VARIATION IN THE FOURBEARD ROCKLING, *ENCHELYOPUS CIMBRIUS*, A NORTH ATLANTIC GADID FISH, WITH COMMENTS ON THE GENERA OF ROCKLINGS

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ABSTRACT

Enchelyopus cimbrius, the fourbeard rockling, is a gadid fish living around the rim of the North Atlantic Ocean. It varies geographically in color pattern; anal, dorsal, and pectoral fin ray counts; and vertebral and gill racker counts. There is a lack of overall concordance in patterns of variation in color and meristics. Morphometric characters do not distinguish populations from different geographical areas, and the fourbeard rockling is considered to be a single species.

New distributional records include the Gulf of Mexico, West Greenland, and West Africa.

We classify the rocklings as a tribe, Gaidropsarini, of the subfamily Lotinae. Characters previously used to separate rocklings into five genera—skull shape, vomerine tooth patch shape, number and distribution of supratemporal pores, length of first dorsal fin ray, and size of jaw teeth—do not distinguish nominal genera. Number of snout barbels divides rocklings into three groups that we tentatively recognize as genera: *Gaidropsarus*, the threebeard rocklings, with two snout barbels; *Enchelyopus*, the fourbeard rockling, with three snout barbels; and *Ciliata*, the fivebeard rocklings, with four or more snout barbels. *Onogadus* and *Antonogadus* are referred to the synonymy of *Gaidropsarus*.

The correct generic name for the fourbeard rockling is *Enchelyopus* Bloch and Schneider 1801, with *Rhinonemus* Gill 1863 as a junior synonym. It is not preempted by *Enchelyopus* Gronovius 1760 in Zoarcidae, which was used in a work that was not consistently binominal.

The fourbeard rockling, *Enchelyopus cimbrius*, is a locally abundant gadid fish found around the margins of the North Atlantic Ocean. Although this fish has been recorded in the literature for more than 200 yr, many aspects of its biology are obscure. Adults are sedentary bottom dwellers taken at depths ranging from about 1 to 650 m [we have been unable to verify depth records to 1,325 m given by Goode and Bean (1896)]. There is some indication that seasonal offshore-onshore movements occur (Bigelow and Schroeder 1953; Tyler 1971). The pelagic larval stages are similar in appearance to young hakes (*Urophycis*) and sometimes occur in silvery swarms near the surface (Bigelow and Schroeder 1953).

Recent collections discussed in this paper show that fourbeard rocklings are more widely distributed than previously was known and that geographical variation is present. One of our objectives in this paper is to describe, compare, and evaluate geographical variation of selected characters and to show that a single species is represented throughout the range of the fish.

The rockling group of the family Gadidae, which is characterized by several distinctive features, recently was divided into five genera (Wheeler 1969), although most ichthyologists have recognized only three (albeit under a variety of names). The second of our objectives is to show that at present there are valid reasons for only three.

The fourbeard rockling is currently named *Enchelyopus cimbrius* by North American ichthyologists and *Rinonemus cimbrius* by Europeans. Our final objective is to show that *Enchelyopus* is the correct generic name.

METHODS

All observations were made on museum specimens listed in the Appendix. Counts of dorsal and anal fin rays and vertebrae were taken from X-ray photographs. Vertebral counts do not include the terminal ural element. Gill raker counts include all rakers on upper and lower arms of the first arch. Head pores were examined with the aid of a compressed air jet. Measurements and their

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statistical analysis are described under Body Proportions. Statistical tests were performed on the IBM 370-148[3] computer at The George Washington University, using computer programs written and maintained at the Systematics Laboratory, NMFS, NOAA, and following statistical methods presented by Zar (1974).

GEOGRAPHICAL VARIATION

The distribution of the fourbeard rockling may be summarized as the coastal waters of the North Atlantic. In the western Atlantic the species occurs in: West Greenland (new record); the northwestern Gulf of Saint Lawrence and around Newfoundland as well (Leim and Scott 1966 and this paper) to Cape Fear (about lat. 34°N) (Bigelow and Schroeder 1953); the northeast coast of Florida (Bullis and Thompson 1965); off the Florida Keys (new record); and in the northern Gulf of Mexico (new record). In the eastern Atlantic the species occurs: around Iceland (Saemundsson 1949) and the Faroes (Joensen and Taaning 1970); from northern Norway at about lat. 71°N in the Barents Sea and south along the coasts of Scandinavia (Andriyashev 1954); in the western Baltic (rarely to the Gulf of Finland, Svetovidov 1973); throughout the North Sea and around the British Isles to the northern Bay of Biscay (Wheeler 1969; Du Buit 1968); and off Cape Blanc, Mauritania (new record). It is not known from the Mediterranean. Figure 1 shows the approximate localities from which we have studied specimens. More detailed locality data are presented in the Appendix.

[3]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Sampling Areas

We have compared fish from the following geographical areas.

Gulf of Mexico. Only 3 localities are represented in our collections. These specimens are among the most darkly pigmented of any we have studied.

Southern Atlantic. Specimens taken from the South Carolina coast at about lat. 33°N to about lat. 29°N on the east coast of Florida, which is as far south as specimens have been caught in the western Atlantic outside of the Gulf of Mexico. There is no reason to doubt that this population is continuous with those farther north, and the northern boundary as here given is arbitrarily limited by available study material.

Intermediate. Fish caught in the vicinity of Cape Hatteras from about lat. 35°N to the vicinity of Norfolk Canyon at about lat. 37°N are included in

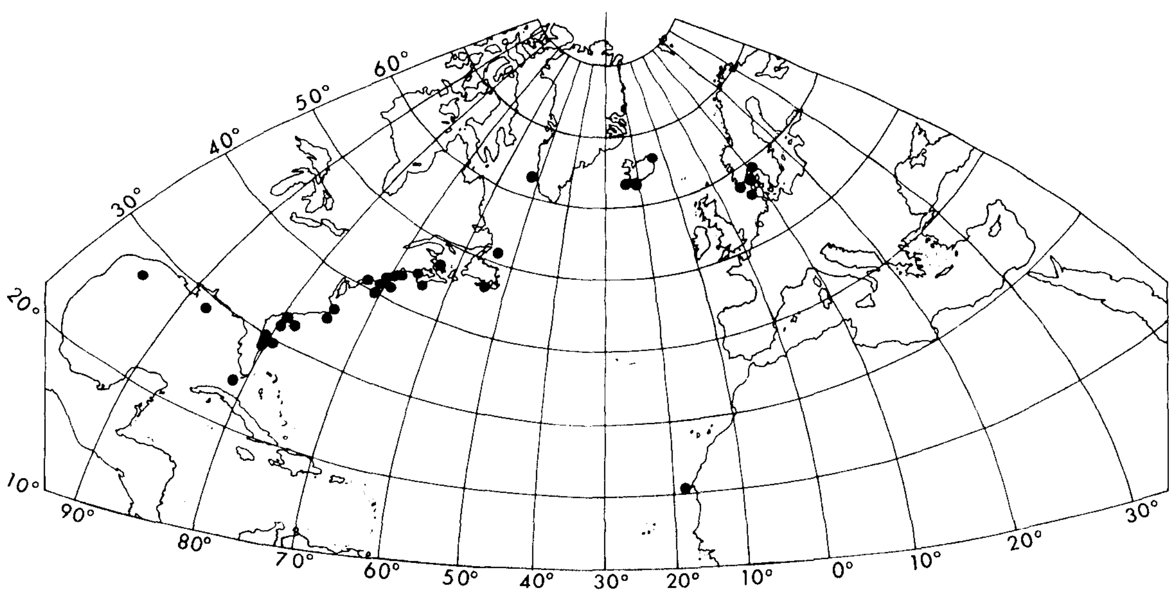

FIGURE 1.—Localities for our specimens of *Enchelyopus cimbrius*. Some dots represent more than one collection. For detailed data on localities see Appendix.

this area, which we separate because it is geographically between the region to the south, where fishes are mostly dark colored.

Northern Atlantic. This region extends along the western Atlantic coast from north of the vicinity of Norfolk Canyon to the northern North American limit of *E. cimbrius* occurrence.

Greenland. A single specimen from West Greenland is apparently the only known occurrence of *E. cimbrius* from Greenland.

Iceland. The region around Iceland.

Europe. Although *E. cimbrius* occupies a considerable area we have examined only a small sample, mainly from Denmark and Norway.

Africa. Two specimens from off the coast of Mauritania ca. lat. 21°N are the most southerly known.

Color

Enchelyopus cimbrius from the Gulf of Mexico and Southern Atlantic areas have on the average more of the dorsal fin colored with dark pigment than do fourbeard rocklings from other areas (Table 1). We have attempted to quantify this character by coding it on a 0-10 scale with 0 representing a fin with no dark pigment and 10 representing a fin that is completely dark. Values were subjectively assigned by a single observer (Cohen). Figure 2A shows a New England fish that would be coded as 1; Figure 2B shows the color pattern of a fish from the Gulf of Mexico, which would be coded as 6. Note that fish are morphologically intermediate and most variable in the Intermediate region[4] where the mean is 3.8 and the standard deviation is highest at 2.8.

TABLE 1.—Frequency distributions of degree of dorsal fin pigmentation in *Enchelyopus cimbrius* from eight geographical areas. 0 = no dark pigment in dorsal fin; 10 = entire fin darkly pigmented.

	Degree of pigmentation													
Area	0	1	2	3	4	5	6	7	8	9	10	*N*	$\bar{x}$	*SD*
Gulf of Mexico				2	1	5	2	4	1	1	2	18	6.2	2.1
Southern Atlantic		1	—	2	6	1	6	17	6	6	2	47	6.7	1.9
Intermediate		7	6	4	6	—	—	2	1	3	1	30	3.8	2.8
Northern Atlantic		29	5	7	3	—	2					46	1.8	1.3
Greenland						1						1	5	—
Iceland		5	2	2	1							10	1.9	1.1
Europe	1	26	1	1	1	2						32	1.4	0.9
Africa		1	1									2	1.5	—

Two other pigment characters were noted; however, neither was quantified. Fish with light fins lacked dark pigment in the groove along the base of the row of filaments between the strong first dorsal ray and the beginning of the normally developed dorsal fin (Figure 3A); fish with dark dorsal fins had varying amounts of dark pigment in this region (Figure 3B). Also, in many Gulf, Southern Atlantic, and Intermediate fish the body was dusky; in most others the body was a rather light straw color.

Meristics

Frequencies of both anal fin rays and dorsal fin rays show a pattern similar to, though less pronounced than, that shown by dorsal fin pigmentation in the western Atlantic (Tables 2, 3), with fish from the Intermediate area being intermediate between fish from the north and the south. Also, for anal fin rays the standard deviation is larger in fish from the Intermediate area than in adjacent samples. These two characters differ from dorsal pigmentation in having the highest mean in the Iceland sample.

Frequencies of pectoral fin rays and vertebrae for North American samples from the Intermediate area have nearly identical means in both

[4]Detailed descriptions of color variation in samples from Norfolk Canyon and comparisons with specimens from the northeast coast of Florida have been presented by: P. Szarek. 1974. A preliminary study of Norfolk Canyon *Enchelyopus cimbrius*. Ichthyology Term Paper, Virginia Institute of Marine Science.

TABLE 2.—Frequency distributions of numbers of anal fin rays in *Enchelyopus cimbrius* from eight geographical areas.

	Number of anal fin rays																
Area	36	37	38	39	40	41	42	43	44	45	46	47	48	49	*N*	$\bar{x}$	*SD*
Gulf of Mexico				6	4	2	4								16	40.2	1.2
Southern Atlantic				6	11	18	8	3							46	40.8	1.1
Intermediate				1	2	5	4	7	2	2	2	—	—	1	26	42.8	2.2
Northern Atlantic						8	8	9	13	9	2	2	1		52	43.5	1.7
Greenland								1							1	43	—
Iceland									2	4	3	1			10	45.3	0.9
Europe	1	—	1	1	—	2	1	3	6	1	—	—	—	1	17	42.6	3.0
Africa									1	1					2	44.5	—

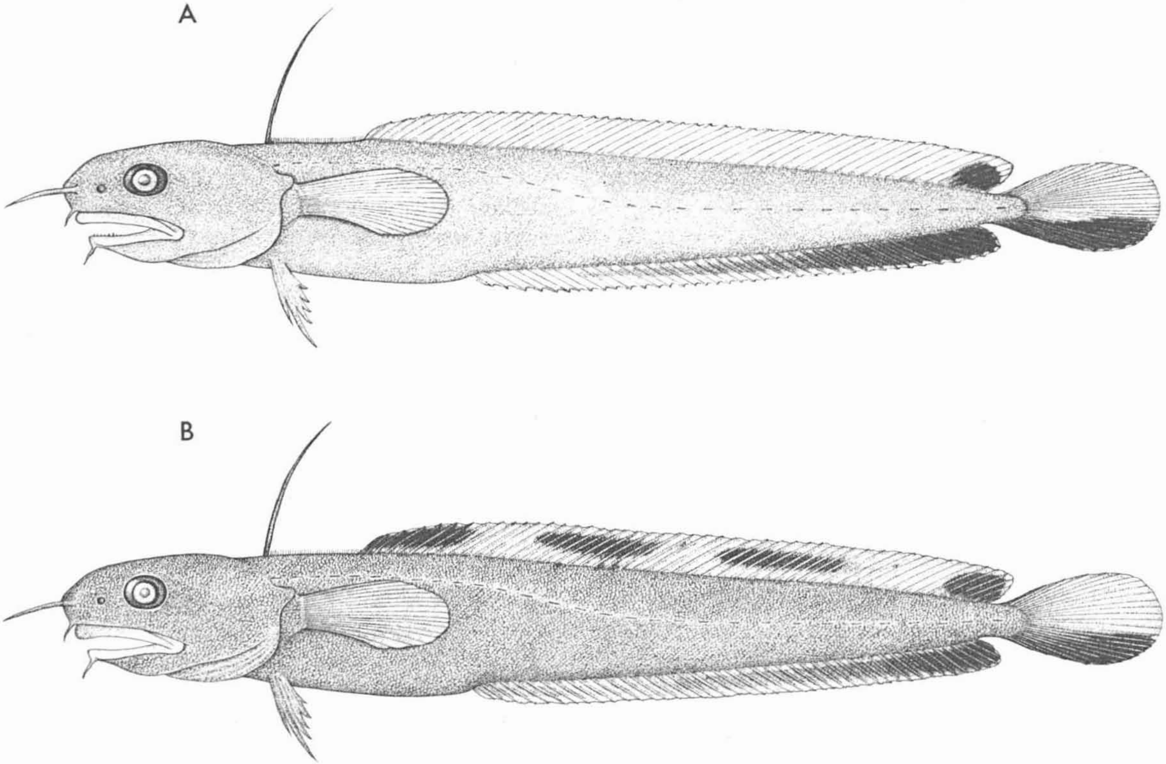

FIGURE 2.—*Enchelyopus cimbrius*. A, USNM 213501, standard length 282 mm, off Cape Cod, dorsal fin pattern coded as 1 (see text). B, color pattern of a fish from the Gulf of Mexico (USNM 217843) drawn on the outline of the fish shown in Figure 2A, dorsal fin pattern coded as 6 (see text).

TABLE 3.—Frequency distributions of numbers of dorsal fin rays in *Enchelyopus cimbrius* from eight geographical areas.

	Number of dorsal fin rays													
Area	45	46	47	48	49	50	51	52	53	54	55	*N*	$\bar{x}$	*SD*
Gulf of Mexico	1	1	11	3								16	47.0	0.7
Southern Atlantic	1	8	10	12	7	8	1					47	47.9	1.5
Intermediate			1	3	8	9	5	—	2	1		29	49.9	1.6
Northern Atlantic	1	—	—	6	13	8	12	4	4	3	1	52	50.4	1.9
Greenland							1					1	51	—
Iceland						5	2	3				10	50.8	0.9
Europe		1	2	3	3	4	3	1				17	49.2	1.7
Africa						2						2	50.0	—

of these characters with Northern Atlantic fish, rather than being intermediate (Tables 4, 5); however, for pectoral fin rays, fish from these two areas have lower counts that are in between Gulf and Alantic, and Greenland, Iceland, and Europe samples. Iceland fish average highest of all in dorsal and anal fin ray counts and in vertebral counts (not including the few specimens from Greenland and Africa). In pectoral counts, however, Iceland and Europe specimens have identical means.

In total gill raker counts (Table 6) eastern Atlantic samples have higher means than do western Atlantic samples, with the highest standard deviation being in the Northern Atlantic samples.

Body Proportions

Measurements were taken of the following eight body parts and compared for six of them in fish from the six geographical areas listed below and described previously under sampling areas (Greenland and Africa are not included in the present analysis). Linear regressions were calculated for the following dependent variables, with standard length as the independent variable:

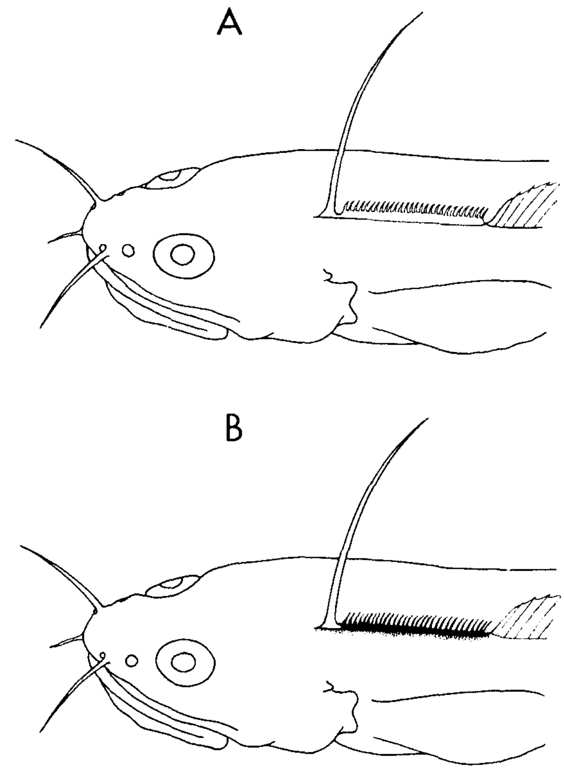

FIGURE 3.—*Enchelyopus cimbrius*. A, USNM 213501, head length 62.8 mm, off Cape Cod, note absence of dark pigment along base of fin with short rays. B, USNM 217843, head length 33.2 mm, Gulf of Mexico, note dark pigment along base of fin with short rays.

TABLE 4.—Frequency distributions of numbers of vertebrae in *Enchelyopus cimbrius* from eight geographical areas.

	Number of vertebrae									
Area	49	50	51	52	53	54	55	*N*	$\bar{x}$	*SD*
Gulf of Mexico			9	7				16	51.4	0.5
Southern Atlantic	1	1	18	22	10			52	51.8	0.9
Intermediate			4	7	12	6	1	30	52.8	1.0
Northern Atlantic			3	14	26	15	1	59	52.9	0.9
Greenland						1		1	54	—
Iceland					4	3	3	10	53.9	0.9
Europe			2	3	7	3		15	52.7	1.0
Africa						1	1	2	54.5	—

snout to first dorsal fin (pre D_1 distance); first dorsal fin to the dorsal fin beginning posterior to the row of small filamentous rays (D_1-D_3 distance); head length; pectoral fin length; upper jaw length; horizontal diameter of eye (orbit length); length of barbel on lower jaw; and ventral fin length. Numbers of specimens measured and their size ranges (standard length in millimeters) were: Gulf of Mexico 17 (125-228); Southern Atlantic 46 (125-263); Intermediate 29 (104-202); Northern Atlantic 53 (50.5-297); Iceland 10 (151-327); Europe 27 (93.8-300).

TABLE 5.—Frequency distributions of numbers of pectoral fin rays in *Enchelyopus cimbrius* from eight geographical areas.

	Number of pectoral fin rays							
Area	15	16	17	18	19	*N*	$\bar{x}$	*SD*
Gulf of Mexico	1	2	9	6	1	19	17.2	0.9
Southern Atlantic		9	21	14	1	45	17.2	0.8
Intermediate	2	9	14	4		29	16.7	0.8
Northern Atlantic	5	21	21	5	1	53	16.5	0.9
Greenland			1			1	17	—
Iceland	1	2	2	5		10	17.1	1.1
Europe	1	2	8	4	1	16	17.1	1.0
Africa		2				2	16	—

TABLE 6.—Frequency distributions of total numbers of gill rakers on first arch in *Enchelyopus cimbrius* from eight geographical areas.

	Number of gill rakers											
Area	5	6	7	8	9	10	11	12	13	*N*	$\bar{x}$	*SD*
Gulf of Mexico				5	3	2	—	1		11	9.0	1.3
Southern Atlantic			2	9	12	17	4			44	9.3	1.0
Intermediate			1	1	11	6	5			24	9.5	1.0
Northern Atlantic	3	1	1	8	8	12	6	2		41	9.1	1.8
Greenland					1					1	9	—
Iceland					2	5	2	1		10	10.2	0.9
Europe					6	4	3	1	1	15	10.1	1.3
Africa					1	—	1			2	10.0	—

Analysis of covariance was used to compare regression lines (Tables 7, 8) for six measurements that we have treated as linear based on a coefficient of determination (r^2) of 0.73 or higher (Table 8). Two measurements, ventral fin length and barbel length, had coefficients of determination ranging from 0.42 to 0.61 and were not further analyzed.

Fishes from all six geographical areas demonstrated overall coincidence at the 0.05 level of significance in two characters, head length and upper jaw length. Hypotheses concerning overall coincidence of regressions for the other characters were rejected and hypotheses concerning the equality of slopes and intercepts were simultaneously tested.

The hypothesis concerning the equality of slopes was rejected for the D_1-D_3 distance versus standard length regression lines. Regression data were

TABLE 7.—Significance of differences in six morphometric characters in *Enchelyopus cimbrius* from six geographical regions. Independent variable is standard length.

Dependent variable	*N*	Overall coincidence	Equality of slopes	Equality of intercepts
Pre D_1 distance	165	[1]0.0048	0.5342	[1,2]4.9×10^{5}
D_1-D_3 distance	165	[1]0.0024	[1]0.0111	[1]0.0012
Head length	182	0.3004	—	—
Pectoral fin length	150	[1]0.0061	0.0617	[1]0.0011
Orbit lengh	166	[1,2]2.0×10^{5}	0.1839	[1,2]2.4×10^{6}
Jaw length	166	0.2892	—	—

[1]Rejection of hypothesis of equality at the 0.05 level of significance.
[2]Rejection of hypothesis of equality at the 0.001 level of significance.

TABLE 8.—Y intercepts in millimeters, slopes, coefficients of determination (r^2), and N for regression lines calculated on *Enchelyopus cimbrius* from six geographical areas. Independent variable is standard length.

	Measurement					
Geographical area	Pre D_1 distance	D_1-D_3 distance	Head length	Pectoral fin length	Upper jaw length	Orbit length
Gulf of Mexico:						
Y intercept	2.91	2.21	2.29	0.17	-3.08	0.10
Slope	0.16	0.12	0.18	0.14	0.11	0.04
r^2	0.89	0.86	0.93	0.87	0.87	0.79
N	16	16	17	14	17	17
Southern Atlantic:						
Y intercept	0.11	-4.74	0.22	-0.89	-1.83	0.76
Slope	0.17	0.15	0.20	0.15	0.11	0.04
r^2	0.96	0.89	0.94	0.91	0.89	0.90
N	43	44	46	43	44	44
Intermediate:						
Y intercept	-0.60	-0.74	-0.71	0.48	-2.69	-0.06
Slope	0.18	0.12	0.21	0.14	0.11	0.05
r^2	0.95	0.86	0.92	0.87	0.92	0.79
N	29	29	29	29	29	28
Northern Atlantic:						
Y intercept	-0.32	0.47	-0.43	-2.22	-3.38	1.64
Slope	0.18	0.12	0.21	0.16	0.12	0.04
r^2	0.97	0.89	0.97	0.92	0.87	0.92
N	51	51	53	38	51	50
Iceland:						
Y intercept	0.47	3.59	2.09	6.02	-5.71	2.65
Slope	0.17	0.10	0.20	0.12	0.13	0.03
r^2	0.79	0.92	0.99	0.87	0.98	0.98
N	10	10	10	10	9	10
Europe:						
Y intercept	-0.61	-4.37	-0.74	-2.06	-4.70	1.29
Slope	0.18	0.16	0.21	0.15	0.12	0.04
r^2	0.97	0.73	0.91	0.90	0.91	0.94
N	16	16	27	16	16	17

submitted to a Newman-Keuls multiple range test in order to determine which population sample or groups of population samples were different from others. This procedure failed to detect differences between any slopes, a not uncommon occurrence due to the fact that the analysis of covariance is a more powerful test than is the multiple range test. The sample from Iceland had the lowest slope at 0.10, the Northern Atlantic, Gulf of Mexico, and Intermediate samples each had a slope of 0.12, the Southern Atlantic sample had a slope of 0.15, and the sample from Europe had a slope of 0.16.

The hypotheses concerning the equality of Y intercepts was rejected at the 0.05 level of significance for all four characters tested. These regression data also were submitted to a Newman-Keuls multiple range test in order to determine which population sample or groups of population samples were different from others. Again, this procedure failed to detect significant differences between any Y intercepts.

If a more stringent 0.001 level of significance is used, only orbit length tests as being significantly different with respect to overall coincidence. Data for this regression from each of the six samples were submitted to a continuation of analysis of covariance to determine whether differences in the regression lines were attributable to the slopes and/or the Y intercepts. We accept equality of the slopes with a probability of 0.85. However we reject the equality of the Y intercepts after calculating a probability of equality of 2.06×10^{-5}. Regression data were submitted to a Newman-Keuls test, which failed to detect differences between any pairs of intercepts. Inspection of our data shows that rocklings from Iceland appear to have a proportionally larger eye than do other rocklings; however, our sample is small and may be biased by larger fishes; hence we do not draw inferences from this apparent difference.

Although differences between samples apparently exist, we do not interpret them as representing the kind of discontinuity that indicates distinct species. Their significance is beyond the scope of this paper.

Discussion

We believe that the fourbeard rockling is best considered as a single species throughout its entire range. Differences in pigment pattern, meristics, and the relative size of several body parts do exist; however, there are neither trenchant discontinuities in variation nor is there any overall concordance in patterns of variation. Differences between and similarities among samples are summarized in Figure 4 and discussed below for meristics and color pattern. Differences in morphometric characters are so slight that we do not further consider them.

Gulf of Mexico and Southern Atlantic samples are quite similar, although at this time the two might be semi-isolated from each other. The clockwise loop current system in the Gulf of Mexico provides a possible pathway for the dispersal of young, pelagic stage rocklings out of the gulf; there is no present avenue for recruitment into the Gulf of Mexico. If the single rockling taken off the Florida Keys represents more than a stray, then perhaps Gulf of Mexico and Southern Atlantic populations are continuous; otherwise, the north Gulf-northeast Florida distribution pattern is similar to that noted first in fishes by Ginsburg (1952). Although *E. cimbrius* seems rare in the Gulf of Mexico its occurrence at two widely separated localities, with a collection of 16 individuals from one of them, indicates that the species is established there. Although pelagic stages have not yet been taken from the Gulf of Mexico or Southern Atlantic areas, it seems reasonable to assume that they occur there and are available for dispersal in the Gulf Stream system.

Rocklings from the Intermediate area are indeed intermediate between adjacent populations to the north and south in degree of pigmentation and in dorsal and anal ray counts. Furthermore, for two of these characters, color and number of anal fin rays, the standard deviation is larger than in other populations, implying that recruits from different spawning populations are entering the area or that the characters are genetic and variability is being maintained during spawning in the Intermediate area. For two characters, numbers of vertebrae and pectoral fin rays, Intermediate and Northern Atlantic fish are nearly identical and differ from Southern Atlantic and Iceland samples. These characters must be determined or mediated differently than are color pattern and dorsal and anal fin ray counts. Gill raker count appears to reflect still a third method of character determination as the means are different on the two sides of the Atlantic. Although pelagic early stages have not been taken in the Intermediate area, they may be available for dispersal to the northeast by means of the Gulf Stream and to the southwest in coastal currents that parallel the Gulf Stream. Such dispersal patterns would help to account for the occurrence of dark-colored rocklings in the north and light-colored ones in the south.

Rocklings from the Northern Atlantic area more closely resemble fish from Europe and Iceland in degree of pigmentation and number of vertebrae than they do their immediate neighbors to the south. Conversely they are closer to other North American samples in numbers of pectoral

CHARACTER	GEOGRAPHICAL AREA					
	Gulf	S. Atl.	Intermed.	N. Atl.	Iceland	Europe
Color	6.2	6.7	3.8	1.8	1.9	1.4
Anal Rays	40.2	40.8	42.8	43.5	45.3	42.6
Dorsal Rays	47.0	47.9	49.9	50.4	50.8	49.2
Vertebrae	51.4	51.8	52.8	52.9	53.9	52.7
Pectoral Rays	17.2	17.2	16.7	16.5	17.1	17.1
Gill Rakers	9.0	9.3	9.5	9.1	10.2	10.1

FIGURE 4.—Summary of means of character states for *Enchelyopus cimbrius* from six geographical areas. Heavy lines are drawn around entries that are discussed in the text as separate entries and that illustrate overall lack of convergence in character states.

rays and gill rakers. Spawning is known to occur in the Northern Atlantic area. Eggs have been taken from surface tows in Passamaquoddy Bay, where spawning peaked at bottom temperatures of 9° to 10°C (Battle 1930). In Long Island Sound eggs were found to be most abundant in the upper 12 m (Williams 1968). In reviewing the natural history of *E. cimbrius* in the Gulf of Maine, Bigelow and Schroeder (1953) mentioned the possibility of planktonic existence as long as 3 mo. Given such a time span, the complex hydrographic regime of the area might occasionally distribute early stages to the south inshore of the Gulf Stream or even more rarely might transport them via the Gulf Stream to the eastern Atlantic.

Iceland rocklings are usually light colored, as are fish from the Northern Atlantic and Europe areas. For counts of dorsal and anal fin rays, and vertebrae, Iceland fish have the highest means of all (ignoring the two fish from Africa); perhaps these characters are influenced by temperature, as Iceland has the lowest temperatures of any of the six areas. In numbers of pectoral rays, Iceland and European fish are identical and in gill rakers nearly so, and different from counts of North American ones. Adults at least of the Iceland population may be isolated as Kotthaus and Krefft (1967) did not catch *E. cimbrius* along the Iceland-Faroe ridge. *Enchelyopus cimbrius* spawns at least around the southwest coast of Iceland (Einarsson and Williams 1968).

The linear range of the fourbeard rockling along the coasts of Europe is about as great as along the coasts of North America. We have examined only a small sample, from southern Scandinavia; hence, it is possible that more variation exists than we have recorded. However, we point out that in our sample the color pattern resembles that of Iceland and Northern Atlantic fish, that counts of anal and dorsal fin rays and vertebrae are lower than those in Iceland, and that in numbers of pectoral fin rays and gill rakers Europe and Iceland fish are more like each other than they are like North American populations. Rocklings are known to spawn in European waters [Svetovidov (1973) gives several references]. *Enchelyopus cimbrius* could have reached Europe from the west via the Gulf Stream system; it seems unlikely that east to west dispersal is possible.

We do not know whether the West Greenland specimen of *E. cimbrius* represents a breeding population or a stray.

The two West African examples are so far removed from their nearest known neighbors (Bay of Biscay) that we forego conjecture as to their origin.

THE GENERA OF ROCKLINGS

The rocklings are classified in the subfamily Lotinae of the family Gadidae (Svetovidov 1948) and can be distinguished by the nature of the three dorsal fins, which, although scarcely separated from each other, bear quite different kinds of rays (Figure 5). The first dorsal fin consists of a single, unsegmented ray which is not bilaterally divided (we have examined microscopic sections) and is supported by a strong pterygiophore. The ray is thicker than any others in the dorsal fin and in many species is longer as well. In *Enchelyopus cimbrius* it is soft, being ossified only proximally. Sharply distinguished from the first and third dorsal fins is a row of small, unsegmented, bilaterally divided filaments which appear fleshy, although they stain with alizarin. These small rays originate on a compressed ridge that rises from a middorsal groove. Although Bogoljubsky (1908) followed by Svetovidov (1948) did not consider these filaments to be true fin rays they should be considered as such, as examination of an alizarin preparation and of sections shows that a simple, ossified, rod-shaped skeletal support is present for each. The third dorsal fin is composed of ordinary, bilaterally divided, segmented rays, each with a well-developed pterygiophore.

A second characteristic of the rocklings is the presence on the snout of prominent barbels (the closest approach to this character among other gadids being a nasal cirrus in *Lota*) in addition to the barbel at the tip of the lower jaw.

Thus, the rocklings are distinguished by two specialized characters and can be considered as a distinct tribe of Lotinae, the Gaidropsarini [classified as a distinct family by some, for example, de Buen (1934)].

Although rocklings have been treated under as many as 14 different generic names [see Svetovidov (1973) for synonyms], many ichthyologists (for example, Andriyashev 1954; Norman 1966) follow Svetovidov (1948) in recognizing three. More recently, however. five genera have been recognized (Wheeler 1969). How many genera should be recognized and why?

In his 1948 treatment of the rocklings, Svetovidov provided diagnoses for the three genera that he recognized based on barbel number, skull shape, vomerine tooth patch shape, and

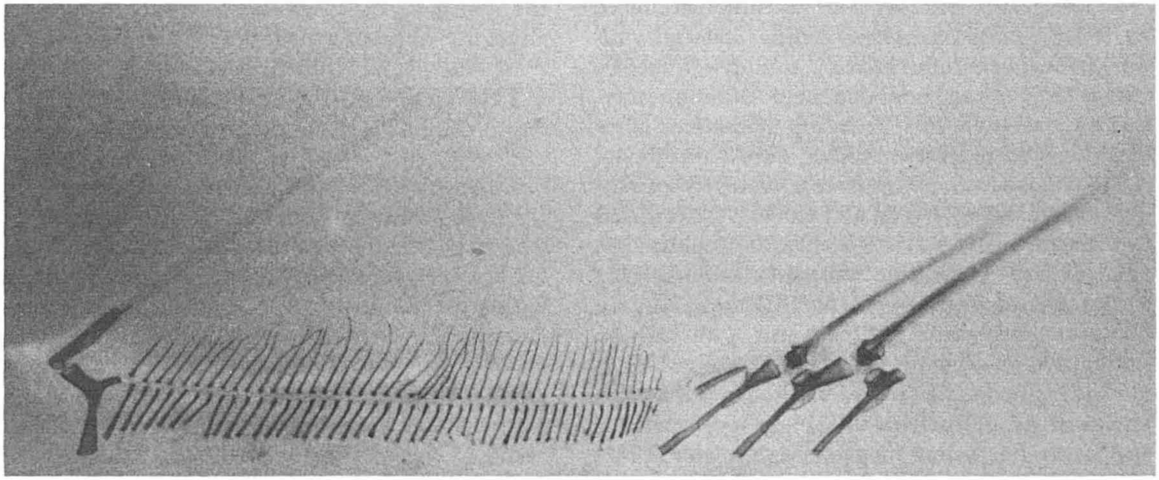

FIGURE 5.—*Enchelyopus cimbrius*, USNM 217900, standard length 135 mm; photograph of an alizarin preparation in glycerin showing the three different kinds of dorsal fin rays and their skeletal supports.

number and distribution of supratemporal pores (our Table 9). Unfortunately, he was unable to study all of the species. We have examined six of the nominal *Gaidropsarus* species that he recognized, both species of *Ciliata*, and, of course, *Enchelyopus* (study material of all genera is listed in the Appendix).

Number of barbels is the only character that unequivocally divides our material according to Svetovidov's classification.

Proper evaluation of the skull-width character will require the examination of osteological preparations, which we have not done. We note, however, that although *Ciliata mustela* has a notably broad skull, that of *C. septentrionalis* appears to be narrower. Also, although most species of *Gaidropsarus* appear to have narrow skulls, that of *G. guttatus* appears broad.

Regarding the size and shape of the vomerine tooth patch, it is highly variable, and although it may serve to distinguish some species it is of doubtful value at the genus level.

TABLE 9.—Summary of diagnostic characters for three rockling genera given by Svetovidov (1948).

Genus and no. of species	Characters			
	No. of barbels	Skull shape	Vomer	Supratemporal pores
Gaidropsarus (13)	3	Narrow	Head large, apex angular	3 = 1 pair + 1 median
Enchelyopus (1)	4	Narrow	Small	3 = 1 pair + 1 median
Ciliata (2)	5 or more	Broad	Head small, anterior a semicircle	2 = 1 pair

Number of supratemporal pores also is a variable character. Five of the *Gaidropsarus* species that we have studied show the pattern given for the genus by Svetovidov (1948), one median and one pair of pores (= 3). However, *G. argentatus* has two pairs and no median pores (= 4). In *Ciliata*, *C. mustela* has one pair (= 2), while *C. septentrionalis* has three pairs (= 6).

As noted above, Wheeler (1969) recognized five genera, the three recognized by Svetovidov (1948): *Enchelyopus*, *Ciliata*, and *Gaidropsarus*; and also *Onogadus* de Buen 1934; and a genus introduced for the first time, *Antonogadus*.

Onogadus was originally proposed for *Gaidropsarus ensis*, one of the threebeard rocklings, because of its elongate first dorsal ray. Wheeler (in Svetovidov 1973) has subsequently assigned to *Onogadus*, *G. argentatus*, a species with a far shorter first dorsal fin ray. We have found the length of the first dorsal fin to be highly variable in *Enchelyopus*. As presently used, this character does not separate genera. (Wheeler[5] has informed us that *Onogadus* may be differentiated on the basis of vertebral counts. Due to insufficient data we have no comment on this character.) As we have mentioned above, *G. argentatus* differs from *G. ensis* and resembles *Ciliata* in lacking a median supratemporal pore.

[5]A. Wheeler, Department of Zoology, British Museum (Natural History), Cromwell Road, London S.W. 7. England. Pers. Commun. March 1978.

Antonogadus Wheeler 1969 was first introduced in the combination *Antonogadus macrophthalmus* (Günther), unfortunately, in a key to species rather than a treatment of genera. Subsequently, another threebeard rockling, *Gaidropsarus megalokynodon* (Kolombatovic 1894), was referred to *Antonogadus* (Wheeler in Svetovidov 1973) in a checklist. There is no way to tell if the original key characters describing dentition, mouth size, and color are diagnostic of the genus *Antonogadus* or the species *A. macropththalmus*; however, we assume that they apply to the genus. Color may be discounted as a generic character as it is highly variable among the species of *Gaidropsarus* and varies geographically in the single species of *Enchelyopus*. Regarding mouth size, Wheeler (1969) noted "mouth large, extending well past eye"; however, figures of *macrophthalmus* given by Günther [1867, pl. 5, fig. B and 1887, pl. 42, fig. D, the latter as *Onus carpenteri*, a junior synonym of *macrophthalmus* according to Wheeler in Svetovidov (1973)] show fish with small mouths. The second species referred to *Antonogadus, megalokynodon*, is figured by Sŏljan (1963) as having a large and capacious mouth, but he shows the same condition for several other species of threebeard rocklings. So far as we can tell mouth size is not a useful generic character. Carrying on to dentition, Wheeler (1969) noted, "A pair of large, fang-like, teeth (sometimes three or four) in front of the upper jaw." If *Antonogadus* is recognized on the basis of such a character then it would be necessary to place the two species of *Ciliata* in separate genera, as *C. mustela*, the type-species of the genus has bands of equal-sized teeth in the upper and lower jaws, while *C. septentrionalis* has in addition to these bands a much enlarged outer row of teeth in the upper jaw and an enlarged inner row in the lower jaw.

It is by no means clear that number of barbels alone divides the rocklings into natural species assemblages; convergence may have occurred and other groupings based on different characters may produce a phyletically more correct classification. Obviously, thorough study and a careful analysis of characters is required. For the present there seems insufficient information available to do other than recognize on the basis of number of barbels a single genus with three subgenera, or three genera. We follow the latter course as it is the most conservative in terms of the present usage of names. We recommend therefore, that for the present *Onogadus* be relegated once again to the synonymy of *Gaidropsarus* where it should be joined by *Antonogadus*.

THE CORRECT GENERIC NAME FOR THE FOURBEARD ROCKLING

Although differences at the species level have not evolved in populations of the fourbeard rockling on both sides of the North Atlantic, curiously enough geographical isolation seems to have affected the evolution of different generic names. *Rhinonemus* is used by European ichthyologists (see, for example, Svetovidov 1973); North American ichthyologists use *Enchelyopus* (see, for example, Leim and Scott 1966). Which is the correct name?

Enchelyopus Gronovius 1760 was the first of the two names proposed. Although only a brief color description was given, reference was made to the same author's pre-Linnean Museum Ichthyologicum published in 1754, in which work under the names *Mustela vivipera* and viviparous eelpout is presented a recognizable description of the species presently named *Zoarces viviparus* (Linnaeus). This identification is further verified by a Gronovius specimen still extant in the British Museum, which Wheeler (1958) has suggested is a type-specimen of *Blennius viviparus* Linnaeus. Use of *Enchelyopus* in Zoarcidae, where it is a senior synonym of *Zoarces* Cuvier 1829 has been accepted by Norman (1966) and noted as being correct by Andriyashev (1973). Some ichthyologists (Gill 1863b; Jordan 1917), however, seem to have overlooked Gronovius (1760) and attributed the name to Gronovius (1763) in his Zoophylaceum, a work subsequently ruled on by the International Commission on Zoological Nomenclature (Opinion 89) as being unavailable for purposes of zoological nomenclature. The Commission noted in its ruling that combinations used in the Zoophylaceum were "binary" though not "binomial," which interpretation complied with the then current edition of the Rules, and the work was declared unavailable by suspension of the Rules.

Although Gronovius (1760) never has been ruled on by the Commission it follows the same system of nomenclature as does Gronovius (1763) and clearly is not binominal. The same is true of Gronovius (1762), which has been rejected (Opinion 332). Under the provisions of the present Code (Article 11(c)), names published in Gronovius (1760) are not available as the author did not consistently apply the principles of binominal nomenclature. Although Article 11.(c)(i) ("Uninominal genus-group names published before 1931 without associated nominal species are accepted as consistent with the principles of binominal nomenclature, in the absence of evidence to the contrary.") might serve as a basis for arguing that the names in Gronovius (1760) are available, the interests of stability would be served best by considering the work unavailable, as its acceptance would require not only that *Enchelyopus* Gronovius 1760 replace *Zoarces* Cuvier 1829, but also that *Cyclogaster* Gronovius 1760 replace *Liparis* Scopoli 1777.

If Gronovius (1760) is considered as unavailable for purposes of zoological nomenclature then the first valid use of *Enchelyopus* is by Bloch and Schneider (1801). The type-species was stated by Jordan (1917) as *Gadus cimbrius* Linnaeus 1766 as first restricted, and Svetovidov (1973) gave the type as *Gadus cimbrius* Linnaeus 1766 by monotypy. However, neither of these methods of type fixation is correct as Bloch and Schneider referred 12 species to the genus, and although *cimbrius* is the first one in order, there is no action that could be construed as a type designation. The earliest type designation for *Enchelyopus* Bloch and Schneider 1801 that we have been able to find is that of Jordan (1917) as *Gadus cimbrius* Linnaeus 1766.

Rhinonemus Gill (1863a) was proposed for *Motella caudacuta* Storer 1848, a junior synonym of *Gadus cimbrius* Linnaeus (Goode and Bean 1879) and is therefore a junior synonym of *Enchelyopus* Bloch and Schneider.

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APPENDIX

The following abbreviations indicate institutions or collections: CU, Cornell University; MCZ, Museum of Comparative Zoology, Harvard University; MNHN, Museum National d'Histoire Naturelle, Paris; NEFC, Northeast Fisheries Center, Woods Hole, Mass.; NMC, National Museum of Natural Sciences, Ottawa; USNM, National Museum of Natural History, Washington, D.C.; ZMUC, Zoologisk Museum, Copenhagen. The "Intermediate" region, below, extends from about lat. 35°N to about lat. 37°N in the western Atlantic.

Enchelyopus cimbrius

GULF OF MEXICO—USNM 190346 (3 specimens), *Silver Bay* stn 294, 27°54'N, 95°23'W, 79 m. USNM 217843 (16), *Oregon* 3724, 29°04'N, 88°31'W, 403 m. USNM 217939 (1), *Oregon* 5795, 24°16'N, 82°30'W, 439 m.

SOUTHERN ATLANTIC—USNM 217923 (2), *Silver Bay* 1611, 29°06'N, 80°00'W, 339-384 m. USNM 217924 (2), *Silver Bay* 223, 29°14'N, 80°05'W, 247 m. USNM 217935 (1), *Oregon* 5798, 29°14'N, 80°05'W, 357 m. USNM 217933 (5), *Oregon* 5098, 29°17'N, 80°05'W, 379 m. USNM 217931 (1), *Silver Bay* 4227, 29°20'N, 80°05'W, 348 m. USNM 217949 (2), *Silver Bay* 224, 29°29'N, 80°09'W, 329 m. USNM 217937 (1), *Combat* 475, 29°30'N, 80°10'W, 293 m. USNM 217934 (3) *Oregon* 5093, 29°31'N, 80°09'W, 384 m. USNM 217932 (1), *Silver Bay* 219, 29°34'N, 80°09'W, 348 m. USNM 217917 (1), *Silver Bay* 1607, 29°34'N, 80°09'W, 371 m. USNM 217943 (1). *Combat* 325, 29°35'N, 80°10'W, 366 m. USNM 217936 (1), *Combat* 314, 29°38'N, 80°11'W, 329 m. USNM 217918 (1), *Oregon* 5238, 29°39'N, 80°12'W, 348 m. USNM 217916 (2), *Silver Bay* 1606, 29°40'N, 80°12'W, 348 m. USNM 217940 (1), *Silver Bay* 217, 29°41'N, 80°08'W, 348 m. USNM 217919 (2), *Silver Bay* 458, 29°49'N, 80°10'W, 220 m. USNM 217921 (2), *Silver Bay* 1552, 29°43'N, 80°12'W, 302 m. USNM 217948 (1), *Combat* 435, 29°46'N, 80°12'W, 366 m. USNM 217920 (1), *Silver Bay* 3742, 29°50'N, 80°13'W, 275 m. USNM 217950 (5), *Silver Bay* 1604, 29°50'N, 80°10'W, 302 m. USNM 217947 (2), *Silver Bay* 3678, 29°53'N, 80°11'W, 329 m. USNM 217944 (3), *Silver Bay* 3675, 29°55'N, 80°11'W, 329 m. USNM 217922 (1) *Silver Bay* 4367, 29°55'N, 80°11'W, 320m. USNM 217945 (1), *Oregon* (1), 5233, 29°54'N, 80°10'W, 348 m. USNM 217925 (1), *Combat* 471, 29°57'N. 80°12'W, 329 m. USNM 217946 (3), *Pelican* 182-8, 32°09'N, 79°02'W, 275 m. USNM 217938 (1), *Combat* 300, 32°15'N, 78°51'W, 348 m. USNM 217927 (1), *Combat* 289, 33°03'N, 77°09'W, 366 m.

INTERMEDIATE—USNM 45898 (1), *Albatross*, 35°40'N, 74°52'W. USNM 45895-6 (7), *Albatross*, 36°02'N, 74°48'W. USNM 217941 (1), *Oregon II* 10763, 36°01'N, 74°48'W, 311-567 m. USNM 217951 (1), *Oregon II* 10664, 36°12'N, 74°47'W, 249-329 m. USNM 217942 (2), *Oregon II* 10724, 36°14'N, 74°45'W, 366-421 m. USNM 217929 (2), *Columbus Iselin* 73-10-40, 36°33'N, 74°42'W, 296 m. USNM 217928 (3), *Columbus Iselin* 73-10-47, 36°37'N, 74°42'W, 316 m. USNM 217926 (3), *Columbus Iselin* 73-10-89, 37°02'N, 74°38'W, 367 m. USNM 217930 (7), *Columbus Iselin* 73-10-73, 37°05'N, 74°43'W, 194-479 m.

NORTHERN ATLANTIC—USNM 28994 (1), *Albatross*, 38°39'N, 73°11'W, 238 m. USNM 45969 (1), *Albatross*, 38°54'N, 72°51'W. USNM 28917 (1), 39°43'N, 71°32'W. USNM 45891 (1), *Albatross*, 39°48'N, 71°49'W. MCZ 37492 (1), *Capt. Bill II* 20, 39°57'N, 71°07'W, 412 m. USNM 28843 (1), *Fish Hawk*, 39°57'N, 70°32'W. USNM 28816 (1), 39°N, 71°W. MCZ 38039 (1), *Caryn* 3-1, 39°59'N, 70°48'W, 381 m. USNM 33352 (1), *Fish Hawk*, 40°20'N, 70°35'W. USNM 28709 (1), 40°24'N, 70°42'W. USNM 35680 (1), 40°21'N, 70°29'W. USNM 28890 (2), 40°28'N, 70°44'W. USNM 126948 (1), *Fish Hawk*, Long Island Sound, 22 m. USNM uncat. (1), *Albatross IV*, 41°14'N, 71°41'W. USNM 213501 (7), *Blesk* 68-18, 22-01, 41°52'N, 68°12'W, 198 m. USNM uncat. (1), *Blesk* 68-18, 24-02, 41°36'N, 68°52'W, 138 m. USNM uncat. (1), *Blesk* 68-18, 28-01, 42°N, 69°39'W, 210 m. USNM 16656 (1), Woods Hole, Mass. CU 18353 (3), *Albatross III* 27-45, 41°53'N, 69°10'W, 212 m. USNM uncat. (1), *Delaware* 60-1-11, 41°52'N, 68°14'W, 227 m. CU 18274 (1), *Albatross III* 61-1, 41°49'N, 68°14'W, 154 m. USNM 23761 (1), Provincetown, Mass. CU 45869 (1), *Albatross IV* 63-5-69, 42°07'N, 67°31'W. NEFC uncat. (3), *Albatross III* 70-23, 42°10'N, 68°38'W, 183 m. NEFC uncat. (1), *Albatross III* 101-103, 42°15'N, 67°10'W, 168 m. CU 23620 (3), *Albatross III* 27-55, 42°41'N, 69°49'W, 256 m. NEFC uncat. (1), *Albatross III* 47B-3-2, 42°41'N, 70°09'W, 84-139 m. USNM 83925 (1), Mass. Bay. USNM 21918 (1), Mass. Bay, 134 m. USNM 131920 (6), Mass. Bay. USNM 21918-9 (2), Mass. Bay. MCZ 34614 (3), 42°56'N, 70°18'W, 165 m. MCZ 34611 (3), *Albatross II*, 43°07'N, 70°10'W, 154 m. USNM 37847 (1), Ipswich Bay, Mass. MCZ 34612 (9), *Albatross II*, 43°03'N, 70°09'W. USNM 45897 (1), *Albatross*, 43°34'N, 63°56'W. MCZ 34613 (4), 43°39'N, 68°12'W, 192 m. MCZ 12340 (1), Eastport, Maine. USNM 39060 (1), Prince Edward Island. USNM 43229 (1), 47°15'N, 53°58'W. NMC 63-151 (1), 51°28'N, 53°52'W.

GREENLAND—ZMUC uncat. (1), *Adolf Jensen* 4420, 64°22'N, 52°54'W, 460-540 m.

ICELAND—ZMUC 95-96, (2), North coast of Iceland, ca. 66°N, 18°30'W. ZMUC 830-32 (3), Vestman Islands. ZMUC 26-27 (2), 63°46'N, 22°56'W. ZMUC P379 (1), south of Iceland. USNM 217909 (1), 65°37'N, 21°00'W, 110 m. USNM 217911 (1), 65°41'N, 21°20'W, 137-152 m.

EUROPE—USNM 39724 (1), Denmark. ZMUC 84-85 (2), 90-93 (4), 501, 503-4 (3), P37284-292 (9), P37294-96 (3), P37298 (1), Denmark. ZMUC P37283 (1), Limfjord, Denmark. P37297 (1). Kallundborg Fjord, Denmark. ZMUC 88 (1), 502 (1), Snekkersten, Denmark. ZMUC 86 (1), 98 (1), Oresund, Denmark. ZMUC 22-23 (2), Skagerak, 200 m. ZMUC 25 (1), off Lindesnøs, Norway, 220 m. USNM 44514 (1), Drobak, Norway.

AFRICA—MNHN 38-110/111 (2), off Cape Blanc, Mauritania.

Ciliata mustela

USNM 130840 (4), Europe. USNM 44510 (1), Norway. USNM 216711 (2), Oresund, Denmark.

Ciliata septentrionalis

ZMUC 371656-7 (2), Faroe Islands.

Gaidropsarus argentatus

MCZ 38353,38387 (2), western North Atlantic. USNM 217907 (1), Iceland. USNM 217912 (1), Iceland. USNM 217910 (1), Spitsbergen. USNM 217908 (2), Iceland.

Gaidropsarus ensis

MCZ 37554 (1), western North Atlantic. MCZ 27882 (1), western North Atlantic. MCZ 38425 (1), western North Atlantic. MCZ uncat. (1), western North Atlantic. USNM 217913 (1), western North Atlantic.

Gaidropsarus guttatus

USNM uncat. (2), (1), (5), San Miguel Island, Azores.

Gaidropsarus mediterraneus

USNM uncat. (1), Tunisia.

Gaidropsarus vulgaris

USNM uncat. (1), (1), (3), Tunsia.

Gaidropsarus sp.

USNM uncat. (5), Amsterdam Island.