FISHES OF THE NEW ENGLAND SEAMOUNTS

by

Christian Canache

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This thesis was prepared under the direction of the candidate's thesis advisor, Dr Jon Moore, and has been approved by the members of her/his supervisory committee. It was submitted to the faculty of the Honors College and was accepted in partial fulfillment of the requirements for the degree of Bachelor of Arts in Liberal Arts and Sciences.

SUPERVISORY COMMITTEE

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Dr. Jon Moore

____
Dr. James Wetterer

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Dean, Wilkes Honors College

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Date

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ABSTRACT

Author: Christian Canache

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Prior to 2000, very little was known about fish biodiversity on the New England Seamount chain. In late 2000, 115 fish species were found on Bear Seamount by the NOAA R/V "Delaware II". Woods Hole Oceanographic Institution conducted two cruises to explore the New England Seamount chain in 2003. This study assessed fish species throughout Alvin submersible dives during these 2003 cruises. Digital video footage was converted to still photographs and video clips using the Macintosh movie program iMovie. Fishes were identified to the lowest possible taxonomic level using keys and literature. The habitat, depth and behavior of observed fishes were compared to the literature available. Geographical distributions of the species were considered. I assessed substrate preference by building a chart that reflects the different sediment regimes that fishes were found on. In all I identified 317 individuals representing 33 different taxa, including two species with new habitat range information *Neocyttus* helgae and *Lepidion* sp.

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Introduction

Seamount biology

Only in the last fifty years have the existence seamounts (mountains in the sea) been known to the scientific community (Rogers, 1994). Seamounts rise steeply from the sea floor to below sea level, and can have an elevation of more than 1000 meters (m). Features of seamounts that have elevations of 500 m up to 1000 m are defined as knolls, and those with elevations of less than 500 m are defined as hills (Rogers, 1994). Seamounts are generally conical, and of volcanic origin though some are formed by tectonic movement along converging plates (Rogers, 1994). Some summits are flattened by wave action, these seamounts are known as guyots. Guyots are remnants of islands and the evidence of this can be seen by the biogenic sediment that are found on these summits such as foraminiferan sand (Rogers, 1994). Seamounts often occur in chains or clusters known as provinces that are likely associated with sea floor hotspots (Rogers, 1994). There are an estimated 30000 seamounts with heights in excess of 1000 m in the Pacific, 810 of these are in the Atlantic (Rogers, 1994). Seamount slopes can often be 60 degrees, causing a steep gradient between themselves and the flat deep ocean floor (Rogers,1994). Seamounts also provide hard substrate rare to the deep ocean, these structures take the form of calderas, terraces, pit craters, canyons, caves, pinnacles, knobs, crevices, rocks, cobbles, and skeletons of marine organisms (Rogers, 1994). Seamounts can also have considerable effects on ocean circulation such as current deflection in the case of the Kuroshio extension (Rogers, 1994), Gulf Stream, and Deep

Western Boundary Current (Moore et al., 2004), and Subarctic currents. Trapped waves, reflection, amplification, and distortion of internal waves and tides, as well as eddies, are other effects (Rogers 1994). Eddies trapped over seamounts form closed circulations known as Taylor columns, after Taylor (1917, cited in Rogers, 1994) who first studied the effects of obstacles on rotating flows. These likely occur when steady currents impinge on a seamount and cause upwelling. Taylor columns have been observed over many seamounts, and they may last for considerable periods of time (Rogers, 1994). These local hydrographic conditions likely cause trophic cascades by suspending nutrients that increase primary productivity and allow high densities of prey organisms to flourish and in turn attract commercially valuable fish species in well-documented concentrations (Rogers, 1994). It is possible that there is a seasonal factor to these phenomena. Another theory suggests that vertical migrators are trapped by the seamount and intercepted by fishes in relative safety from their own predators as they are protected to some degree by the seamount (Rogers, 1994). This theory is supported by the work of Isaacs and Schwartzlose (1965, cited in Rogers, 1994)), which showed that fish were predating on vertically migrating plankton around the San Isidro Bank off of Southern California. Genin et al (1988, cited in Rogers, 1994) showed the stomach content of *Sebastes* spp. was primarily composed of the diurnal vertical migrators *Euphasia pacifica*. Ocean seamounts in the deep-sea area act as biological islands with characteristic biota quite different from those found in the surrounding soft sediment and abyssal habitats. Large depth ranges, hard substrates, steep gradients, complex topography, swift currents, upwellings, clear oceanic water, and geographic isolation all combine to make seamounts specialized habitats for deep-sea organisms (Rogers, 1994).

Moore et al. (2004) suggests seamounts serve as dispersal corridors, or rather “stepping-stones” that may provide species access to potentially new habitat.

The New England Seamounts

The New England Seamounts (NES) make up the longest seamount chain in the North Atlantic, encompassing more than 30 major volcanic peaks that extend from Georges Bank for about 1 100 km to the eastern end of the Bermuda Rise, ending with Nashville Seamount to the East North East of Bermuda (Moore et al., 2004). The New England Seamount Chain, the Corner Rise Seamounts, the mid- Atlantic Ridge, and the deep sides of the Azores are a practically continuous series of hard substrate “islands” in a sea of otherwise muddy abyssal habitat extending across the North Atlantic Ocean. These islands are therefore rare habitats within the context of the whole North Atlantic basin (Auster and Watling, 2005). The major peaks of the New England Seamounts rise as much as 4000 m above the floor of the Sohm Abyssal Plain (Moore et al., 2004), which is approximately 5000 m in depth (Heirtzler et al., 1977). The Corner Rise Seamounts form a cluster of peaks midway between the eastern end of the New England Seamounts and the Mid Atlantic Ridge, about 300 km east of Nashville Seamount (Moore et al., 2004). The New England Seamounts and the Corner Rise Seamounts are the result of a mantle-plume hotspot, which has migrated eastward under the Mid Atlantic Ridge and now resides underneath Great Meteor Seamount (Moore et al., 2004). The New England Seamount chain is roughly perpendicular to two major currents, the Gulf Stream flowing to the northeast and the Deep Western Boundary Current (DWBC) flowing southwesterly along the continental slope (Moore et al., 2004). These seamounts alter the flow of the currents in their vicinity, which may influence the recruitment of benthic and pelagic organisms (Moore et al., 2004). The first exploration to the New England Seamounts was conducted by Ziegler (1955) (Heirtzler et al., 1977). On this exploration many of the peaks were named (after ships of the Woods Hole Oceanographic Institution), simple bathymetric charts were made from early sonar, and rock samples were collected (Heirtzler et al., 1977). Until recently, very little was known about fish diversity on the New England Seamount chain in the northwest Atlantic. In 2000, an expedition by the NOAA R/V ship "Dellaware II" found 115 fish species on Bear Seamount (Moore et al., 2004). In 2003, Woods Hole Oceanographic institution conducted two cruises to explore the New England Seamount chain. In the present study, I assessed fish species diversity recorded by the manned submersible Alvin during dives 3883-3893 and 3901-3907, which took place on May 30th through July 18th of 2003.

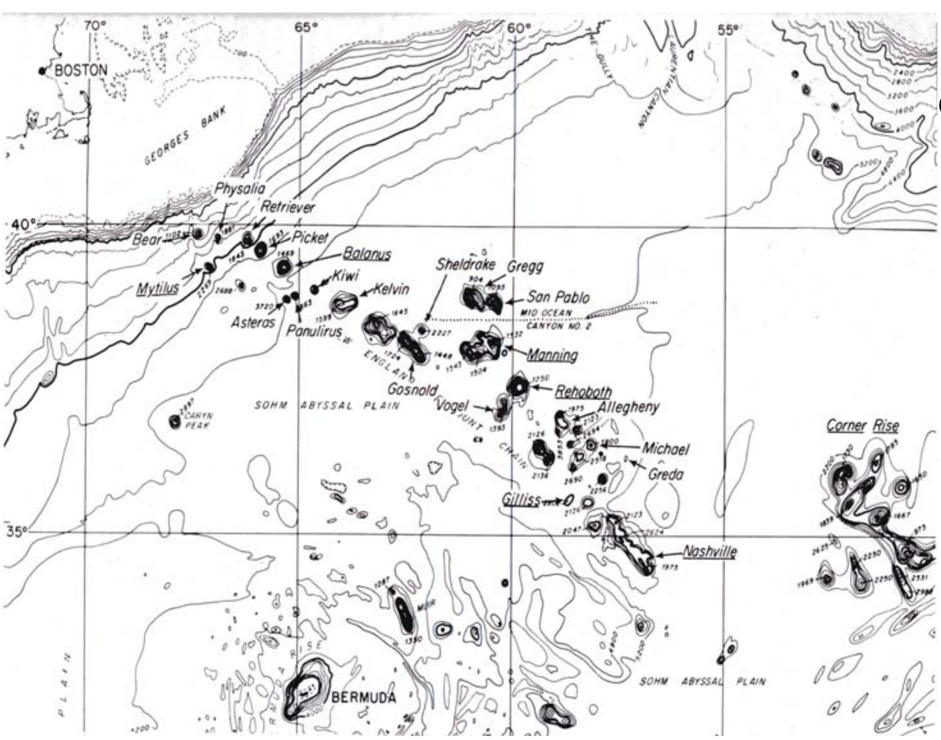


Fig. 1 Map of the New England Seamounts, Corner Rise, and Muir Seamount.

Methods

Study areas

The seamounts explored on these dives were Manning (38° 11.96'N 60° 31.44' W), Muir (33° 47.45'N 62° 35.92' W), Gregg (38° 57.18'N 61° 01.39' W), Kelvin (38° 47.330'N 64° 07.948' W), and Bear (39° 53.668'N 67° 22.960' W) seamounts.

Data analyses

Approximately 240 hours of DV Cam video-cassettes were taken during Alvin dives 3883-3893 and 3901-3907. A primary and secondary camera located on the Alvin submersible designated VCR1 and VCR2 were used to record footage. Each dive consisted of up to 16 hours of video footage half from VCR1 and half from VCR2. Using the Macintosh iMovie program I copied clips of fishes from the footage and then took "framegrabs" (still photographs) of them for identification. Because the primary objective of these dives was to study deep corals and not to catalog fish species, many of the photographs taken are sub-optimal for identification (due to distance from the submersible, and poor focus). Consequently many fishes cannot be identified to species. Identification was accomplished using keys and literature including Moore et al (2003), and personal identification keys belonging to Dr. Moore. Three species were selected for the assessment of habitat preference are *Coryphaenoides rupestris*, *Caelorinchus caelorinchus*, and *Neocyttus helgae*. I chose these species because there are multiple individuals per dive, and they are easily identifiable by noting distinctive morphological traits.

Habitat definitions

I used three basic habitat designations: Basalt, rubble, and fine sediment. In the case that a combination of two or more substrates was visible at a single time the substrate that occupied fifty percent of the frame, or more, was chosen. Basalt consists of rocky ledges, walls, or outcroppings often, but not necessarily, covered with coral and sponge attachments as well as other microhabitat creating organisms. Rubble is any textured surface with no visible rock, often is made up of broken coral, and can also have attached organisms. Fine sediment is any flat surface with no exposed rock that has only ripples in the sand to increase surface area for any kind of habitat exploitation.

Results

Table 1 summarizes all the dives of the 2003 expedition used in this study, including seamount name, dive number, date, time (in Coordinated Universal Time or UTC), coordinates for the start and end of the dive and depth range.

Table 1.

2003 Alvin Dives on New England Seamounts

Location	Dive #	Date	Time (UTC)	Lat&long	depth
Manning Seamount	3883	May 30	12:22-13:46	38° 11.96’N 60° 31.44’ W- 38° 11.77’N 60° 31.23’ W	1505-1576m
	3890	June 11	12:40-17:47	38° 13.69’N 60° 27.37’ W- 38° 13.47’N 60° 28.47’ W	1381-2004m
	3892	June 13	13:21-17:52	38° 12.18’N 60° 32.10’ W- 38° 12.59’N 60° 31.88’ W	1468-1701m

	3893	June14	12:00-16:00	38° 12.87’N 60° 30.74’ W- 38° 13.02’N 60° 30.70’ W	1327-1401m
	3901	July 13	14:55-19:06	38° 15.793’N 60° 33.010’ W- 38° 15.838’N 60° 32.705’ W	1451-1734m
	3902	July 14	14:11-18:29	38° 13.037’N 60° 30.683’ W - 38° 13.161’N 60° 30.935’ W	1333-1375m
Gregg Seamount	3891	June 12	13:37-17:58	38° 57.18’N 61° 01.39’ W- 38° 56.83’N 61° 01.67’ W	1075-1222 m
Muir Seamount	3884	June 3	13:30-17:47	33° 47.45’N 62° 35.92’ W- 33° 47.23’N 62° 35.05’ W	2084-2273m
	3885	June 4	12:39-17:44	33° 46.54’N 62° 34.29’ W- 33° 45.99’N 62° 33.91’ W	1776-2027m
	3886	June 5	12:48-13:35	33° 45.42’N 62° 36.06’ W- 33° 45.52’N 62° 35.96’ W	2750-2892m
	3887	June 6	12:50-16:54	33° 45.53’N 62° 35.86’ W- 33° 45.20’N 62° 35.10’ W	2265-2636m
	3888	June 7	15:05-18:06	33° 48.57’N 62° 34.01’ W- 33° 48.54’N 62° 33.97’ W	2730-2762m
	3889	June 8	13:11-17:36	33° 51.56’N 62° 40.34’ W- 33° 51.22’N 62° 38.67’ W	1520-1722m
Kelvin Seamount	3903	July 15	13:58-17:45	38° 47.330’N 64° 07.948’ W- 38° 47.248’N 64° 07.665’ W	1800-2063m
	3904	July 16	13:51-19:46	38° 51.600’N 63° 54.847’ W- 38° 50.992’N 63° 55.572’ W	1859-2174m
Bear Seamount	3905	July 17	13:45-18:29	39° 53.668’N 67° 22.960’ W- 39° 53.680’N 67° 23.129’ W	1659-1780m
	3906	July 18	13:04-14:49	39° 53.508’N 67° 21.295’ W- 39° 53.666’N 67° 21.156’ W	1300-1642m

3907	July 18	18:17-19:57	39° 52.334'N 67° 24.349' W- 39° 53.724'N 67° 25.327' W	1398-1430m

The following table show species diversity and number of observations for each of the five seamounts: Manning, Muir, Gregg, Kelvin and Bear. In all, 317 individuals were identified to the lowest taxonomic level possible from the video footage provided by the 2003 New England Seamount exploration. All individuals were not identifiable to the level of species due to a variety of variables, the taxonomic level to which I was able to identify them are represented in the table. Species are listed in phylogenetic order, starting with sharks and chimeras and proceeding to higher orders of bony fishes.

Table 2.

Species Found by Seamount

MANNING SEAMOUNT

Species	# individuals
Apristurus manis	2
Hydrolagus affinis	1
Aldrovandia sp.	11
Notocanthis chemnitzii	1
Histiobranchis bathybius	1
Synaphobranchidae	3
Alepocephalus sp.	2
Gonostoma atlanticum	1
Cyclothone sp.	8
Bathypterois sp.	2
Lamprogramus niger	2
Macrouridae	14
Coryphaenoides rupestris	8
Caelorhincus caelorhincus	2
Macrurus berglax	1
Antimora rostrata	2

Gigantactinidae	1
Neocyttus helgae	4

GREGG SEAMOUNT

Species	# individuals
Squalidae	5
Halosauropsis macrochir	1
Cyclothone sp.	15
Alepocephalus sp.	2
Macrouridae	4
Coryphaenoides rupestris	1
Caelorhincus caelorhincus	1
Moridae	1
Neocyttus helgae	2

MUIR SEAMOUNT

Species	# individuals
Apristurus manis	1
Squalidae	4
Aldrovandia sp.	16
Halosauropsis microchir	1
Synaphobranchidae	2
Bathypterois	2
Bathysaurus mollis	1
Alepocephalus sp.	5
Gonostoma atlanticum	1
Roulina attrita	1
Cyclothone sp.	1
Bassozetusn sp.	1
Macrouridae	14
Sphagemacrourus	1
Corypaenoides rupestris	1
Caelorinchus caelorhincus	1
Antimora rostrata	1
Myctophidae	1
Chaunacidae	1
Neocyttus helgae	8

KELVIN SEAMOUNT

Species	# individuals
Aldrovandia sp.	2
Halosaurus	2
Halosauropsis microchir	4
Synaphobranchus sp.	2
Bathypterois sp.	1
Ophidiidae	1
Lamprogramus niger	3
Macrouridae	6
Coryphaenoides rupestris	2
Caelorinchus ceolorhincus	2
Lepidion	1
Neocyttus helgae	6

BEAR SEAMOUNT

Species	# individuals
Apristurus manis	3
Hydrolagus affinis	2
Hydrolagus pallidus	2
Aldrovandia sp.	27
Eel	8
Synaphobranchidae	5
Synaphobranchus sp.	1
Alepocephalus sp.	3
Bathysaurus mollis	1
Bathypterois sp.	8
Bathypterois phenax	1
Cyclothone sp.	2
Macrouridae	6
Macrurus berglax	2
Caelorinchus caelorhincus	1
Antimora rostrata	2
Neocyttus helgae	6

The following table compiles all observations of fishes from all five seamounts visited in 2003. The four most commonly encountered groups of fishes were in descending rank: macrourids or rattails (Macrouridae + *Macrourus* + *Sphagemacrourus* + *Coryphaenoides* + *Caelorinchus*) = 70 fish encountered; halosaurids (*Aldrovandia* + *Halosaurus* + *Halosauropsis*) = 66 fish encountered; the oreo dory *Neocyttus helgae* = 47 fish encountered; and gonostomatids or bristlemouths (*Cyclothone* + *Gonostoma*) = 28 encountered.

Table 3.

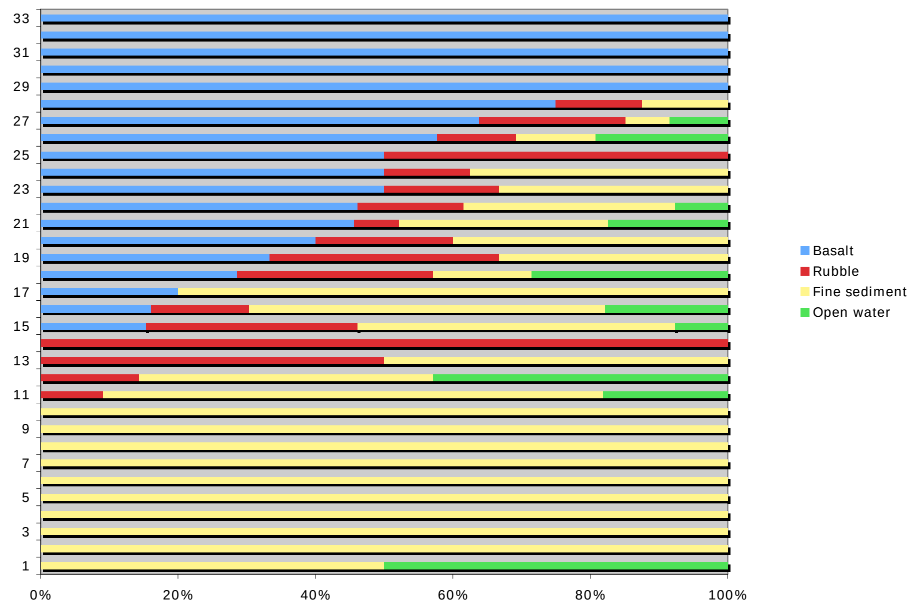
<u>Total Identified Individuals</u>

Squalidae	8
Apristurus manis	6
Hydrolagus affinis	3
Hydrolagus pallidus	2
Aldrovandia sp	56
Halosaurus	2
Halosauropsis microchir	8
Notochanthis chemnitzii	1
Histiobranchis bathybius	1
Synaphobranchidae	7
Synaphobranchus sp.	2
Alepocephalus sp.	13

Roulina attrita	1
Gonostoma atlanticum	2
Cyclothone sp.	26
Bathysaurus mollis	1
Bathypterois sp.	11
Bathypterois phenax	1
Ophidiidae	1
Lamprogramus niger	5
Bassozetus sp.	1
Macrouridae	46
Macrurus berglax	3
Sphagemacrourus	1
Corypaenoides rupestris	13
Caelorinchus caelorhincus	7
Moridae	1
Lepidion sp.	1
Antimora rostrata	5
Myctophidae	1
Chaunacidae	1
Gigantactinidae	1
Neocyttus helgae	47

Substrate was noted for each fish encountered and the compiled data is shown below in Fig. 1. From the number of individuals seen and proportions of substrates observed over, some conclusions regarding substrate preferences can be made.

Fig. 2 **Substrate Preference of Fishes in this Study**



Order of Individual Appearance on Graph

1 *Halosaurus sp.*
2 *Hydrolagus affinis*
3 *Notochanthis chemnitzii*
4 *Roulina attrita*
5 *Gonostoma atlanticum*
6 *Bathysaurus mollis*
7 *Ophidiidae*
8 *Sphagemacrourus*
9 *Moridae*
10 *Chaunacidae*
11 *Bathypterois sp.*
12 *Synaphobranchidae*
13 *Hydrolagus pallidus*
14 *Gigantactinidae*
15 *Alepocephalus sp.*
16 *Aldrovandia sp*
17 *Antimora rostrata*
18 *Caelorinchus caelorhincus*
19 *Macrurus berglax*
20 *Lamprogramus niger*
21 *Macrouridae*
22 *Corypaenoides rupestris*
23 *Apristurus manis*
24 *Halosauropsis microchir*
25 *Synaphobranchus sp.*
26 *Cyclothone sp.*
27 *Neocyttus helgae*
28 *Squalidae*
29 *Lepidion sp.*

30 *Myctophidae*
31 *Bassozetusn sp.*
32 *Bathypterois phenax*
33 *Histiobranchis bathybius*

Discussion

New fish distribution data

According to fishbase *Neocyttus helgae* only occurs in the Eastern Atlantic. Unpublished work by Moore et al. asserts that in addition to their currently documented distribution across the Eastern Atlantic (west of the United Kingdom, Madeira, Iceland, Faroe Islands, northwest Spain, Bay of Biscay, Porcupine Seabight, and the Mid-Atlantic Ridge north of the Azores; *Neocyttus helgae* is only reported in the western North Atlantic from the Corner Rise Seamounts) they have accessed the Western Atlantic, likely facilitated by the New England Seamount chain. This assertion is in accord with my findings of *Neocyttus helgae* on all five of the seamounts (located west of the Corner Rise) explored during the 2003 expedition. This finding also supports the theory that seamounts serve as dispersal corridors (Moore et al., 2004). *Lepidion sp* was potentially identified on Kelvin seamount, this identification was settled on due to the presence of a single barbel under the individual's chin as well as the presence of a very slender, elongate dorsal fin. The caudal fin however seemed to be more truncated. Fishbase.com states that their range is restricted to the Mediterranean.

Behavioral observations

CHIMAERIFORMES

Hydrolagus affinis sighted three times and *H. pallidus*, twice, all came within very close range to the camera and submersible. Neither species seemed deterred by the light and sounds of the submersible and stayed for several seconds, and in one case *H. affinis* stayed up to a minute in very close proximity to the submersible. *Hydrolagus affinis* were spotted at 1859 to 2170 m depth and *H. pallidus* in 1659 and 1563 m depth. Both are close to previously recorded ranges of 293 to 2452m and 1188- 2075m, respectively (Moore et. al., 2003).

CARCHARHINIFORMES

Apristurus manis individuals were spotted from 1328 to 1505 m depth, which somewhat deeper than the maximum dept recorded in Moore et. al. (2003) of 1462m. This individual was recorded by the submersible on Manning Seamount during dive number 3883. Of the 6 sharks all but one spent more than a few seconds in the frame or in direct path of the sub, the outlier is due likely to the fact that the sub followed it for some distance at a low speed.

SQUALIFORMES

Squalid sharks were spotted in 1075 to 1734 m depth, behavior includes schooling and aversion to the submersible and its lights. Species were not discernible making depth comparisons problematic, however, these depth findings are well within ranger for this Order with some species being found as deep as 3600 m (Moore et. al. 2003)

ALBULIFORMES

Aldrovandia spp. were very numerous, and in fact were the second most common genus of fishes seen on the expedition footage. They were most commonly found along the bottom facing in a parallel direction to the bottom, often swimming away from the submersible, but a great number were also stationary. Of the total 56 individuals seen, only 3 were facing different orientations, one face up in the water column, and two facing down. *Aldrovandia* were spotted at depths of 1506 to 2485 m which is deeper than its recorded maximum depth of 2200, a few individuals were seen at this new deeper depth on Muir during dive number 3887 .Only two *Halosaurus* sp. individuals were identified, though there may have been more or mistaken identities due to poor resolution or great distance from the submersible. Two individuals were seen on Kelvin seamount during dives 3903 and 3904 with potential depths of 1800- 2174m. Though they were captured by camera two which does not give depth readings on the frame it is likely that these individuals have exceeded the current depth maximum of 1600m (Moore et. al., 2003). The first individual swims through the frame slowly and does not return. *Halosauropsis microchir* was seen a total of 8 times, in all sightings they were parallel to the substrate and on the bottom. In six out of the eight sightings *Halosauropsis microchir* was stationary on the bottom, and twice swimming away from the submersible. This species was found from 1075 to 2892m, which is only slightly shallower than the 1100m minimum depth of its currently recorded depth range (Moore et. al. 2003).

NOTACANTHIDAE

Notachanthus chemnitzii was seen only once, swimming in the water column at approximately 1333 m depth. This is in accordance with the current depth records of 128-3285m (Moore et. al., 2003).

ANGUILLIFORMES

Eels of the family *Synaphobranchidae* (unable to reduce to any lower taxonomic level) were seen 7 times, swimming away from the submersible.

Histiobranchus bathybus seen once, at 1333 –1375 m, which is well within its depth range, according to current literature, of 731-4700m (Moore et. al., 2003).

Synaphobranchus sp. was spotted twice at 1333-1375 m depth, behavior included swimming closely to the submersible. One individual had a very large copepod parasite. These individuals were also within current depth ranges for both *affinis* and *kaupii*, 500-1500m and 131- 2346m respectively (Moore et. al., 2003).

ALEPOCEPHALIDAE

Alepocephalus sp. were seen 13 times and displayed a variety of different behaviors including darting out of the light field of the submersible rapidly, becoming disoriented and running into the substrate, swimming directly into the submersible, and one individual swam on its side along the bottom for over a minute while being followed by the submersible's camera. Individuals were spotted in 994 - 2004 m, which are also within the currently recorded depth ranges for the Order (Moore et. al., 2003).

Roulina attrita was only identified once. This individual was likely disoriented by the submersible's lights, and swam into the substrate, and back up towards the sub carrying with it a small piece of sediment. It was spotted in 1715 m depth which agrees with current depth ranges of 800- 2300m for the species (Moore et. al., 2003).

STOMIIFORMES

Cyclothone sp. was identified 26 times. Behavior consisted of wriggling and rapid motion swimming. Individuals were seen between 987 and 1576 m, within ranges found in literature (Moore et. al., 2003). These small fishes were often carried through the field of view by the local water currents and often disappeared in a matter of seconds. *Gonostoma atlanticum* was identified twice and was seen swimming rapidly through the frame once, and another time was seen swimming into a current that was strong enough to keep it relatively stationary over the bottom. These individuals were spotted in 1333 – 1375 m.

AULOPIFORMES

Bathysaurus mollis was identified once, swimming away from the submersible at 1721 m depth, within currently documented ranges of 1683- 4903m

Bathyterois sp. were seen 11 times virtually all of which were stationary on the bottom. One individual was seen swimming, and landing on the bottom. All individuals were seen at depths between 1333 and 2885 m, this is within range of most species according to current literature (Moore et. al. 2003).

Bathypterois phenax was identified once at 2778 m, also within the current depth ranges of 800- 2900m (Moore et. al. 2003).

MYCTOPHIFORMES

Myctophidae was identified only once between 2084 – 2273 m depth on dive number 3884 to Muir Seamount, this is deeper than most Myctophid species on record (Moore et. al., 2003). However, the classification is tenuous due to distance from the camera and resolution.

OPHIDIIFORMES

One ophidiid that could not be reduced to any lower taxonomical level was seen between 2309 and 2460 m which is within range of most species belonging to the Order Ophidiformes. *Bassozetus* sp. was identified once at 2084 – 2273 m, this is within the depth range of *Bassozetus normalis* which is 1725-3512m (Moore et. al. 2003). The individual abruptly swims off as the submersible approaches.

Lamprogramus niger was identified 5 times, all individuals were seen in or around rocky ledges. Two individuals were seen drifting in a head down orientation. Individuals were seen between 1333 and 1889 m. The depth range currently recorded for this species is 604- 2615m (Moore et. al., 2003).

GADIFORMES

Forty six macrourids that could not be reduced to any lower taxonomical level were seen between 937 and 2829 m, this fits within the average range of most fishes belonging to the family Macrouridae (Moore et. al., 2003). A variety of behaviors were observed, including swimming parallel to the substrate, drifting head up or head down, swimming away from the sub, swimming toward the sub, and disorientation likely caused by the submersible.

Caelorhincus caelorhincus was identified a total of 7 times from 1333 to 1889 m depth compared to the current depth range according to literature of 90- 850m, this is somewhat deeper. Behavior consisted of swimming into currents, drifting in the head up orientation, and drifting parallel to the bottom.

Coryphaenoides rupestris was identified 13 times between 919 and 1889 m, somewhat deeper than current literature documents (180- 2200m). Found mostly swimming away from the submersible.

Macrurus berglax was identified three times between 1327 and 1780 m, this is somewhat deeper than 100-1000m which is the current depth range for the species (Moore et. al., 2003). It may not go to the extreme suggested above because the individual in dive number 3905 was seen on camera 2 which does not give a depth reading in the frame. Seen drifting with its head oriented downwards twice.

Sphagemacrurus sp. was identified once swimming away from the submersible rapidly. On Muir Seamount with a minimum of 1776 and maximum of 2892 m, though it was not likely as deep as the maximum (according to current literature depth range for this species is 1000- 1960m) (Moore et. al., 2003) .

MORIDAE

Antimora rostrata was identified 5 times between 1333 and 2524 m depth, well within current depth ranges for this species of 299- 3000m. Behavior consisted of swimming slowly around the submersible and staying for periods longer than a minute in some cases.

Lepidion sp was identified once at 1800- 2023m depth. According to fishbase.com depth range for this species is 500-2230m. Seen in a stationary position, other than the motion of its dorsal fin, which was very elongate.

LOPHIIFORMES

Chaunacidae was identified once on Muir Seamount, at a potential depth of 1776-2892m, though likely not as deep as the maximum stated here because the image of this individual was captured on camera 2. Depth ranges for this family are within 220- 3200 m.

Gigantactidae was identified once at 1468 – 1701 m, largely within the depth range of this family (300-2300m). This individual was seen being swept end over end by the current. Further taxonomical identification could not take place because this individual was missing a portion of its lure.

ZEIFORMES

Neocytus helgae was identified 47 times from 941 to 2004 m, somewhat deeper than current depth ranges of 915- 1829m (Moore et. al., unpublished ms.). Behavior consisted of extended the first dorsal fin and presented the body laterally in front of the vehicle, which is a territorial fish display (Moore et. al. unpublished ms.). Fish also bumped into the substrate or outcroppings likely due to disorientation caused by the submersible.

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