom trawling gear (Moore et al., 2001). The New England seamounts have been explored by the National Oceanographic and Atmospheric Institute http://www.oceanexplorer.noaa.gov/explorations/04mountains/welcome.html , which has documented many corals, including octocoral gardens. In

Division 6G (Corner Rising area) the retrieval of lost pots may indicate not only previous fishing activity on certain banks in the area but the presence of coral contributing to gear loss. During an experimental fishery conducted by a Canadian vessel in 1995 on the Corner Rising seamount, a crab vessel was encountered and reported that some of its gear was lost due to entangling in coral, forcing it to leave the area. Presence of large mounds on the Orphan Knoll has been documented from seismic work (Enachescu 2004), and it has been speculated that these may be organic in nature, possibly reef-like objects, or structures related to bottom vents.

Data collection protocols have recently been established for fisheries in other areas. Appendix 2 contains an example of an existing coral collection protocol for fisheries observers working on Canadian vessels (V. Wareham, DFO St. John's, pers. comm).

3. Area specific studies

3.1 Bathymetry

Area of the New England, Corner Rising, Newfoundland Seamounts and the Orphan Knoll shallower than 2000 m is estimated to be 3,813 km^2 or 0.46% of the total area of the seamounts and surrounding abyssal plain down to 5,500 m (Table 1, Fig. 2). This is based on measuring the area within existing bathymetric depth countours. A significant portion, about 50% of the area < 2000 m, or 1905 km^2, falls outside of the NAFO Convention Area, which means that the seamount area in the NAFO closed zones which is < 2000 m in depth is 1908 km. Compare this to the area of the Flemish Cap at depths < 2000 m, which is 64,048 km^2.

A total of 43 seamount peaks were examined, not all of which fall within the 4 closed areas. Some of these 43 are considered to be connected, ie. not separated at the base.

3.2 Newfoundland Seamounts: Most of the information is on the geology of the area (Sullivan and Keen 1972, 1977). No information was found on significant species, or any commercial fishing or research surveys. We examined 6 seamount peaks in this area, none of which were shallower than 2400 m (Tables 1 and 4; Fig. 2), and most of which were > 3500 m.

3.2 Orphan Knoll: As with the Newfoundland Seamounts, no biological or commercial fishing data could be found. Orphan Knoll is a single peak, with no depths shallower than 1800 m (Tables 1 and 4; Fig. 2). The area has been visited by seismic surveys in relation to oil and gas exploration. Seismic data collected by Geological Survey Incorporated (GSI) was donated to MUN for research, and Enachescu (2004) published a paper on deepwater submarine mounds in the north-eastern Orphan Basin and on the Orphan Knoll. He noted that the presence in the Orphan Knoll area of giant, deepwater mounds was known previously, and that a comprehensive account on the subject, history of mound discovery and record of the attempts to dredge them is given by van Hinte and Ruffman (1995). Other researchers have published papers on this feature as well, dating back to the early 1970's, although it was not speculated that these mounds may be biological in origin.

The mounds were found at depths of between 1800–2300m. Details of these "seamounds", which were named in the Enachescu paper, are as follows: Einarsson Mound is 1500-2000 m wide and 300m tall, and Nader Mound is between 400-800m wide and 300 m tall (Enachescu 2004), including the height of the base (root) which is covered in sediment. He concluded that based on seismic characteristics, regional mapping, their location in proximity to deep seated fault zones, and comparison with similar features identified and sampled in Northwest Atlantic margin, these mounds are interpreted as large deep water bioherms (ancient organic reef of mound-like form built up by invertebrates) or live colonies connected to water bottom vents. Enachescu (2004) proposed "a mixed organic-inorganic origin for the mounds, which implies the existence of deep, coldwater marine organisms feeding from either hydrocarbon rich vents or hydrothermal fluids rising through deep-seated faults at the water bottom." He noted that other mounds were also detected, covered by sediment, ie. not protruding from the ocean floor.

This paper also noted that "Ten years ago Canadian scientists discovered deep sea corals in the Orphan Knoll area", although no details were given. This was the only reference made to species being found on Orphan Knoll.

Enachescu (2004) noted that “a comprehensive inventory of the mounds and study of their genesis has to be undertaken. If an organic origin is proven, these mounds will be the most northerly, deepest cold water North American large reefal structures or organic build-ups ever encountered. If mounds are bioherms or colonies around hydrocarbon/hydrothermal vents, a Natural Protected Area (NPA) would need to be established for the conservation of these formations.”

It was noted that further research was planned on these mounds, but it is not known at this time if such research has been conducted or published, and this needs to be investigated further.

3.3 New England Seamounts: Seventeen individual seamount peaks were examined, with no depths shallower than 1900 m being found (Tables 1 and 2; Fig. 2). Two studies from the New England Seamounts were examined: the Moore et al., 2001 study on Bear Seamount, and results from an exploratory fishery by a Spanish trawler in 2004 (Duran et al. 2005). In the latter paper, the specific locations of fishing effort in Division 6EF (containing the New England Seamounts), were not specified, so it was not possible to determine which seamounts may have been fished. Heirtzler et al. (1974) also reported on research on the New England and Corner Rising Seamounts.

Biodiversity of Bear Seamount, New England Seamount Chain: Results of Exploratory Trawling

In December 2000 a USA research vessel Delaware II made twenty hauls on and over Bear Seamount. Bear Seamount is located just inside the United States Exclusive Economic Zone and is part of the New England Seamount chain, but is outside the NAFO closed area. The exploratory cruise documented the biodiversity of fishes, cephalopods and crustaceans (Moore et al 2001).

Six hauls with a IYGPT midwater trawl, five hauls with a standardized shrimp trawl, and nine tows with a Yankee 36 otter trawl produced 115 different fish species. Cephalopods comprise 26 species, crustaceans numbered 46 species, and other invertebrates numbered 113 species.

In addition to a solitary coral species *Vaughanella margaretata* and an undescribed species of gorgonian coral several rare fish species were caught. Two fish species with potential commercial importance were encountered; the roundnose grenadier and the roughhead grenadier. A total of 88 roundnose grenadier weighing 65.1kg were caught at 4 stations, while twenty one roughhead grenadier were caught at 5 stations. Both species were caught at depths of 1100-1800m.

Species caught in this study are comparable to a published list of fishes found on the Corner Rising seamount (Vinnichenko 1997). Live species of *Lophelia pertusa* were present in two bottom hauls, suggesting that deepwater coral banks may exist on this seamount.

Spanish exploratory fishing in Divisions 6EF

During the last quarter of 2004 a Spanish trawler, using “Gloria” pelagic gear (60-135 mm cod end) and bottom gear (130 mm cod end) conducted an experimental survey in the NAFO Regulatory Area (Divisions 6EFGH and 4XWVs) and adjacent international waters to the south (Duran et al 2005). The purpose of the survey was to obtain information on the distribution and biology of pelagic and demersal species in areas not traditionally fished by the Spanish. A scientific observer collected information on fishing activity (i.e., effort, depth, etc.) and biological data (i.e., length distribution, length-weight relationships, etc.). Sampling was conducted over a wide geographical range at depths ranging from 200–1400 m. The survey area encompassed the New England Seamounts (encompassed in NAFO Division 6EF) and the Corner Seamounts (encompassed within NAFO Division 6GH). The specific locations of fishing effort in Division 6EF (containing the New England Seamounts), were not listed in the paper, so it was not possible to determine which seamounts may have been fished.

With respect to NAFO Division 6EF (containing the New England Seamounts) 115.1 hours of fishing effort was directed using pelagic gear and 5.25 hours using bottom gear. Pelagic gear yielded 108.3 kg total catch of the three listed species (alfonsino, Lanternfish, and deep-sea hooked squid) whereas the bottom gear catch reported was nil. With respect to sessile and low mobility benthic invertebrates (i.e., sea anemones, corals, sponges, etc.), 5.25 hrs of bottom effort in NAFO Division 6EF produced a number of hauls with such invertebrate presence (Duran et al 2005). More recent information on this fishery, presented at the June 2007 SC meeting and including some biological data on alfonsinos taken in the catches, can be found in Gonzalez-Costas and Lorenzo (2007).

3.4 Corner Rising Seamount: Nineteen individual seamount peaks were studied in this area, although 9 of these could be considered as linked with one or more peaks (Tables 1 and 3; Fig. 2).

Spanish exploratory fishing in Divisions 6GH

With respect to NAFO Division 6GH, containing the Corner Rising Seamounts, the Duran et al (2005) study reported 102 hours of Spanish exploratory fishing effort using pelagic gear and 104.25 hours (NAFO Div 6G only) using bottom gear. Pelagic gear yielded 3031.3 kg total catch of the three main species (alfonsino, Lanternfish, and deep-sea hooked squid) whereas the bottom gear yielded a catch of 436,422 kg, mostly alfonsino, with some black scabbardfish and cardinalfish. The authors noted that retrieval of lost pots in NAFO Division 6G likely indicated past fishing activity in the area.

Similar effort using pelagic gear in Division 6GH yielded 3031.3 kg of alfonsino, lanternfish, and deep sea hooked squid, a marked increase compared to Division 6EF. Unlike the New England seamount area, more fishing effort was directed towards bottom gear in Division 6G.

Russian Investigations and Deep water Fishery on the Corner Rising Seamounts.

Vinnichenko (1997) reported that both pelagic and bottom trawls of minimum mesh size 60-90 mm were used by Russian vessels throughout their commercial, scouting and research programs on the Corner Rising Seamounts from 1976-96. From the information in this paper, it was not possible to determine which of the seamounts were fished, although some of the catch was taken in the seamounts just outside the NAFO Convention Area (Vinnichenko, pers. comm.). During the 1976-96 period, a total of 19,780 tons of fish were reported. A total of 175 fish species from 53 families were observed throughout the course of Russian operations. Alfonsino were observed primarily at depths of 420–750m with some aggregations at 900m. Small quantities of wreckfish and barrelfish were observed at depths of 660-800m, while cardinal fish and flint-perch were found at 760-900m. Black scabbard fish were the main species noted in depths >900m.

The identification of commercial aggregations of fish on the Corner Rising Seamounts in 1976 resulted in a catch 10,200 tons, comprised mostly of alfonsino. In 1977, the total catch dropped to 800 tons, and this was interpreted to be a result of the extremely large removal of fish in the previous year. The next commercial fishing program did not occur until 1987 when 2,300,tons of fish were caught, and from 1994-1996, the total catch was 4,500 tons. Despite intermittent commercial activity, numerous scouting and research operations were also undertaken in the area. Biological observations were made on the main species (alfonsino, black scabbard fish, wreckfish, barrelfish, cardinal fish, and flint perch) including spawning habits, feeding habits, and distribution and formation of deepwater aggregations.

The author expressed concerns that the limited stocks of deep water fish found in this study exhibit the necessity for the development of an international fishery management plan for Corner Rising and other seamounts.

Five species were seen in catches in both the Russian investigations in 1997 and the Spanish experimental fishery in 2004. These included alfonsino, black scabbardfish, cardinal fish, flint-perch, and barrelfish.

Fishing the Corner Rising Seamounts on a Canadian trawler - April 2005

A Canadian fishing company undertook exploratory fishing on the Corner Rising Seamounts to ascertain the viability of an orange roughy fishery in the spring 1995.

A standard groundfish "Alfredo" trawl was used with some changes to minimize damage to the seamounts. Fishing was undertaken at depths of 650–900m under the direction of a New Zealand fish captain with experience fishing seamounts in New Zealand. Gear technologists from DFO and the fishing company, and an observer were also on board, and available information came from these sources. The use of inaccurate charts made locating the seamounts difficult and finding suitable bottom proved to be challenging. Some of this fishing straddled the southern boundary of the NAFO Convention Area, at 35 degrees N latitude as seen in Fig. 3. A total of 11 sets were completed on the first trip. The main species caught were identified as alfonsino, wreckfish, blue nosed grouper, barracudina, and cardinal fish for a combined total of 9137 kg with alfonsino and wreckfish and making up 90%.

Despite low catches, echo soundings and catch per unit effort suggested the presence of some large aggregations of alfonsino. During this fishing trip, other vessels were also observed fished in this area. A Russian vessel in the area indicated that they were catching 1,000-5,000 kg. of alfonsino per tow, however on several occasions observations were made of hauls of ~30,000 kg. per 2 hour tow. Another vessel (possibly Canadian) fishing crab pots and long lines indicated that most of their gear was lost due to entanglement in coral and it subsequently left the area. Two more trips were made to the Corner Rising Seamount but catches were not deemed significant enough to further pursue a fishery.

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Table 1. Summary of Seamount spatial statistics. Table provides sum of area for all seamount clusters in or near the NAFO Convention Area comprising 7 clusters (total) and as well, a summary column (seamounts in NRA) of only those clusters that occur fully or partially within the NAFO Area (New England, Corner, Newfoundland and Orphan Knoll). Yellow delineates depths < 2000 m thought to be maximum fishable depth.

Depth (m)	New England	Corner Rising	Newfound land	Orphan Knoll	Milne	Bermuda	Sohm	Total	% by Depth	Seamount s in NRA	% by Depth
601-700											
701-800		2						2	0.000%	2	0.000%
801-900		13						13	0.001%	13	0.002%
901-1000		48						48	0.005%	48	0.006%
1001-1100		48						48	0.005%	48	0.006%
1101-1200		42						42	0.004%	42	0.005%
1201-1300		46						46	0.005%	46	0.006%
1301-1400		49						49	0.005%	49	0.006%
1401-1500		134						134	0.014%	134	0.016%
1501-1600		205						205	0.021%	205	0.025%
1601-1700		239						239	0.025%	239	0.029%
1701-1800		233						233	0.024%	233	0.028%
1801-1900		333		398	8	42		781	0.082%	731	0.088%
1901-2000	10	515		1,500	43	98		2,166	0.227%	2,025	0.244%
2001-2100	86	446		530	89	86		1,237	0.129%	1,062	0.128%
2101-2200	96	384		442	71	84		1,077	0.113%	922	0.111%
2201-2300	70	427		442	66	90		1,095	0.115%	939	0.113%
2301-2400	70	441		527	75	90		1,203	0.126%	1,038	0.125%
2401-2500	72	676	5	742	110	119	12	1,736	0.182%	1,495	0.180%
2501-2600	96	743	15	1,114	516	123	26	2,633	0.276%	1,968	0.237%
2601-2700	111	687	12	1,086	464	104	27	2,491	0.261%	1,897	0.229%
2701-2800	147	742	14	1,395	338	106	24	2,765	0.289%	2,298	0.277%
2801-2900	516	1,059	31	1,441	722	127	24	3,920	0.410%	3,047	0.368%
2901-3000	594	1,453	74	1,790	622	207	35	4,776	0.500%	3,912	0.472%
3001-3100	656	1,384	95	955	688	199	47	4,025	0.421%	3,090	0.373%
3101-3200	573	1,305	80	724	697	198	40	3,617	0.379%	2,682	0.324%
3201-3300	556	1,308	93	728	806	209	38	3,739	0.391%	2,685	0.324%
3301-3400	615	1,436	107	593	943	231	40	3,965	0.415%	2,751	0.332%
3401-3500	649	1,796	189	849	1,465	262	41	5,252	0.550%	3,484	0.420%
3501-4000	5,052	12,922	4,724	3,033	11,358	1,607	325	39,020	4.084%	25,730	3.105%
4001-4500	18,406	28,081	14,661	5,966	14,910	7,814	846	90,683	9.491%	67,114	8.099%
4501-5000	285,210	68,872	21,623		16,146	52,097	2,044	445,992	46.679%	375,705	45.341%
5001-5500	251,775	71,185	34			3,241	5,981	332,216	34.771%	322,994	38.979%
Total	565,360	197,254	41,757	24,257	50,136	67,134	9,549	955,446		828,628	
Fishable (< 2000m)	10	1907	0	1898	50.8	140	0	4005.8			

Depth (m)	New England	Corner Rising	Newfound land	Orphan Knoll	Milne	Bermuda	Sohm	Total			
501-1000	0	61	0	0	0	0	0	61	0.006%	61	0.007%
1001-1500	0	319	0	0	0	0	0	319	0.033%	319	0.038%
1501-2000	10	1,525	0	1,898	51	140	0	3,624	0.379%	3,433	0.414%
2001-2500	394	2,374	5	2,683	410	469	12	6,347	0.664%	5,456	0.658%
2501-3000	1,464	4,684	147	6,826	2,662	667	135	16,585	1.736%	13,121	1.583%
3001-3500	3,049	7,229	564	3,850	4,599	1,099	206	20,597	2.156%	14,692	1.773%
3501-4000	5,052	12,922	4,724	3,033	11,358	1,607	325	39,020	4.084%	25,730	3.105%
4001-4500	18,406	28,081	14,661	5,966	14,910	7,814	846	90,683	9.491%	67,114	8.099%
4501-5000	285,210	68,872	21,623	0	16,146	52,097	2,044	445,992	46.679%	375,705	45.341%
5001-5500	251,775	71,185	34	0	0	3,241	5,981	332,216	34.771%	322,994	38.979%
< 2000 m	10	1,905	0	1,898	51	140	0	4,004	0.42%	3,813	0.46%

Table 2. Spatial statistics for 17 New England Seamounts (Refer to Fig. 1 for seamount # references at top of table).

Depth (m)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**All**
801-900																		
901-1000																		
1001-1100																		
1101-1200																		
1201-1300																		
1301-1400																		
1401-1500																		
1501-1600																		
1601-1700																		
1701-1800																		
1801-1900																		
1901-2000	6.2															0.1	3.5	10.0
2001-2100	22.9															8.3	51.5	86.0
2101-2200	19.0													3.5		6.1	65.3	96.0
2201-2300	17.7													5.6		5.6	42.7	70.0
2301-2400	18.2													4.1		6.4	39.7	70.0
2401-2500	19.5													5.2		6.0	41.9	72.0
2501-2600	19.9													5.1		8.6	62.1	96.0
2601-2700	22.9													5.7		9.2	72.7	111.0
2701-2800	24.1							41.1						6.6		10.2	63.8	147.0
2801-2900	55.8		42.2			1.2	24.9	120.3		74.5				7.5	1.5	28.1	148.5	516.0
2901-3000	30.0		53.0			23.3	79.4	39.8		81.6				18.8	30.2	17.3	138.0	594.0
3001-3100	28.8	31.2	36.8	23.1	29.5	14.9	106.4	32.5		62.5				17.1	19.1	16.5	162.8	656.0
3101-3200	32.9	83.0	29.7	44.4	27.7	14.7	85.8	27.1		51.8				20.5	14.4	20.9	141.1	573.0
3201-3300	30.1	53.2	28.9	59.6	20.5	13.1	85.0	27.3		50.5				20.7	13.6	19.5	145.0	556.0
3301-3400	32.0	49.9	31.0	48.6	20.1	12.9	94.7	27.1		55.9				23.1	12.9	23.5	179.4	615.0
3401-3500	37.5	51.0	31.9	43.8	23.3	15.0	92.7	26.4		55.2				25.4	14.9	27.9	181.9	649.0
3501-4000	257.3	60.8	394.2	47.2	24.2	145.6	658.7	187.4		530.2				29.4	94.2	205.3	971.0	5052.0
4001-4500	364.8	350.7	1252.8	414.8	221.2	333.0	1582.3	438.6	17.2	1695.1	26.4	132.1	70.8	247.0	245.9	678.9	1418.9	18406.0
4501-5000	90.6	820.6	1758.0	940.0	733.3	694.2	3105.3	876.3	464.9	3507.7	405.7	624.8	752.7	606.4	907.8	1498.4	7563.2	285210.0
5001-5500		1440.5	101.9	2348.1	1014.2	387.7	2179.2	238.6	1485.2	34.2	1735.1	3189.6	4494.5	2380.8	74.1	1.7	5519.6	251775.0
Total	1130.3	2940.9	3760.3	3969.6	2114.0	1655.6	8094.4	2082.6	1967.3	6199.0	2167.3	3946.4	5318.1	3432.4	1428.6	2598.4	17012.6	565360.0
<500																		
501-1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1001-1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1501-2000	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.5	10.0
2001-2500	97.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.3	0.0	32.4	241.1	394.0
2501-3000	152.8	0.0	95.2	0.0	0.0	24.6	104.3	201.2	0.0	156.1	0.0	0.0	0.0	43.6	31.7	73.4	485.1	1464.0
3001-3500	161.3	268.2	158.3	219.5	121.1	70.5	464.7	140.5	0.0	275.8	0.0	0.0	0.0	106.8	74.9	108.2	810.2	3049.0
3501-4000	257.3	60.8	394.2	47.2	24.2	145.6	658.7	187.4	0.0	530.2	0.0	0.0	0.0	29.4	94.2	205.3	971.0	5052.0
4001-4500	364.8	350.7	1252.8	414.8	221.2	333.0	1582.3	438.6	17.2	1695.1	26.4	132.1	70.8	247.0	245.9	678.9	1418.9	18406.0
4501-5000	90.6	820.6	1758.0	940.0	733.3	694.2	3105.3	876.3	464.9	3507.7	405.7	624.8	752.7	606.4	907.8	1498.4	7563.2	285210.0
5001-5500		1440.5	101.9	2348.1	1014.2	387.7	2179.2	238.6	1485.2	34.2	1735.1	3189.6	4494.5	2380.8	74.1	1.7	5519.6	251775.0

Table 3. Spatial statistics for 14 Corner Rising Seamounts (Refer to Fig. 1 for seamount # references at top of table).

Depth (m)	**1**	**2**	**3a**	**3b**	**3c**	**4**	**5**	**6**	**7**	**8**	**9a**	**9b**	**10a**	**10b**	**11a**	**11b**	**12**	**13**	**14**	**All**
701-800														2.0						2.0
801-900														12.8						13.0
901-1000											30.1			17.9						48.0
1001-1100											29.3			18.4						48.0
1101-1200											23.0			18.8						42.0
1201-1300											26.2			19.7						46.0
1301-1400											29.1			19.8						49.0
1401-1500											35.3	65.7		19.8	13.1					134.0
1501-1600											37.0	86.2		21.4	60.0					205.0
1601-1700											41.5	68.1		23.3	106.3					239.0
1701-1800											45.9	63.3		26.3	97.9					233.0
1801-1900			17.8						8.6		101.6	69.8		31.5	116.1					333.0
1901-2000			77.3						68.8		143.1	71.4		38.8	116.1					515.0
2001-2100			49.0						43.2		155.4	68.2		40.9	89.4					446.0
2101-2200		9.3	37.7						39.4		113.6	59.3		39.1	85.7					384.0
2201-2300		51.9	38.5						39.5		108.2	59.6		40.3	89.3					427.0
2301-2400		52.2	41.7						42.3		105.6	56.2		38.8	103.8					441.0
2401-2500	139.0	35.8	46.2				23.7		45.2		116.4	58.2		74.8	130.3			6.1		676.0
2501-2600	154.6	31.6	52.3				31.3		48.7		121.9	59.3		67.2	158.2			18.0		743.0
2601-2700	126.6	27.0	55.6				31.0		50.5		122.8	63.2		65.6	131.0			14.0		687.0
2701-2800	139.1	30.0	57.0	18.0			33.9		59.8		122.2	67.5		66.6	130.5			16.9		742.0
2801-2900	141.8	31.5	63.3	78.8			54.5		67.7	54.5	139.4	94.4	15.5	70.0	156.7	2.7	5.4	80.8		1,059.0
2901-3000	136.9	44.5	66.7	61.4		13.9	64.5	70.9	71.9	110.3	143.1	162.7	25.9	71.5	192.2	21.4	63.4	130.6		1,453.0
3001-3100	107.3	86.0	68.1	51.1		15.8	60.1	50.7	76.8	85.4	142.3	167.2	26.2	70.7	158.1	23.2	63.5	128.6		1,384.0
3101-3200	101.1	86.0	77.9	47.6		15.3	56.9	47.6	82.7	79.6	145.0	157.3	24.8	74.0	142.3	22.5	48.2	96.1		1,305.0
3201-3300	98.8	81.3	96.9	63.3		18.0	62.9	52.9	93.5	78.4	137.7	119.6	23.7	75.0	137.7	23.4	53.7	96.7		1,308.0
3301-3400	100.4	86.5	144.5	103.6		21.1	70.5	56.5	112.9	87.0	148.7	108.4	23.3	87.8	140.5	24.4	59.4	94.2		1,436.0
3401-3500	106.1	101.3	171.4	68.1		23.7	76.4	65.7	161.6	94.4	153.9	97.1	24.4	131.8	135.9	29.7	178.7	103.5	74.0	1,796.0
3501-4000	634.8	664.4	782.2	430.8	14.7	141.8	560.8	389.6	1,108.1	812.7	1,195.9	526.0	171.4	956.8	983.8	207.0	1,607.5	638.3	428.7	12,922.0
4001-4500	798.1	823.5	408.9	854.2	83.8	347.7	727.8	537.2	622.6	1,081.7	785.1	976.1	589.6	981.9	910.3	614.7	3,436.6	2,333.6	1,358.0	28,081.0
4501-5000	386.0	947.5	45.3		215.4	592.9	1,225.7	254.3	196.8	393.9	236.4	1,006.3	792.0	213.9	494.5	528.3	2,565.8	1,126.9		68,872.0
5001-5500	100.4	480.9	11.5			1,022.5	3,272.3	270.7	119.4	1,166.5	27.7	34.4	721.7	30.7	12.0	6.9	85.8	105.6		71,185.0
Total	3,270.9	3,671.0	2,409.9			2,212.7	6,352.2	1,795.9	3,159.7	4,044.2	4,654.5		2,438.5		4,891.5		8,168.1	4,989.9	1,860.7	197,055.0
<500																				
501-1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.1	0.0	0.0	30.7	0.0	0.0	0.0	0.0	0.0	61.0
1001-1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	142.8	65.7	0.0	96.4	13.1	0.0	0.0	0.0	0.0	319.0
1501-2000	0.0	0.0	95.1	0.0	0.0	0.0	0.0	0.0	77.4	0.0	369.1	358.8	0.0	141.3	496.3	0.0	0.0	0.0	0.0	1,525.0
2001-2500	139.0	149.2	213.1	0.0	0.0	0.0	23.7	0.0	209.5	0.0	599.1	301.5	0.0	233.9	498.5	0.0	0.0	6.1	0.0	2,374.0
2501-3000	699.0	164.6	295.0	158.2	0.0	13.9	215.1	70.9	298.6	164.8	649.4	447.1	41.4	340.9	768.6	24.1	68.8	260.3	0.0	4,684.0
3001-3500	513.6	441.0	558.9	333.7	0.0	93.9	326.8	273.4	527.4	424.7	727.5	649.6	122.3	439.3	714.4	123.3	403.6	519.1	74.0	7,229.0
3501-4000	634.8	664.4	782.2	430.8	14.7	141.8	560.8	389.6	1,108.1	812.7	1,195.9	526.0	171.4	956.8	983.8	207.0	1,607.5	638.3	428.7	12,922.0
4501-5000	386.0	947.5	45.3	0.0	215.4	592.9	1,225.7	254.3	196.8	393.9	236.4	1,006.3	792.0	213.9	494.5	528.3	2,565.8	1,126.9	0.0	68,872.0
5001-5500	100.4	480.9	11.5	0.0	0.0	1,022.5	3,272.3	270.7	119.4	1,166.5	27.7	34.4	721.7	30.7	12.0	6.9	85.8	105.6	0.0	71,185.0

Table 4. Spatial statistics for 6 Newfoundland Seamounts and Orphan Knoll. (Refer to Fig. 1 for seamount # references at top of table).

	Newfoundland Seamounts							Orphan Knoll
Depth (m)	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**All**	**1.0**
801-900								
901-1000								
1001-1100								
1101-1200								
1201-1300								
1301-1400								
1401-1500								
1501-1600								
1601-1700								
1701-1800								
1801-1900								397.7
1901-2000								1,500.3
2001-2100								529.9
2101-2200								442.3
2201-2300								442.2
2301-2400								526.8
2401-2500		5.2					5.2	741.9
2501-2600		14.7					14.7	1,114.1
2601-2700		12.3					12.3	1,086.3
2701-2800		14.0					14.0	1,394.8
2801-2900	16.6	14.8					31.4	1,440.6
2901-3000	22.4	31.7	9.9	20.3			74.4	1,790.4
3001-3100	20.3	48.5	24.1	26.3			95.1	955.2
3101-3200	19.8	42.9	21.5	17.1			79.7	724.2
3201-3300	24.3	51.9	25.7	16.6			92.8	728.2
3301-3400	28.4	57.5	31.0	17.0	3.6		106.6	593.4
3401-3500	62.0	76.7	36.0	17.1	30.7	11.6	189.3	849.4
3501-4000	1,058.9	611.5	300.0	108.7	229.2	61.8	4,723.6	3,032.6
4001-4500	1,220.8	1,346.3	203.4	161.3	586.4	89.9	14,660.5	5,966.2
4501-5000		990.8		255.5	1,328.7	162.4	21,623.3	
Total	2,473.4	3,318.7	651.5	639.9	2,178.7	325.7	41,722.8	24,256.5
<500								4,581.1
501-1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1001-1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1501-2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2001-2500	0.0	5.2	0.0	0.0	0.0	0.0	5.2	1,898.0
2501-3000	0.0	55.7	9.9	63.7	0.0	0.0	146.7	2,683.1
3001-3500	103.4	232.5	138.3	320.6	34.3	11.6	563.5	6,826.2
3501-4000	28.4	76.7	300.0	255.5	229.2	61.8	4,723.6	3,850.4
4001-4500	1,220.8	1,346.3	203.4	161.3	586.4	89.9	14,660.5	5,966.2

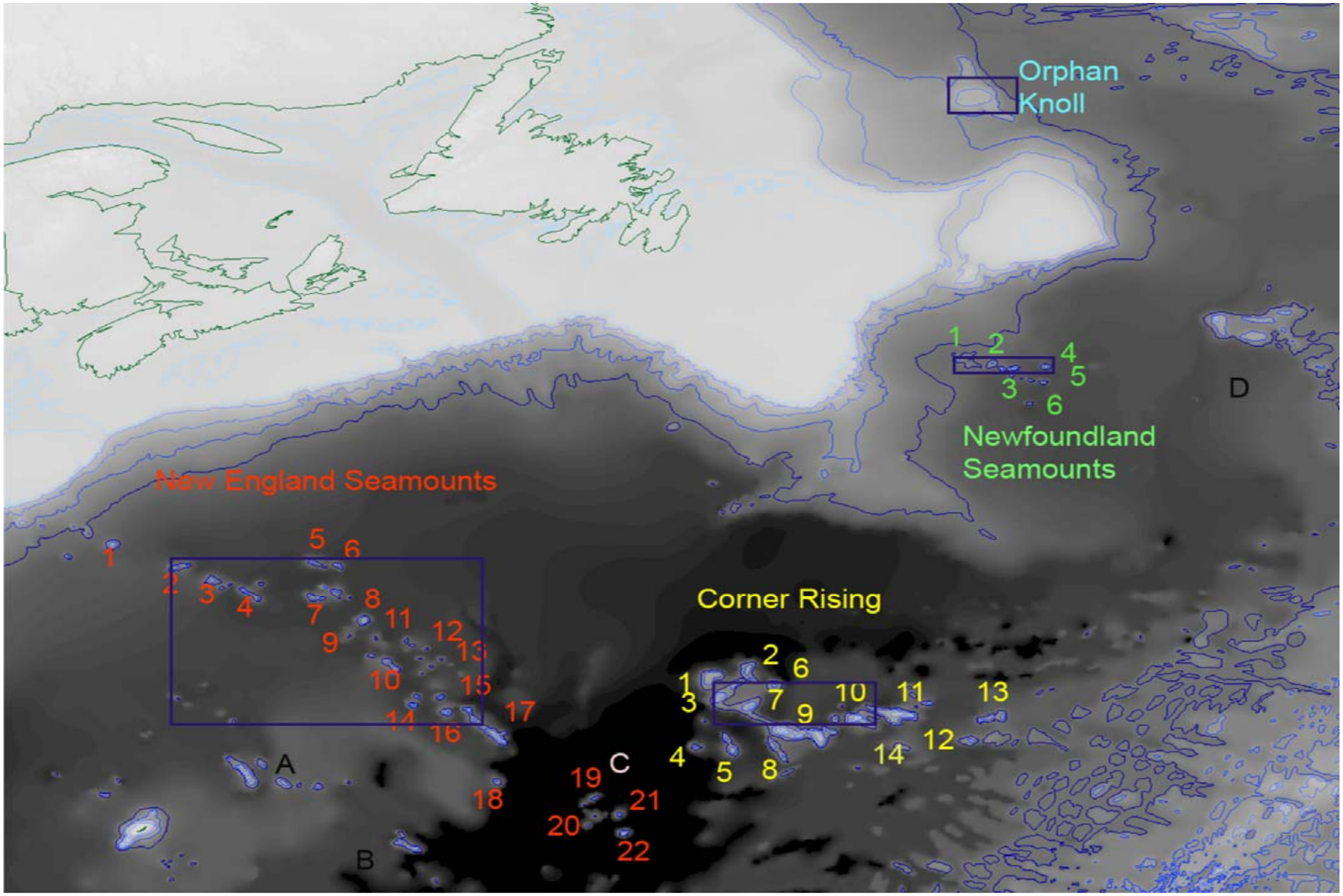

Fig. 1. Four seamount zones in NAFO Convention Area currently closed to demersal fishing. Map also shows individually numbered seamounts in these areas.

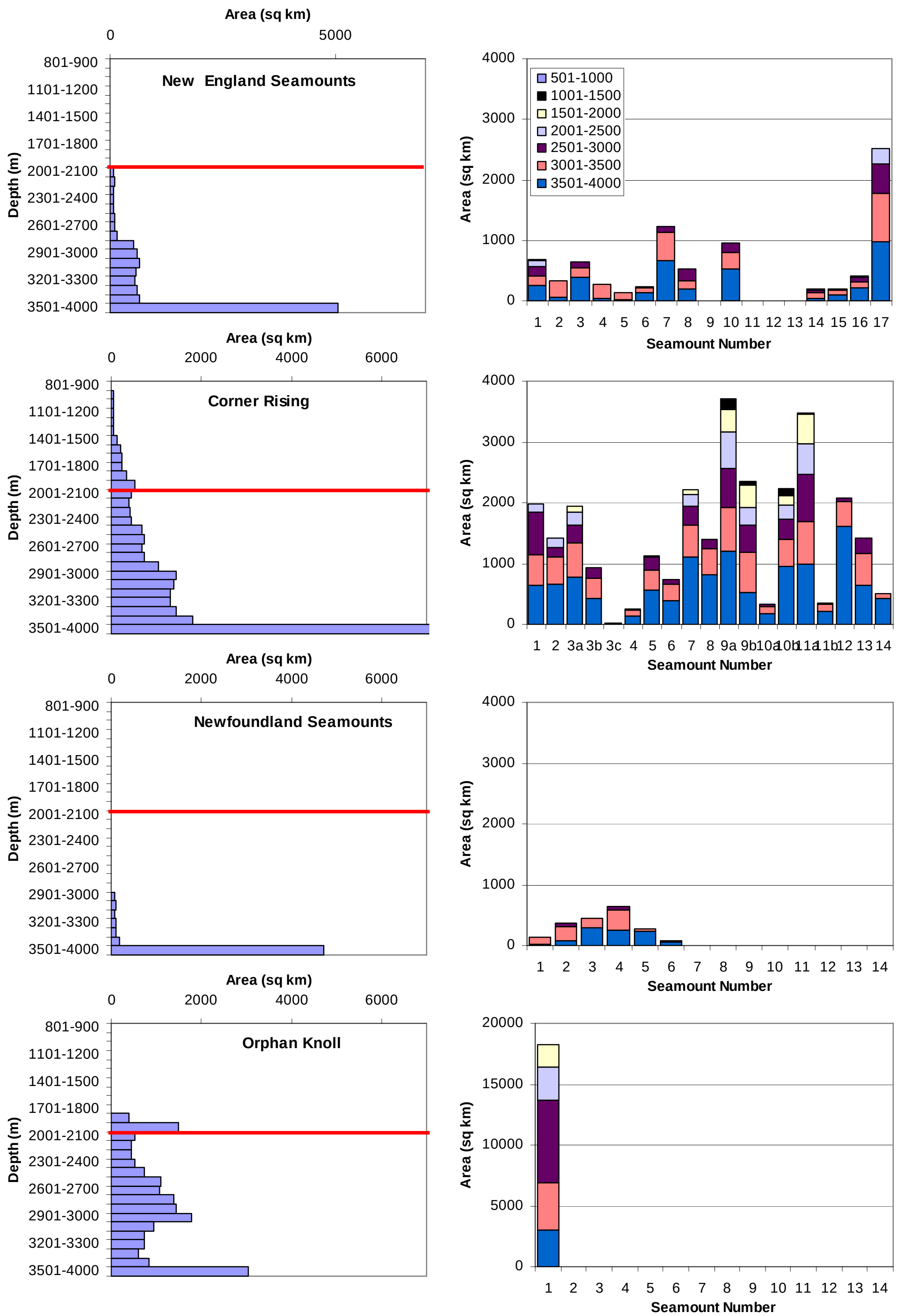

Figure 2. Spatial statistics for the four Seamount clusters, area at depths < 4000 m from the surface. Left column shows the overall area of each cluster by depth. Right column shows area of individual seamounts by depth range. Seamounts number corresponds to those displayed on Fig. 1.

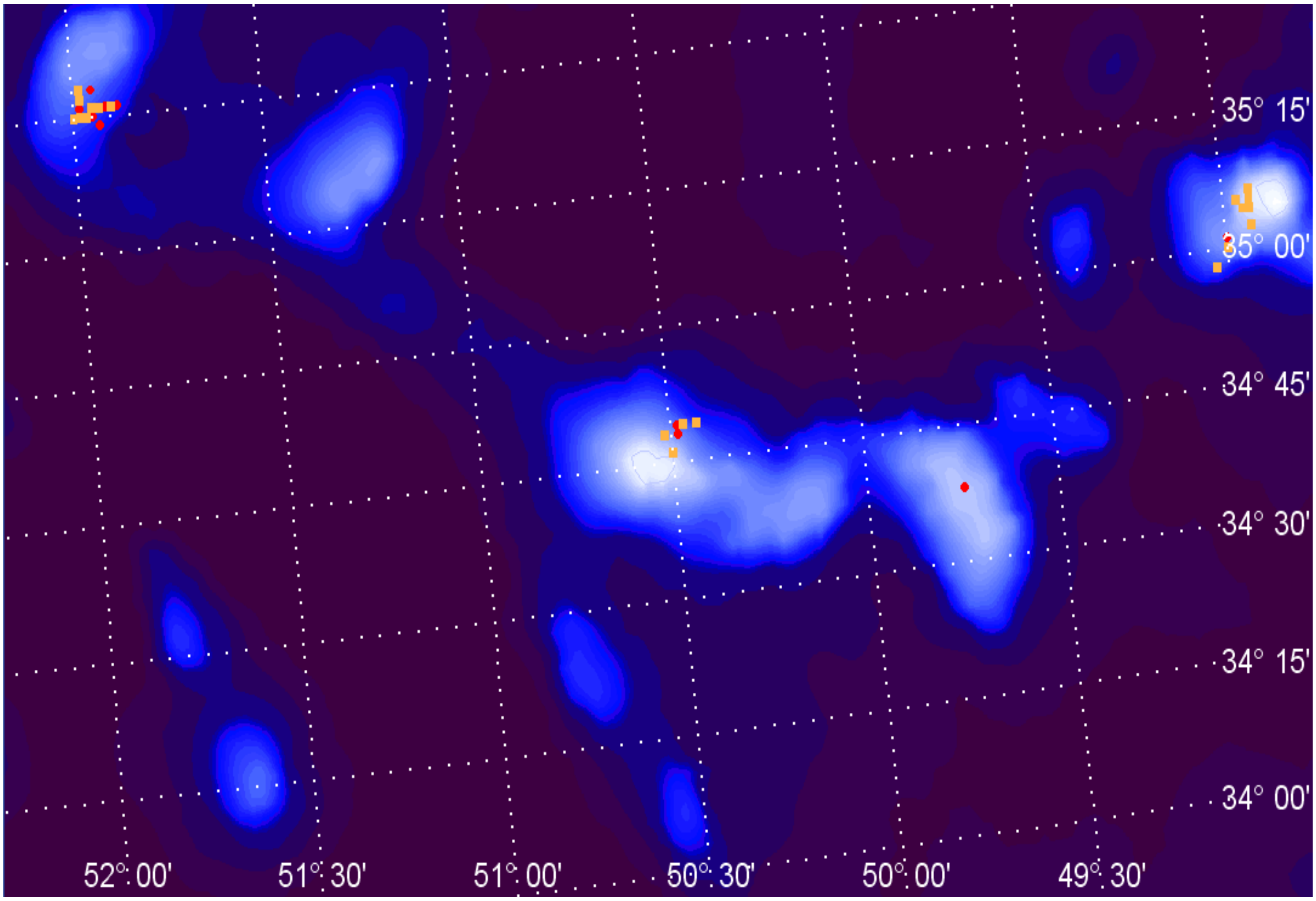

Figure 3. Locations of fishing stations on the Corner Seamounts from Canadian exploratory fishing in 1995. Squares are midwater, dots are bottom trawl.

Appendix 1. NAFO Conservation and Enforcement measures, Article 12

5. As of January 1, 2007, and until December 31, 2010, the following areas shall be closed to all fishing activities involving demersal fishing gears. The closed areas are defined by connecting the following coordinates (in numerical order and back to coordinate 1).

Area	Coordinate 1	Coordinate 2	Coordinate 3	Coordinate 4
Orphan Knoll	50°00'30"N 45°00'30"W	51°00'30"N 45°00'30"W	51°00'30"N 47°00'30"W	50°00'30"N 47°00'30"W
Corner Seamounts	35°00'00"N 48°00'00"W	36°00'00"N 48°00'00"W	36°00'00"N 52°00'00"W	35°00'00"N 52°00'00"W
Newfoundland Seamounts	43°29'00"N 43°20'00"W	44°00'00"N 43°20'00"W	44°00'00"N 46°40'00"W	43°29'00"N 46°40'00"W
New England Seamounts	35°00'00"N 57°00'00"W	39°00'00N 57°00'00"W	39°00'00N 64°00'00"W	35°00'00"N 64°00'00"W

6. At the 2007 Annual Meeting, the Fisheries Commission shall consider providing access to a small scale and restricted exploratory fishery, effective January 1, 2008, not to exceed 20% of the fishable area of each seamount. These representative areas that may be fished on each seamount will be recommended by the Scientific Council based on existing survey and commercial data from these seamount areas. Scientific Council is requested to provide the Fisheries Commission, at the 2007 Annual Meeting, recommendations on: 1) areas that could be fished on each seamount and, 2) a protocol for the collection of the data required to assess these seamounts, with a view to future recommendations on management measures for these areas.

7. Contracting Parties shall provide the Executive Secretary, in advance of the June 2007 Scientific Council meeting, with all existing data from survey and commercial fisheries that have taken place in these seamount areas. The Executive Secretary will forward this information to the Scientific Council for its review in making the above noted recommendations to the Fisheries Commission.

8. Vessels may only fish in the defined areas in accordance with the protocol established by the Scientific Council and adopted by the Fisheries Commission. In addition to the protocol, vessels fishing in the areas defined in paragraph 5, shall have a scientific observer onboard.

9. If vessels fishing in the areas defined in paragraph 5 encounter hard corals, notification of the location of the coral area is to be provided to the Executive Secretary which will implement an immediate temporary closure of that area to all Contracting Parties pending a Fisheries Commission decision at the next Annual Meeting.

10. The measures referred to in paragraphs 5-9 shall be reviewed in 2010 by the Fisheries Commission, based on the advice from the Scientific Council, and a decision shall be taken on future management measures which may include extending the application of these measures for an additional period or making the closure(s) permanent.

Appendix 2. Example of existing coral collection protocol for fisheries observers.

NL Fisheries Observer Program - Deep-Sea Coral Collection Protocol

The Coral Project is a joint project of the Department of Fisheries and Oceans and Memorial University. The goals of this project are to collect coral samples, and data from the commercial fisheries to address the following questions:

- What is the geographic and bathymetric distribution of deep-sea corals in Atlantic Canada, especially Newfoundland and Labrador?
- Which species of deep-sea corals are represented in Newfoundland & Labrador?
- Do deep-sea corals provide essential habitat for commercial fish species? Specifically, what commercial fish species are associated with deep-sea corals in catch statistics?
- Are Newfoundland, Labrador, and Nova Scotia populations of deep-sea corals genetically distinct?
- Can geochemistry of deep-sea corals record oceanographic change or high seas pollution?

To help achieve these goals through the NL Fisheries Observer Program, Observers are requested to:

1. **Set and Catch:** Monitor all sets observed for the presence of corals and identify the deep-sea corals to species. Record the corals by species on the Set & Catch datasheet using appropriate codes listed on the coral ID sheets. Observers are asked to record the presence of deep-sea coral bycatch as **consistently as possible**. If corals (or suspected corals) are observed but time does not permit species identification or the observer is unsure of the species, record "**Species Name**" on the Set and Catch datasheet as "**Coral A" "Coral B"** etc. and record "**Species Code**" as **"8900"** corals unspecified**. Please be consistent within a trip when identifying corals as Coral A, Coral B etc.**

2. **Sample Collection**: Collect as many coral samples as possible ***but at least 1 sample of each species must be collected from each "Deployment"***. Samples will be used to confirm species identification and for genetics and geochemistry analyses. Collect a small (~ 5 cm) piece of each coral species caught and freeze it in a plastic bag, with a pre-printed waterproof label indicating Species Code (or Coral A etc.), Trip#, Set#, Vessel Name, Gear Type, Lat/Long, Depth, Date and Name of Observer. For species with large skeletons (*Primnoa, Paragorgia, Paramuricea, Bathypathes*), collect as large a piece of the coral as possible, label it with total weight and subsample weight, and freeze it. Researchers at M.U.N. will identify **all coral samples returned and confirm identifications to individual observers.** Return coral samples to DFO.

It is recognized that an Observer's ability to monitor catches for the presence of corals and to collect and return samples to DFO is influenced by many factors such as the time available, size of the catch, other duties, travel, freezer availability etc. To ensure the success of this project Observers need to **monitor catches for the presence of corals as consistently as possible.** As well **the collection of coral samples is vital** for confirming the Observer's identification and for performing more detailed analysis.