ON THE RESTRICTED DISTRIBUTION OF TWO DEEP-SEA FISHES, *BOROPHRYNE APOGON* AND *STOMIAS COLUBRINUS*

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ABSTRACT

The restricted distribution of *Borophryne apogon* and *Stomias colubrinus*, both bathypelagic fishes, is notable. Although relatively few specimens have been caught to date, there is good evidence to indicate that their geographical distribution is limited. Knowledge about the epipelagic life of the early stages and about the bathypelagic life of the adolescents and adults of these species has been combined with our recent knowledge of ocean currents in the Pacific (including the Cromwell Current) to provide an explanation of their peculiar distribution.

INTRODUCTION

One may postulate that no animal species in the sea is rare. At least it is not easy to conceive of breeding populations of marine species totalling only a small number of specimens, as is the case with several terrestrial species, *e. g.*, some mammals and birds. Still many marine species are called *rare*, which in most instances probably means only that they have been *caught rarely*. Be that as it may, unlike the commercial fisherman or fisheries biologist, who can usually obtain specimens of a given species in as large quantities as is desirable for study, the biologist of the oceans must be satisfied with relatively few specimens. But, like the fisheries biologist, the oceanic biologist would like to know how the distributional pattern of a species is maintained, why it is rarely caught, etc. In short, he too would like to obtain knowledge of a species' life pattern and distribution by employing, when possible, chemical and physical observations of a species' environment.

On the following pages, two deep-water species (*B. apogon* and *S. colubrinus*) are discussed, largely from a viewpoint of distribution. The 50 specimens of *B. apogon* used in this study may seem a ridiculously small number compared with the thousands of specimens handled by fisheries biologists, but the correlations and conclusions

have been drawn along lines similar to those used for well known species. *S. colubrinus*, a more commonly caught fish than *B. apogon*, provides a more or less parallel case to that of *B. apogon*.

Borophryne apogon Regan 1925

Early Collections. In 1922 the DANA Expedition caught four females of a deep-sea angler fish in the Gulf of Panama in open ring-nets with 3500 m of wire out. They were described as a new genus and species, *Borophryne apogon*, by Regan (1925:564). The generic characters are so distinct that no other species has as yet been described for this genus.

When the DANA again visited the Gulf of Panama in 1928, four more specimens were caught: two females, each with a parasitic male attached to the abdomen. Thus far interest in the catch was mainly a zoological one (Regan and Trewavas, 1932:106). I still remember what a rare sight these specimens were when we got them from the deep. This later voyage of the DANA was under the leadership of Johannes Schmidt, and on her trip around the world the same methods of fishing were employed at all times. In the 801 open ring-net hauls with 600 m wire or more, several bathypelagic species showed a more or less cosmopolitan distribution, but *Borophryne* was taken only in the Gulf of Panama, in six hauls. Furthermore, in some 2380 hauls with less than 600 m wire and open ring-nets, no *Borophryne* were taken anywhere.

Beebe and Crane (1947:171), who visited the Central American Pacific also, in 1925 and 1938, caught three females, two of them with parasitic males, all from the vicinity of the Cocos Island and the Gulf of Panama. They were taken with open nets presumably from depths of 500 to 700 fathoms.

In 1951 Bertelsen revised all of the ceratioid fishes treated formerly by Regan (1926) and by Regan and Trewavas (1932), including the larval stages not studied by these authors. Bertelsen also identified the free living males of *B. apogon*, four of which were larvae only 7–16 mm long. Thus the number of *B. apogon* caught by the two DANA Expeditions totals seven females and 28 males; in addition Beebe and Crane had taken their three females and two males. All of these were taken in the Panamanian region.

Recent Collections. The GALATHEA Expedition 1950–1952, the Danish Deep Sea Expedition around the world, pursued an east-

TABLE I. BOROPHRYNE APOGON REGAN COLLECTED BY THE GALATHEA IN 1952

Sta.	*Date*	*Locality*	*Depth to Bottom (m)*	*Gear*	*Range of Catch (m)*	♀	♂	*Length (mm)* Total	Stand.
726	13 May	5°49′ N, 78°52′ W	3270–3670	Open otter-trawl	3670–0	1	..	*c.* 65	..
—	—	—	—	—	—	1	..	69	54
—	—	—	—	—	—	..	1	17	12
727	13 May	6°26′ N, 78°43′ W	3570	Pelagic otter-trawl	1150–0	1	..	52	40
—	—	—	—	—	—	1	..	60	44
—	—	—	—	—	—	1	..	83	63
—	—	—	—	—	—	..	1	19	13
—	—	—	—	—	—	..	1	*c.* 20	..
739	15 May	7°22′ N, 79°32′ W	915–975	Open triangular otter-trawl	975–0	1	..	74	57
—	—	—	—	—	—	1	..	79	58

ward course, in the opposite direction of the westward-bound DANA in 1928–1930. There was little pelagic fishing, but quite large bottom trawls (foot-rope 32 m) were used. These open nets brought up a considerable number of pelagic organisms caught between the bottom and the surface, among them a number of ceratioid fishes.

Figure 1. Distribution of *Borophryne apogon*. *a*, GALATHEA records; *b*, Earlier records.

Again, it was only when we arrived in the Panamanian region that we met with *Borophryne*; the catch was seven females, one with a parasitic male, and two free-living males; thus 10 specimens were added to the 40 noted above (see Table I, Fig. 1).

The Ceratioid Fauna of the Gulf of Panama. In his thorough revision of the ceratioid fishes, Bertelsen (1951) has ascertained that about 650 specimens had been described previously, of which 392 were taken on the DANA Expeditions; in his own study he added about 100 metamorphosing or metamorphosed males and about 2400 larvae. Regarding ceratioids in general, he concluded (1951:223): "From the information available we may presume that *the majority*

of the Ceratioid species will be found distributed in all the oceans and that species hardly occur with a distribution restricted to the Atlantic Ocean."

But here the Panamanian region is a striking exception. Bertelsen (1951:223) has written

> As pointed out earlier by R. and T. (1932, p. 13) a specially rich, both as to species and individuals, Ceratioid fauna was found by the "DANA" in the Gulf of Panama. This area has been investigated by 3 expeditions, and about 30 % of all known Ceratioids in the metamorphosed condition have been collected there. Apart from doubtfully identified larvae, males and members of the previously mentioned groups of species, representatives of 30 species have been taken there and of these 14 are not known from other areas. 6 of these however are only known from single specimens and amount to no greater percentage of the catches than one would expect from a comparison with other areas. On the other hand, some of the remaining 8 species occur in such relatively large numbers ... that this cannot be ascribed to chance. It is doubtfull, however, that the distribution of these species should actually be restricted to this narrow area. As will be noted in the following ecological section, we can find neither any natural barrier which might conceivably prevent a scattering of the larvae or older Ceratioids away from the area, nor special hydrographical conditions which might probably cause such a restricted distribution. It seems more probable that the special current conditions in the Gulf of Panama both horizontally and vertically have led to an accumulation of Ceratioids, which in other parts of their area of distribution are found so scattered that such a relatively large part of the species have not yet been observed elsewhere.

Regarding the distribution of ceratioid larvae in general relative to their environment, Bertelsen noted that the larvae are found only within the temperature interval 11 to 29° C and that most, if not all, species have at this stage their greatest frequency within the interval 15 to 25° C. This means that the larvae live in the thermosphere, above the thermocline.

This is in contrast to adult ceratioids in general, which live most often in the psychrosphere, below the thermocline; as Bertelsen (1951:232) has stated: "... the frequency maximum most often falls in the layers where the temperature is between 4° and 5°." This means that ceratioid adults in general are bathypelagic in the true sense of the word. However, *Borophryne* is an exception to the rule for ceratioids in general, since a female with a parasitic male attached was caught at 13° in the Gulf of Panama at a depth of only about 200 m (Bertelsen, 1951:231).

Another remarkable feature of ceratioids is their ability to tolerate

notably low amounts of oxygen, as Bertelsen (1951:233–234) has pointed out in his special analysis of this phenomenon in the Gulf of Panama. Suffice it to state here that the above mentioned female *Borophryne* with a parasitic male attached must have lived in water where the oxygen content was at most 0.1 ml/l, at a depth that is slightly less than that of the oxygen minimum (0.06 ml/l) for this station.

Stomias colubrinus

Like *B. apogon*, *S. colubrinus* Garman 1899 also has a peculiar pattern of distribution. The adults of this species probably live at much the same depths as those of *B. apogon*, in the psychrosphere, since practically all of the adolescents and adults were taken with 600 m wire or more. Also, the larvae probably live in the thermosphere, like those of *B. apogon*.

The DANA collections of the genus *Stomias* comprise 4879 specimens from all oceans. Ege (1934), who has given a detailed analysis of all of this material, has recognized six well defined species. Fig. 2 shows the distribution of *S. colubrinus*. Although only 210 specimens have been taken, it is safe to state that the species does not occur where bathypelagic fishing has been carried out except where shown in Fig. 2. For details, see Ege (1934).

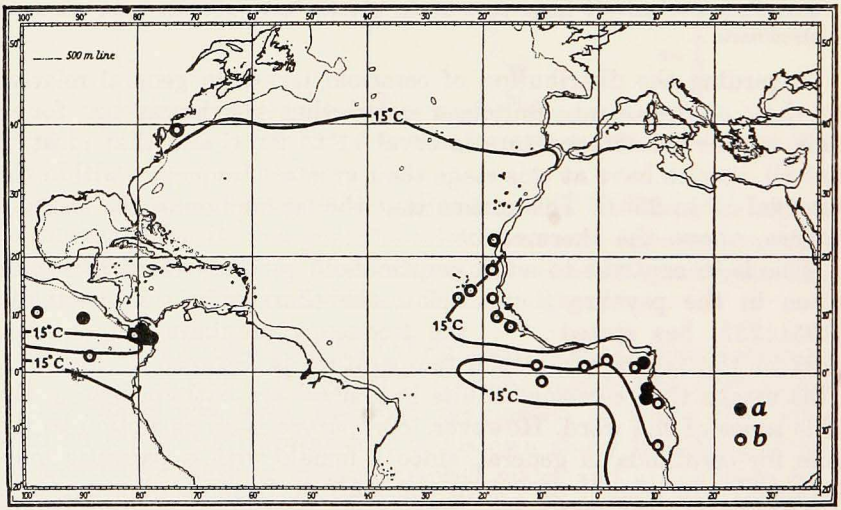

Figure 2. Distribution of *Stomias colubrinus*. *a*, GALATHEA records; *b*, Earlier records. Isotherms of 15° C at 100 m.

TABLE II. STOMIAS COLUBRINUS GARMAN COLLECTED BY THE GALATHEA

Sta.	*Date*	*Locality*	*Depth to Bottom (m)*	*Gear*	*Range of Catch (m)*	*No. of Specimens*	*Length (mm)*	
							Total	*Stand.*
52	30 November 1950	1°42′ N, 7°51′ E	2550	Shrimp otter-trawl	2550–0	1	68	65
—	—	—	—	—	—	1	178	168
65	4 December 1950	2°17′ S, 8°10′ E	2770	3 m sledge-trawl	2770–0	1	..	228
66	5 December 1950	4°00′ S, 8°25′ E	4020	3 m sledge-trawl	4020–0	1	..	96
—	—	—	—	—	—	1	..	103
716	6 May 1952	9°23′ N, 89° 32′W	3570	Open otter-trawl	3570–0	1	270	254
726	13 May 1952	5°49′ N, 78°52′ W	3270–3670	Open otter-trawl	3670–0	1	..	113
—	—	—	—	—	—	1	399	380
—	—	—	—	—	—	1	..	383
727	13 May 1952	6°26′ N, 78°43′ W	3570	Pelagic otter-trawl	1150–0	1	152	141
739	15 May 1952	7°22′ N, 79°32′ W	915–975	Open otter-trawl	975–0	1	..	*c.* 81
—	—	—	—	—	—	1	..	88
—	—	—	—	—	—	1	..	100
—	—	—	—	—	—	1	..	109
—	—	—	—	—	—	1	..	118
—	—	—	—	—	—	1	..	126

In the Gulf of Panama it has been recorded repeatedly ever since it was first described in 1889 from material taken on American expeditions. In 1922 it was caught by the DANA at the same stations which yielded *Borophryne* for the first time, and when we found it again on the DANA Expedition in 1928, it was like greeting an old friend. After we left the Panamanian region, for all our fishing, we did not encounter it again until we reached the West African region where it had been taken by the DANA in 1921; here it had been known since the German VALDIVIA Expedition recorded it in 1898.

The GALATHEA, as mentioned earlier, circled the earth in the opposite direction from the DANA, so we met with *S. colubrinus* promptly in its previously known area of occurrence (Fig. 2, Table II). Thus we met with it first in the West African region, and only then until we arrived in the Central American Pacific, where we collected it together with *Borophryne*.

The catch of a single specimen from the Hudson Gorge may eventually fit into the pattern discussed, but more material from this region is needed to determine whether or not it occurs there regularly.

THE CROMWELL CURRENT

In 1954 Cromwell, *et al.* made a significant contribution when they described the Pacific Equatorial Undercurrent, and in 1958 Knauss and King, who have suggested that it be called the Cromwell Current following the untimely death of its discoverer, described it thus:

> "The Undercurrent is an east-flowing current centred at the equator just below the west-flowing South Equatorial Current. Measurements at long. 140° W indicate a transport of the order of 30 million cubic metres a second or about the same as the transport of the Florida Current. Measurements along the current indicate that it is at least 3500 miles long."

CONCLUSIONS

To most biogeographers, including myself (Bruun, 1936), it has always been a puzzle how adult animal species remain in a restricted area, as in the case of *B. apogon* and *S. colubrinus*, particularly when their larvae, living epipelagically, have apparently been carried far from that area by surface currents. That a solution would be found

by correlating our knowledge of a species' life history with that of current systems seemed clear. In the recent discovery of the Cromwell Current, physical oceanology has offered us what may prove to be a key to the puzzle of the distribution of *B. apogon* and *S. colubrinus*, and probably of many other problems as well. Is it not probable that the larvae of *B. apogon*, at about the time that they are metamorphosing into adolescents, seek deeper layers and that the Cromwell Current may take them back to the Pacific Panamanian region whence they came?

As we know, there are some general similarities between West African waters and corresponding tropical waters to the west of Central America (*e. g.*, upwelling, abundant nutrients, food, etc.). All things considered, a biologist might postulate a current in the Atlantic similar to the Cromwell Current in the Pacific which would provide an ecological set-up for *S. colubrinus* and other species of the Atlantic that is similar to that for *B. apogon*. Cromwell, *et al.* (1954) have stated, "whether or not the current prevails in the eastern and western Pacific and in the Atlantic remains to be determined by further study". Certainly much more detailed information is required before a satisfactory picture incorporating all factors can be developed and consummated.

I have presented these striking examples of the distribution of two deep-sea species to demonstrate how much biologists need more observations of the physical and chemical aspects of oceanology, particularly from deep waters close to both West Africa and Central America, since they may be just as varied and complicated as surface waters (Brandhorst, 1958).

Thomas G. Thompson, my highly esteemed friend for many years, has been a great spirit in this field; may he still inspire many followers.

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