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ON THE MIDWATER FISH FAUNAS OF GULF STREAM RINGS
WITH RESPECT TO HABITAT DIFFERENCES BETWEEN
SLOPE WATER AND NORTHERN SARGASSO SEA

by

ANDREW E. JAHN

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Signature of Author:
Department of Biology, Woods Hole Oceanographic
Institution, April, 1976.

Certified by:
Thesis Supervisor

Accepted by:
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Submitted to the Woods Hole Oceanographic Institution program in Biological Oceanography in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Forty-three 1000-m oblique Isaacs-Kidd midwater trawl collections were made on six cruises. In most cases, these were accompanied by 1500-m hydrocasts and plankton tows to 800 m. The fish collections comprise 19,400 specimens in 129 species, from Slope Water, Gulf Stream, Northern Sargasso Sea, and four cold-core rings. Temperature, salinity, oxygen, phosphate, and zooplankton biomass information accompany the collections.

A model predicts that expatriate populations of Caribbean species can be maintained in the Slope Water and Northern Sargasso Sea in excess of 15 per cent of their Caribbean population density. With Caribbean contamination accounted for, the relative abundances of species in Slope Water and Northern Sargasso Sea are used to assign habitat preferences. Species clusters derived from an ordination using correspondence analysis agree well with the habitat preference groups.

The assemblage of species in the rings occupies the middle of a gradient in faunal composition from winter conditions in Slope Water to fall conditions in the Northern Sargasso Sea.

The midwater habitat is modeled as two layers, and the ring environment as a hybrid habitat consisting of a surface layer of Northern Sargasso Sea habitat and a deep layer of Slope Water habitat. This model is consistent with patterns of species abundance. It is argued that the dramatic change in the depth of the main thermocline on crossing the Gulf Stream is the major physical factor affecting fish distributions with respect to this boundary.

Thesis Supervisor: Richard H. Backus, Senior Scientist
Woods Hole Oceanographic Institution

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INTRODUCTION

As distributional patterns of oceanic animals become well-known, they set the stage for ecological studies. Zoogeographic work in the Pacific on several taxonomic groups by various authors has been summarized by McGowan (1974), who recognizes eight major "biotic provinces" having broadly overlapping boundaries. In the Atlantic, studies of the distributions of mesopelagic fishes (Backus et al., in press) have identified 20 faunal provinces in seven faunal regions and drawn their boundaries according to hydrographic discontinuities. Although the approaches in these two oceans have been somewhat different, the results are much the same: 1) the center(s) of abundance of a pelagic species generally lies in a hydrographically well-defined region(s), 2) such a region supports a characteristic assemblage of species, and 3) the boundaries of species distributions tend to coincide with hydrographic boundaries.

McGowan (1974) emphasizes the idea that the "core" assemblages of faunal regions (biotic provinces) compose communities, and that the regions comprise ecosystems whose structure and function should be investigated in the centers of semi-enclosed oceanic gyres. Such studies will be essential in understanding high seas ecology. However, this understanding will be incomplete without knowing which aspects of the physical environment are important parameters of oceanic habitats. Environmental conditions in a given faunal region are either constant (horizontally) or change monotonically until a boundary is reached. While

the mixture of species encountered at a boundary is unlikely to be suited for synecological studies, it is precisely at the boundary between two regions where perturbations in the physical environment will be apt to stress the species in such a way as to illuminate important habitat differences.

In the western North Atlantic, the northern edge of the Gulf Stream separates the Slope Water province of the North Atlantic Temperate Region from the Northern Sargasso Sea province of the North Atlantic Subtropical Region (Backus et al., 1970; Jahn and Backus, in press; Backus et al., in press). The Jahn and Backus study was done as background for the present one. Their data were from 51 horizontal tows made with a 10-foot Isaacs-Kidd midwater trawl in Slope Water, Gulf Stream, and Northern Sargasso Sea. The collections were taken in summer and fall, almost exclusively in the upper 500 m. Using cluster analysis it was found that the Slope Water and Northern Sargasso Sea collections formed two distinct groups. The three Gulf Stream collections from the upper 100 m clustered with the Northern Sargasso Sea group, and the four deeper ones joined a subset of the Slope Water group. The Gulf Stream was viewed as a special zone of overlapping habitats, and it was concluded that biological studies of the Stream itself would be valuable in investigating the mechanism by which it serves as a faunal boundary.

The present study, while not of the Gulf Stream proper, takes advantage of a remarkable phenomenon associated with it. With some regularity,

the meandering Gulf Stream forms long loops which pinch off from the main current, forming eddies of a special class known as Gulf Stream rings (Fuglister, 1972). So-called "warm-core rings", which form to the left of the downstream direction of the current, inject large amounts of Gulf Stream water along with its biota into the Slope Water. This research makes particular use of cold-core rings, which form to the right of the Gulf Stream, isolating a piece of the Slope Water environment, along with its biota, within another faunal province (and region), the Northern Sargasso Sea. The ensuing decay of the rings was expected to be accompanied by changes in the midwater fish fauna that could be interpreted in terms of specific changes in the environment.

MATERIAL AND METHODS

The data are from six cruises: Atlantis II 71 (September and October, 1972), Chain 110 and 111 (January and February, 1973), Knorr 35 (November and December, 1973), Knorr 38 (March and April, 1974), and Atlantis II 85 (October, 1974). All cruises except Chain 110, a gear-testing cruise in the Slope Water, were designed mainly to find and sample cyclonic, cold-core Gulf Stream rings. In order to identify and delineate the rings, running plots were maintained of the temperature structure of the surface layer using BT's (Atlantis II 71) and XBT's (all cruises). When a ring is first transected, knowledge of the current field is helpful in locating its center. Satellite navigation was used to monitor the set of the ship, thus allowing successive transects to be made in optimal ways.

Stations were made in the Slope Water, Northern Sargasso Sea, and cold-core rings, and sometimes in the Gulf Stream and in warm-core rings. Each station consisted of a hydrocast (1000 m on Atlantis II 71, and 1200 or 1500 m on subsequent cruises), plankton tows, and a midwater trawl, all spaced as closely as efficient use of ship time permitted. An overview of the entire operation, including chemical analytical techniques, is given in Wiebe et al. (in press). Midwater trawls and plankton tows were all made at night in order to avoid variability due to diel vertical migration and net avoidance.

The trawl used was a 10-foot Isaacs-Kidd midwater trawl, fully

lined with one-quarter-inch stretch mesh and equipped with a Benthos time-depth recorder and a General Oceanics model 2030 digital flowmeter.

The flowmeters used were tested near Woods Hole on a measured course and found to agree within 10% of the factory calibration. To make all trawls comparable 1000 m oblique tows were used, insuring that the meso-pelagial would be thoroughly sampled. Trawling procedure was to set the net at low speed, and then pay out 3000 m of wire at about 75 m per minute with a ship speed of about five knots. Ship speed was then reduced to about three knots, and the net was hauled at 25 m per minute. The entire tow thus took about three hours, covering a distance of about 10 miles. The actual maximum depth of tow, measured by the time-depth recorder, varied between 775 and 1355 m with a mean of 960 m.

Although the three parts of each station - hydrocast, trawl, and plankton tow - were designed to complement one another, the combined distance covered by the latter two activities was sometimes as great as 20 miles. Because of the strong horizontal gradients in physical properties of the rings, the three parts of a station were often not made in strictly comparable environments. This situation can be appreciated in Figure 1, which shows the relationship of trawls and hydrocasts to the 300 m temperature field of the Knorr 35 ring (Ring 3). Trawls were bracketed by XBT's, and associated with the most appropriate hydrocast on the basis of 300 m temperatures. For instance, trawl 403 (300 m $T = 14.3-12.6$) was intended to match hydrocast 357 ($T = 11.1$) but was

Figure 1. Segment of Cruise track of Knorr cruise 35 (broken line) showing hydrocast positions (x's) and midwater trawls (heavy segments) superimposed on contours of temperature at 300 m.

KNORR 35
300m

instead associated with hydrocast 358 (T = 12.5). Similarly, trawl 405 (T = 12.9-12.1) was associated with hydrocast 358, and trawl 404 (T = 10.8-11.8) was matched with hydrocast 359 (T = 11.8). The collection data appear in Appendix A.

Collections were preserved at sea in 10% buffered formalin. In the laboratory, the fishes were separated from the invertebrates and transferred to 70% ethanol. Displacement volumes were measured for both fractions, and biomass estimates were made assuming the factory calibration for the flowmeter and a mouth opening of 8.36 m^2 (9 x 10 feet) for the IKMT.

All adult and juvenile eels, stomiatoids, myctophids, and melamphoids were identified and for each species lot (all individuals of a single species in a single collection), the minimum and maximum standard lengths to the nearest mm, the total displacement volume to the nearest tenth ml, and the number of individuals were recorded. This information (presented in Appendix B) was stored on magnetic tape for computer processing.

Identification and nomenclature authorities used for eels are as follows: Nemichthyidae, Beebe and Crane (1937); Derichthyidae and Nessorhamphidae, Beebe (1935a, b); Serrivomeridae, Beebe and Crane (1936), Tighe (1975).

Stomiatoid fishes were assigned to families according to the recent revision by Weitzman (1974) and identified by use of the various contributions of Gibbs, Grey, and Morrow to part 4 of Fishes of the

Western North Atlantic (1964), supplemented with the following: genera Sternoptyx and Argyropelecus, Baird (1971); genus Cyclothone, Mukhacheva (1964). The head pigment technique of Bond and Tighe (1974) for identifying lightly-pigmented Cyclothone was useful but could not be relied upon in this material for positive separation of C. braueri and C. alba. Many specimens of C. braueri as large as 15-16 mm standard length were found to display the spotless condition diagnostic of C. alba.

The lanternfishes (Myctophidae) were assigned to genera according to Paxton (1972). The basic text for identifications was Fraser-Brunner (1949), supplemented as follows: Symbolophorus, Bolin (1959); Myctophum affine and M. nitidulum, Gibbs (1957); Lobianchia and Diaphus, Nafpaktitis (1968); Lampadena, Nafpaktitis and Paxton (1968); Taaningichthys, Davy (1972); Lampanyctus, Bolin (unpublished key); Bolinichthys and Ceratoscopelus, Nafpaktitis and Nafpaktitis (1969); Notoscopelus, Nafpaktitis (1975).

Melamphids were identified according to Ebeling and Weed (1973).

HYDROGRAPHY

The name 'Sargasso Sea' originated as a biogeographic term, referring to the distinctive presence of drifting seaweeds (Sargassum sp.), first reported by Columbus and known to early Portuguese sailors as salgazo. Varenus (1650) has been credited with first using the term in print, referring to "the famous area called by the Portuguese mare de Sargasso" (quoted in Winge, 1923). Krummel (1891) and Winge (1923) published maps of the sea based on the distribution of the weed. Iselin (1936), in describing the distinctive physical properties of the region, retained the term Sargasso Sea for that portion of the western North Atlantic bounded on the west and north by the Gulf Stream, but having ill-defined boundaries to the east and south. Worthington (in press) defines the boundaries of the Sargasso Sea as the limits of water with a salinity at 300 m of 36.40-36.60‰.

In Worthington's (in press) model of North Atlantic circulation, the Gulf Stream turns south at the tail of the Grand Banks, and circulates west of the Mid-Atlantic Ridge, with about two thirds of the volume transport circulating north of Bermuda. In the "warm water layer", a considerable portion of the Gulf Stream system flows through the Caribbean Sea, where it is joined by a small amount of South Atlantic water, to reenter the Sargasso Sea through the straits of Florida. Thus, the Sargasso Sea is equivalent to that portion of the Gulf Stream system circulating north of the Antilles; it is envisioned as an anti-cyclonic gyre nearly closed except for the contribution of South Atlantic

water, which is apparently balanced by occasional outbreaks from the gyre into the eastern Atlantic.

Morphologically, the outstanding feature of the Sargasso Sea is its superabundance of water at a temperature of about 18°C and salinity of about 36.5‰. This so-called 18° water is formed north of Bermuda in winter through cooling of the surface water by contact with the atmosphere. Thus modified, the surface waters converge, and in early March, just south of the Gulf Stream, 18° water may occupy the entire upper 400 m of the water column (Worthington, 1959, in press). While a seasonal thermocline develops in the upper 200 m, between 200 m and 400 m the northern Sargasso Sea contains 18° water the year round.

Below the 18° water begins the main thermocline, approximately centered at the 10° isotherm (Iselin, 1936). Just south of the Gulf Stream, the 10° isotherm lies at about 900 m, rising abruptly through the Stream to level off between 200 to 300 m in the Slope Water.

The oxygen minimum layer, delimited by the isopleths of 60% saturation, follows the main thermocline almost exactly (Seiwell, 1934). Oxygen values do not drop below about three ml/l in the western Atlantic, so that the minimum, while distinct, is poorly developed compared to such areas as the eastern tropical Atlantic and Pacific oceans (Sverdrup et al., 1942).

The Slope Water lies over the continental slope and the continental rise, inshore of the Gulf Stream from the offing of Cape Hatteras to about the tail of the Grand Banks. Iselin's (1936) discussion of

Slope Water was largely based on stations off Chesapeake Bay, in the extreme western part of the region. He reported the seasonal temperature and salinity cycles and noted that the water below the main thermocline was less saline than Sargasso Sea water by 0.02‰ to 0.04‰.

McLellan (1957), working south of the Grand Banks and Scotian Shelf, found this salinity difference to be as much as 0.1‰, attributing the discrepancy to greater Labrador-Coastal water influence in the eastern sector. In the present data, below about 12° Slope Water and Sargasso Sea water are virtually indistinguishable in their T-S relations.

Besides the radical difference in the depth of the main thermocline, the Slope Water differs markedly from the Sargasso Sea in the characteristics of its surface water. Formed, ultimately, from a mixture of Labrador Current water and Gulf Stream water (McLellan, 1957), the Slope Water above the main thermocline is fresher than Northern Sargasso Sea water by as much as 3‰. As noted by Pollak (1947), the copious intrusions of Gulf Stream water via warm-core, anticyclonic Gulf Stream rings (Saunders, 1971; Parker, 1972) distributed over the relatively small area of the Slope Water, make its hydrography extremely unpredictable. The situation is further complicated by large scale fluctuations in the amount of input of cold, relatively fresh Labrador-coastal water (Worthington, 1964).

In order to balance the input of Gulf Stream water to Slope Water by "warm-core rings", McLellan (1957) postulated an eastward-flowing current in the Slope Water transporting 20 million m³ per second. The regularity of the occurrence of cold-core rings, which remove sufficient

water from the Slope Water to approximately balance the Gulf Stream input, was not then appreciated. Worthington (in press) notes that the transport of the Slope Water current can be only about two million m^3 per second and doubts that it is a steady feature.

The seasonal temperature cycles of Slope Water and Northern Sargasso Sea are shown in Figure 2. The Slope Water curves were drawn from data averaged over a period of 19 years (from Colton and Stoddard, 1972) for a 30-minute quadrangle centered at $39^{\circ}45'N$, $69^{\circ}00'W$. The Sargasso Sea curves are redrawn from Fuglister (1947), and are based on from 27 to 203 observations per month (number of years unspecified) for the area bounded by 34° - $37^{\circ}N$, 62° - $68^{\circ}W$. Note that even on the average, the Slope Water displays a wider range of temperature in the surface layer. Surface temperatures reported here (Appendix A) range from $9.2^{\circ}C$ (February) to $23.7^{\circ}C$ (September) in the Slope Water and from $19.1^{\circ}C$ (February and March) to $27.1^{\circ}C$ (September) in the Sargasso Sea. The general shape of the two pairs of curves in Figure 2 is the same. As the seasonal thermocline develops, the temperature contrast between the surface and 100 m increases. As fall and winter conditions destroy the stratification, heat is mixed downwards, producing the later temperature maximum at 100 m. Note also that complete mixing does not extend to 100 m in the Slope Water. Fourteen $^{\circ}C$ marks the top of the main thermocline (Iselin, 1936).

The major differences between Slope Water and Northern Sargasso Sea are summarized by the temperature-salinity (T-S) correlations shown

Figure 2. Seasonal temperature cycles of Northern Sargasso Sea and Slope Water. Slope Water data from Colton and Stoddard (1972), Northern Sargasso curves redrawn from Fuglister (1947).

Figure 3. T-S plots for Slope Water, Northern Sargasso Sea, and four cyclonic Gulf Stream rings (see Table 1 and Figure 5).

in Figure 3. Above the main thermocline, at a given temperature, Slope Water is nearly always fresher than Sargasso Sea water, owing to the admixture of Labrador current water in the former. In contrast to the tight packet of curves for the Northern Sargasso Sea, the T-S relation in the Slope Water displays marked variability both temporally and spatially (e.g., the two Slope Water curves for Knorr cruise 38).

Also shown in Figure 3 are T-S curves for the four Gulf Stream rings to be dealt with here. The formation of a cold-core Gulf Stream ring is shown diagrammatically in Figure 4a (redrawn from Fuglister, 1972). A southward meander of the Stream pinches off from the main current, surrounding a core of colder, fresher Slope Water. These structures can be recognized in the Sargasso Sea by their intense cyclonic rotation (ca. 200 cm/sec) and their anomalously low temperatures and salinities at depth.

The formation of a so-called "warm-core ring" (Figure 4b) proceeds somewhat differently. Whereas a cold-core ring involves the entire width of the Stream, budding off a deep column of Slope Water, the large eddies forming to the left of the Stream are of a more peripheral nature. Water from the left-hand side of the Stream spills into a large meander, where current speeds decrease to about 50 cm/sec. When separated from the Stream, the resulting eddy is a conical lens of Gulf Stream water extending below the thermocline of the Slope Water, to a depth of slightly more than 600 m. Since Richards and Redfield (1955) were able to trace Caribbean low-oxygen water along the left-hand side of the Stream at

Figure 4. Schematic of formation of (A) a cyclonic, cold-core ring and (B) an anticyclonic, warm-core ring. 'A' redrawn from Fuglister (1972).

least as far east as 62°W , it seems unlikely that any considerable amounts of water from the Northern Sargasso Sea are introduced directly into the Slope Water by these relatively shallow "warm-core rings".

It has been estimated that from five to eight of each type of ring form annually (Newton, 1961; Barrett, 1971; Fuglister, 1972). Recent surveys have found support for the number five for cold-core rings (Cheney and Richardson, 1975) and eight for warm-core rings (Parker, personal communication). The size and shape of rings vary, but cold-core rings are on the order of 150 km in diameter, as measured by the extent of the Slope Water core at 200 m (Parker, 1971), and warm-core rings are somewhat smaller, on the order of 100 km (15 at 200 m) (Saunders, 1971; Parker, 1972).

Parker's unpublished survey indicates that the warm-core rings are formed in the vicinity of 65° - 70°W and reside in the Slope Water for several months, during which time they migrate more-or-less steadily toward the west and south. They are eventually recaptured by the Gulf Stream near Cape Hatteras, as observed by Thompson and Gotthardt (1971), having decreased in surface area by about one-half.

Because of the substantial structural and dynamic differences between the two types of large eddies, it is doubtful that the term "ring", first applied to the cyclonic eddies (Fuglister, 1972) should be used for both. However, for convenience, the term "warm-core ring" will be used here to refer to anticyclonic Gulf Stream eddies of sufficient magnitude to cause perturbations in the main thermocline of the Slope

Water. Unless otherwise specified, the unmodified term "ring" will refer to cyclonic, cold-core Gulf Stream eddies.

The Slope Water core of a ring can be viewed as a hump in the pycnocline of the Sargasso Sea. The hump gradually shrinks and flattens as potential energy is converted to kinetic energy in the spin-down process (Newton, 1961; Barrett, 1971). Decay rates have been estimated by the rates of subsidence of isothermal surfaces, rates of horizontal shrinking of the core, and rates of decay of the available potential energy (Barrett, 1971; Parker, 1971; Fuglister, 1972; Cheney and Richardson, 1976). The last authors show that all three methods give similar results, and attribute the range in the various estimates to differences in the rings studied, errors in measurements, and vagaries in extrapolating from short time periods of observation. The estimates of decay rate cited above imply life expectancies of from one to four years. Because the depth of an isotherm is easiest to measure, it is the method of age estimate used on two of the rings in this study.

The shape, size, depth of the 15° isotherm, and age (known or estimated) of the rings are summarized in Table 1. Rings 2 and 3 (Chain 111 and Knorr 35) were observed by satellite during formation, and their ages are known to within a week (NAVOCEANO communication to P. Wiebe). The ages of Rings 1 and 4 (Atlantis II 71 and Knorr 38) were estimated by successive approximation, using a subsidence rate of 0.6 m/day for the 15° isotherm, and assuming the average seasonal temperature cycle in the Slope Water (Colton and Stoddard, 1972) to indicate

TABLE 1

Ring characteristics

Ring no.	Cruise	Shape	Dimensions (km) 15° at 300 m	Depth (m) of 15° isotherm		Age (months)	Method (see text)
				Observed minimum	Extrapolated initial value		
1	<u>Atlantis II</u>	circular	40 x 35	250	50	10-11	estimate
2	<u>Chapin III</u>	bilobed	120 x 20	225	120	3.5	satellite
3	<u>Knorr 35</u>	elliptical	95 x 65	177	100	3	satellite
4	<u>Knorr 38</u>	circular	55 x 50	245	60	10	estimate

the initial conditions for the rings. The subsidence rate used is that found by Parker (1971) for the 17° isotherm of a recently-formed ring. It should be clear from the above discussion of decay rate estimation that the age estimates in Table 1 are crude. In addition to the vagaries of estimating initial conditions and arbitrarily choosing a subsidence rate (which vary in the literature from ~ 1 to ~ 0.3 m/day), it is not known for certain that the decay rate is actually linear.

Rings 2 and 3, then, were three and three and one-half months old, respectively, and Rings 1 and 4 are thought to have been about 10 months old. The rings also differ markedly in shape, from nearly circular (1 and 4) to elliptical (2 and 3), Ring 2 resembling a peanut (Figure 5). It can also be seen, in the spacing of isotherms in the figure, that the horizontal temperature gradients in the two younger rings (2 and 3) are considerably sharper than those of the older two (1 and 4). Thus, while there are differences among all of them, the four rings tend to fall into two categories, a trend also seen in the T-S plots (Figure 3). The curves for Rings 2 and 3 diverge at about 12° with the set of Slope Water curves, being somewhat saltier at higher temperatures, while Rings 1 and 4 diverge from the basic Sargasso Sea curve at about 14° . Either these older rings were saltier to begin with, or else their salinity anomalies have disappeared sooner below 14° than at higher temperatures.

Figure 5. 300-m temperature contours of four rings, numbered as in Table 1.

1

2

3

4

Summary of hydrography

1. The Northern Sargasso Sea is the northern half of a nearly-closed gyre, the Gulf Stream System.

2. The main thermocline is centered at about 900 m in the Northern Sargasso Sea, rising abruptly through the Gulf Stream to a depth of about 250 m in the Slope Water. The oxygen minimum layer, which is poorly developed, coincides with the middle of the main thermocline.

3. Above the main thermocline, the temperature-salinity characteristics change markedly on crossing the Gulf Stream. A mixture of Labrador current water and Sargasso Sea water, the surface Slope Water is cooler and fresher, and much more variable both temporally and spatially than the Northern Sargasso Sea.

4. At an estimated rate of eight times per year, shoreward meanders of the Gulf Stream form large eddies approximately 100 km in diameter at 200 m, and about 600 m deep at their centers. These so-called "warm-core rings" persist for several months before being recaptured by the Stream.

5. At an estimated rate of five times per year, seaward meanders of the Stream pinch off, enclosing a core of Slope Water approximately 150 km in diameter. These rings extend nearly to the bottom and can persist for periods on the order of two years, during which time temperature and salinity anomalies subside.

6. Four such rings reported here fall into two classes based on age, size of cold core, shape, T-S correlation, and intensity of

horizontal temperature gradient. Rings 2 and 3 are known to have been three and three and one-half months old, respectively, and Rings 1 and 4 were probably at least 10 months old. The younger rings were roughly elliptical and had more extensive cold cores bounded by sharper temperature gradients than the older rings, which were nearly circular with more diffuse horizontal temperature gradients. The T-S curves for the younger rings diverge from the basic Sargasso Sea curve at about 12°C, whereas those of the older rings diverge at about 14°C.

THEORETICAL CONSIDERATIONS

In order to relate the faunal changes in Gulf Stream rings to changes in the habitat, it will be useful to know which species are adapted to ambient conditions in the Slope Water, which are adapted to conditions in the Northern Sargasso Sea, and which are present in these areas mainly as expatriated waifs. Over oceanic areas, fishes of a size treated here (ca. 20 to 200 mm) must be considered planktonic, that is, they will generally be carried along with any large-scale water movements. Although random swimming will introduce small numbers into neighboring environments, these fish will display no significant ability to actively select a habitat by horizontal movements.

From the water movements described in the previous section, it is clear that the Slope Water has inputs from the Gulf Stream and the Labrador Current. Since the Labrador water flows over the continental shelf and enters the Slope Water mainly as so-called Labrador-Coastal water, it is assumed not to be a major carrier of mesopelagic fishes. From the manner of formation of warm-core rings (Figure 4b) it is apparent that the major input to the Slope Water of Gulf Stream water is from the left-hand (inshore) side of the current. Richards and Redfield (1955) traced low-oxygen water of Caribbean origin along the left-hand side of the Stream as far east as 62°W. Their Figure 14 clearly shows an intrusion of this low-oxygen water into the Slope Water. Therefore, it will be assumed that the major source of expatriate fishes in the

Slope Water is the Caribbean Sea fauna, introduced by way of the Florida Current and Gulf Stream.

Only a small fraction of the volume transport of the Florida Current can enter the Slope Water. The remainder must circulate within the Sargasso Sea. Thus, the Northern Sargasso Sea fauna receives inputs from the Caribbean and from the Slope Water, the latter via cold-core rings.

By quantitatively modeling the appropriate advective processes, the rates of expatriation to Slope Water and Northern Sargasso Sea can be estimated. Species present in a habitat in numbers greater than expected by expatriation must represent spawning populations adapted to the habitat.

Thus, once the effects of expatriation are accounted for, the relative abundance of a species in the Slope Water and the Northern Sargasso Sea can be used as an index of its habitat "preference". The assignment of species to habitat preference groups will facilitate the interpretation of the faunal composition of the rings.

MIXING MODEL

In modeling the inputs to Slope Water and Northern Sargasso Sea it will be assumed that the fishes mix in the same proportions as the water and, for simplicity, that the effects of the mixing are uniform throughout each habitat. For reasons stated in the previous section, the Labrador Current is ignored, and direct intrusion of Northern Sargasso Sea water into Slope Water is assumed to be negligible. The areas of the Slope Water ($4.85 \times 10^5 \text{ km}^2$) and Northern Sargasso Sea ($32.9 \times 10^5 \text{ km}^2$) used in the following computations were planimetered from the map of faunal regions and provinces of Backus et al. (in press). The chart they use is a Mollweide equal area projection, and the derivation of the boundaries is described in their paper.

In a crude way, both cold- and warm-core rings are modeled as cylinders advecting the entire depth of the water column. In this case, eight warm-core rings, 150 km in diameter, shrinking by one-half their area before recapture by the Stream, would account for $7.05 \times 10^4 \text{ km}^2$ of Florida Current (Caribbean) water, or 15 percent of the Slope Water area annually. Five cold-core rings with core diameters of 150 km would advect $8.33 \times 10^4 \text{ km}^2$ of Slope Water, or slightly less than three percent of the Northern Sargasso Sea surface area each year.

Because of the great change of current speed with depth, this model cannot be applied to the input of Florida current water to the Northern Sargasso Sea. Therefore, a second model, employing volume

transports, is presented.

G. Fleiri's unpublished model of cold-core ring dynamics predicts a level on the order of 1000 m above which particles (water molecules, fish, etc.) will be transported by the rings. One thousand m is commonly considered the lower limit of the mesopelagial (Hedgpeth, 1957). To the extent that cold-core rings can be modeled as cylinders, the volume advected is directly proportional to the area advected, and therefore the input of Slope Water to the Northern Sargasso Sea mesopelagial is the same as in the first model, or about three per cent per year.

In computing the inputs of Florida current water to Slope Water and to Northern Sargasso Sea, only water warmer than 12°C is considered. The 12° isotherm lies at about 500 m in the Caribbean, 800 m in the Northern Sargasso Sea, 200 m in the Slope Water (Fuglister, 1960), and 450 m in the center of newly-formed warm-core rings (Saunders, 1971; Parker, 1972). The most serious deficiency of this model is its incomplete "sampling" of the Caribbean mesopelagial. Although most mesopelagic fishes have their centers of abundance above 500 m at night, many of them live below this depth in the daytime, so that the estimate of expatriation from the Caribbean may be low by roughly 25 per cent. Warm-core rings, which only extend to 600 m, will be modeled as cones, so that the input of Florida Current water to Slope Water below 12° would be the relatively small volume at the apex of the cone, an unimportant deletion for the present purpose.

Restricting the volumetric model to water warmer than 12° allows

use of Worthington's (in press) estimates of volume transport for the upper thermocline (12° to 17°) and warm water ($>17^{\circ}$) layers. Furthermore, since 12° is the temperature above which Slope Water differs in its T-S characteristics from Gulf Stream water, the model can be checked against the composition of Slope Water.

In this model, eight conical warm-core rings, 450 m deep and 150 km in surface diameter, shrinking in surface area by one-half before being recaptured by the Gulf Stream, would contribute $1.06 \times 10^4 \text{ km}^3/\text{yr}$ of Florida Current water to the Slope Water, or 11 per cent of the volume of the upper 200 m.

The average volume transport of the Florida Current in the upper thermocline and warm water layers is 25 million m^3/sec , or $7.9 \times 10^5 \text{ km}^3/\text{yr}$. About 60 percent of the Gulf Stream circulates within the Northern Sargasso Sea, suggesting an input from the Florida Current of $4.7 \times 10^5 \text{ km}^3/\text{yr}$, or 18 per cent of the volume of the upper 800 m.

A consequence of this first model is the problem of balancing the inputs of Labrador and Gulf Stream waters in the upper 200 m of the Slope Water. According to McLellan (1957), the Labrador:Gulf Stream ratio in the surface layers of the Slope Water varies from 1:1 to 1:3 with an average of about 1:2. Estimates of the amount of Labrador water input into the Slope Water vary considerably, but Worthington (personal communication) notes that it must be at least one-half million m^3/sec . To satisfy the 1:2 ratio requires an average Gulf Stream input into the Slope Water of at least one million m^3/sec , or $3.16 \times 10^4 \text{ km}^3/\text{yr}$. The

model predicts a Gulf Stream input to Slope Water of only $1.06 \times 10^4 \text{ km}^3/\text{yr}$, leaving a deficit of $2.1 \times 10^4 \text{ km}^3$. This must be made up by either a greater contribution from warm-core rings or by a very large number of smaller, shallower Gulf Stream eddies, or both. In any case, the predicted input of Caribbean water to Slope Water in the second model is undoubtedly too small, though it is of the right order of magnitude.

If the required amount of Gulf Stream water enters the Slope Water in the form of warm-core rings, the input of the Caribbean mesopelagial will be about three times that supplied in the second model and twice that supplied in the first. On the other hand, if much of the volume is due to smaller Gulf Stream eddies, the mixing will occur much nearer the surface and involve fewer mesopelagic fish. These effects cannot at present be evaluated. The best course is to use the value of 15 per cent from the first model, realizing that the input of Caribbean water to the Slope Water mesopelagial may actually be somewhat greater.

Summary of mixing model

1. Mesopelagic fishes are assumed to be transported by the Gulf Stream and by cold- and warm-core Gulf Stream rings and to mix in the same proportions as the water.

2. The major source of expatriate fish populations in the Slope Water is considered to be the Caribbean Sea. Caribbean fishes are expected to be found in Slope Water concentrations on the order of 15 per cent of their Caribbean levels.

3. The sources of expatriation to the Northern Sargasso Sea are the Slope Water and the Caribbean Sea. Slope Water fishes are expected in the Northern Sargasso Sea in about 3 per cent of their Slope Water concentrations. Caribbean fishes are expected in the Northern Sargasso Sea in about 18 per cent of their Caribbean concentrations.

ASSIGNMENT OF HABITAT PREFERENCES

Criteria for assignments

The foregoing considerations indicate that intrusions of the Slope Water and Northern Sargasso Sea habitats into one another are minor, on the order of a few percent or less. Once the contamination by Caribbean species is accounted for, the relative abundance of species in the Slope Water and Northern Sargasso Sea can be used to assign habitat preferences. Species that are about 10 times as abundant in the Northern Sargasso Sea as in the Slope Water are considered to show strong preference for the Northern Sargasso Sea, and are placed in preference group 'N'. Species that are less than 10 times but more than twice as abundant in the Northern Sargasso Sea as in the Slope Water are considered to show moderate preference for the Northern Sargasso Sea, and are placed in preference group 'n'. Likewise, species that are about 10 times as abundant in the Slope Water as in the Northern Sargasso Sea are placed in preference group 'S' (strong Slope Water preference), and those less than 10 times but more than twice as abundant in the Slope Water as in the Northern Sargasso Sea are placed in preference group 's' (moderate Slope Water preference).

Species showing strong preference for a habitat are thought to have little or no spawning success in the other habitat. Those with moderate preference are thought to spawn successfully in both the Slope Water and the Northern Sargasso Sea but to be better adapted to one or

the other habitat. A few species appear to do equally well, or poorly, in both habitats, and are designated 'no preference' species.

Contamination by Caribbean species was predicted on the basis of unpublished data on file at the Woods Hole Oceanographic Institution (Backus et al.). Table 2 lists the seven most abundant myctophid species in 22 nighttime collections from the Caribbean. The collections were made in the upper 200 m and comprise 71.5 hours of fishing with a 10-foot Isaacs-Kidd midwater trawl. A sample calculation follows for Notolychnus valdiviae: 1132 specimens in 71.5 hours of fishing = 15.8 specimens/hr. The trawls in the present study took about three hours each and the 13 trawls in Slope Water spent an average of 17 per cent of the time above 200 m. Multiplying 13 trawls x 17% x 3 hrs/trawl x 15.8 specimens/hr x 15% (Caribbean contribution to Slope Water) predicts 15 expatriate specimens of N. valdiviae for the Slope Water collections. Similarly, the 13 Northern Sargasso Sea trawls spent an average of 21 per cent of the time above 200 m, and an introduction rate of 18 per cent per year of Caribbean water to the Northern Sargasso Sea predicts 23 expatriate specimens of N. valdiviae in the latter set of collections.

Thus, of the 26 observed specimens of Notolychnus valdiviae in the Slope Water (Table 2), 15 are accounted for by expatriation. Of the 110 Northern Sargasso Sea specimens, only 23 are accounted for by expatriation. The remaining 87 Northern Sargasso Sea specimens certainly represent a spawning population in that habitat, and are about eight

TABLE 2

Seven most abundant myctophids in 22 nighttime collections* from the
upper 200 m of the Caribbean Sea

	Caribbean abundance			Number of specimens in			
	Number		% of total myctophids	S.W.		N.S.S.	
	Collections	Specimens		P	O	P	O
<i>Diaphus dumerili</i>	21	1861	19.4	25	46	38	7
<i>Lepidophanes guentheri</i>	22	1682	17.5	23	38	33	24
<i>Ceratoscopelus warmingi</i>	18	1296	13.5	18	52	27	164
<i>Notolychnus valdiviae</i>	18	1132	11.8	15	26	23	110
<i>Diaphus splendidus</i>	18	599	6.2	8	3	12	6
<i>Diaphus brachycephalus</i>	17	311	3.2	4	0	6	3
<i>Diaphus fragilis</i>	12	295	3.1	4	0	6	0

S.W. = Slope Water

N.S.S. = Northern Sargasso Sea

P = predicted number of expatriate specimens (see text)

O = observed number of specimens

* = unpublished data of Backus et al.

times the 11 Slope Water specimens unaccounted for by the expatriation prediction. In view of the expected underestimation of Caribbean input to Slope Water (page 41), the 10 times criterion for strong preference for the Northern Sargasso Sea has been relaxed somewhat, and N. valdiviae is tentatively assigned to group 'N'.

Assignments to preference groups

Forty-one species were used in analysing faunal composition (page 61). The numbers of specimens of these species in the Slope Water and Northern Sargasso Sea collections are given in Table 3. Since the number of collections is the same in both sets (13 each), the numbers of specimens can be directly compared in assessing relative abundance.

Seven species show strong preference for the Slope Water. The gulper eel Eurypharynx pelecanoides and the melamphaid Scopelogadus beanii are eight and 10 times as abundant in the Slope Water as in the Northern Sargasso Sea. These two species are both abundant below 1000 m (Bohlke, 1966; Ebeling and Weed, 1973), so that any cross-Gulf Stream difference in their depth distribution could cause inequities in their representation in these 1000 m samples. The assignments of Eurypharynx and Scopelogadus to group 'S' are therefore tentative. The lantern-fish (myctophid) Myctophum affine is 10 times as abundant in the Slope Water as in the Northern Sargasso Sea. This has been called a "tropical" species by Backus et al. (in press). However, its abundance in the Caribbean is too low to account for any of the observed Slope Water

TABLE 3

Numbers of specimens of 41 ranking species in
Slope Water and Northern Sargasso Sea sets

	SW	NSS	Preference
Eurypharynx pelecanoides	16	2	S?
Serrivomer beanii	47	20	s
Cyclothone acclinidens	25	6	s
Cyclothone alba	44	96	n?
Cyclothone braueri	263	1236	N?
Cyclothone microdon	3899	719	s
Cyclothone pallida	270	343	-
Cyclothone pseudopallida	136	103	-
Bonapartia pedaliota	0	138	N
Gonostoma elongatum	39	35	-
Pollichthys mauii	3	47	N
Vinciguerrria attenuata	8	59	n
Vinciguerrria poweriae	8	32	n
Argyropelecus aculeatus	28	31	-
Argyropelecus hemigymnus	19	109	n
Maurolicus muelleri	24	0	S
Sternoptyx diaphana	118	255	n
Valenciennellus tripunctulatus	12	27	n
Chauliodus danae	3	50	N
Chauliodus sloani	54	31	s
Benthoosema glaciale	847	20	S
Bolinichthys indicus	9	143	N
Ceratoscopelus maderensis	656	12	S
Ceratoscopelus warmingi	52	164	n
Diaphus dumerili	46	7	-
Diaphus rafinesquei	30	11	s
Diogenichthys atlanticus	17	100	n
Hygophum benoiti	34	113	n
Hygophum hygomi	12	45	n
Lampanyctus cuprarius	22	45	n
Lampanyctus macdonaldi	22	0	S
Lampanyctus photonotus	5	34	n
Lampanyctus pusillus	19	93	n

TABLE 3 (Continued)

Numbers of specimens of 41 ranking species in
Slope Water and Northern Sargasso Sea sets

	SW	NSS	Preference
<i>Lepidophanes guentheri</i>	<u>38</u>	24	-
<i>Lobianchia dofleini</i>	<u>69</u>	31	s
<i>Myctophum affine</i>	<u>21</u>	2	S
<i>Myctophum punctatum</i>	1	5	-
<i>Notolychnus valdiviae</i>	26	<u>110</u>	N?
<i>Melanphaes pumilus</i>	3	<u>109</u>	N
<i>Scopeloberyx opisthopterus</i>	<u>62</u>	<u>32</u>	s
<i>Scopelogadus beanii</i>	<u>38</u>	4	S?

Underlined values indicate top 20 ranking species in each set. Preference assignments are described in the text. S = strong Slope Water preference, s = moderate Slope Water preference, N = strong Northern Sargasso Sea preference, n = moderate Northern Sargasso Sea preference. A dash (-) = no preference.

population. M. affine may be associated with nearshore areas, as is the sternoptychid genus Polyipnus (Baird, 1971). The myctophids Benthosema glaciale, Ceratoscopelus maderensis, and Lampanyctus macdonaldi are all overwhelmingly more abundant in the Slope Water than in the Northern Sargasso Sea. B. glaciale and L. macdonaldi are designated "subarctic-temperate" species, and C. maderensis a "temperate-north subtropical" species by Backus et al. (in press). The sternoptychid Maurolicus muelleri, taken here in only five collections, is apparently associated with the upper continental slope and outer shelf (Steele, 1967), and so is excluded from the Sargasso Sea.

Seven species also are assigned strong preference for the Northern Sargasso Sea habitat. The gonostomatid Cyclothone braueri is abundant in the Caribbean (Backus et al., unpublished data), and while the data do not permit a quantitative estimate, its expatriation rate may well be high enough to account for a large fraction of the observed Slope Water population. The assignment of C. braueri to group 'N' remains tentative. Another gonostomatid, Bonapartia pedaliota, is abundant in the Northern Sargasso Sea, but absent from the Slope Water collections. The photichthyid Pollichthys maui, the viper fish Chauliodus danae, and the myctophid Bolinichthys indicus are all present in the Slope Water set at about six per cent of their Northern Sargasso Sea levels. P. maui is moderately abundant in the Caribbean, but C. danae and B. indicus do not occur there (Backus et al., unpublished data, and in press). The presence in Slope Water of the last two species must

be due either to spawning or to direct intrusion of Northern Sargasso Sea water into Slope Water. Their presence in identical proportions of their Northern Sargasso Sea populations suggests the latter, although life history studies are clearly necessary in order to interpret their Slope Water populations. Notolychnus valdiviae has been mentioned above. The last group 'N' species, Melamphaes pumilus, is a dwarf melamphaid having its center of distribution in the Sargasso Sea (Ebeling, 1962).

The remaining 27 species show moderate to no preference for either the Slope Water or the Northern Sargasso Sea. Only a few of these assignments bear mentioning.

The assignment of Cyclothone alba to group 'n' is in question. This species, like C. braueri, is abundant in the Caribbean (Backus et al., unpublished data). The data do not permit a calculation of its expected transport by the Florida current, but it is possible that much of its presence in the Northern Sargasso Sea is due to expatriation and not indicative of habitat preference.

The two most abundant Caribbean myctophids, Diaphus dumerili and Lepidophanes guentheri, are present in the Slope Water in slightly less than half their predicted expatriate numbers (Table 2). In view of the uncertainties in predicting these expatriation rates, it seems likely that the presence of these species in the Slope Water and Northern Sargasso Sea is due solely to expatriation from the Caribbean. They are therefore assigned to the 'no preference' group. Ceratoscopelus warmingi is the only abundant Caribbean myctophid present in the Slope

Water in more than twice the numbers predicted by the expatriation calculation. C. warmingi is the most abundant myctophid in these Northern Sargasso Sea collections, but since it appears to spawn with fair success in Slope Water, it is assigned only a moderate preference for the Northern Sargasso Sea. D. dumerili and L. guentheri are called "tropical" species, and C. warmingi a "tropical-subtropical" species by Backus et al. (in press).

Myctophum punctatum was not well-sampled in these collections. Its membership in the list of ranking species (page 61) is due to 26 small juveniles in Ring 4, the apparent source of the five Northern Sargasso Sea specimens. M. punctatum is a year-round resident of the Slope Water and of the adjoining Gulf of Maine (Musick, 1973). It is designated a "subarctic-temperate" species by Backus et al. (in press), whose data show it to be most abundant north and east of the Slope Water. For convenience, M. punctatum is here considered a 'no preference' species.

GENERAL CHARACTERISTICS OF SLOPE WATER AND
NORTHERN SARGASSO SEA FISH COMMUNITIES

The data comprise 19,391 specimens in 129 species from 43 collections (Appendix B). Collections were made in the Slope Water, in four cold-core rings, in a warm-core ring, in the Gulf Stream, in an old cold-core ring recently coalesced with the Gulf Stream, and in the Northern Sargasso Sea. Table 4 presents diversity and biomass information for three important sets of collections, the 13 Slope Water collections, the 14 ring collections, and the 13 Northern Sargasso Sea collections.

Species diversity indexed by the information function H (Shannon and Weaver, 1963) and the evenness component of the diversity E (Lloyd and Ghelardi, 1964) are given in Table 4, where it is seen that the higher diversity of the Northern Sargasso Sea ($H = 3.1$) compared with the Slope Water ($H = 2.0$) is due less to the greater number of species in the former habitat than to the evenness with which the individuals are distributed among the species. In the Slope Water, the three most abundant species, Cyclothone microdon, Benthosema glaciale, and Ceratoscopelus maderensis, comprise 74 per cent of the catch. In the Northern Sargasso Sea, the top three species, Cyclothone braueri, C. microdon, and C. pallida, comprise only 48 per cent of the catch, and it takes the top 14 species to total 74 percent. The fauna of the rings is intermediate in these respects.

These differences in diversity indicate differences in community

TABLE 4
Diversity and biomass

Set	Number of collections	Number of specimens	Specimens per collection	Number of species	H	E	% top 3 species	% top 20 species	Biomass, cc/10 ³ m ³
Slope Water	13	7266	558	86	2.0	.09	74	93	2.4
Rings	14	6022	430	92	2.2	.10	67	92	2.0
Northern Sargasso Sea	13	4799	369	104	3.1	.21	48	85	1.3

$H = - \sum_{i=1}^n p_i \ln p_i$, where p_i = the proportion of species i in the sample (Shannon and Weaver, 1963).

$E = e^H/S$, where S = the number of species in the sample (Lloyd and Ghelardi, 1964).

% top 3 species = the percent of total specimens in set comprised by the three most abundant species.

% top 20 species = the percent of total specimens in set comprised by the twenty most abundant species.

structure (MacArthur, 1965). Biomass estimates and sound-scattering observations provide further evidence that the Slope Water and Northern Sargasso Sea fish communities are organized differently.

The biomass estimates given in Table 4 are the averages of the individual observations in each set. The Slope Water and Ring sets have highly significantly greater biomass than the Northern Sargasso Sea set ($p \leq .01$) and the Slope Water set has significantly greater biomass than the Ring set ($p = .10$, one-tailed test) (Mann-Whitney U-test; Tate and Clelland, 1958). The Slope Water:Northern Sargasso Sea biomass ratio reported here (Table 4) is approximately 2:1. That reported by Jahn and Backus (in press) is 4:1. In the present study only 21 per cent of the fishing effort was above 200 m, compared to 57 percent in the previous study. This suggests that in the Slope Water the biomass is concentrated much nearer the surface than in the Northern Sargasso Sea.

In addition to the finding that the Slope Water biomass is concentrated nearer the surface than that of the Northern Sargasso Sea, there is evidence of a difference in vertical migratory behavior of fishes in the two habitats. An examination by Cole et al. (1970) of 12 kHz echograms on several crossings of the Gulf Stream consistently revealed a deep scattering layer (DSL) in the Slope Water which had a maximum day time depth of 550 m and migrated entirely into the upper 200 m at night. In the Northern Sargasso Sea, they found a DSL between 400 and 600 m that always had a nonmigratory component. The partial

migration of the Northern Sargasso Sea DSL suggests a finer partitioning of the habitat.

The midwater fish communities of Slope Water and Northern Sargasso Sea differ markedly in composition and organization. In terms of biomass and diversity and evenness the species assemblage of the rings is intermediate between the Slope Water and Northern Sargasso Sea communities. The apparent faunal changes resulting in the ring assemblage can profitably be analysed by the ordination technique described in the following section.

CORRESPONDENCE ANALYSIS

Description of problem

The collections to be analysed consist of a number of samples from different species assemblages. The ultimate goal of the analyses is to explain the relationships among these assemblages in terms of variations in the environment. The first step toward this goal is to describe the relationships, which are expected to represent a gradient in species composition from the Slope Water community to the Northern Sargasso Sea community. This will be done with an ordination.

The basic idea of ordination is simple, as a very simple example will show. Suppose we have three collections, A, B, and C, containing 100, 50, and zero specimens of Benthoosema glaciale.

	A	B	C
BGLA	100	50	0

The collections so ordered obviously represent a gradient from an environment that favors Benthoosema glaciale to one that does not. If the collections also contain Melamphaes pumilus in the following manner,

	A	B	C
BGLA	100	50	0
MPUM	0	50	100

we have the same gradient, but with Benthoosema and Melamphaes favored by the opposite extremes.

If our hypothetical collections also contain Diogenichthys atlanticus as follows,

	A	B	C
BOLA	100	50	0
MPUM	0	50	100
DATL	30	45	75

the gradient is still the same. We can say that Diogenichthys responds to the gradient in the same direction as Melamphaes does, but not so strongly.

If the above situation, or anything approaching it in simplicity, were actually encountered in nature, the gradient, if not its ecological interpretation, would be immediately apparent. However, in a realistic situation with a large number of collections and many species varying in abundance in different ways, the trends in the data might not be obvious; without a formal method of ordination, an informative ordering of the collections could be very difficult to achieve.

Method of ordination

The method of ordination employed was named "correspondence analysis" by Benzecri (1969), who gave a geometrical interpretation of the procedure. More appropriate to ecological use is the treatment by Hill (1973), who describes the method as a combination of gradient analysis (Whittaker, 1967) and successive approximation. The present application will be described in terms of Hill's rationale.

As a first approximation to the ordination, all the collections can be ordered by their decreasing abundance of Benthosema glaciale and increasing abundance of Melamphaes pumilus. Then the species are all scored according to their average positions along the gradient. The order of the collections can then be improved by obtaining collection scores which are averages of the scores of the species in each collection.

With the collections reordered by the collection scores, new species scores are assigned according to each species' average position along the improved gradient. This process continues until the order of species and collections stabilizes. It can be shown with matrix algebra that the same stabilized order is achieved regardless of the initial order.

The gradient so obtained is the principal axis of variation in species composition. However, it will not describe all the variation in the data. With the effects of the first axis accounted for, the remaining variation can be subjected to further analysis, and a second

axis derived in the same manner as the first. The process can be continued until the desired amount of variation is accounted for.

Thus, as with other types of multivariate analysis, correspondence analysis seeks to partition the variability of a multivariate sample into a small set of linear factors. Hill (1974) has shown that it is a special case of principal components analysis. The main advantage of correspondence analysis over the latter technique is that it gives a good species ordination to go along with the ordination of collections.

Plotting and interpretation of the ordination

The positions of the species and collections along the axes are their factor scores. Scatter diagrams can be prepared in which collections and/or species are plotted according to their factor scores on two perpendicular axes. The axes can be viewed as the dimensions of an imaginary space. The scatter diagrams are thus planar projections of this space.

Although the first axis (factor) describes the major faunal gradient, subsequent axes reveal important details of species composition. In the analysis to be presented here, the first three axes are used to present two views of a three-dimensional space in which the relationships of the species and collections can be appreciated.

Hill (1973) notes that in ecological studies where a strong gradient is encountered the scatter based on the first two factors will

commonly assume a U-shaped configuration. The interpretation of this is that the second factor is approximately a quadratic of the first, reflecting the centers of abundance of certain species at the extreme ends of the gradient.

The mathematics of the correspondence analysis involve routines for computing eigenvectors and plotting results modified from programs written by J. P. Bordet of the Ecole Nationale Supérieure des Mines de Paris, Centre d'Informatique Géologique.

ANALYSES AND RESULTS

Choice of species for analysis

In order to obtain a list of well-sampled species representative of the various hydrographic conditions encountered, the collections were divided according to season and water type (Table 5). The Slope Water collections of Atlantis II cruises 71 and 85 (two each, September - October), though from different years, were combined into a single subset, S0. The Chain cruises 110 and 111 Slope Water collections, subset SF, were taken in the same two-week period in January - February, 1973. The meander collection was included as a "subset" by virtue of the history of the water parcel as a cold-core ring.

The species chosen for the ordination were those ranking in the top 10 of any of the 13 subsets or in the top 20 of any two of them. The resulting list of 41 species (Tables 3 and 6) includes 34 of the 35 top-ranking species in the total collection. The least abundant species in the list, Lampanyctus macdonaldi (22 specimens) ranks 58th in the total collection.

For comparison with the species diversity values given for the three major collection sets in Table 4 (page 53), diversities are given in Table 5 for the 13 subsets. The values for the Slope Water and Ring subsets are consistently lower than those for the Northern Sargasso Sea subsets. Taken individually, the rings are no longer intermediate between the Slope Water and Northern Sargasso Sea, but

TABLE 5
13 subsets of collections

Slope Water	Subset	Number of			H
		Collections	Species	Specimens	
A II 85 & 71	SO	4	72	1650	2.6
Ch 110 & 111	SF	4	59	3022	1.5
Kn 35	SN	3	57	1783	1.9
Kn 38	SM	2	39	811	1.8
Rings					
A II 71	R1	5	65	1800	2.6
Ch 111	R2	3	53	1797	1.8
Kn 35	R3	3	47	960	1.5
Kn 38	R4	3	64	1457	2.0
Meander					
A II 85	M	1	47	337	3.1
Northern Sargasso Sea					
A II 71	NS	6	72	2142	2.8
A II 85	NO	4	78	1332	3.1
Ch 111	NF	1	52	522	3.0
Kn 38	NM	2	63	803	2.7

A II 71 - September, October, 1972
A II 85 - October, 1974
Ch 110 - January, February, 1973
Ch 111 - February, 1973
Kn 35 - November, December, 1973
Kn 38 - March, April, 1974

H = species diversity

rather are indistinguishable from the Slope Water subsets in terms of species diversity.

Ordination of collections

In the first run of correspondence analysis most of the species and collections were clumped into an elongate, cylindrical cloud about the first axis. Seventy-seven per cent of the variation accounted for by the second axis was contributed by Ceratoscopelus maderensis, an abundant Slope Water species showing extreme fluctuations in numbers. Similarly, Maurolicus muelleri and Diaphus dumerili, abundant in a few Slope Water collections and nowhere else (Appendix B), together contributed 31 per cent of the variation accounted for by the third axis. In order that the second and third axes might describe more general trends in the data, these three species were removed and the analysis redone.

The second analysis gave a clearer picture of the data, represented in Figure 6 as two views of a three-dimensional space. The main feature of the plots is the U-shaped cloud, seen best in Figure 6a, in which one end is occupied by Slope Water collections and the other by Northern Sargasso Sea collections, with the ring collections in between.

Although the ordination is continuous, those collections whose interrelationships are relatively constant in the two projections are enclosed as separate clouds. The cloud containing mostly ring collections is the most spread on axis 1, and it can be seen that the

Figure 6. Collections and species plotted according to their factor scores on (a) axes 1 and 2 and (b) axes 2 and 3 of the correspondence analysis. The big letters associated with collection numbers refer to water type and month. Slope Water in February = SF, in March = SM, in September = SS, in October = SO, in November = SN. Northern Sargasso Sea in February = NS, in March = NM, and so on. W = "warm-core ring". G = Gulf Stream. M = Gulf Stream meander (see text).

The small letters are species codes. The first letter is the first letter of the generic name; the remaining three are the first three letters of the trivial name, e.g., Benthosema glaciale = BGLA. The exception to the code is that Serrivomer beanii = SBEV. The species are those listed in Tables 3 and 6 and in Figure 9.

Figure 6a

Figure 6b

main effect of the third axis is to further spread this cloud in a plane perpendicular to that defined by axes 1 and 2 (Figure 6b).

Ordination of species

It is evident in Figure 6 that the species are more highly scattered than the collections. In light of the foregoing division of species into habitat preference groups, the ordination can advantageously be viewed as five species clusters, seen in Figure 7. The species clusters, like the collection clouds in Figure 6, contain elements (species) whose spatial relationships are relatively constant in the two projections. The apparent overlap of the clusters in Figure 7b is due to the compression of the first axis into the plane of the page.

The species are listed according to habitat preference group in Table 6, where their numbers in the Slope Water, Ring, and Northern Sargasso Sea sets are given. There is good agreement between species clusters and habitat preference groups.

Of the seven species in preference group 'S', two (Maurolicus muelleri and Ceratoscopelus maderensis) were removed from the ordination for reasons mentioned above. Of the remaining five species, four are in cluster 1 in Figure 7. Eurypharynx pelecanoides was nearly as abundant in the rings as in the Slope Water (Table 6) and therefore plots more near the center of the diagram.

Cluster 2 contains the seven members of group 's'. It is obvious,

TABLE 6

Habitat preference groups

Values given are numbers of specimens in Slope Water (S.W.), ring (R.), and Northern Sargasso Sea (N.S.S.) sets. Underlined values emphasize that the species has its greatest abundance in the ring set (see text). A "?" following a species name indicates a questionable assignment to the preference group.

S	S.W.	R.	N.S.S.
(strong S.W. preference)			
Eurypharynx pelecanoides?	16	15	2
Maurolicus muelleri	24	0	0
Benthoosema glaciale	847	325	20
Ceratoscopelus maderensis	656	136	12
Lampanyctus macdonaldi	22	0	0
Myctophum affine	21	0	2
Scopelogadus beanii?	38	2	4
s			
(moderate S.W. preference)			
Serrivomer beanii	47	25	20
Cyclothone acclinidens	25	9	6
Cyclothone microdon	3899	3344	719
Chauliodus sloani	54	<u>82</u>	31
Diaphus rafinesquei	30	<u>54</u>	11
Lobianchia dofleini	69	<u>25</u>	31
Scopeloberyx opisthopterus	62	<u>89</u>	32
'no preference'			
Cyclothone pallida	270	102	343
Cyclothone pseudopallida	136	96	103
Gonostoma elongatum	39	26	35
Argyropelecus aculeatus	28	24	31
Diaphus dumerili	46	0	7
Lepidophanes guentheri	38	7	24
Myctophum punctatum	1	26	5

TABLE 6 (Continued)

Habitat preference groups

N	S.W.	R.	N.S.S.
(strong N.S.S. preference)			
Cyclothone braueri?	263	350	1236
Bonapartia pedaliota	0	20	138
Pollichthys mauli	3	9	47
Chauliodus danae	3	16	50
Bolinichthys indicus	9	<u>145</u>	143
Notolychnus valdiviae?	26	45	110
Melamphaes pumilus	3	2	109
n			
(moderate N.S.S. preference)			
Cyclothone alba?	44	39	96
Vinciguerrria attenuata	8	<u>71</u>	59
Vinciguerrria poweriae	8	27	32
Argyroleleucus hemigymnus	19	108	109
Sternoptyx diaphana	118	60	255
Valenciennellus tripunctulatus	12	<u>53</u>	27
Ceratoscopelus warmingi	52	40	164
Diogenichthys atlanticus	17	60	100
Hygophum benoiti	34	<u>169</u>	113
Hygophum hygomi	12	29	45
Lampanyctus cuprarius	22	4	45
Lampanyctus photonotus	5	26	34
Lampanyctus pusillus	19	<u>144</u>	93

Figure 7. First interpretation of species clustering by the correspondence analysis. a - axes 1 and 2, b - axes 2 and 3. Cluster 1 = preference group 'S'. Cluster 2 = group 's'. Clusters 3 and 4 = group 'n', except that BIND (Bolinichthys indicus) is a group 'N' species. Cluster 5 = group 'N'. See text for definition of preference groups.

The small letters are species codes. The first letter is the first letter of the generic name; the remaining three are the first three letters of the trivial name, e.g., Bentho-sema glaciale = BGLA. The exception to the code is that Serrivomer beanii = SBEV. The species are those listed in Tables 3 and 6 and in Figure 9.

Figure 7a

Figure 7b

especially in Figure 8b, that the exclusion of Gonostoma elongatum, Argyropelecus aculeatus and Cyclothone pseudopallida from cluster 2 is somewhat arbitrary. It would perhaps be more objective to include these species in a cluster with Cyclothone acclinidens, Serrivomer beanii, and Lobianchia dofleini, and to enclose Cyclothone microdon, Diaphus rafinesquei, Scopeloberyx opisthopterus, and Chauliodus sloani in a separate cluster. Such an interpretation is discussed below.

Cluster 3, with the exception of 'no-preference' species Cyclothone pallida, contains only members of group 'n'. The spatial relationship of this cluster, particularly of Ceratoscopelus warmingi and Cyclothone alba, to cluster 5 (all group 'N') is close. The members of cluster 3 all have their lowest abundance in the Ring set (Table 6). Eight of the nine remaining members of group 'n' are in cluster 4, where they are joined by 'N' species Bolinichthys indicus.

Three species, Hygophum hygomi, Lepidophanes guentheri, and Myctophum punctatum, have patterns of abundance radically different from the rest of the species. Group 'n' species H. hygomi, although it appears close to cluster 4 in Figure 7a, is widely separated from this cluster by the third axis (Figure 7b) and resembles 'no preference' species M. punctatum in being most abundant in the Ring 4 and Northern Sargasso Sea collections of Knorr cruise 38. L. guentheri, a 'no preference' species, bears closest resemblance to Lobianchia dofleini of cluster 2.

A particularly interesting cluster containing members of clusters

2 and 4, and combining species of groups 's', 'n', and 'N', is enclosed by a dashed line in Figure 7. Bolinichthys indicus, the only group 'N' species not a member of cluster 5, is also the only 'N' species that is more numerous in the Ring set than in the Northern Sargasso Sea set. Reference to Table 6 shows that all members of this special cluster share the property of being most abundant in the Ring set (underlined values). It is apparent that these species, particularly Hygophum benoiti, Vinciguerrria attenuata, Lampanyctus pusillus, and Argyropelecus hemigymnus, are responsible for the spreading of the ring collections along axis 3 of the ordination (Figure 6b).

The all-or-nothing response

In view of the expectation that the rings should represent a transitional regime from Slope Water to Northern Sargasso Sea conditions, it is surprising that Vinciguerrria attenuata, Valenciennellus tripunctulatus, Chauliodus sloani, Bolinichthys indicus, Diaphus rafinesquei, Hygophum benoiti, and Lampanyctus pusillus (dashed cluster in Figure 7) all have their highest abundance in the Ring set. The abundance patterns of these species, plus Cyclothone braueri, C. microdon, Benthoosema glaciale, and Ceratoscopelus maderensis, the four top-ranking species in the total collection, can be examined in Table 7. The subsets of collections in the table are those used in choosing the species for the ordination (Table 5), except that the Slope Water collections of September and October cruises Atlantis II 71 and 85

TABLE 7

Average number per collection of 12 species in 13 subsets. The second letter of the subset code refers to month of sampling. F = February, M = March, S = September, O = October, N = November. The two largest abundance values for each species are underlined.

Subset Code (No. of collections)	Slope Water				Rings (month)					N. Sargasso Sea			
	SF (4)	SM (2)	SS (2)	SO (2)	SN (3)	R3(N) (3)	R2(F) (3)	R4(M) (3)	R1(S) (5)	NF (1)	NM (2)	NS (6)	NO (4)
<i>Benthosema glaciale</i>	<u>93.0</u>	53.5	36.5	<u>70.0</u>	51.7	33.3	46.7	6.7	13.0	6.0	2.0	1.3	0.5
<i>Ceratoscopelus maderensis</i>	12.8	4.0	<u>82.5</u>	<u>25.0</u>	<u>127.3</u>	9.7	33.3	2.0	0.2	1.0	2.5	0.3	1.0
<i>Cyclothone microdon</i>	<u>506.8</u>	238.0	158.5	116.0	282.3	220.0	<u>306.7</u>	310.0	130.8	46.0	124.0	65.8	10.0
<i>Diaphus rafinesquei</i>	1.5	3.5	4.0	0.5	2.7		<u>11.0</u>	<u>6.0</u>	0.6	2.0	2.0	0.3	1.0
<i>Scopeloberyx opisthopterus</i>	6.0	5.0	4.5	1.5	5.3	7.0	<u>6.3</u>	<u>8.7</u>	4.6	6.0	4.5	2.7	0.3
<i>Chauliodus sloani</i>	4.3	4.0	4.5	3.0	4.7	2.7	<u>7.3</u>	6.0	<u>6.8</u>	3.0	0.5	3.7	1.8
<i>Valenciennesellus tripunctulatus</i>	0.3	0.5	1.5	2.0	1.0	0.3	<u>6.0</u>	<u>4.3</u>	4.2	2.0	1.0	1.8	3.0
<i>Hygophum benoiti</i>	3.3	1.0	3.0	4.5	1.3	2.3	<u>23.3</u>	2.7	<u>16.7</u>	7.0	1.0	<u>16.7</u>	1.0
<i>Lampanyctus pusillus</i>	2.0		2.5	3.5	1.0	2.7	11.7	6.3	<u>16.4</u>	<u>15.0</u>	5.0	9.6	3.0
<i>Bolinichthys indicus</i>	0.8		1.0	0.5	1.0	4.7	13.3	<u>15.7</u>	8.8	<u>32.0</u>	2.0	11.7	6.3
<i>Vinciguerrina attenuata</i>	0.5		1.5		1.0	0.3	2.7	1.0	<u>11.8</u>	5.0	1.5	<u>5.5</u>	4.5
<i>Cyclothone braueri</i>	<u>14.8</u>	9.0	27.0	15.0	27.3	1.0	8.7	11.3	59.4	<u>122.0</u>	78.0	<u>103.7</u>	84.0

(SS and SO) are no longer pooled. The Slope Water and Northern Sargasso Sea subsets are ordered by season, and the Ring subsets are ordered by their average scores on factor 1 of the ordination. The 12 species are likewise ordered by their scores on factor 1. The abundance values given are the average number of specimens per collection for each subset. The two highest abundance values for each species are underlined in Table 7.

The abundance patterns are marked by more-or-less erratic fluctuations. As tested by the nonparametric Mann-Whitney U-test, only one species, Scopeloberyx opisthopterus (preference group 's') is significantly more abundant in the Ring set ($p < .10$). In general, the species show an "all-or-nothing" response to the ring environment. This trend can be seen in the numbers of specimens in the three major collection sets in Table 6, but is better represented in Figure 8, a second interpretation of species clustering by the ordination.

Cluster 1 contains species of groups 'S', 's', and 'no preference'. With the exception of Benthoosema glaciale, which decreases gradually in numbers with ring age (Table 7), the members of this cluster share the property that their abundance in the Ring set is much more like that in the Northern Sargasso Sea set than that in the Slope Water set. Similarly, cluster 3 contains species of groups 'N', 'n', and 'no preference' whose low abundance in the Ring set resembles that in the Slope Water set. Clusters 1 and 3, then, demonstrate the "all" response, that is, these species react to the ring environment as though it were on the opposite

Figure 8. Second interpretation of species clustering by the correspondence analysis, illustrating the "all-or-nothing" response to the ring environment (see text). a - axes 1 and 2, b - axes 2 and 3.

The small letters are species codes. The first letter is the first letter of the generic name; the remaining three are the first three letters of the trivial name, e.g., Benthosema glaciale = BGLA. The exception to the code is that Serrivomer beanii = SBEV. The species are those listed in Tables 3 and 6 and in Figure 9.

Figure 8a

Figure 8b

side of the Gulf Stream from their preferred habitat.

The "nothing" response is demonstrated by cluster 2. These species, of the 'S', 's', 'N', and 'n' groups, are about equally abundant in the ring environment as they are in their preferred habitats, Slope Water or Northern Sargasso Sea as the case may be. They appear to be unaffected by the presence of a ring.

The faunal gradient

The all-or-nothing response of species to the ring environment is an approximation that will be useful in a later discussion of habitat structure. Nevertheless, the rings are all different, and it is apparent from the spread of the collections along the first axis in Figure 6a that there is a gradient in species composition from Slope Water to Northern Sargasso Sea.

The Slope Water collections are the most spread along axis 2, which separates them from the ring collections. Within the Slope Water cloud there is a seasonal gradient from left to right on axis 1, with winter collections (SF and SM) to the left and fall collections (SS and SO) to the right. The November Slope Water collections project between the fall and winter ones on axis 1, indicating a reversion toward winter conditions.

The ring collections project onto axis 1 in the order of ring age (R3, R2, R4, R1) which is also the order of increasing depth of the 15° isotherm (Table 1, page 30). The three-month-old rings, R3 and R2,

Figure 9. Diagonal trend of species abundance illustrating the faunal gradient from winter conditions in Slope Water (SF and SM) to fall conditions in the Northern Sargasso Sea (SS and SO). First the Slope Water subsets, and then the remaining subsets are listed in order of their average projections on the first axis of the correspondence analysis. The species are also listed in order of their projections on the first axis (first factor score). The shading indicates the abundance of species in each subset.

	SM	SF	SN	SO	R3	R2	M	R4	R1	NM	NS	NF	NO
Lampanyctus macdonaldi													
Ceratoscopelus maderensis													
Maurolicus muelleri													
Eurypharynx pelecyanoides													
Benthoosema glaciale													
Myctophum affine													
Scopelogadus beanii													
Cyclothone microdon													
Diaphus dumerili													
Diaphus rafinesquei													
Myctophum punctatum													
Cyclothone acclinidens													
Scopeloberyx opisthopterus													
Chauliodus sloani													
Serrivomer beanii													
Lobianchia dofleini													
Cyclothone pseudopallida													
Lepidophanes guentheri													
Valenciennellus tripunctulatus													
Gonostoma elongatum													
Hygophum hygomi													
Argyropelecus aculeatus													
Hygophum benoiti													
Lampanyctus pusillus													
Bolinichthys indicus													
Cyclothone pallida													
Cyclothone alba													
Lampanyctus photonotus													
Argyropelecus hemigymnus													
Diogenichthys atlanticus													
Vinciguerrria poweriae													
Sternoptyx diaphana													
Vinciguerrria attenuata													
Notolychnus valdiviae													
Ceratoscopelus warmingi													
Lampanyctus cuprarius													
Cyclothone braueri													
Chauliodus danae													
Pollichthys mauili													
Bonapartia pedaliota													
Melamphaes pumilus													

TOP 20
TOP 10
TOP 5

were sampled in November and February, respectively, while the 10-month-old rings, R4 and R1, were sampled in March and September. It appears that the age of a ring has more influence on faunal composition than the season in which it is sampled. The Northern Sargasso Sea collections, like the Slope Water ones, project onto axis 1 in the order of season, except for the February collection (NF).

The faunal gradient from winter Slope Water conditions to fall Northern Sargasso Sea conditions is seen as the diagonal trend in Figure 9. First the Slope Water subsets, then the other nine subsets are arranged in order of their average score on the first factor. The species are likewise listed in order of their first factor scores. The shading indicates relative abundance within each subset.

Correlations with environmental parameters

In order to see if the axes of the ordination might be interpreted in terms of a small set of environmental parameters, stepwise multiple regressions were performed, using the factor scores of the collections as dependent variables and the environmental parameters of Appendix A as independent variables. The uncertainties induced by the use of missing values in multiple regression were avoided by using only 33 collections and omitting zooplankton biomass, for which only 22 observations could be matched with these collections. The first variable to enter a regression equation was the one that explained the most variance in the factor scores on the axis in question. Subsequent variables were

entered so as to maximize the total variance explained, with the stipulation that a variable would not enter the equation unless at least 50 per cent of its variance was unexplained by the variables already in the equation. The purpose of the 50 percent tolerance level was to insure that the independent variables in the regression equation would not be highly intercorrelated, and therefore redundant.

The regression statistics for the first three factors, and the major species contributing to the factors, are given in Table 8. The regressions of the first three factors are all highly significant ($p < .01$), but only that of the first factor is ecologically meaningful. As seen in the table, the equation for factor 3 accounts for only 38 per cent of the variability in the factor scores. The high negative correlation of factor 2 with the percentage of trawling time below 500 m may well reflect some dependence of species composition, particularly the proportion of Cyclothone microdon, on depth distribution of fishing effort. However, the major contributor to factor 2 is Benthoosema glaciale, an abundant species with strong Slope Water preference. As discussed on page 60, the best interpretation of factor 2 is that it reflects faunal composition at the extreme ends of the gradient and is mathematically a higher order (non-linear) function of the first factor.

The correlation of the first axis with the depth of the 15° isotherm and the surface temperature is capable of simple interpretation. The 15° isotherm (D15) is always shallower than 200 m in the Slope Water

TABLE 8

Statistics for correspondence analysis, 43 collections, 38 species

		Factors		
		1	2	3
% variation explained		45.7	11.9	8.4
Major species	C. microdon 29.0(-)	B. glaciale 39.0(+)	H. benoiti 30.0(-)	
with	C. braueri 28.9(+)	C. pallida 8.5(+)	B. glaciale 12.0(-)	
% contribution	B. glaciale 5.8(-)	C. microdon 6.7(-)	L. pusillus 9.4(-)	
	B. pedaliota 5.0(+)	L. guentheri 6.2(+)	H. hygomi 8.0(+)	
	M. pumilus 4.7(+)			
R ² , F	87, 64.8	65, 18.4	38, 9.07	
Variables in equation, r	D15 (.87) Tsurf (.66) BEL5 (-.25)	BEL5 (-.65) T200 (-.48) Tsurf (-.12)	D15 (.30) Tsurf (-.27)	

The sign of the species contribution is the direction the species projects on the particular axis.

R² = % of variation in factor scores explained by regression

F = mean square due to regression/mean square of residual

r = simple correlation coefficient

D15 = depth of 15° isotherm

BEL5 = % of tow below 500 m

T200, Tsurf = temperature at 200 m, surface

and deeper than 500 m in the Northern Sargasso Sea, so that intermediate values indicate points of transition between the two habitats. In Figure 10 the collections are plotted with respect to the depth of the 15° isotherm. That the relationship between faunal composition and the depth of this temperature surface is only approximate can be seen by comparison of Figures 6 and 10. The general trend of the collections is the same with regard to both factor 1 and D15; however, local perturbations in the temperature field (e.g., NM collection 506 vs. 502) do not noticeably affect species composition.

The second term in the regression equation, surface temperature, is an obvious correlate of the seasonal aspect of the faunal gradient (page 80).

Simple correlation coefficients were computed to examine the dependence of species' relative abundance on the environmental parameters measured. The index of relative abundance used was the percentage contribution of a species to a collection, after the combined numbers of Cyclothone microdon and C. braueri were subtracted from the total (Table 9). The coefficients for C. microdon and C. braueri were computed simply on the basis of numbers of individuals. In addition to the three variables found to correlate best with the factor scores, salinity at 300 m and zooplankton biomass were used. The number of observations for each independent variable is given at the bottom of each row in Table 9. Species with correlation coefficients of absolute value greater than .30 are listed in the table,

Figure 10. Plot of collections with respect to the depth of the 15° isotherm. The vertical dimension is meaningless. Compare with projections on first axis of correspondence analysis, Figure 6a.

TABLE 9

Species' correlation coefficients with environmental parameters

	D15	Tsurf	Sal	BEL5	Zoop
<i>Benthoosema glaciale</i>	-.78	-.58	-.81	.23	.28
<i>Cyclothone microdon</i> *	-.67	-.71	-.55	.60	.60
<i>Scopelogadus beanii</i>	-.54	-.46	-.49	.39	.17
<i>Ceratoscopelus maderensis</i>	-.45	-.33	-.61	-.05	.14
<i>Lampanyctus macdonaldi</i>	-.43	-.26	-.32	.08	.40
<i>Myctophum affine</i>	-.23	-.04	-.35	-.11	.43
<i>Scopeloberyx opisthopterus</i>	-.22	-.14	-.15	.49	.47
<i>Maurolicus muelleri</i>	-.19	-.09	-.28	-.05	.55
<i>Lobianchia dofleini</i>	-.16	.10	-.39	-.06	-.24
<i>Lepidophanes guentheri</i>	-.13	.03	-.25	-.41	.15
<i>Diaphus dumerili</i>	-.11	-.03	-.19	-.06	.56
<i>Diaphus rafinesquei</i>	-.10	-.32	-.08	-.17	.22
<i>Argyrolepecus aculeatus</i>	.07	-.04	.11	-.37	.33
<i>Hygophum benoitii</i>	.13	.34	.16	.01	-.44
<i>Lampanyctus pusillus</i>	.28	.51	.29	.09	-.51
<i>Vinciguerrria poweriae</i>	.29	.35	.34	-.12	.02
<i>Vinciguerrria attenuata</i>	.36	.54	.39	.03	-.48
<i>Argyrolepecus hemigymnus</i>	.41	.44	.46	-.23	-.47
<i>Lampanyctus cuprarius</i>	.45	.18	.31	-.22	-.03
<i>Sternoptyx diaphana</i>	.48	.13	.40	-.22	-.09
<i>Lampanyctus photonotus</i>	.49	.32	.38	-.09	-.26
<i>Bolinichthys indicus</i>	.50	.28	.45	-.04	-.26
<i>Ceratoscopelus warmingi</i>	.56	.31	.46	-.18	-.23
<i>Diogenichthys atlanticus</i>	.56	.19	.53	.14	-.11
<i>Notolychnus valdiviae</i>	.56	.39	.43	-.19	-.19
<i>Pollichthys mauii</i>	.62	.35	.53	-.32	.07
<i>Bonapartia pedaliota</i>	.65	.53	.64	-.17	-.24
<i>Chauliodus danae</i>	.68	.40	.63	-.44	-.05
<i>Cyclothone braueri</i> *	.69	.49	.64	-.08	-.45
<i>Melamphaes pumilus</i>	.74	.44	.64	-.23	-.31
(No. observations)	(41)	(43)	(34)	(40)	(22)

Species abundance computed as $A = S_i / (N - (S_m + S_b))$, where A = abundance, S_i = number of species i in collection, N = total number of specimens in collection, S_m and S_b are numbers of *Cyclothone microdon* and *C. braueri*, respectively, in collection.

*Abundance of *C. microdon* and *C. braueri* taken simply as number of specimens.

D15 = depth of 15 isotherm

Tsurf = surface temperature

Sal = salinity at 300 m

BEL5 = percent of trawling time below 500 m

Zoop = zooplankton biomass (Appendix A)

in order of their correlation with D15.

It can be seen in Table 9 that the ordering of species approximates their ordering by the correspondence analysis (Figure 9). Four species with strong Slope Water preference, Benthoosema glaciale, Scopelogadus beanii, Ceratoscopelus maderensis, and Lampanyctus macdonaldi, and one with moderate Slope Water preference, Cyclothone microdon, have correlation coefficients with D15 more negative than -.40. All the species with strong preference for the Northern Sargasso Sea, plus Ceratoscopelus warmingi and Diogenichthys atlanticus (moderate preference), have correlation coefficients equal to or greater than .50 with D15.

There is good agreement between the correlations with D15 and those with the salinity at 300 m. The agreement between D15 and surface temperature is less pronounced, in keeping with the large seasonal effects on the latter variable. Only two species, Cyclothone microdon and Scopeloberyx opisthopterus, show strong correlations of abundance with the proportion of trawling below 500 m. These are the most frequently taken bathypelagic species in this study, and as already noted, they are clearly subject to sampling bias by the trawling procedure. Scopelogadus beanii, another bathypelagic species, shows a moderately high positive correlation with BEL5. Lepidophanes guentheri, Argyropelecus aculeatus, Pollichthys maui, and Chauliodus danae, all with moderate to high negative correlations with BEL5, were most abundant during the October cruise, Atlantis II 85, when the tows were systematically somewhat shallow.

Slope Water species tend to correlate positively with zooplankton biomass; Northern Sargasso Sea species, negatively. The small number of observations and the difficulty of measuring this last variable render the magnitude of the correlations with zooplankton biomass suspect.

Life history notes

The changing environment in a degrading ring can have measurable physiological effects on the entrained Slope Water animals (S. Boyd, personal communication). The manifestation of such effects in the reproductive biology of fishes might help illuminate ontogenetic aspects of habitat preference. Two observations indicate that life history studies of ring populations of Slope Water fishes would be a profitable line of research.

Benthosema glaciale, the second most abundant species in the Slope Water set, shows a rather smooth transition from Slope Water to Northern Sargasso Sea, being relatively abundant in the younger rings (R3 and R2) and less so in the older ones (Table 7, page 75). A point of interest regarding this species is the presence of small (17 to 20 mm) individuals in Ring 1 (Appendix B), sampled in September. These must be young of the year spawned in the previous spring (Halliday, 1970; Gjosaeter, 1973) and if the age estimate of this ring is correct, represent a successful spawning of B. glaciale in a ring that had been separated from the Slope Water for several months.

Figure 11. Length frequencies of Diaphus rafinesquei from two cruises.

The abundance of Diaphus rafinesquei in the Ring set (Table 7) is due to high numbers of small (<28 mm) individuals in Rings 2 and 4 (Figure 11). The Ring 2 samples, taken in February, are characterized by a peak in the size distribution in the 11-16 mm range, which was represented by only two specimens in the Slope Water collections at that time. Ring 4 samples, taken in March, contained mostly specimens larger than 20 mm, while the few Slope Water specimens at that time were mostly smaller than 20 mm. It is possible that the high numbers of D. rafinesquei in Ring 2 are the result of early spawning and/or accelerated development in the warm surface waters of this three-month-old ring.

Summary of results

1. The Slope Water is richer in biomass and numbers of individuals than the Northern Sargasso Sea. The latter habitat supports a higher species diversity, due mainly to the more even representation of species. The Gulf Stream rings are intermediate in these respects.
2. After adjusting for inputs from the Caribbean Sea, the relative abundance of species in the Slope Water and Northern Sargasso Sea can be used to assign habitat preferences. Of the 41 ranking species, seven show strong, and seven moderate preference for the Slope Water habitat. Seven show strong, and 13 moderate preference for the Northern Sargasso Sea. Seven species could not be assigned a habitat preference.
3. An ordination using correspondence analysis reveals a gradient

in faunal composition from winter conditions in the Slope Water to fall conditions in the Northern Sargasso Sea, with the rings occupying the middle of the gradient. Ring age is more important in this regard than is the season in which the ring is observed.

4. Species clusters derived from the ordination show good agreement with the habitat preference groups.

5. The species tend to show an all-or-nothing response to the ring environment, that is, the abundance of each species in the rings tends not to be intermediate between its Slope Water and Northern Sargasso Sea values but rather to closely resemble one or the other.

6. The first axis of the correspondence analysis, which accounts for 46 per cent of the variation in the collections, is highly correlated with the depth of the 15° isotherm and the surface temperature, in agreement with the subjective interpretation of the ordination.

7. Species with strong preference for the Slope Water and Northern Sargasso Sea habitats have high (negative and positive, respectively) correlations with the depth of the 15° isotherm.

TWO-LAYERED HABITAT MODEL

Slope Water - Northern Sargasso Sea contrasts

The gradient from Slope Water to Northern Sargasso Sea faunas, as represented by the first axis of the ordination, has been shown to correlate strongly with the depth of the 15° isotherm, D15. This isotherm approximately marks the top of the main thermocline, which changes in depth by about 500 m on crossing the Gulf Stream. Any property that varies systematically between the Slope Water and the Northern Sargasso Sea will therefore correlate with D15. This is the reason that the correlations of species abundance with D15 and with the salinity at 300 m (Table 9, page 89) are so similar.

Correlation coefficients between a number of environmental parameters are given in Table 10. All temperature and salinity measurements made at 200 m and below correlate highly with one another and with D15 and the depth of the oxygen minimum ($r \geq .75$). It can be appreciated that several variables, such as the depth of the oxygen minimum or the salinity or temperature at 300 m, will correlate nearly as well with the first axis of the ordination as does D15. The search for the important environmental parameters influencing species composition with respect to the Gulf Stream must clearly be more intuitive than mere correlation and regression with arbitrarily chosen variables.

As a consequence of the shallower thermocline, winter storms mix

TABLE 10
Matrix of correlation coefficients of environmental parameters

	Tsurf	T ₂₀₀	T ₃₀₀	T ₁₀₀₀	D ₁₅	DO ₂	Sal Surf	Sal 300	BEL5	PO ₄
T ₂₀₀	.54									
T ₃₀₀	.54	.96								
T ₁₀₀₀	.54	.75	.83							
D ₁₅	.64	.89	.94	.93						
DO ₂	.55	.87	.94	.88	.96					
Sal Surf	.32	.71	.70	.44	.64	.61				
Sal 300	.57	.93	.99	.85	.95	.95	.63			
BEL5	-.34	-.24	.09	-.01	-.36	.03	.11	.02		
PO ₄	-.43	-.81	-.77	-.43	-.56	-.66	-.91	-.69	-.31	
Zoop	-.44	-.58	-.55	-.40	-.46	-.54	-.09	-.55	.09	.44

Tsurf, T₂₀₀, T₃₀₀, T₁₀₀₀ = Temperature at surface, 200 m, 300 m, 1000 m.

D₁₅ = Depth of 15°C isotherm.

DO₂ = Depth of oxygen minimum.

Sal Surf, Sal 300 = Salinity at surface, 300 m.

BEL5 = percent of trawling time below 500 m.

PO₄ = Phosphate in upper 200 m.

Zoop = Zooplankton biomass in upper 700-800 m.

more nutrients into the euphotic zone in the Slope Water than in the Northern Sargasso Sea, resulting in a two-fold difference in annual primary production (Ryther, 1963). The higher productivity of the Slope Water is no doubt responsible for its higher biomass of zooplankton (Grice and Hart, 1962; Wiebe et al., in press) and consequently of fishes (this study, and Jahn and Backus, in press). The lower food supply in the Northern Sargasso Sea is probably unfavorable to fishes with strong preference for Slope Water. It is possible, though it seems unlikely, that Northern Sargasso Sea fishes are stressed by the abundance of food in the Slope Water. However, regardless of trophic requirements, a species must be able to tolerate the physical conditions of a habitat in order to exploit it.

The model

Midwater fishes near Bermuda typically live at daytime depths of 500 to 800 m, and many of them migrate into the upper 200 m at night (Gibbs et al., 1971). The deep scattering layer in the Slope Water follows the same pattern. For simplicity, the midwater environment can be modeled as two layers, a surface layer (upper 200 m) and a deep layer. The Slope Water and Northern Sargasso Sea habitats differ in both these layers.

The center of the main thermocline, represented by the 10° isotherm, lies at about 250 m in the Slope Water. Typical vertical migrators

must pass entirely through the thermocline in order to enter the surface layer. Furthermore, winter cooling in the surface layer is extensive, the entire upper 200 m sometimes cooling below 12°.

In the Northern Sargasso Sea, the center of the thermocline is at about 900 m, so that most of the fishes there live mainly in water warmer than 10°. Typical vertical migrators are always in warmer water than they would occupy in the deep layer of the Slope Water habitat. In the Northern Sargasso Sea winter cooling produces the thick layer of 18° water, so that the surface layer never gets colder than about 18°.

The trends of faunal composition found in this study are consistent with the two-layered model. Habitat preferences are determined by the species' responses to both layers.

The seasonal aspect of the gradient in faunal composition from winter Slope Water conditions to fall Northern Sargasso Sea conditions is in keeping with the seasonal temperature cycle of the surface layer (Figure 2). Slope Water species sensitive to surface layer conditions will encounter temperatures above 20° only in the upper 50 m in summer time. They will find Northern Sargasso Sea conditions most favorable in the winter, when the high surface temperatures have disappeared. On the other hand, Northern Sargasso Sea species will never encounter surface layer temperatures below about 18°. They will find Slope Water most salubrious in late summer and fall.

Gulf Stream rings as hybrid habitats

In all the rings sampled, the temperature structure of the upper 200 m or so was nearly identical to ambient Northern Sargasso Sea conditions, being at most 2° cooler. As seen in Figure 10, though, the thermocline depth of even the older rings, represented by D15, more closely resembled that of the Slope Water. It is therefore convenient to model the ring environment as a hybrid habitat consisting of a surface layer of Northern Sargasso Sea habitat and a deep layer of Slope Water habitat.

Biological evidence for the hybrid nature of the ring environment is the finding of Wiebe et al. (in press) that the significantly higher zooplankton biomass of the rings as compared to the Northern Sargasso Sea is due solely to a concentration at 300-800 m in the rings. In the upper 200-300 m, the biomass of each of these rings was indistinguishable from that of the surrounding Northern Sargasso Sea.

It can be seen in the T-S plots (Figure 3) that salinity in the surface layers of the rings is clearly intermediate between Slope Water and Northern Sargasso Sea conditions. The small variations in salinity in the open ocean are probably not important to fishes generally, but are certainly not involved in the all-or-nothing response to the ring environment (page 76).

The all-or-nothing response is consistent with the two-layered model. In this scheme, there are four groups of species. Two groups represent the "all" response. These are Slope Water and Northern

Sargasso Sea species with pure habitat preferences, requiring both the surface and deep layers of their preferred habitat. Species with pure habitat preferences find the ring environment unfavorable.

The other two groups are abundant in the rings. The first are Slope Water species closely associated with the deep layer of the habitat and only indirectly affected by changes in the surface layer. The last group are Northern Sargasso Sea species envisioned as being most affected by the surface layer and tolerant of modifications to the deep layer of the habitat.

In keeping with the model, the Slope Water species that are abundant in the rings are deep-living ones. Bohlke (1966) reports that Eurypharynx pelecyanoides is generally most concentrated in the depth range 1400-2800 m. Cyclothone microdon, Diaphus rafinesquei, and Scopeloberyx opisthopterus are non-migrators all living below 500 m in the Sargasso Sea but occurring 100-200 m shallower in the Slope Water (Gibbs, 1976). Chauliodus sloani is reported to live at depths of 550-1000 m in the Sargasso Sea, with some migration of juveniles to as shallow as 50 m at night. Its congener, C. danae (here, a group 'N' species) occurs at 500-850 m during the day, but is concentrated at 50-350 m at night (Green, 1972).

It must, however, be mentioned that three deep-living Slope Water species, Serrivomer beanii, Cyclothone acclinidens, and Scopelogadus beanii are not abundant in the rings, as expected from the two-layered

model. It is possible that these species live below the depth to which the water column is advected by the rings.

It was noted earlier that Benthosema glaciale was an exception to the trend toward an all-or-nothing response to the ring environment. This species shows a gradual decline in numbers with ring age (Table 7). Similarly, Ceratoscopelus maderensis is in moderate abundance in the younger rings but not in the older ones. Both these species are present in the Sargasso Sea set in numbers expected of expatriate Slope Water species, indicating they can survive in the Northern Sargasso Sea but not spawn there. The apparent spawning success of B. glaciale in Ring 1 is not necessarily an exception to this scheme. This ring was one of the bigger ones, and Fuglister (1972), in a study of two rings of similar size, found that although there was considerable warming in the upper 50 m, both rings maintained cold ($<15^{\circ}$) cores extending well above 200 m for at least four months. The spawning, then, may well have occurred before Ring 1 attained its "hybrid" condition.

Literature records of the vertical distribution of Benthosema glaciale help fit the species into the present scheme. Off Nova Scotia, B. glaciale has its day time concentration below 450 m, rising to between 50 and 100 m at night. This pattern appears constant throughout the year, and the species is rare in water above 18° , preferring the 4° - 16° temperature range (Halliday, 1970). The few specimens taken near Bermuda (Gibbs et al., 1971) were all captured below 750 m, mostly at 1000 m. B. glaciale thus seems to survive expatriation by altering its migratory behavior,

remaining in the cooler water at depth.

It is not known how the Sargasso Sea species get into the rings. Regardless of the mechanism, however, it is unlikely that advection can provide the selective process by which some species invade a ring and others do not. The vertical ranges of the two groups are about the same, and there is no systematic difference in their vertical migratory patterns (Gibbs and Roper, 1970; Gibbs et al., 1971; Krueger and Bond, 1972).

Thus, the species abundance data is consistent with a two-layered habitat model in which the Slope Water and Northern Sargasso Sea differ from one another in both layers, and the rings reported here are a hybrid formed of the upper layer of the Northern Sargasso Sea and the deep layer of the Slope Water.

THE GULF STREAM AS A FAUNAL BOUNDARY

Faunal boundaries in the Atlantic (Backus et al., 1970, in press) and Pacific (McGowan, 1971, 1974) are remarkably similar. While derived from mosaics of species distribution patterns, both systems adhere closely to the same kinds of hydrographic phenomena. The Atlantic boundaries are derived from the distributions of midwater fishes; the Pacific ones are based on organisms ranging from protozoa to tuna fish. As these boundaries are based on diverse taxa and ecological types, it is natural to seek a general explanation for oceanic faunal distributions.

The so-called water mass hypothesis proposed by Pickford (1946) with regard to the bathypelagic cephalopod Vampyroteuthis states that the distributions of pelagic animals conform to the distributions of water masses as defined by their T-S relations. This scheme has given mixed results, but its failures are largely due to the misapprehension that there must be some constituent of the water itself that limits species distribution.

This problem was mollified somewhat by Ebeling (1962) who stated (p. 118): "Though important, this T-S relation may not principally influence the range of a species, but may index other more important biological parameters associated with this range." In his treatment of the distribution of the fish genus Melamphaes, Ebeling found that the water mass paradigm gave good results if used in conjunction with levels of

primary productivity. Similarly, Backus et al. (1969) invoked differences in primary productivity as the fundamental agent in the faunal boundary at the thermal fronts dividing the Northern and Southern Sargasso Sea habitats, which occupy the same water mass. Recently, Hartmann and Clarke (1975), in considering lanternfish distributions in the central equatorial Pacific, have had some success with primary productivity, but note that even this refinement to the water mass hypothesis is insufficient to explain the details of certain species' distributions.

The area under consideration in the present study is dominated by a single water mass, the North Atlantic Central Water. The surface layer of the Slope Water is diluted by input of Labrador-Coastal water and is therefore cooler and fresher than Northern Sargasso Sea water of the same density. Differences in primary productivity are no doubt important underlying factors affecting community structure, but it is argued that the change in thermal structure on crossing the Gulf Stream, largely determined by the thermocline depth, is the major physical factor affecting the distribution of midwater fishes with respect to this boundary.

It is not proposed that thermal structure per se will be found to be a general determinant of faunal distributions, but rather that oceanic habitats should be viewed as three-dimensional structures, to which breeding populations of animals must be entirely adapted. The water mass concept provides such a view. Though it should no longer be considered a tenable hypothesis, it remains a useful paradigm for oceanic biogeography.

REFERENCES

- Backus, R. H., J. E. Craddock, R. L. Haedrich, and D. L. Shores, 1969:
Mesopelagic fishes and thermal fronts in the western Sargasso Sea. -
Mar. Biol. 3:87-106.
- Backus, R. H., J. E. Craddock, R. L. Haedrich, and D. L. Shores, 1970:
The distribution of mesopelagic fishes in the equatorial and west-
ern North Atlantic Ocean. - J. Mar. Res. 28:179-201.
- Backus, R. H., J. E. Craddock, R. L. Haedrich, and B. A. Robison, in
press: A contribution to the zoogeography of the pelagic Atlantic
Ocean. - Limnol. and Oceanogr.
- Baird, R. C., 1971: The systematics, distribution, and zoogeography of
the marine hatchetfishes (family Sternoptychidae). - Bull. Mus.
Comp. Zool. 142:1-128.
- Barrett, J. R., 1971: Available potential energy of Gulf Stream rings. -
Deep-Sea Res. 18:1221-1231.
- Beebe, W., 1935a-1935b: Deep-sea fishes of the Bermuda oceanographic
expeditions. - Zoologica:20:1-24. Family Derichthyidae., Family
Nessorhamphidae. 20:25-51.
- Beebe, W., and J. Crane, 1936-1937: Deep-sea fishes of the Bermuda oceano-
graphic expeditions. - Zoologica; Family Serrivomeridae. Part 1:
genus Serrivomer. 20:53-102. Family Nemichthyidae. 22:349-383.
- Benzecri, J. P., 1969: Statistical analysis as a tool to make patterns
emerge from data. In Methodologies of Pattern Recognition.

- S. Watanabe, ed. - Academic Press, New York. pp. 35-60.
- Bohlke, J. E., 1966: Order Lyomeri. In Fishes of the Western North Atlantic. - Mem. Sears Found. Mar. Res. No. 1, part 5:603-628.
- Bolin, R. L., 1959: Iniomi. Myctophidae from the "Michael Sars" North Atlantic Deep-Sea Expedition 1910. - Rep. Sci. Results "Michael Sars" N. Atl. Deep-Sea Exped. 1910. 4(7):1-45.
- Bond, G. W., Jr., and K. A. Tighe, 1974: A diagnostic character for rapid identification of lightly pigmented species of the genus Cyclothone (Gonostomatidae) in the North Atlantic. - Copeia (1) 272-275.
- Cheney, R. E., and P. L. Richardson, 1975: Distribution of Gulf Stream rings in the northwestern Sargasso Sea. - Mode Hotline News, No. 79. Woods Hole Oceanographic Inst., unpublished manuscript.
- Cheney, R. E., and P. L. Richardson, 1976: Observed decay of a cyclonic Gulf Stream ring. - Deep-Sea Res.
- Cole, H. P., G. M. Bryan, and A. L. Gordon, 1970: The deep scattering layer: patterns across the Gulf Stream and the Sargasso Sea. In Proceedings of an International Symposium on Biological Sound Scattering in the Ocean. G. B. Farquar, ed. - U.S. Government Printing Office, Washington, D.C.
- Colton, J. R., and R. R. Stoddard, 1972: Average montly sea-water temperatures Nova Scotia to Long Island. - Serial Atlas of the Marine Environment. American Geographical Society, New York.
- Davy, B., 1972: A review of the lanternfish genus Taaningichthys (family Myctophidae) with description of a new species. - Fish. Bull. 70:67-78.

- Ebeling, A. W., 1962: Melamphidae 1. Systematics and zoogeography of the species in the bathypelagic fish genus Melamphaes ["]Gunther. Dana Report No. 58 - The Carlsberg Foundation, Copenhagen.
- Ebeling, A. W., and W. H. Weed, 1973: Order Xenoberyces (Stephanoberyciformes). In Fishes of the Western North Atlantic. - Mem. Sears Found. Mar. Res. No. 1, part 6:397-478.
- Fraser-Brunner, A., 1949: A classification of the family Myctophidae. - Proc. Zool. Soc. Lond. 118:1019-1106.
- Fuglister, F. C., 1947: Hydrography of the western North Atlantic; the hydrography of the northwestern Sargasso Sea. - W.H.O.I. Techn. Rept. No. 4, Woods Hole Oceanographic Inst. unpublished manuscript.
- Fuglister, F. C., 1960: Atlantic Ocean atlas of temperature and salinity profiles and data from the International Geophysical Year of 1957-1958. - The Woods Hole Oceanographic Institution Atlas Series 1, 209 pp.
- Fuglister, F. C., 1972: Cyclonic rings formed by the Gulf Stream, 1965-66. In Studies in Physical Oceanography: a tribute to Georg Wüst on His 80th Birthday, A. Gordon, ed. - Gordon & Breach, pp. 137-168.
- Gibbs, R. H., Jr., 1957: A taxonomic analysis of Myctophum affine and M. nitidulum, two lanternfishes previously synonymized in the western North Atlantic. - Deep-Sea Res. 1:230-237.
- Gibbs, R. H., Jr., 1964: In Fishes of the Western North Atlantic. - Mem. Sears Found. Mar. Res. No. 1, part 4: Family Astronesthidae, pp. 311-350., Family Idiacanthidae, pp. 351-511.
- Gibbs, R. H., Jr., 1976: Nekton abundance, stratification, and vertical

- movement in the region of Deep Water Dump Site 106. - Interim report, NOAA grant 04-5-158-60. unpublished manuscript.
- Gibbs, R. H., Jr., R. H. Goodyear, M. J. Keene, and D. W. Brown, 1971: Biological studies of the Bermuda Ocean Acre II. Vertical distribution and ecology of the lanternfishes (family Myctophidae). - Report to the U.S. Navy Underwater Systems Center, Contract No. N00140-70-C-0307.
- Gibbs, R. H., Jr., and C.F.E. Roper, 1970: Ocean Acre preliminary report on vertical distribution of fishes and cephalopods. In Proceedings of an International Symposium on Biological Sound Scattering in the Ocean. - U.S. Government Printing Office, Washington, D.C.
- Gjosaeter, J., 1973: Age, growth, and mortality of the myctophid fish, Benthosema glaciale (Reinhardt), from western Norway. - Sarsia 52: 1-14.
- Green, J. R., 1972: Vertical distribution and life histories of chauliodontid fishes in the Bermuda Ocean Acre. - Am. Soc. Ichthyol. Herpetol. 52nd annual meeting, abstract.
- Grey, M., 1964: Family Gonostomatidae. In Fishes of the Western North Atlantic. - Mem. Sears Found. Mar. Res. No. 1, part 4:78-240.
- Grice, G. D., and A. D. Hart, 1962: The abundance, seasonal occurrence, and distribution of the epizooplankton between New York and Bermuda. - Ecol. Monogr. 32:287-307.
- Halliday, R. G., 1970: Growth and vertical distribution of the glacier lanternfish, Benthosema glaciale, in the northwestern Atlantic. -

- J. Fish. Res. Bd. Can. 27:105-116.
- Hartmann, A. R., and T. A. Clarke, 1975: The distribution of myctophid fishes across the central equatorial Pacific. - Fish. Bull. 73:633-641.
- Hedgpeth, J. W., 1957: Classification of marine environments. In Treatise on Marine Ecology and Paleoecology. - The Geological Society of America, Mem. 67. J. W. Hedgpeth, ed. 1:17-28.
- Hill, M. O., 1973: Reciprocal averaging: an eigenvector method of ordination. - J. Ecol. 61:237-251.
- Hill, M. O., 1974: Correspondence analysis: a neglected multivariate method. - Appl. Statist. 23:340-354.
- Iselin, C. O'D., 1936: A study of the circulation of the western North Atlantic. - Pap. Phys. Oceanogr. Met. 4 (4):1-101.
- Jahn, A. E., and R. H. Backus, in press: On the mesopelagic fish faunas of Slope Water, Gulf Stream, and Northern Sargasso Sea. - Deep-Sea Res.
- Krueger, W. H., and G. W. Bond, 1972: Biological studies of the Bermuda Ocean Acre III. Vertical distribution and ecology of the bristlemouth fishes (family Gonostomatidae). Report to the U.S. Navy Underwater Systems Center, contract no. N00140-72-C-0315.
- Krummel, O., 1891: Die nordatlantische Sargassosee. - Petermann's Mitteilungen, Bd. 37, 129 pp.
- Lloyd, M., and R. J. Ghelardi, 1964: A table for calculating the "equitability" component of species diversity. - J. Anim. Ecol. 33: 217-225.

- MacArthur, R. H., 1965: Patterns of species diversity. - Biol. Rev. 40: 510-533.
- McGowan, J. A., 1971: Oceanic biogeography of the Pacific. In Micropaleontology of Oceans. B. M. Funnel and W. R. Riedel, eds. - Cambridge Univ.
- McGowan, J. A., 1974: The nature of oceanic ecosystems. In The Biology of the Oceanic Pacific. C. B. Miller, ed. - Oregon State Univ.
- McLellan, H. J., 1957: On the distinctness and origin of the Slope Water off the Scotian Shelf and its easterly flow south of the Grand Banks. - J. Fish. Res. Bd. Can. 14:213-239.
- Morrow, J. E., Jr., 1964: In Fishes of the Western North Atlantic. - Mem. Sears Found. Mar. Res. No. 1, part 4: Family Chauliodontidae. pp. 274-289., Family Stomiatidae. pp. 290-310., Family Malacosteidae. pp. 523-549.
- Morrow, J. E., Jr., and R. H. Gibbs, Jr., 1964: Family Melanostomiatidae. In Mem. Sears Found. Mar. Res. No. 1, part 4:351-511.
- Mukhacheva, V. A., 1964: The composition of species of the genus Cyclothone (pisces, Gonostomatidae) in the Pacific Ocean. In Fishes of the Pacific and Indian Oceans, Biology and Distribution. T. S. Rass, ed. - Akad. Nauk. SSSR transl., Israel Progr. Sci. Transl.
- Musick, J. A., 1973: Mesopelagic fishes from the Gulf of Maine and the adjacent continental slope. - J. Fish. Res. Bd. Cana. 30:134-137.
- Nafpaktitis, B. G., 1968: Taxonomy and distribution of the lanternfishes, genera Lobianchia and Diaphus, in the North Atlantic. Dana Report

- No. 73 - The Carlsberg Foundation, Copenhagen.
- Nafpaktitis, B. G., 1975: Review of the lanternfish genus Notoscopelus (family Myctophidae) in the North Atlantic and Mediterranean. - Bull. Mar. Sci. 25:75-87.
- Nafpaktitis, B. G., and M. Nafpaktitis, 1969: Lanternfishes (family Myctophidae) collected during cruises 3 and 6 of the R/V Anton Bruun in the Indian Ocean. - Bull. L. A. Co. Mus. Nat. Hist.; Sci. No. 5, 79 pp.
- Nafpaktitis, B. G., and J. R. Paxton, 1968: Review of the lanternfish genus Lampadena with a description of a new species. - L. A. Co. Mus. Contrib. Sci. 138:1-29.
- Newton, C. W., 1961: Estimates of vertical motions and meridional heat exchange in Gulf Stream eddies and a comparison with atmospheric disturbances. - J. Geophys. Res. 66:853-870.
- Parker, C. E., 1971: Gulf Stream rings in the Sargasso Sea. - Deep-Sea Res. 18:981-993.
- Parker, C. E., 1972: Some direct observations of currents in the Gulf Stream. - Deep-Sea Res. 19:879-893.
- Paxton, J. R., 1972: Osteology and relationships of the lanternfishes (family Myctophidae). Bull. Nat. Hist. Mus. L. A. Co.; Sci. No. 13, 81 pp.
- Pickford, G. E., 1946: Vampyroteuthis infernalis Chun an archaic dibran-
chiate cephalopod. I. Natural history and distribution. Dana Rept. No. 29 - The Carlsberg Foundation, Copenhagen.

- Pollak, M. J., 1947: Hydrography of the western North Atlantic; hydrography of the subsurface Slope Water. - WHOI Techn. Rept. No. 5, Woods Hole Oceanographic Institution, unpublished manuscript.
- Richards, F. A., and A. C. Redfield, 1955: Oxygen-density relationships in the western North Atlantic. - Deep-Sea Res. 2:182-199.
- Ryther, J. H., 1963: Geographic variations in productivity. In The Sea vol. 2. M. N. Hill, ed. - Interscience. pp. 347-380.
- Saunders, P. M., 1971: Anticyclonic eddies formed from shoreward meanders of the Gulf Stream. - Deep-Sea Res. 18:1201-1219.
- Shannon, C. E., and W. Weaver, 1963: The mathematical theory of communication. - Univ. Illinois Press, Urbana, Ill. 117 pp.
- Seiwell, H. R., 1934: The distribution of oxygen in the western basin of the North Atlantic. - Pap. Phys. Oceanogr. Met. 5:1-43.
- Steele, D. H., 1967: The occurrence of the pearlsides, Maurolicus muelleri (Gmelin), in the northwestern Atlantic. - Can. Field-Nat. 81:184-186.
- Sverdrup, H. U., M. W. Johnson, and R. H. Fleming, 1942: The Oceans Their Physics, Chemistry, and General Biology. - Prentice-Hall, Inc., New York.
- Tate, M. W., and R. C. Clelland, 1957: Nonparametric and Shortcut Statistics. - The Interstate, Danville.
- Thompson, B. J., and G. A. Gotthardt, 1971: Life cycle of a North Atlantic eddy. - Trans. Am. Geophys. Un. 52:241.
- Tighe, K. A., 1975: A taxonomic revision of the family Serrivomeridae

- in the western North Atlantic. - Amer. Soc. Ichthyol. Herpetol.
55th annual meeting, abstract.
- Varenius, B., 1650: *Geografia Generalis*. - Amsterdam.
- Weitzman, S. H., 1974: Osteology and evolutionary relationships of the
Sternoptychidae, with a new classification of stomiatoid fishes. -
Bull. Am. Mus. Nat. Hist. 153:329-478.
- Whittaker, R. H., 1967: Gradient analysis of vegetation. - Biol. Rev. 42:
207-264.
- Wiebe, P. H., E. M. Hulburt, E. J. Carpenter, A. E. Jahn, G. P. Knapp,
III, S. H. Boyd, and P. B. Ortner, in press: Gulf Stream cold core
rings: large scale interaction sites for open ocean planktonic
communities. - Deep-Sea Res.
- Winge, O., 1923: The Sargasso Sea, its boundaries and vegetation. -
Rept. Dan. Oceanogr. Exped. 3, No. 2, 34 pp.
- Worthington, L. V., 1959: The 18° water in the Sargasso Sea. - Deep-
Sea Res. 5:297-305.
- Worthington, L. V., 1964: Anomalous conditions in the Slope Water area
in 1959. - J. Fish. Res. Bd. Can. 21: 327-333.
- Worthington, L. V., in press: On the North Atlantic Circulation. -
Johns Hopkins Oceanographic studies.

APPENDIX A

Collection data

The codes for the collections refer to water type and time of cruise, e.g.,

SS = Slope Water, September,

NS = Northern Sargasso Sea, September,

R1 = Ring 1, and so on

W = "warm-core ring"

M = meander of Gulf Stream

G = Gulf Stream

The positions given for the trawls, most of which covered a distance of about 10 nautical miles, are the averages of the starting and finishing positions. Likewise, the temperatures for the surface, 200 m and 300 m are in most cases averages of bathythermograph observations at the beginning and end of each trawl.

Some of the 300 m temperatures, and all of the 1000 m temperatures, and salinity, oxygen and phosphate information are from the hydrostation data. Because the bottles below 200 m were placed at 100 m intervals, the error in estimating the depth of the oxygen minimum is on the order of ($\pm$) 50 m. The smoothness of temperature-depth curves allows more reliable interpolations, so that the depth of the 15° isotherm is considered accurate to within ($\pm$) 10 m.

Zooplankton biomass data were provided by Peter Wiebe. The values were obtained by liquid displacement. The zooplankton collections,

described in Wiebe et al. (in press), are from oblique tows in the upper 700-800 m.

Phosphate values are averages of four (Atlantis II 71) or nine evenly-spaced observations in the upper 200 m.

Cruise, Collection Code and Number	Hydrostation Number	Mean Trawl Position		Temperature, °C				Depth (m) of	
		North Lat. deg.-min.	West Long. deg.-min.	Surface	200 m	300 m	1000 m	15°C isotherm	Oxygen minimum
Atlantis II 71 - September, October, 1972									
SS 002	1895	38-25	69-28	23.7	11.9	9.9	4.4	100	--
R1 003	1896	35-30	67-32	26.0	17.2	16.2	5.2	350	600
NS 004	1897	35-19	68-21	25.8	18.6	17.9	7.2	600	750
R1 005	1898	35-37	67-14	25.9	16.8	15.0	5.2	300	450
R1 006	1898	35-26	67-12	25.8	17.2	15.5	5.2	300	450
NS 007	1900	36-34	67-47	26.2	18.7	18.0	7.5	600	850
NS 008	1901	36-27	68-23	25.7	19.2	18.0	7.5	600	800
R1 009	1902	35-31	67-41	26.2	17.4	16.0	5.2	350	550
R1 010	1902	35-26	67-31	26.1	17.4	16.0	5.2	350	550
NS 011	1903, 1904	33-31	65-41	27.1	17.9	17.5	6.0	500	750
NS 033	--	33-04	56-11	25.5	17.8	--	--	--	--
NS 034	--	33-07	56-26	25.2	18.1	--	--	--	--
SS 036	--	38-09	67-06	23.7	12.9	--	--	130	--
Chain 110 and 111 - January, February, 1973									
SF 2701	--	39-28	70-52	9.2	12.0	--	--	0	--
SF 2702	--	39-40	71-00	9.2	12.0	--	--	0	--
SF 2703	--	39-32	69-57	13.5	11.6	--	--	0	--
SF 100	1310	40-57	65-19	14.2	14.3	11.0	--	0	--
W 101	1311	39-49	64-35	17.4	17.5	16.5	4.6	330	530
NF 102	1312	35-18	59-53	19.1	18.5	17.9	6.0	570	840
R2 103	1313	36-27	62-07	18.8	18.4	14.1	4.6	260	420
R2 104	1314	36-05	62-25	17.6	17.7	14.4	4.8	275	480
R2 105	1314	35-59	62-27	18.1	18.2	14.1	4.8	260	465

Cruise, Collection Code and Number	Salinity, ‰		Percent of Trawling Time		Maximum Trawl Depth (m)	Biomass cc/10 ³ m ³		Phosphate µg-atoms P/2
	Surface	300 m	Above 200 m	Below 500 m		Fish	Zooplankton	
<u>Atlantis II 71</u>								
SS 002	35.3	35.3	--	--	800	--	--	--
R1 003	35.8	36.1	19	56	1000	1.9	25	.25
NS 004	36.0	36.5	19	54	1075	1.7	--	.14
R1 005	35.9	36.0	20	54	960	1.8	--	.16
R1 006	35.9	36.0	15	60	1075	1.7	25	.17
NS 007	36.1	36.5	14	54	1175	0.7	27	.17
NS 008	36.1	36.5	22	50	850	--	28	.15
R1 009	35.9	36.1	19	53	1000	1.3	30	.17
R1 010	35.9	36.1	19	56	1055	2.9	25	.25
NS 011	36.2	36.4	19	53	1020	1.7	29	.17
NS 033	--	--	13	69	1210	0.5	33	--
NS 034	--	--	25	38	875	0.6	33	--
SS 036	--	--	--	--	1250	1.1	--	--
<u>Chain 110 and 111</u>								
SF 2701	--	--	11	62	1055	2.5	--	--
SF 2702	--	--	3	82	1190	1.8	--	--
SF 2703	--	--	7	83	950	2.4	--	--
SF 100	35.3	--	--	--	--	--	37	.37
W 101	36.4	36.2	28	40	860	1.4	--	.21
NF 102	36.4	36.4	30	47	890	2.0	34	.10
R2 103	36.1	35.7	25	52	900	--	23	.21
R2 104	36.1	35.8	23	48	925	1.8	22	.17
R2 105	36.1	35.8	21	49	925	1.8	--	.17

Cruise, Collection Code and Number	Hydrostation Number	Mean Trawl Position		Temperature, °C				Depth (m) of	
		North Lat. deg.-min.	West Long. deg.-min.	Surface	200 m	300 m	1000 m	15°C isotherm	Oxygen minimum
Knorr 35 - November, December, 1973									
SN 401	355	39-34	70-33	12.5	12.0	9.1	4.4	90	200
G 402	--	38-04	70-06	22.0	14.1	10.6	--	185	--
R3 403	358	36-04	71-37	21.5	16.0	13.5	4.4	200	400
R3 404	359	35-44	71-30	21.4	14.2	11.4	4.2	160	300
R3 405	358	35-52	71-25	21.4	15.0	12.5	4.2	190	300
SN 406	362	38-30	68-23	17.7	11.3	8.8	4.1	125	180
SN 407	363	39-41	69-53	16.8	12.8	9.5	4.3	145	175
Knorr 38 - March, April, 1974									
NM 502	469	36-19	61-55	19.1	18.7	18.0	6.0	500	900
R4 503	470	35-27	61-07	18.0	18.1	14.8	4.8	290	400
R4 504	471	35-32	60-59	18.0	18.0	15.0	4.8	295	400
R4 505	472	36-01	61-00	18.1	18.3	15.8	5.1	320	600
NM 506	474	36-46	64-30	21.0	19.9	18.7	8.2	690	800
SM 507	475	38-00	67-53	18.5	12.4	11.0	4.4	150	300
SM 509	477	39-43	69-50	20.5	11.4	8.7	4.4	0	200
Atlantis II 85 - October, 1974									
NO 701	2114	35-26	66-28	25.2	20.2	19.1	7.0	640	850
NO 702	2114	35-25	66-30	25.3	20.3	19.2	7.0	640	850
M 703	--	37-00	66-29	26.2	17.3	14.1	--	270	--
NO 705	2118	37-51	66-28	26.7	19.2	18.1	6.0	585	700
NO 706	2118	37-58	66-38	25.0	19.0	17.6	6.0	580	700
SO 707	2121	39-01	69-15	19.6	11.0	8.0	3.9	80	200
SO 708	2121	39-03	69-12	19.6	11.0	8.4	3.9	80	200

Cruise, Collection Code and Number	Salinity, ‰		Percent of Trawling Time		Maximum Trawl Depth (m)	Biomass cc/10m ³		Phosphate µg-atoms P/2
	Surface	300 m	Above 200 m	Below 500 m		Fish	Zooplankton	
<u>Knorr 35</u>								
SN 401	33.8	35.3	23	45	910	2.4	--	.85
G 402	--	--	20	48	950	1.5	--	--
R3 403	36.0	35.7	14	69	1355	2.3	50	.15
R3 404	36.0	35.4	20	51	925	1.1	--	.23
R3 405	36.0	35.6	20	56	1025	1.8	--	.15
SN 406	35.8	35.2	22	50	920	2.6	44	.52
SN 407	35.5	35.2	16	56	1050	2.1	44	.33
<u>Knorr 38</u>								
NM 502	36.4	36.4	17	60	1140	2.0	25	.07
R4 503	36.3	35.9	26	46	900	1.8	35	.20
R4 504	36.2	35.9	18	54	1000	2.0	53	.30
R4 505	36.3	36.2	21	49	930	3.1	36	.17
NM 506	36.5	36.4	23	48	900	1.3	33	.08
SM 507	36.1	35.4	21	52	850	1.9	61	--
SM 509	34.4	35.2	23	46	800	3.8	--	.85
<u>Atlantis II 95</u>								
NO 701	36.3	36.5	26	44	820	1.8	--	--
NO 702	36.3	36.5	20	48	900	1.4	--	--
M 703	--	--	26	40	800	1.6	--	--
NO 705	36.1	36.5	26	35	810	0.7	--	--
NO 706	36.1	36.5	22	45	775	1.4	--	--
NO 707	35.5	35.1	23	36	775	3.5	--	--
SO 708	35.5	35.1	27	44	835	2.8	--	--

APPENDIX B

Species data

The following is a computer-printed list of species records, including minimum and maximum standard lengths (size) and volume measured by liquid displacement. The three-letter prefixes to the station numbers are those of the actual field notes, but are not used in the main text or in Appendix A.

SYSTEMATIC LIST OF SPECIES DATA

	STATION	QUANTITY	SIZE (MM)		VOLUME
			MIN	MAX	(CC)
ANGUILLIFORMES					
ANGUILLIDAE					
NESSORHAMPHIDAE					
NESSORHAMPHUS					
			INGOLFIANUS		
	AEJ 401	1	156 "	156	.9
	AEJ 502	1	132 "	132	.5
	AEJ 506	1	505 "	505	80.0
	AEJ 509	1	155 "	155	2.0
	AEJ 702	1	89 "	89	.4
	AEJ 705	1	310 "	310	8.9
	AEJ 706	1	92 "	92	.5
	AEJ 707	2	220 "	224	8.5
	AEJ 708	1	175 "	175	2.0
	RHB2703	1	199 "	199	3.5
	TOTAL	11	89 "	505	107.6
DERICHTHYIDAE					
DERICHTHYS					
			SERPENTINUS		
	AEJ 10	2	126 "	126	2.0
	AEJ 100	1	162 "	162	2.2
	AEJ 104	1	173 "	173	3.9
	AEJ 105	1	203 "	203	6.0
	AEJ 402	3	167 "	202	13.5
	AEJ 405	1	118 "	118	1.2
	AEJ 503	1	109 "	109	.6
	AEJ 509	2	199 "	210	14.2
	AEJ 702	1	165 "	165	5.3
	AEJ 706	1	79 "	79	.4
	AEJ 707	2	128 "	240	14.5
	RHB2702	2	288 "	350	17.2
	RHB2703	2	160 "	189	7.9
	TOTAL	20	79 "	350	89.4
SERRIVOMERIDAE					
SERRIVOMER					
			BEANII		
	AEJ 2	1	152 "	152	.2
	AEJ 3	1	300 "	300	4.0
	AEJ 4	2	236 "	236	1.0
	AEJ 7	1	147 "	147	.3
	AEJ 9	7	66 "	191	2.2
	AEJ 10	2	255 "	280	2.1
	AEJ 11	2	185 "	230	1.2
	AEJ 34	2	135 "	170	.5

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 36	1	373 "	373	3.4
AEJ 100	2	240 "	451	12.1
AEJ 101	2	166 "	205	.8
AEJ 102	3	168 "	196	.9
AEJ 103	1	155 "	155	.1
AEJ 105	2	247 "	425	11.3
AEJ 401	5	276 "	437	30.0
AEJ 402	1	250 "	250	1.5
AEJ 403	1	283 "	283	1.7
AEJ 404	1	287 "	287	1.5
AEJ 405	1	290 "	290	1.8
AEJ 406	1	327 "	327	3.9
AEJ 407	1	180 "	180	.4
AEJ 503	1	258 "	258	1.2
AEJ 504	6	104 "	430	23.0
AEJ 505	2	202 "	540	24.0
AEJ 507	3	105 "	465	14.5
AEJ 509	7	108 "	455	50.0
AEJ 702	2	173 "	205	2.1
AEJ 703	5	110 "	414	11.3
AEJ 705	1	302 "	302	1.6
AEJ 706	7	144 "	295	5.0
AEJ 707	7	173 "	286	4.9
AEJ 708	4	151 "	210	1.9
RH82701	7	220 "	564	73.0
RH82702	8	170 "	530	30.0
TOTAL	100	65 "	564	323.4

SERRIVOMER		BREVIDENTATUS		
AEJ 5	1	255 "	255	1.2
AEJ 9	1	175 "	175	.4
AEJ 701	1	217 "	217	2.2
AEJ 703	2	142 "	198	.8
TOTAL	5	142 "	255	4.6

NEMICHTHYIDAE		SCOLSPACEUS		
NEMICHTHYS				
AEJ 4	2	200 "	270	1.3
AEJ 6	1	235 "	235	.3
AEJ 7	4	155 "	235	3.1
AEJ 8	3	250 "	290	1.3
AEJ 9	1	230 "	230	.2
AEJ 33	2	240 "	285	2.6

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 100	1	400 "	400	2.0
AEJ 401	1	745 "	745	11.0
AEJ 403	1	240 "	240	.7
AEJ 407	1	260 "	260	.5
AEJ 701	1	290 "	290	.8
AEJ 702	4	230 "	269	3.0
AEJ 703	2	262 "	262	.9
AEJ 705	2	290 "	740	10.0
AEJ 706	1	250 "	250	.5
AEJ 707	1	297 "	297	.2
RHB2701	8	595 "	710	41.0
RHB2702	3	656 "	770	21.0
TOTAL	39	155 "	770	100.4

EURYPHARYNGIDAE

EURYPHARYNX

AEJ 3	1	265 "	265	2.4
AEJ 6	1	507 "	507	41.0
AEJ 104	1	181 "	181	.9
AEJ 401	3	135 "	273	7.5
AEJ 402	1	0 "	0	.1
AEJ 404	1	170 "	170	.8
AEJ 405	4	125 "	495	48.0
AEJ 502	1	152 "	152	.5
AEJ 503	1	237 "	237	2.1
AEJ 504	3	104 "	437	34.0
AEJ 505	3	160 "	270	7.0
AEJ 506	1	100 "	100	.1
RHB2701	2	108 "	247	2.2
RHB2702	3	206 "	400	33.0
RHB2703	8	150 "	510	77.0
TOTAL	34	0 "	510	256.6

PELECANIDAE

SALMONIFORMES

STOMIATOIDEI

GONOSTOMATIDAE

BONAPARTIA

AEJ 3	2	27 "	33	.4
AEJ 4	10	19 "	51	5.9
AEJ 5	4	38 "	44	1.0
AEJ 6	2	24 "	43	.6
AEJ 7	3	35 "	47	1.6
AEJ 8	12	16 "	46	3.0

PEDALISTA

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 9	2	27 "	35	.5
AEJ 10	4	26 "	60	2.3
AEJ 11	25	15 "	54	5.9
AEJ 33	4	35 "	43	1.8
AEJ 34	8	34 "	46	4.5
AEJ 101	2	36 "	37	.6
AEJ 102	12	16 "	77	9.2
AEJ 402	3	12 "	38	.6
AEJ 502	5	21 "	60	5.0
AEJ 503	2	17 "	39	.5
AEJ 504	2	15 "	20	.1
AEJ 505	2	20 "	44	.6
AEJ 506	2	21 "	42	.8
AEJ 701	11	34 "	60	12.3
AEJ 702	17	12 "	55	9.8
AEJ 703	3	35 "	44	1.0
AEJ 705	14	19 "	55	8.5
AEJ 706	15	16 "	51	7.7
TOTAL	166	12 "	77	84.7

CYCLOTHONE

ACCLINIDENS

AEJ 3	1	33 "	33	.1
AEJ 4	2	32 "	35	.2
AEJ 5	3	20 "	33	.4
AEJ 9	1	23 "	23	.1
AEJ 11	1	27 "	27	.1
AEJ 100	1	25 "	25	.1
AEJ 401	2	24 "	35	.3
AEJ 405	2	28 "	35	.2
AEJ 407	3	29 "	33	.4
AEJ 502	2	28 "	34	.2
AEJ 505	2	25 "	42	.6
AEJ 507	2	26 "	31	.2
AEJ 509	5	25 "	38	1.1
AEJ 703	3	33 "	35	.6
AEJ 706	1	26 "	26	.1
AEJ 707	1	33 "	33	.2
AEJ 708	1	25 "	25	.1
RHB2701	4	24 "	32	.5
RHB2702	2	29 "	35	.3
RHB2703	4	26 "	29	.4
TOTAL	43	20 "	42	6.2

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME
		MIN	MAX	(CC)
CYCLOTHONE		ALBA		
AEJ 2	6	20 "	27	.2
AEJ 3	5	9 "	24	.1
AEJ 4	2	23 "	25	.1
AEJ 6	1	26 "	26	.1
AEJ 7	4	12 "	22	.2
AEJ 8	1	24 "	24	.1
AEJ 9	5	10 "	25	.3
AEJ 10	3	22 "	25	.1
AEJ 11	2	22 "	24	.1
AEJ 33	1	20 "	20	.1
AEJ 34	2	14 "	26	.1
AEJ 35	3	14 "	16	.1
AEJ 100	1	15 "	15	.1
AEJ 101	4	13 "	22	.1
AEJ 102	24	11 "	26	.6
AEJ 103	5	18 "	28	.2
AEJ 104	1	18 "	18	.1
AEJ 105	1	21 "	21	.1
AEJ 401	4	12 "	28	.3
AEJ 402	1	25 "	25	.1
AEJ 403	2	14 "	22	.1
AEJ 404	1	18 "	18	.1
AEJ 405	11	20 "	26	.7
AEJ 406	5	18 "	24	.2
AEJ 407	3	13 "	28	.3
AEJ 502	13	12 "	28	.6
AEJ 503	2	21 "	24	.1
AEJ 505	2	17 "	23	.1
AEJ 506	8	12 "	28	.2
AEJ 507	8	16 "	24	.5
AEJ 509	2	27 "	29	.3
AEJ 702	14	11 "	26	.7
AEJ 703	6	15 "	26	.4
AEJ 705	13	12 "	27	.3
AEJ 706	12	11 "	23	.5
AEJ 707	1	23 "	23	.1
RHB2701	4	23 "	29	.2
RHB2702	5	21 "	24	.2
RHB2703	2	19 "	24	.1
TOTAL	190	9 "	29	8.9
CYCLOTHONE		BRAUER I		
AEJ 2	39	14 "	26	2.0

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 3	23	10 "	23	0.7
AEJ 4	108	11 "	25	3.5
AEJ 5	54	11 "	27	2.2
AEJ 6	41	10 "	27	1.2
AEJ 7	74	11 "	27	2.7
AEJ 8	124	9 "	25	5.2
AEJ 9	90	10 "	26	3.0
AEJ 10	79	10 "	26	2.2
AEJ 11	80	10 "	26	3.7
AEJ 33	67	11 "	25	2.8
AEJ 34	169	11 "	25	6.2
AEJ 36	15	12 "	25	0.5
AEJ 100	4	17 "	24	0.1
AEJ 101	28	13 "	28	1.4
AEJ 102	122	14 "	29	6.1
AEJ 103	9	16 "	24	0.6
AEJ 104	8	13 "	25	0.2
AEJ 105	9	17 "	26	0.5
AEJ 401	43	13 "	27	2.3
AEJ 402	6	16 "	22	0.3
AEJ 405	3	11 "	27	0.1
AEJ 406	4	18 "	28	0.2
AEJ 407	35	17 "	29	2.3
AEJ 502	67	13 "	29	5.2
AEJ 503	10	17 "	27	0.9
AEJ 504	11	16 "	28	0.7
AEJ 505	13	17 "	28	0.8
AEJ 506	89	12 "	27	5.2
AEJ 507	6	17 "	26	0.3
AEJ 509	12	20 "	28	1.2
AEJ 701	34	11 "	28	2.6
AEJ 702	101	11 "	26	4.9
AEJ 703	49	16 "	27	2.4
AEJ 705	59	13 "	25	2.3
AEJ 706	142	11 "	27	6.3
AEJ 707	8	13 "	28	0.4
AEJ 708	22	23 "	30	1.7
RHB2701	14	16 "	27	0.6
RHB2702	26	19 "	28	1.6
RHB2703	35	16 "	24	1.2
TOTAL	1932	9 "	30	89.3
CYCLOTHONE	MICROBEN			
AEJ 2	177	14 "	54	18.0

SYSTEMATIC LIST OF SPECIES DATA

STATION		QUANTITY	SIZE (MM)		VOLUME (CC)
			MIN	MAX	
AEJ	3	95	17 "	43	5.5
AEJ	4	39	11 "	55	3.0
AEJ	5	142	18 "	43	12.0
AEJ	6	224	15 "	47	15.0
AEJ	7	81	14 "	40	6.1
AEJ	8	63	10 "	54	3.5
AEJ	9	90	11 "	39	3.3
AEJ	10	103	8 "	41	6.6
AEJ	11	84	10 "	36	4.2
AEJ	33	78	11 "	42	6.3
AEJ	34	50	11 "	41	3.0
AEJ	36	140	11 "	53	25.0
AEJ	100	77	20 "	40	8.5
AEJ	101	147	20 "	53	18.0
AEJ	102	46	15 "	35	3.0
AEJ	103	368	16 "	52	51.0
AEJ	104	314	15 "	46	36.0
AEJ	105	418	14 "	48	63.0
AEJ	401	296	12 "	50	49.0
AEJ	402	308	15 "	52	45.0
AEJ	403	203	17 "	51	40.0
AEJ	404	152	14 "	55	22.0
AEJ	405	305	12 "	49	35.0
AEJ	406	266	19 "	58	45.0
AEJ	407	285	11 "	57	42.0
AEJ	502	105	13 "	52	20.0
AEJ	503	234	16 "	56	3.7
AEJ	504	417	12 "	58	70.0
AEJ	505	279	13 "	48	48.0
AEJ	506	143	12 "	51	14.0
AEJ	507	206	13 "	52	34.0
AEJ	509	270	14 "	54	56.0
AEJ	702	4	11 "	34	.3
AEJ	703	58	12 "	50	3.0
AEJ	705	13	10 "	48	.6
AEJ	706	13	11 "	33	.7
AEJ	707	53	17 "	40	7.0
AEJ	708	179	17 "	48	26.0
RHB2701		467	12 "	55	67.0
RHB2702		785	14 "	55	99.0
RHB2703		698	21 "	57	107.0
TOTAL		8475	8 "	58	1129.3
CYCLOTHONE		PALLIDA			
AEJ	2	32	18 "	55	9.0

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 3	8	12 "	55	1.0
AEJ 4	24	11 "	46	3.4
AEJ 5	7	14 "	39	.9
AEJ 6	13	14 "	48	2.1
AEJ 7	7	11 "	58	1.5
AEJ 8	34	11 "	53	6.9
AEJ 9	14	14 "	48	2.1
AEJ 10	8	16 "	43	1.2
AEJ 11	9	16 "	46	1.6
AEJ 33	13	21 "	59	4.5
AEJ 34	23	16 "	46	3.8
AEJ 36	13	24 "	51	3.1
AEJ 100	11	22 "	48	2.3
AEJ 101	12	20 "	57	2.9
AEJ 102	35	11 "	53	9.6
AEJ 103	9	15 "	50	1.9
AEJ 104	2	23 "	27	.1
AEJ 105	2	34 "	37	.3
AEJ 401	27	17 "	43	3.7
AEJ 402	9	30 "	57	3.1
AEJ 403	6	16 "	44	.9
AEJ 404	8	18 "	43	1.2
AEJ 405	12	12 "	57	4.0
AEJ 406	8	19 "	53	2.0
AEJ 407	18	19 "	45	2.2
AEJ 502	9	17 "	52	2.6
AEJ 503	6	38 "	52	2.7
AEJ 504	2	16 "	23	.1
AEJ 505	5	33 "	52	1.8
AEJ 506	21	24 "	52	6.8
AEJ 507	1	33 "	33	.1
AEJ 509	20	15 "	57	8.4
AEJ 701	15	11 "	43	2.8
AEJ 702	24	11 "	48	3.0
AEJ 703	26	11 "	56	7.1
AEJ 705	31	10 "	56	7.8
AEJ 706	98	12 "	54	19.8
AEJ 707	18	15 "	51	5.8
AEJ 708	25	17 "	56	7.5
RHB2701	26	19 "	53	6.4
RHB2702	37	18 "	50	6.1
RHB2703	34	19 "	60	13.7
TOTAL	762	10 "	60	177.8

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
CYCLOTHONE		PSEUDOPALLIDA		
AEJ 2	8	26 "	37	.9
AEJ 3	4	25 "	34	.4
AEJ 4	11	20 "	38	1.2
AEJ 5	9	21 "	40	1.0
AEJ 6	12	22 "	42	1.5
AEJ 7	2	27 "	29	.1
AEJ 8	9	25 "	42	1.2
AEJ 9	13	20 "	41	1.2
AEJ 10	13	21 "	37	1.5
AEJ 11	3	21 "	32	.1
AEJ 33	7	24 "	33	.7
AEJ 34	5	26 "	36	.5
AEJ 36	3	20 "	37	.2
AEJ 100	4	14 "	40	.2
AEJ 101	28	11 "	37	1.1
AEJ 102	24	11 "	32	1.0
AEJ 103	8	19 "	38	.9
AEJ 104	7	19 "	42	.8
AEJ 105	9	19 "	41	1.1
AEJ 401	8	17 "	38	.8
AEJ 402	18	24 "	40	2.1
AEJ 403	2	24 "	38	.3
AEJ 404	1	29 "	29	.1
AEJ 405	5	10 "	42	.4
AEJ 406	4	33 "	40	.9
AEJ 407	10	20 "	37	1.0
AEJ 502	3	29 "	37	.6
AEJ 503	5	28 "	39	1.2
AEJ 504	5	17 "	42	.8
AEJ 505	3	16 "	36	.4
AEJ 506	9	26 "	35	1.2
AEJ 507	5	21 "	35	.5
AEJ 509	8	31 "	38	1.5
AEJ 701	3	24 "	35	.5
AEJ 702	10	19 "	35	1.0
AEJ 703	4	28 "	38	.6
AEJ 705	1	40 "	40	.3
AEJ 706	16	12 "	36	1.3
AEJ 707	8	28 "	44	1.1
AEJ 708	8	27 "	47	1.7
RHB2701	7	26 "	42	1.2
RHB2702	39	12 "	43	4.6
RHB2703	24	14 "	37	1.5
TOTAL	385	10 "	47	41.2

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
GONOSTOMA ATLANTICUM				
AEJ 503	1	29 "	29	.2
AEJ 706	1	26 "	26	.1
AEJ 703	1	21 "	21	.1
TOTAL	3	21 "	29	.4
GONOSTOMA ELONGATUM				
AEJ 2	4	31 "	110	4.5
AEJ 6	2	169 "	259	46.0
AEJ 7	2	43 "	87	3.5
AEJ 8	6	19 "	85	3.0
AEJ 10	3	194 "	230	80.0
AEJ 11	1	204 "	204	30.0
AEJ 33	2	66 "	101	4.0
AEJ 35	1	31 "	31	.1
AEJ 100	5	85 "	193	45.0
AEJ 101	4	28 "	81	1.3
AEJ 102	2	39 "	40	.4
AEJ 103	6	55 "	185	57.0
AEJ 104	3	94 "	161	28.0
AEJ 105	4	83 "	162	39.0
AEJ 401	9	23 "	200	87.0
AEJ 402	6	29 "	152	28.0
AEJ 403	2	146 "	177	29.0
AEJ 407	6	25 "	103	9.0
AEJ 502	1	106 "	106	3.8
AEJ 504	3	37 "	71	2.4
AEJ 505	3	90 "	242	72.0
AEJ 506	2	50 "	56	2.1
AEJ 507	1	138 "	138	8.3
AEJ 509	1	204 "	204	44.0
AEJ 701	1	242 "	242	57.0
AEJ 702	10	8 "	227	45.0
AEJ 703	11	12 "	34	.8
AEJ 705	3	13 "	95	2.4
AEJ 706	5	29 "	101	7.5
AEJ 707	3	80 "	125	12.2
AEJ 708	5	60 "	159	21.5
RHB2701	1	131 "	131	7.0
RHB2702	2	133 "	175	23.5
RHB2703	1	201 "	201	26.0
TOTAL	121	8 "	259	830.3

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME
		MIN	MAX	(CC)
MARGRETHIA		OBTUSIROSTRA		
AEJ 3	2	13 "	18	.2
AEJ 4	1	23 "	23	.1
AEJ 5	1	21 "	21	.1
AEJ 8	1	19 "	19	.1
AEJ 9	2	12 "	24	.1
AEJ 11	1	22 "	22	.1
AEJ 502	1	41 "	41	1.1
AEJ 701	1	18 "	18	.1
AEJ 702	1	15 "	15	.1
AEJ 705	2	8 "	16	.1
TOTAL	13	8 "	41	2.1
PHOTICHTHYIDAE				
DIPLOPHOS		TAENIA		
AEJ 405	1	65 "	65	.4
AEJ 705	1	47 "	47	.1
TOTAL	2	47 "	65	.5
ICHTHYOCOCCLUS		OVATUS		
AEJ 4	1	11 "	11	.1
AEJ 5	1	18 "	18	.1
AEJ 7	1	11 "	11	.1
AEJ 8	1	15 "	15	.1
AEJ 102	1	22 "	22	.1
AEJ 105	1	18 "	18	.1
AEJ 505	2	28 "	30	1.0
AEJ 506	1	21 "	21	.2
AEJ 701	1	10 "	10	.1
AEJ 705	1	13 "	13	.1
AEJ 706	1	11 "	11	.1
TOTAL	12	10 "	30	2.1
POLLICHTHYS		MAULI		
AEJ 4	1	40 "	40	.1
AEJ 7	2	41 "	41	.3
AEJ 8	2	33 "	37	.4
AEJ 9	2	34 "	34	.1
AEJ 11	1	38 "	38	.1
AEJ 34	4	36 "	43	1.0
AEJ 101	1	24 "	24	.1
AEJ 102	2	29 "	41	.2

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 103	1	31 "	31	.1
AEJ 405	2	37 "	38	.4
AEJ 407	1	37 "	37	.2
AEJ 502	3	29 "	41	.5
AEJ 504	3	30 "	38	.6
AEJ 505	1	34 "	34	.1
AEJ 506	1	33 "	33	.1
AEJ 701	7	16 "	26	.5
AEJ 702	9	17 "	37	1.0
AEJ 703	2	20 "	21	.1
AEJ 705	5	27 "	40	.7
AEJ 706	10	20 "	37	1.0
AEJ 707	1	33 "	33	.1
AEJ 708	1	20 "	20	.1
TOTAL	62	16 "	43	7.8

VINCIGUERRIA		ATTENUATA			
AEJ	2	3	16 "	21	.3
AEJ	3	14	12 "	21	.6
AEJ	4	7	12 "	17	.4
AEJ	5	11	12 "	27	.4
AEJ	6	11	13 "	23	.6
AEJ	7	5	16 "	23	.5
AEJ	8	4	13 "	16	.2
AEJ	9	15	13 "	19	.5
AEJ	10	8	14 "	29	.7
AEJ	11	5	13 "	18	.1
AEJ	33	3	12 "	19	.1
AEJ	34	9	13 "	20	.5
AEJ	100	1	29 "	29	.2
AEJ	101	1	28 "	28	.1
AEJ	102	5	24 "	26	.7
AEJ	103	1	26 "	26	.1
AEJ	104	4	28 "	38	1.2
AEJ	105	3	28 "	40	1.5
AEJ	401	2	21 "	24	.2
AEJ	402	1	17 "	17	.1
AEJ	405	1	18 "	18	.1
AEJ	407	1	23 "	23	.1
AEJ	502	3	32 "	39	1.6
AEJ	503	3	34 "	38	1.5
AEJ	701	3	14 "	21	.3
AEJ	702	5	16 "	20	.3
AEJ	705	3	19 "	21	.2

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 706	7	16 "	22	.5
RHB2701	1	24 "	24	.1
TOTAL	140	12 "	40	13.7

VINCIGUERRIA

NIMBARIA

AEJ 36	1	24 "	24	.1
AEJ 100	1	12 "	12	.1
AEJ 101	1	20 "	20	.1
AEJ 402	1	25 "	25	.1
AEJ 502	1	37 "	37	.6
AEJ 509	1	39 "	39	.7
AEJ 701	2	18 "	23	.2
AEJ 702	4	20 "	25	.5
AEJ 703	3	14 "	17	.1
AEJ 705	4	14 "	21	.3
AEJ 706	3	14 "	18	.1
AEJ 707	1	24 "	24	.2
TOTAL	23	12 "	39	3.1

VINCIGUERRIA

POWERIAE

AEJ 2	3	16 "	28	.5
AEJ 3	2	22 "	24	.4
AEJ 4	7	17 "	26	1.0
AEJ 5	8	13 "	35	1.2
AEJ 6	3	16 "	21	.2
AEJ 8	5	14 "	28	.5
AEJ 9	2	11 "	21	.1
AEJ 10	2	13 "	22	.1
AEJ 11	1	15 "	15	.1
AEJ 33	1	20 "	20	.1
AEJ 34	9	15 "	29	1.3
AEJ 100	1	38 "	38	.5
AEJ 101	3	20 "	28	.6
AEJ 401	2	29 "	30	.7
AEJ 402	3	23 "	32	1.0
AEJ 502	1	22 "	22	.1
AEJ 503	3	16 "	35	.6
AEJ 504	4	18 "	39	1.4
AEJ 505	3	15 "	17	.1
AEJ 506	1	24 "	24	.1
AEJ 701	1	15 "	15	.1
AEJ 702	2	13 "	24	.2
AEJ 703	1	18 "	18	.1

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 705	3	12 "	15	•2
AEJ 706	1	13 "	13	•1
AEJ 708	1	14 "	14	•1
RHB2703	1	21 "	21	•1
TOTAL	74	11 "	39	11•5

STERNOPTYCHIDAE

ARGYROPELECUS

ACULEATUS

AEJ 2	3	53 "	55	15•0
AEJ 3	2	40 "	47	10•0
AEJ 4	2	19 "	44	4•0
AEJ 7	2	10 "	11	•1
AEJ 8	2	10 "	14	•2
AEJ 9	1	12 "	12	•1
AEJ 10	1	49 "	49	3•5
AEJ 11	2	7 "	8	•1
AEJ 33	1	19 "	19	•4
AEJ 34	6	9 "	18	•7
AEJ 36	1	25 "	25	•9
AEJ 100	6	15 "	60	15•0
AEJ 101	9	9 "	54	15•0
AEJ 102	1	19 "	19	•4
AEJ 103	3	11 "	63	12•0
AEJ 104	3	10 "	51	5•0
AEJ 401	1	8 "	8	•1
AEJ 402	2	48 "	63	20•0
AEJ 405	1	48 "	48	5•0
AEJ 406	2	67 "	70	33•0
AEJ 407	2	41 "	42	7•5
AEJ 502	2	10 "	15	•2
AEJ 503	3	10 "	46	5•0
AEJ 504	7	10 "	34	4•0
AEJ 505	3	11 "	22	1•0
AEJ 507	1	37 "	37	2•1
AEJ 701	3	15 "	34	3•6
AEJ 702	4	15 "	54	11•0
AEJ 703	7	11 "	50	13•0
AEJ 705	3	18 "	45	5•0
AEJ 706	3	12 "	21	•7
AEJ 707	3	16 "	41	4•5
AEJ 708	6	37 "	54	23•0
RHB2701	1	48 "	48	5•0
RHB2702	1	16 "	16	•2
RHB2703	1	10 "	10	•1
TOTAL	101	7 "	70	226•4

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
ARGYROPELECUS		HEMIGYMNUS		
AEJ 2	1	17 "	17	.1
AEJ 3	12	6 "	20	1.0
AEJ 4	4	9 "	16	.4
AEJ 5	16	6 "	26	2.3
AEJ 6	11	6 "	30	1.0
AEJ 7	5	6 "	34	3.2
AEJ 8	10	6 "	26	1.9
AEJ 9	21	6 "	19	1.7
AEJ 10	6	7 "	29	.9
AEJ 11	7	75 "	23	.8
AEJ 33	2	8 "	11	.1
AEJ 34	24	6 "	24	2.5
AEJ 36	4	10 "	17	.3
AEJ 100	6	11 "	25	1.2
AEJ 101	11	15 "	39	5.0
AEJ 102	11	10 "	27	2.1
AEJ 103	5	12 "	16	.4
AEJ 104	6	10 "	30	1.7
AEJ 105	16	12 "	29	4.5
AEJ 402	10	10 "	33	3.3
AEJ 404	2	17 "	20	.5
AEJ 405	3	9 "	18	.2
AEJ 406	1	16 "	16	.1
AEJ 407	1	11 "	11	.1
AEJ 502	4	11 "	35	1.6
AEJ 503	4	15 "	19	.5
AEJ 505	6	11 "	22	1.0
AEJ 506	6	14 "	21	1.2
AEJ 701	4	7 "	36	1.8
AEJ 702	15	13 "	30	2.8
AEJ 703	9	8 "	29	2.0
AEJ 705	3	8 "	12	.1
AEJ 706	14	9 "	24	1.8
AEJ 707	3	11 "	24	.8
RHB2701	1	28 "	28	.5
RHB2703	2	11 "	17	.1
TOTAL	266	6 "	39	49.5
MAUROLICUS		MUELLERI		
AEJ 2	1	23 "	23	.1
AEJ 101	1	15 "	15	.1
AEJ 407	1	9 "	9	.1
AEJ 507	17	10 "	19	.9

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 509	4	11 "	23	.3
AEJ 703	1	19 "	19	.1
AEJ 707	1	21 "	21	.1
TOTAL	26	9 "	23	1.7
STERNOPTYX		DIAPHANA		
AEJ 2	5	8 "	24	10.0
AEJ 3	3	6 "	8	.1
AEJ 4	10	4 "	28	7.0
AEJ 5	10	8 "	26	4.8
AEJ 6	2	13 "	21	1.0
AEJ 7	6	5 "	24	3.0
AEJ 8	37	5 "	28	19.4
AEJ 9	3	5 "	12	.2
AEJ 10	4	6 "	26	1.4
AEJ 11	5	6 "	10	.2
AEJ 33	14	14 "	17	1.1
AEJ 34	17	9 "	26	7.0
AEJ 36	3	12 "	28	2.0
AEJ 100	10	11 "	30	7.1
AEJ 101	8	8 "	18	1.0
AEJ 102	35	8 "	26	20.5
AEJ 104	4	9 "	29	2.5
AEJ 105	4	8 "	22	.6
AEJ 401	7	8 "	21	1.8
AEJ 402	8	9 "	21	3.3
AEJ 404	1	9 "	9	.1
AEJ 405	1	27 "	27	1.3
AEJ 406	3	11 "	18	.6
AEJ 407	4	9 "	21	1.1
AEJ 502	9	8 "	26	3.8
AEJ 503	11	8 "	24	5.3
AEJ 504	7	7 "	19	1.4
AEJ 505	10	12 "	31	5.7
AEJ 506	40	10 "	34	16.0
AEJ 507	2	20 "	32	2.3
AEJ 509	2	18 "	28	1.5
AEJ 701	7	6 "	25	3.3
AEJ 702	14	7 "	26	3.1
AEJ 703	6	9 "	20	1.2
AEJ 705	18	13 "	29	11.0
AEJ 706	43	7 "	33	21.0
AEJ 707	27	11 "	31	19.3
AEJ 708	27	8 "	33	12.2

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
RH32701	9	8 "	27	4.4
RH32702	14	12 "	27	6.6
RH32703	5	11 "	23	2.3
TOTAL	455	4 "	34	217.5

STERNOPTYX	PSEUDOBSCURA			
AEJ 5	1	21 "	21	.9
TOTAL	1	21 "	21	.9

VALENCIENNELUS	TRIPUNCTULATUS			
AEJ 3	4	13 "	22	.3
AEJ 4	2	18 "	21	.1
AEJ 5	4	25 "	29	.9
AEJ 6	6	19 "	22	.5
AEJ 7	4	19 "	22	.4
AEJ 8	1	12 "	12	.1
AEJ 9	4	17 "	26	.6
AEJ 10	3	21 "	27	.2
AEJ 11	2	17 "	22	.1
AEJ 33	1	21 "	21	.1
AEJ 34	1	19 "	19	.1
AEJ 36	3	11 "	20	.1
AEJ 101	8	19 "	23	.9
AEJ 102	2	16 "	16	.1
AEJ 103	5	23 "	25	.7
AEJ 104	10	21 "	27	1.7
AEJ 105	3	15 "	20	.2
AEJ 402	2	18 "	22	.1
AEJ 405	1	19 "	19	.1
AEJ 406	1	17 "	17	.1
AEJ 407	2	19 "	23	.1
AEJ 502	1	19 "	19	.1
AEJ 503	2	22 "	30	.3
AEJ 504	8	17 "	27	1.1
AEJ 505	3	20 "	22	.3
AEJ 506	1	17 "	17	.1
AEJ 509	1	21 "	21	.1
AEJ 701	2	19 "	21	.2
AEJ 702	4	22 "	30	.8
AEJ 703	3	17 "	30	.3
AEJ 705	3	17 "	26	.4
AEJ 706	3	24 "	24	.5
AEJ 707	2	20 "	26	.4

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 703	2	15 "	21	.3
RHB2702	1	23 "	23	.1
TOTAL	105	11 "	30	12.5
ASTRONESTHIDAE				
ASTRONESTHES		CYANEUS		
AEJ 102	1	40 "	40	.5
TOTAL	1	40 "	40	.5
ASTRONESTHES		GEMMIFER		
AEJ 105	1	21 "	21	.1
AEJ 502	1	31 "	31	.3
AEJ 706	1	31 "	31	.4
TOTAL	3	21 "	31	.8
ASTRONESTHES		LONGICEPES		
AEJ 33	1	23 "	23	.1
TOTAL	1	23 "	23	.1
ASTRONESTHES		NIGER		
AEJ 33	1	26 "	26	.1
TOTAL	1	26 "	26	.1
BOROSTOMIAS		ANTARCTICUS		
AEJ 405	1	175 "	175	25.0
TOTAL	1	175 "	175	25.0
NEONESTHES		CAPENSIS		
AEJ 103	1	22 "	22	.1
TOTAL	1	22 "	22	.1
MELANOSTOMIATIDAE				
BATHOPHILUS		BREVIS		
AEJ 702	1	29 "	29	.9
TOTAL	1	29 "	29	.9
BATHOPHILUS		METALLICUS		
AEJ 2	1	91 "	91	2.9

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 505	1	88 "	88	2.7
AEJ 505	1	88 "	88	2.7
AEJ 702	1	51 "	51	.5
TOTAL	4	51 "	91	8.8
CHIROSTOMIAS	PLIOPTERUS			
AEJ 503	1	57 "	57	1.1
AEJ 506	1	65 "	65	1.5
AEJ 702	1	56 "	56	.8
AEJ 707	1	200 "	200	32.0
TOTAL	4	56 "	200	35.4
ECHIOSTOMA	BARBATUM			
AEJ 102	1	69 "	69	2.5
AEJ 402	1	27 "	27	.1
AEJ 407	1	29 "	29	.1
TOTAL	3	27 "	69	2.7
EUSTOMIAS	ACHIRUS			
AEJ 100	1	72 "	72	.7
TOTAL	1	72 "	72	.7
EUSTOMIAS	ENBARBATUS			
AEJ 405	1	130 "	130	4.0
TOTAL	1	130 "	130	4.0
EUSTOMIAS	FILIFER			
AEJ 503	1	93 "	93	2.5
TOTAL	1	93 "	93	2.5
EUSTOMIAS	PARRI			
AEJ 403	1	52 "	52	.1
TOTAL	1	52 "	52	.1
EUSTOMIAS	POLYASTER			
AEJ 33	1	54 "	54	.2
TOTAL	1	54 "	54	.2

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
EUSTOMIAS	SCHMIDTI			
AEJ 8	1	103 "	103	2.7
TOTAL	1	103 "	103	2.7
FLAGELLSTOMIAS	BOUREEI			
AEJ 34	1	34 "	34	.1
AEJ 102	1	58 "	58	.5
RHB2701	1	126 "	126	3.4
TOTAL	3	34 "	126	4.0
LEPTOSTOMIAS	HAPLOCAULUS			
AEJ 702	1	51 "	51	.3
TOTAL	1	51 "	51	.3
MELANOSTOMIAS	BISERIATUS			
AEJ 5	1	47 "	47	.2
AEJ 6	1	26 "	26	.1
AEJ 9	1	33 "	33	.1
AEJ 10	1	25 "	25	.1
AEJ 11	1	33 "	33	.1
AEJ 33	1	34 "	34	.1
AEJ 34	1	28 "	28	.1
TOTAL	7	25 "	47	.8
MELANOSTOMIAS	MELANOPS			
AEJ 105	1	105 "	105	2.8
AEJ 702	1	36 "	36	.1
TOTAL	2	36 "	105	2.9
MELANOSTOMIAS	SPILORYNCHUS			
RHB2701	1	215 "	215	26.0
TOTAL	1	215 "	215	26.0
PACHYSTOMIAS	MICRODON			
AEJ 3	1	188 "	188	33.0
TOTAL	1	188 "	188	33.0
PHOTONECTES	MARGARITA			
AEJ 100	1	22 "	22	.1

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 101	1	26 "	26	.1
AEJ 102	1	271 "	271	149.0
AEJ 505	1	307 "	307	256.0
AEJ 708	1	234 "	234	95.0
TOTAL	5	22 "	307	500.2

PHOTONECTES	MIRABILIS			
AEJ 34	1	62 "	62	.7
TOTAL	1	62 "	62	.7

MALACOSTEIDAE

ARISTOSTOMIAS	GRIMALDII			
AEJ 36	1	34 "	34	.1
AEJ 402	1	25 "	25	.1
AEJ 403	1	33 "	33	.2
AEJ 706	1	34 "	34	.3
TOTAL	4	25 "	34	.7

ARISTOSTOMIAS	LUNIFER			
AEJ 33	1	42 "	42	.3
TOTAL	1	42 "	42	.3

ARISTOSTOMIAS	TITTMANNI			
AEJ 103	1	34 "	34	.1
AEJ 404	1	32 "	32	.1
AEJ 407	1	34 "	34	.1
AEJ 502	1	49 "	49	.7
AEJ 503	1	51 "	51	.8
AEJ 504	2	44 "	48	1.2
RHB2703	1	33 "	33	.1
TOTAL	8	32 "	51	3.1

MALACOSTEUS	NIGER			
AEJ 5	1	155 "	155	25.5
AEJ 9	1	125 "	125	15.9
AEJ 10	2	89 "	91	9.7
AEJ 11	2	110 "	125	22.5
AEJ 36	2	86 "	114	12.0
AEJ 101	1	82 "	82	2.1
AEJ 102	1	96 "	96	4.8

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 103	2	71 "	126	16.2
AEJ 401	1	37 "	37	.2
AEJ 504	1	48 "	48	.7
AEJ 506	1	39 "	39	.3
AEJ 702	1	40 "	40	.3
AEJ 703	2	78 "	85	6.2
AEJ 707	6	94 "	158	82.0
RHB2703	1	123 "	123	11.7
TOTAL	25	37 "	158	210.1

PHOTOSTOMIAS		GUERNEI		
AEJ 5	2	58 "	110	4.8
AEJ 6	1	116 "	116	5.1
AEJ 7	1	90 "	90	1.9
AEJ 8	1	69 "	69	.9
AEJ 33	1	67 "	67	1.3
AEJ 34	1	55 "	55	.6
AEJ 102	1	82 "	82	1.4
AEJ 105	1	94 "	94	3.3
AEJ 401	1	98 "	98	4.3
AEJ 404	1	64 "	64	.9
AEJ 405	1	120 "	120	5.8
AEJ 504	3	77 "	107	8.0
AEJ 505	1	101 "	101	4.5
AEJ 506	2	56 "	62	1.7
AEJ 701	1	62 "	62	.9
AEJ 702	4	26 "	59	2.0
AEJ 706	4	34 "	86	4.5
TOTAL	27	26 "	120	51.9

CHAULIODONTIDAE		DANAE		
CHAULIODUS				
AEJ 4	2	38 "	39	.4
AEJ 5	1	27 "	27	.1
AEJ 6	2	27 "	70	.8
AEJ 7	1	36 "	36	.2
AEJ 8	3	19 "	51	.5
AEJ 9	1	65 "	65	.5
AEJ 10	1	21 "	21	.1
AEJ 11	2	27 "	108	3.5
AEJ 34	13	23 "	90	5.7
AEJ 101	1	141 "	141	4.1
AEJ 102	3	95 "	116	9.1

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 105	1	20	20	.1
AEJ 402	2	44	108	3.2
AEJ 503	3	34	121	4.5
AEJ 503	3	34	121	4.5
AEJ 505	4	49	85	2.7
AEJ 506	4	35	56	1.2
AEJ 507	2	20	79	1.5
AEJ 701	3	20	53	.6
AEJ 702	6	28	111	4.6
AEJ 703	5	34	77	1.5
AEJ 705	3	26	80	2.1
AEJ 706	10	35	101	6.0
AEJ 707	1	65	65	.7
TOTAL	77	19	141	58.2

CHAULIODUS		SLUANI		
AEJ 2	6	25	227	28.0
AEJ 3	3	22	85	1.5
AEJ 4	2	27	231	26.0
AEJ 5	6	23	83	3.6
AEJ 6	7	23	127	5.1
AEJ 7	3	30	36	.4
AEJ 8	3	28	35	.3
AEJ 9	7	35	258	47.0
AEJ 10	11	28	107	7.9
AEJ 11	7	22	240	44.0
AEJ 33	1	35	35	.1
AEJ 34	4	26	33	.5
AEJ 36	3	32	108	3.2
AEJ 100	3	42	152	8.1
AEJ 101	6	46	196	23.0
AEJ 102	3	35	226	26.0
AEJ 103	7	53	154	22.0
AEJ 104	7	41	152	24.0
AEJ 105	8	91	190	44.5
AEJ 401	6	38	108	9.0
AEJ 402	5	81	108	11.0
AEJ 403	3	187	240	98.0
AEJ 404	2	110	193	20.5
AEJ 405	3	57	215	30.0
AEJ 406	6	27	206	25.0
AEJ 407	2	41	50	.7
AEJ 502	1	65	65	1.0
AEJ 503	6	86	190	30.0

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 504	5	54 "	151	15.0
AEJ 505	7	51 "	101	10.2
AEJ 507	5	33 "	99	8.7
AEJ 509	3	52 "	191	24.0
AEJ 701	1	127 "	127	5.1
AEJ 702	3	25 "	77	1.5
AEJ 703	2	79 "	233	35.0
AEJ 705	1	61 "	61	.6
AEJ 706	2	33 "	56	.7
AEJ 707	3	60 "	198	22.0
AEJ 708	3	91 "	111	6.7
RHB2701	6	50 "	103	8.0
RHB2702	3	47 "	182	21.5
RHB2703	5	77 "	220	55.0
TOTAL	180	22 "	258	754.4

STOMIATIDAE

MACRSTOMIAS

LONGIBARBATUS

AEJ 34	1	89 "	89	.2
TOTAL	1	89 "	89	.2

STOMIAS

BGA

AEJ 7	1	38 "	38	.1
AEJ 9	1	39 "	39	.2
AEJ 10	2	56 "	62	.6
AEJ 11	1	62 "	62	.3
AEJ 100	2	180 "	190	20.0
AEJ 101	1	221 "	221	25.0
AEJ 104	2	88 "	165	25.0
AEJ 105	3	78 "	193	24.0
AEJ 401	6	94 "	230	64.0
AEJ 402	3	62 "	160	8.3
AEJ 406	1	62 "	62	.4
AEJ 407	1	71 "	71	.7
AEJ 502	1	77 "	77	.9
AEJ 506	1	70 "	70	.7
AEJ 703	1	274 "	274	34.0
AEJ 708	1	136 "	136	3.8
RHB2701	4	84 "	203	21.0
RHB2703	1	102 "	102	1.6
TOTAL	33	38 "	274	230.6

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME
		MIN	MAX	(CC)
IDIACANTHIDAE				
IDIACANTHUS		FASCIOLA		
AEJ 103	1	75 "	75	0.1
AEJ 402	1	33 "	33	0.1
AEJ 707	1	150 "	150	0.7
AEJ 708	1	79 "	79	0.2
RHB2701	1	60 "	60	0.2
RHB2702	1	32 "	32	0.1
TOTAL	6	32 "	150	1.4
MYCTOPHOIDEI				
MYCTOPHIDAE				
BENTHOSEMA		GLACIALE		
AEJ 2	62	18 "	66	42.0
AEJ 3	24	23 "	65	19.0
AEJ 5	7	24 "	59	5.1
AEJ 6	6	17 "	50	4.0
AEJ 7	3	22 "	57	4.6
AEJ 8	2	37 "	50	1.7
AEJ 9	18	23 "	62	20.0
AEJ 10	10	24 "	61	7.1
AEJ 11	3	28 "	49	2.3
AEJ 36	11	16 "	55	5.5
AEJ 100	100	22 "	60	101.0
AEJ 101	27	35 "	69	39.0
AEJ 102	6	18 "	59	6.6
AEJ 103	30	18 "	60	15.0
AEJ 104	48	16 "	60	21.0
AEJ 105	62	17 "	58	28.0
AEJ 401	85	19 "	60	64.0
AEJ 402	48	18 "	59	48.5
AEJ 403	13	17 "	58	10.0
AEJ 404	56	15 "	50	12.7
AEJ 405	31	14 "	45	6.2
AEJ 406	45	20 "	58	29.0
AEJ 407	25	17 "	57	19.7
AEJ 502	3	44 "	57	5.8
AEJ 503	6	19 "	53	6.8
AEJ 504	7	20 "	53	6.0
AEJ 505	7	33 "	61	8.5
AEJ 506	1	51 "	51	1.6
AEJ 507	35	22 "	64	36.5
AEJ 509	72	24 "	62	57.0
AEJ 702	1	29 "	29	0.2

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 703	36	13 "	55	15.6
AEJ 706	1	42 "	42	1.0
AEJ 707	68	17 "	62	45.0
AEJ 708	72	18 "	69	28.0
RHB2701	72	19 "	62	61.0
RHB2702	173	21 "	61	93.0
RHB2703	27	21 "	62	30.0
TOTAL	1303	13 "	69	908.0

BENTHOSEMA

SUBORBITALE

AEJ 4	1	13 "	13	.1
AEJ 10	1	23 "	23	.1
AEJ 33	1	23 "	23	.1
AEJ 34	1	16 "	16	.1
AEJ 36	4	16 "	21	.2
AEJ 100	1	12 "	12	.1
AEJ 101	2	11 "	14	.1
AEJ 102	2	18 "	24	.1
AEJ 103	2	13 "	29	.3
AEJ 402	1	19 "	19	.1
AEJ 406	1	18 "	18	.1
AEJ 407	1	17 "	17	.1
AEJ 502	1	10 "	10	.1
AEJ 503	2	27 "	35	.9
AEJ 505	1	18 "	18	.1
AEJ 506	2	11 "	23	.2
AEJ 507	1	13 "	13	.1
AEJ 701	2	12 "	14	.1
AEJ 702	2	15 "	16	.2
AEJ 703	2	20 "	27	.3
AEJ 705	1	13 "	13	.1
AEJ 706	1	19 "	19	.1
AEJ 708	6	12 "	26	1.0
TOTAL	39	10 "	35	4.7

BOLINICHTHYS

INDICUS

AEJ 3	8	10 "	16	.3
AEJ 4	10	11 "	35	1.3
AEJ 5	7	10 "	35	.6
AEJ 6	3	11 "	13	.1
AEJ 7	25	11 "	32	1.4
AEJ 8	8	10 "	29	.5
AEJ 9	17	11 "	40	3.9

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SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 10	9	12 "	35	1.7
AEJ 11	12	10 "	34	1.9
AEJ 33	8	11 "	18	.2
AEJ 34	7	12 "	37	1.8
AEJ 36	2	11 "	13	.1
AEJ 101	4	16 "	25	.3
AEJ 102	32	13 "	31	2.2
AEJ 103	22	14 "	32	4.5
AEJ 104	11	16 "	31	2.1
AEJ 105	7	14 "	33	1.3
AEJ 402	4	16 "	28	.8
AEJ 403	2	12 "	13	.1
AEJ 404	5	20 "	33	1.1
AEJ 405	7	14 "	24	.9
AEJ 406	3	12 "	25	.3
AEJ 502	4	17 "	26	.9
AEJ 503	27	18 "	34	8.7
AEJ 504	10	20 "	37	3.6
AEJ 505	10	26 "	34	4.4
AEJ 506	12	18 "	52	6.4
AEJ 701	3	14 "	22	.3
AEJ 702	7	11 "	32	1.2
AEJ 703	6	10 "	22	.3
AEJ 705	6	15 "	32	1.5
AEJ 706	9	11 "	26	.5
AEJ 708	1	13 "	13	.1
RHB2701	1	14 "	14	.1
RHB2703	2	14 "	16	.1
TOTAL	311	10 "	52	55.5

BOLINICHTHYS

SUPRALATERALIS

AEJ 100	1	17 "	17	.1
AEJ 401	2	17 "	23	.2
AEJ 402	4	13 "	26	.4
AEJ 502	1	32 "	32	.5
AEJ 503	1	23 "	23	.2
AEJ 507	1	23 "	23	.2
AEJ 701	5	12 "	21	.3
AEJ 702	6	13 "	18	.3
AEJ 705	2	16 "	20	.2
AEJ 706	1	16 "	16	.1
AEJ 708	2	15 "	89	14.0
TOTAL	26	12 "	89	16.5

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
CENTROBRANCHUS	NIGROSCOLLATUS			
AEJ 8	1	28 "	28	.3
AEJ 102	1	17 "	17	.1
AEJ 502	1	18 "	18	.1
AEJ 701	1	16 "	16	.1
AEJ 702	2	24 "	25	.4
TOTAL	6	16 "	28	1.0
CERATOSCOPELUS	MADERENSIS			
AEJ 2	34	16 "	22	1.5
AEJ 5	1	26 "	26	.2
AEJ 7	2	21 "	28	.3
AEJ 36	131	18 "	29	10.2
AEJ 100	11	22 "	40	3.5
AEJ 101	24	22 "	62	9.8
AEJ 102	1	34 "	34	.2
AEJ 103	63	19 "	42	22.0
AEJ 104	20	25 "	39	5.2
AEJ 105	17	25 "	42	5.1
AEJ 401	248	16 "	39	55.0
AEJ 402	31	16 "	41	5.2
AEJ 403	3	15 "	20	.3
AEJ 404	17	18 "	22	1.2
AEJ 405	9	18 "	21	.6
AEJ 406	88	20 "	65	21.5
AEJ 407	46	17 "	41	7.1
AEJ 502	5	36 "	41	3.0
AEJ 503	1	40 "	40	.5
AEJ 504	3	40 "	42	2.1
AEJ 505	2	35 "	37	.9
AEJ 507	3	39 "	47	2.7
AEJ 509	5	45 "	68	11.0
AEJ 701	1	19 "	19	.1
AEJ 702	3	18 "	20	.2
AEJ 703	12	16 "	28	1.0
AEJ 707	17	16 "	31	2.2
AEJ 708	33	16 "	32	3.4
RHB2701	17	21 "	42	6.9
RHB2703	23	23 "	64	8.4
TOTAL	871	15 "	68	191.3
CERATOSCOPELUS	WARMINGI			
AEJ 2	5	30 "	67	7.5

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 3	2	28 "	49	1.7
AEJ 4	9	15 "	21	.3
AEJ 5	7	15 "	48	5.3
AEJ 6	5	18 "	69	5.9
AEJ 7	11	17 "	58	6.8
AEJ 8	4	17 "	33	.6
AEJ 9	7	16 "	64	17.0
AEJ 10	2	33 "	38	1.0
AEJ 11	7	16 "	65	12.6
AEJ 33	5	25 "	60	6.1
AEJ 34	5	16 "	46	2.0
AEJ 36	6	15 "	35	1.4
AEJ 100	5	17 "	47	1.9
AEJ 101	7	20 "	59	5.0
AEJ 102	28	18 "	50	7.7
AEJ 103	2	19 "	21	.1
AEJ 104	4	19 "	28	.4
AEJ 105	1	20 "	20	.1
AEJ 403	1	18 "	18	.1
AEJ 407	8	19 "	51	7.1
AEJ 502	26	33 "	55	24.0
AEJ 503	5	32 "	66	6.7
AEJ 504	3	25 "	47	2.0
AEJ 505	1	33 "	33	.5
AEJ 506	11	29 "	58	9.6
AEJ 507	3	16 "	18	.2
AEJ 701	15	16 "	53	10.8
AEJ 703	10	29 "	50	9.1
AEJ 705	15	17 "	51	9.5
AEJ 705	10	18 "	41	3.5
AEJ 706	13	16 "	59	7.2
AEJ 707	15	26 "	46	14.8
AEJ 708	9	38 "	55	11.6
RHB2703	1	54 "	54	1.5
TOTAL	273	15 "	69	201.6

DIAPHUS	BERTELSENI			
AEJ 406	1	15 "	15	.1
TOTAL	1	15 "	15	.1

DIAPHUS	BRACHYCEPHALUS			
AEJ 34	2	35 "	36	1.9
AEJ 705	1	23 "	23	.3
TOTAL	3	23 "	36	2.2

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SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
DIAPHUS	DUMERILI			
AEJ 7	1	31 "	31	0.4
AEJ 33	1	22 "	22	0.2
AEJ 36	7	16 "	23	0.7
AEJ 401	1	38 "	38	0.7
AEJ 402	2	31 "	37	1.0
AEJ 406	3	28 "	31	1.1
AEJ 507	30	13 "	38	4.2
AEJ 701	4	12 "	27	0.4
AEJ 703	6	12 "	52	2.6
AEJ 705	1	20 "	20	0.1
AEJ 707	3	25 "	49	3.1
AEJ 708	1	43 "	43	1.0
RHB2701	1	23 "	23	0.1
TOTAL	61	12 "	52	15.6
DIAPHUS	EFFULGENS			
AEJ 3	1	118 "	118	25.0
AEJ 5	1	71 "	71	7.0
AEJ 7	1	18 "	18	0.1
AEJ 8	2	9 "	14	0.1
AEJ 34	1	11 "	11	0.1
AEJ 100	2	63 "	80	10.0
AEJ 101	2	16 "	45	1.2
AEJ 103	1	82 "	82	8.6
AEJ 104	1	68 "	68	5.1
AEJ 503	1	62 "	62	4.0
AEJ 702	1	12 "	12	0.1
AEJ 705	1	28 "	28	0.3
TOTAL	15	9 "	118	61.6
DIAPHUS	ELUCENS			
AEJ 3	1	57 "	57	2.5
AEJ 402	3	21 "	28	0.7
AEJ 703	1	17 "	17	0.1
AEJ 705	1	10 "	10	0.1
AEJ 707	3	28 "	53	4.2
AEJ 708	1	36 "	36	0.9
TOTAL	10	10 "	57	8.5
DIAPHUS	LUCIDUS			
AEJ 402	2	13 "	17	0.1
TOTAL	2	13 "	17	0.1

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SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
DIAPHUS	LUETKENI			
AEJ 705	1	11 "	11	.1
TOTAL	1	11 "	11	.1
DIAPHUS	METOPHCLAMPUS			
AEJ 2	1	26 "	26	.3
AEJ 3	1	60 "	60	3.1
AEJ 6	1	60 "	60	4.0
AEJ 7	1	73 "	73	8.0
AEJ 8	3	10 "	25	.3
AEJ 9	2	31 "	59	4.7
AEJ 11	2	10 "	10	.1
AEJ 33	3	11 "	12	.1
AEJ 36	1	70 "	70	7.5
AEJ 101	1	77 "	77	11.4
AEJ 102	1	12 "	12	.1
AEJ 103	2	15 "	41	1.0
AEJ 105	2	41 "	79	12.0
AEJ 401	1	32 "	32	.7
AEJ 402	1	12 "	12	.1
AEJ 406	1	11 "	11	.1
AEJ 407	2	10 "	70	8.1
AEJ 503	3	14 "	45	2.0
AEJ 504	2	16 "	20	.2
AEJ 505	1	71 "	71	8.1
AEJ 506	2	14 "	15	.1
AEJ 702	1	11 "	11	.1
AEJ 705	1	12 "	12	.1
AEJ 706	1	9 "	9	.1
TOTAL	37	9 "	79	72.3
DIAPHUS	MOLLIS			
AEJ 3	2	10 "	15	.1
AEJ 4	3	11 "	50	1.7
AEJ 5	4	12 "	16	.2
AEJ 6	3	10 "	51	2.1
AEJ 7	3	18 "	19	.3
AEJ 8	2	29 "	33	1.3
AEJ 9	3	11 "	44	1.4
AEJ 11	1	36 "	36	.5
AEJ 34	6	10 "	42	4.3
AEJ 102	1	37 "	37	.5
AEJ 103	2	36 "	47	1.9

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SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 104	1	22 "	22	.1
AEJ 405	3	20 "	23	.5
AEJ 406	1	27 "	27	.3
AEJ 407	2	11 "	26	.3
AEJ 502	4	22 "	44	3.0
AEJ 503	2	36 "	41	1.9
AEJ 504	2	31 "	37	1.3
AEJ 505	2	42 "	46	2.6
AEJ 701	7	10 "	28	1.0
AEJ 702	1	12 "	12	.1
AEJ 703	2	10 "	19	.1
AEJ 705	1	14 "	14	.1
AEJ 706	2	20 "	24	.3
AEJ 707	1	14 "	14	.1
AEJ 708	1	15 "	15	.1
TOTAL	62	10 "	51	26.1

DIAPHUS

RAFINESQUEI

AEJ 3	1	65 "	65	5.0
AEJ 4	1	50 "	50	1.5
AEJ 6	2	73 "	78	13.1
AEJ 34	1	82 "	82	8.3
AEJ 36	8	63 "	72	35.0
AEJ 100	4	12 "	74	10.8
AEJ 101	13	10 "	70	5.2
AEJ 102	2	14 "	16	.1
AEJ 103	10	11 "	72	6.3
AEJ 104	16	12 "	72	6.1
AEJ 105	7	12 "	20	.5
AEJ 401	4	37 "	72	8.0
AEJ 402	3	67 "	69	14.0
AEJ 406	1	74 "	74	5.6
AEJ 407	3	11 "	70	6.1
AEJ 502	3	27 "	68	10.5
AEJ 503	8	21 "	73	30.5
AEJ 504	8	15 "	28	1.7
AEJ 505	2	13 "	23	.2
AEJ 506	1	28 "	28	.3
AEJ 507	7	14 "	22	.8
AEJ 701	1	74 "	74	6.9
AEJ 702	1	71 "	71	5.7
AEJ 703	3	12 "	65	8.9
AEJ 706	1	68 "	68	4.9
AEJ 707	1	41 "	41	1.0

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
RHB2701	1	68 "	68	4.6
RHB2703	1	68 "	68	4.0
TOTAL	114	10 "	82	205.6
DIAPHUS	SPLENDIDUS			
AEJ 2	1	27 "	27	.2
AEJ 33	1	32 "	32	.4
AEJ 34	1	35 "	36	.6
AEJ 36	2	10 "	14	.1
AEJ 102	1	64 "	64	2.8
AEJ 506	1	57 "	57	2.6
AEJ 701	1	27 "	27	.2
AEJ 705	1	25 "	25	.1
TOTAL	9	10 "	64	7.0
DIAPHUS	SUBTILIS			
AEJ 402	2	19 "	27	.2
TOTAL	2	19 "	27	.2
DIAGENICHTHYS	ATLANTICUS			
AEJ 2	2	12 "	12	.1
AEJ 3	2	12 "	12	.1
AEJ 4	8	11 "	15	.3
AEJ 5	6	10 "	18	.3
AEJ 6	3	11 "	12	.1
AEJ 7	11	5 "	16	.2
AEJ 8	11	8 "	15	.3
AEJ 9	12	10 "	13	.2
AEJ 10	4	11 "	14	.1
AEJ 11	2	14 "	17	.1
AEJ 33	5	11 "	17	.1
AEJ 34	3	12 "	15	.1
AEJ 36	1	13 "	13	.1
AEJ 101	3	12 "	13	.1
AEJ 102	26	12 "	19	1.0
AEJ 103	7	11 "	13	.2
AEJ 105	2	12 "	22	.1
AEJ 402	1	16 "	16	.1
AEJ 403	2	13 "	14	.1
AEJ 404	1	12 "	12	.1
AEJ 405	1	13 "	13	.1
AEJ 407	4	11 "	19	.2

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 502	13	9 "	20	1.2
AEJ 503	10	13 "	21	1.0
AEJ 504	7	14 "	20	.5
AEJ 505	3	12 "	18	.2
AEJ 506	11	14 "	20	1.0
AEJ 507	1	18 "	18	.1
AEJ 701	5	12 "	15	.3
AEJ 703	3	11 "	17	.1
AEJ 705	1	13 "	13	.1
AEJ 706	4	10 "	11	.1
AEJ 707	1	19 "	19	.1
RHB2701	4	10 "	13	.2
RHB2702	2	10 "	13	.1
RHB2703	2	12 "	12	.1
TOTAL	184	5 "	22	9.2

GONICHTHYS		COCCHI		
AEJ 2	2	16 "	34	.3
AEJ 3	1	27 "	27	.2
AEJ 6	1	20 "	20	.1
AEJ 9	2	17 "	32	.4
AEJ 33	2	9 "	9	.1
AEJ 100	1	21 "	21	.1
AEJ 103	1	20 "	20	.1
AEJ 104	3	17 "	24	.2
AEJ 402	2	39 "	40	1.1
AEJ 404	1	21 "	21	.1
TOTAL	16	9 "	40	2.7

HYGOPHUM		BENNETTI		
AEJ 2	1	12 "	12	.1
AEJ 3	22	10 "	22	1.0
AEJ 4	4	14 "	22	.4
AEJ 5	18	10 "	14	.7
AEJ 6	15	10 "	19	.4
AEJ 7	25	11 "	19	1.0
AEJ 8	2	13 "	13	.1
AEJ 9	14	11 "	17	.5
AEJ 10	15	11 "	20	.3
AEJ 11	15	12 "	28	.8
AEJ 33	7	13 "	18	.2
AEJ 34	47	12 "	23	2.6
AEJ 36	5	14 "	17	.3

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 100	8	24	30	1.7
AEJ 101	2	27	30	.5
AEJ 102	7	20	24	1.1
AEJ 103	6	26	36	1.8
AEJ 104	36	20	37	13.4
AEJ 105	28	21	37	9.5
AEJ 401	2	31	34	1.0
AEJ 402	13	13	32	2.1
AEJ 403	5	16	26	.5
AEJ 404	1	16	16	.1
AEJ 405	1	25	25	.2
AEJ 406	2	19	19	.2
AEJ 502	2	30	33	.9
AEJ 503	4	29	35	2.0
AEJ 504	1	38	38	.7
AEJ 505	3	29	38	1.7
AEJ 507	2	11	36	.8
AEJ 703	4	13	24	.5
AEJ 705	3	17	22	.2
AEJ 706	1	15	15	.1
AEJ 707	3	16	28	.6
AEJ 708	6	14	26	.9
RHB2701	1	36	36	.5
RHB2702	2	24	27	.4
RHB2703	2	24	25	.3
TOTAL	335	10	38	50.1

HYGOPHUM		HYGOMI		
AEJ 2	1	49	49	1.9
AEJ 4	2	54	55	5.1
AEJ 7	1	54	54	2.5
AEJ 10	1	46	46	2.8
AEJ 102	10	15	20	.6
AEJ 103	2	14	17	.1
AEJ 104	1	16	16	.1
AEJ 105	1	16	16	.1
AEJ 502	19	13	33	1.9
AEJ 503	9	15	37	2.2
AEJ 504	8	12	35	.9
AEJ 505	7	13	33	1.7
AEJ 506	11	15	38	2.1
AEJ 507	11	19	29	2.6
AEJ 706	2	47	51	4.7
TOTAL	86	12	55	29.3

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
HYGOPHUM REINHARDTI				
AEJ 3	1	12 "	12	•1
AEJ 8	2	11 "	11	•1
AEJ 101	1	12 "	12	•1
AEJ 404	1	20 "	20	•1
AEJ 503	1	32 "	32	•4
AEJ 504	1	45 "	45	1•1
AEJ 507	1	15 "	15	•1
AEJ 705	2	10 "	11	•1
TOTAL	10	10 "	45	2•1
HYGOPHUM TAANINGI				
AEJ 3	1	16 "	16	•1
AEJ 4	2	14 "	25	•3
AEJ 5	1	15 "	15	•1
AEJ 7	1	22 "	22	•1
AEJ 8	5	12 "	21	•2
AEJ 36	1	13 "	13	•1
AEJ 101	1	31 "	31	•3
AEJ 406	1	10 "	10	•1
AEJ 407	1	16 "	16	•1
AEJ 506	1	24 "	24	•2
AEJ 507	3	12 "	13	•1
AEJ 702	1	35 "	35	•7
AEJ 703	1	20 "	20	•2
AEJ 706	3	11 "	13	•1
AEJ 707	2	22 "	27	•4
AEJ 708	1	32 "	32	•5
TOTAL	26	10 "	35	4•1
LAMPADENA CHAVESI				
AEJ 9	1	31 "	31	•1
AEJ 102	1	17 "	17	•1
TOTAL	2	17 "	31	•2
LAMPADENA DEA				
AEJ 503	1	18 "	18	•1
TOTAL	1	18 "	18	•1
LAMPADENA LUMINOSA				
AEJ 101	1	34 "	34	•3

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 701	1	18 "	18	.1
TOTAL	2	18 "	34	.4
LAMPADENA	SPECULIGERA			
AEJ 2	1	123 "	123	30.0
AEJ 5	1	33 "	33	.3
AEJ 8	1	25 "	25	.1
AEJ 502	2	19 "	128	31.0
AEJ 505	4	18 "	25	.4
AEJ 506	2	20 "	22	.2
AEJ 507	1	120 "	120	28.0
AEJ 707	1	140 "	140	40.0
RHB2701	1	57 "	57	1.9
TOTAL	14	18 "	140	131.9
LAMPADENA	UROPHAPS			
AEJ 9	1	19 "	19	.1
AEJ 705	1	48 "	48	1.2
AEJ 104	1	199 "	199	110.0
TOTAL	3	19 "	199	111.3
LAMPANYCTUS	ALATUS			
AEJ 2	2	33 "	39	.5
AEJ 4	3	28 "	45	1.4
AEJ 8	1	34 "	34	.3
AEJ 10	1	48 "	48	.7
AEJ 34	1	24 "	24	.1
AEJ 36	1	34 "	34	.3
AEJ 101	1	42 "	42	.8
AEJ 402	2	21 "	29	.3
AEJ 406	1	27 "	27	.2
AEJ 407	2	37 "	44	1.5
AEJ 504	1	27 "	27	.1
AEJ 507	1	39 "	39	.6
AEJ 705	2	24 "	38	.5
AEJ 707	5	26 "	35	1.3
AEJ 708	4	19 "	36	1.1
RHB2701	1	46 "	46	.9
RHB2702	1	23 "	23	.1
TOTAL	30	19 "	48	10.7

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
LAMPANYCTUS	ATER			
AEJ 2	1	56 "	56	1.0
AEJ 3	1	86 "	86	4.1
AEJ 4	4	48 "	85	9.0
AEJ 7	1	53 "	53	.9
AEJ 8	4	23 "	44	.6
AEJ 10	1	49 "	49	.7
AEJ 34	1	56 "	56	.8
AEJ 101	2	56 "	64	1.9
AEJ 103	1	90 "	90	3.7
AEJ 401	1	89 "	89	3.8
AEJ 402	1	93 "	93	5.1
AEJ 403	2	59 "	85	4.6
AEJ 502	1	22 "	22	.1
AEJ 503	5	33 "	96	9.0
AEJ 504	1	62 "	62	1.3
AEJ 505	2	58 "	103	6.8
AEJ 506	2	31 "	64	1.3
AEJ 509	1	61 "	61	1.8
AEJ 701	3	42 "	88	4.0
AEJ 702	3	45 "	93	7.9
AEJ 703	1	26 "	26	.1
AEJ 705	4	23 "	87	6.8
AEJ 706	3	38 "	81	3.6
AEJ 707	2	36 "	86	3.7
AEJ 708	3	43 "	61	3.1
RHB2701	1	72 "	72	2.0
RHB2702	1	95 "	95	5.6
TOTAL	53	22 "	103	93.3

LAMPANYCTUS	CRUCODILUS			
AEJ 2	1	36 "	36	.2
AEJ 3	2	31 "	32	.4
AEJ 5	1	31 "	31	.2
AEJ 6	2	32 "	38	.7
AEJ 9	3	23 "	32	.6
AEJ 10	1	28 "	28	.2
AEJ 11	1	33 "	33	.2
AEJ 404	1	132 "	132	21.0
AEJ 505	1	47 "	47	1.0
AEJ 701	1	26 "	26	.1
AEJ 707	1	47 "	49	1.8
TOTAL	15	26 "	132	26.4

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
LAMPANYCTUS	CUPRARIUS			
AEJ 2	2	66 "	69	4.5
AEJ 4	6	49 "	64	6.0
AEJ 8	8	22 "	53	5.6
AEJ 33	1	69 "	69	2.0
AEJ 34	4	44 "	54	3.8
AEJ 36	1	23 "	23	.1
AEJ 102	3	27 "	71	3.1
AEJ 401	2	42 "	51	1.5
AEJ 404	1	69 "	69	2.3
AEJ 407	2	22 "	49	1.0
AEJ 502	1	69 "	69	2.5
AEJ 504	1	34 "	34	.3
AEJ 505	2	35 "	56	1.5
AEJ 506	7	31 "	70	6.9
AEJ 701	5	44 "	70	6.7
AEJ 702	3	43 "	58	3.0
AEJ 703	2	38 "	44	.9
AEJ 705	4	24 "	70	4.6
AEJ 706	3	53 "	76	6.0
AEJ 707	3	50 "	62	4.6
AEJ 708	7	51 "	72	14.7
RHB2701	2	61 "	61	3.0
RHB2702	2	22 "	34	.1
RHB2703	1	52 "	52	1.0
TOTAL	73	22 "	76	85.7
LAMPANYCTUS	FESTIVUS			
AEJ 4	2	35 "	40	.6
AEJ 5	1	29 "	29	.1
AEJ 7	1	31 "	31	.2
AEJ 10	3	18 "	30	.3
AEJ 11	3	18 "	99	10.0
AEJ 33	4	18 "	32	.5
AEJ 34	1	18 "	18	.1
AEJ 36	1	31 "	31	.3
AEJ 102	1	42 "	42	.5
AEJ 402	1	36 "	36	.5
AEJ 407	1	77 "	77	4.3
AEJ 701	1	33 "	33	.3
AEJ 702	3	25 "	78	4.3
AEJ 703	1	33 "	33	.2
AEJ 705	2	70 "	93	10.2
AEJ 707	2	28 "	29	.3
TOTAL	23	18 "	99	32.7

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
LAMPANYCTUS	INTRICARIUS			
AEJ 5	1	34 "	34	•2
TOTAL	1	34 "	34	•2
LAMPANYCTUS	LINEATUS			
AEJ 36	2	26 "	27	•3
AEJ 405	1	32 "	32	•3
AEJ 406	1	86 "	86	3•7
AEJ 502	1	54 "	54	1•0
AEJ 503	1	96 "	96	4•4
AEJ 504	2	21 "	27	•2
AEJ 505	1	134 "	134	4•1
AEJ 702	4	22 "	46	•9
AEJ 706	2	22 "	27	•2
AEJ 708	1	33 "	33	•1
AEJ 101	2	34 "	93	3•5
AEJ 102	3	24 "	74	4•8
RHB2703	1	29 "	29	•1
TOTAL	22	21 "	134	23•6
LAMPANYCTUS	MACDONALDI			
AEJ 36	2	48 "	64	2•7
AEJ 100	2	96 "	125	23•4
AEJ 406	2	30 "	86	6•0
AEJ 507	1	113 "	113	14•1
AEJ 509	8	47 "	134	52•0
RHB2701	3	56 "	88	8•3
RHB2702	3	45 "	104	20•0
RHB2703	1	70 "	70	2•1
TOTAL	22	30 "	134	128•6
LAMPANYCTUS	NOBILIS			
AEJ 36	1	25 "	25	•1
AEJ 708	1	33 "	33	•2
TOTAL	2	25 "	33	•3
LAMPANYCTUS	PROTONOTUS			
AEJ 4	3	18 "	19	•2
AEJ 5	1	18 "	18	•1
AEJ 6	5	16 "	32	•4
AEJ 7	6	15 "	22	•3

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 8	2	18 "	20	.2
AEJ 9	1	58 "	58	1.4
AEJ 10	4	12 "	55	2.7
AEJ 11	1	16 "	16	.1
AEJ 33	2	17 "	20	.1
AEJ 34	2	20 "	26	.2
AEJ 102	4	20 "	33	.7
AEJ 103	1	42 "	42	.6
AEJ 104	1	59 "	59	1.7
AEJ 105	3	29 "	51	1.9
AEJ 402	2	26 "	39	.6
AEJ 407	3	20 "	61	2.5
AEJ 503	7	32 "	47	5.4
AEJ 504	1	45 "	45	.9
AEJ 505	2	42 "	45	1.6
AEJ 506	7	28 "	54	4.6
AEJ 701	4	19 "	55	1.9
AEJ 702	2	19 "	19	.2
AEJ 703	4	16 "	28	.4
AEJ 706	1	62 "	62	1.7
AEJ 707	1	53 "	53	1.3
AEJ 708	1	21 "	21	.1
TOTAL	71	12 "	62	31.8

LAMPANYCTUS

PUSILLUS

AEJ 2	2	29 "	29	.5
AEJ 3	18	14 "	30	2.1
AEJ 4	4	13 "	22	.3
AEJ 5	12	18 "	32	2.0
AEJ 6	14	15 "	31	2.2
AEJ 7	7	19 "	32	1.0
AEJ 8	6	15 "	28	.6
AEJ 9	27	15 "	33	4.1
AEJ 10	11	16 "	34	1.5
AEJ 11	15	16 "	36	2.3
AEJ 33	9	21 "	31	1.6
AEJ 34	15	17 "	28	1.9
AEJ 36	3	19 "	27	.4
AEJ 100	3	29 "	30	.5
AEJ 102	15	18 "	32	2.6
AEJ 103	10	15 "	35	2.9
AEJ 104	15	26 "	37	4.6
AEJ 105	9	24 "	35	1.6
AEJ 402	2	26 "	29	.5

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 403	3	27 "	32	.8
AEJ 404	4	21 "	31	.8
AEJ 405	1	28 "	28	.3
AEJ 407	3	16 "	33	.6
AEJ 502	5	16 "	31	1.4
AEJ 503	7	21 "	36	2.6
AEJ 504	6	13 "	33	1.4
AEJ 505	6	18 "	32	1.5
AEJ 506	5	12 "	33	1.2
AEJ 701	2	15 "	38	.6
AEJ 702	4	16 "	25	.5
AEJ 703	8	16 "	35	1.8
AEJ 705	3	22 "	27	.4
AEJ 706	3	16 "	29	.4
AEJ 707	5	21 "	32	.9
AEJ 708	2	22 "	23	.3
RH82703	1	30 "	30	.2
TOTAL	266	12 "	38	48.9
LAMPANYCTUS	TENUIFORMES			
AEJ 104	1	69 "	69	2.6
TOTAL	1	69 "	69	2.6
LEPIDOPHANES	GAUSSI			
AEJ 4	1	14 "	14	.1
AEJ 5	1	33 "	33	.2
AEJ 7	1	18 "	18	.1
AEJ 8	2	18 "	31	.4
AEJ 33	1	27 "	27	.1
AEJ 34	3	19 "	28	.3
AEJ 36	1	20 "	20	.1
AEJ 102	1	38 "	38	.5
AEJ 402	1	29 "	29	.1
AEJ 404	1	25 "	25	.1
AEJ 701	1	28 "	28	.2
AEJ 702	5	16 "	39	1.1
AEJ 703	3	18 "	23	.3
AEJ 705	3	19 "	45	1.1
AEJ 706	4	17 "	28	.4
AEJ 707	1	56 "	56	1.6
TOTAL	30	14 "	56	6.7

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
LEPIDOPHANES		GUENTHERI		
AEJ 2	2	31 "	37	.5
AEJ 4	1	44 "	44	.8
AEJ 7	1	50 "	50	1.1
AEJ 8	2	19 "	43	.7
AEJ 33	2	57 "	60	3.4
AEJ 34	1	44 "	44	.8
AEJ 36	3	18 "	43	1.8
AEJ 100	6	30 "	48	2.5
AEJ 101	4	35 "	61	5.1
AEJ 102	7	32 "	60	3.6
AEJ 104	1	34 "	34	.3
AEJ 402	14	17 "	59	11.0
AEJ 404	1	37 "	37	.4
AEJ 405	2	30 "	58	1.6
AEJ 406	2	36 "	36	.9
AEJ 407	3	25 "	60	2.8
AEJ 502	1	57 "	57	1.6
AEJ 503	1	60 "	60	2.0
AEJ 505	2	44 "	60	2.6
AEJ 507	1	15 "	15	.1
AEJ 701	1	18 "	18	.1
AEJ 702	2	41 "	49	1.6
AEJ 703	7	22 "	46	2.4
AEJ 705	5	15 "	29	.7
AEJ 706	1	53 "	53	1.4
AEJ 707	15	20 "	56	12.5
AEJ 708	6	34 "	53	6.3
TOTAL	94	15 "	61	68.6
LOBBIANCHIA		DOFLEINI		
AEJ 2	12	26 "	36	5.1
AEJ 3	4	23 "	28	1.0
AEJ 4	1	29 "	29	.3
AEJ 5	4	23 "	33	1.1
AEJ 6	1	28 "	28	.4
AEJ 7	4	24 "	29	1.0
AEJ 9	4	18 "	30	1.1
AEJ 10	6	23 "	29	1.7
AEJ 11	4	22 "	35	1.0
AEJ 33	2	26 "	28	.6
AEJ 34	2	25 "	26	.5
AEJ 36	1	25 "	25	.3
AEJ 100	3	28 "	55	3.2

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 102	5	22 "	32	1.7
AEJ 103	4	28 "	36	1.6
AEJ 401	8	22 "	33	3.4
AEJ 402	9	26 "	35	4.3
AEJ 404	1	27 "	27	.3
AEJ 405	1	35 "	35	.8
AEJ 406	11	27 "	36	5.1
AEJ 407	6	29 "	35	3.4
AEJ 502	8	12 "	15	.4
AEJ 506	2	28 "	30	.8
AEJ 701	1	29 "	29	.5
AEJ 702	2	24 "	27	.5
AEJ 703	2	25 "	28	.7
AEJ 707	12	25 "	39	6.8
AEJ 708	14	25 "	36	7.3
RHB2703	2	30 "	31	.6
TOTAL	136	12 "	55	55.5

LOBIANCHIA		GEMELLARI		
AEJ 3	1	72 "	72	5.3
AEJ 6	1	32 "	32	.5
AEJ 34	2	57 "	97	17.2
AEJ 101	2	52 "	95	14.2
AEJ 102	2	14 "	93	13.0
AEJ 401	1	48 "	48	1.2
AEJ 403	1	45 "	45	1.3
AEJ 502	3	17 "	20	.5
AEJ 503	2	15 "	23	.3
AEJ 504	3	12 "	18	.2
AEJ 505	2	19 "	72	5.6
AEJ 506	4	12 "	21	.5
AEJ 707	3	46 "	92	24.5
TOTAL	27	12 "	97	84.3

MYCTOPHUM		AFFINE		
AEJ 8	1	24 "	24	.1
AEJ 36	7	13 "	17	.2
AEJ 402	13	23 "	42	6.1
AEJ 406	7	27 "	48	4.7
AEJ 506	1	13 "	13	.1
AEJ 507	3	16 "	33	.7
AEJ 707	3	33 "	42	2.2
RHB2701	1	31 "	31	.2
TOTAL	36	13 "	48	14.3

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
MYCTOPHUM	NITIDULUM			
AEJ 4	1	40 "	40	.7
TOTAL	1	40 "	40	.7
MYCTOPHUM	OBTUSIROSTRIS			
AEJ 101	1	15 "	15	.1
TOTAL	1	15 "	15	.1
MYCTOPHUM	PUNCTATUM			
AEJ 100	1	82 "	82	8.9
AEJ 101	7	70 "	75	34.0
AEJ 502	5	18 "	19	.3
AEJ 503	12	17 "	20	1.0
AEJ 504	7	16 "	20	.5
AEJ 505	7	16 "	19	.7
TOTAL	39	16 "	82	45.4
MYCTOPHUM	SELENOPS			
AEJ 503	1	55 "	55	3.8
TOTAL	1	55 "	55	3.8
NOTOLYCHNUS	VALDIVIAE			
AEJ 2	4	14 "	20	.3
AEJ 3	1	22 "	22	.1
AEJ 4	4	13 "	19	.2
AEJ 7	13	10 "	20	.3
AEJ 8	7	13 "	16	.2
AEJ 9	3	20 "	21	.2
AEJ 10	6	18 "	23	.4
AEJ 11	3	19 "	22	.3
AEJ 33	9	11 "	19	.2
AEJ 34	15	11 "	20	.5
AEJ 36	1	17 "	17	.1
AEJ 100	1	15 "	15	.1
AEJ 101	7	15 "	20	.2
AEJ 102	9	16 "	19	.2
AEJ 103	5	16 "	23	.1
AEJ 104	5	18 "	20	.1
AEJ 401	3	17 "	21	.1
AEJ 402	2	15 "	16	.1
AEJ 403	1	17 "	17	.1

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 404	3	15 "	19	•1
AEJ 405	8	10 "	19	•4
AEJ 407	3	12 "	20	•1
AEJ 502	4	16 "	20	•2
AEJ 503	10	17 "	23	•8
AEJ 504	3	20 "	21	•3
AEJ 506	5	16 "	19	•3
AEJ 507	2	16 "	17	•1
AEJ 701	9	10 "	18	•5
AEJ 702	13	9 "	16	•4
AEJ 703	4	10 "	16	•1
AEJ 705	11	13 "	19	•5
AEJ 706	8	9 "	19	•3
AEJ 707	4	14 "	19	•1
AEJ 708	4	15 "	19	•2
RHB2701	3	16 "	19	•2
RHB2702	1	17 "	17	•1
TOTAL	194	9 "	23	8•5

NOTOSCOPULUS

CAUDISPINOSUS

AEJ 100	2	25 "	28	•4
AEJ 101	3	19 "	31	•5
AEJ 104	1	23 "	23	•1
AEJ 105	1	22 "	22	•1
AEJ 503	1	30 "	30	•3
AEJ 505	1	29 "	29	•3
AEJ 506	3	22 "	34	•8
AEJ 507	6	24 "	33	3•6
AEJ 701	1	66 "	66	3•8
AEJ 702	1	81 "	81	5•1
AEJ 703	1	76 "	76	5•0
TOTAL	21	19 "	81	20•0

NOTOSCOPULUS

RESPLENDENS

AEJ 2	3	51 "	55	4•8
AEJ 5	1	50 "	50	1•0
AEJ 36	1	58 "	58	2•0
AEJ 102	2	59 "	62	4•1
AEJ 105	1	66 "	66	2•7
AEJ 402	1	56 "	56	1•8
AEJ 404	1	72 "	72	4•5
AEJ 406	4	50 "	59	7•9
AEJ 407	2	56 "	62	4•6

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 502	2	18 "	62	2.4
AEJ 702	1	41 "	41	.7
AEJ 707	2	53 "	57	3.5
AEJ 708	2	48 "	60	3.3
TOTAL	23	18 "	72	43.3

SYMBOLOPHORUS	VERANYI			
AEJ 101	1	24 "	24	.1
AEJ 502	1	40 "	40	.5
AEJ 708	1	21 "	21	.1
TOTAL	3	21 "	40	.7

TAANINGICHTHYS	BATHYPHILUS			
AEJ 3	2	40 "	54	1.6
AEJ 6	1	32 "	32	.2
AEJ 9	1	35 "	35	.4
AEJ 104	1	72 "	72	2.5
AEJ 503	1	28 "	28	.2
AEJ 504	2	16 "	59	2.0
AEJ 707	2	29 "	44	.8
RHB2703	2	41 "	45	1.2
TOTAL	12	16 "	72	8.9

TAANINGICHTHYS	MINIMUS			
AEJ 502	1	33 "	33	.4
AEJ 503	1	28 "	28	.2
AEJ 506	1	35 "	35	.5
TOTAL	3	28 "	35	1.1

IFORMES

STEPHANØBERYCOIDE

MELAMPHAIDAE

MELAMPHAES

PUMILUS

AEJ 4	9	14 "	20	.8
AEJ 7	6	10 "	22	.6
AEJ 8	6	9 "	19	.4
AEJ 11	2	11 "	12	.1
AEJ 33	4	18 "	21	.7
AEJ 34	8	13 "	23	1.1
AEJ 36	1	11 "	11	.1
AEJ 101	2	20 "	21	.3

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 102	4	17 "	20	0.5
AEJ 103	1	11 "	11	0.1
AEJ 401	1	14 "	14	0.1
AEJ 404	1	22 "	22	0.1
AEJ 502	6	11 "	21	0.9
AEJ 506	5	20 "	21	1.0
AEJ 701	8	17 "	21	1.5
AEJ 702	24	10 "	23	3.0
AEJ 705	13	14 "	20	1.3
AEJ 706	14	12 "	17	1.1
AEJ 708	1	22 "	22	0.3
TOTAL	116	9 "	23	14.0
MELAMPHAES	SIMUS			
RHB2701	1	28 "	28	0.5
TOTAL	1	28 "	28	0.5
MELAMPHAES	SUBORBITALIS			
AEJ 100	1	87 "	87	13.0
AEJ 401	1	93 "	93	19.5
AEJ 707	1	99 "	99	24.0
RHB2703	1	98 "	98	20.0
TOTAL	4	87 "	99	76.5
MELAMPHAES	TYPHLOPS			
AEJ 102	1	37 "	37	1.0
AEJ 702	1	52 "	52	3.5
TOTAL	2	37 "	52	4.5
POROMITRA	CAPITO			
AEJ 102	3	18 "	96	21.0
AEJ 103	3	15 "	19	0.2
AEJ 503	1	83 "	83	25.5
AEJ 506	2	30 "	32	1.5
TOTAL	9	15 "	96	48.2
POROMITRA	MEGALOPS			
AEJ 707	2	58 "	60	7.0
TOTAL	2	58 "	60	7.0

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
SCOPELOBERYX		OPISTHOPTERUS		
AEJ 2	2	23 "	30	.7
AEJ 4	4	15 "	28	.9
AEJ 5	4	21 "	33	1.3
AEJ 6	6	27 "	34	3.0
AEJ 7	2	13 "	22	.3
AEJ 8	5	14 "	32	1.0
AEJ 9	5	27 "	30	1.5
AEJ 10	8	22 "	32	2.7
AEJ 11	2	24 "	27	.2
AEJ 33	3	23 "	25	.7
AEJ 36	7	26 "	39	3.7
AEJ 100	1	20 "	20	.1
AEJ 101	2	19 "	31	.5
AEJ 102	6	17 "	21	.6
AEJ 103	12	23 "	36	6.3
AEJ 104	5	26 "	36	2.2
AEJ 105	2	33 "	36	1.2
AEJ 401	3	15 "	23	.4
AEJ 402	3	16 "	34	1.2
AEJ 403	10	24 "	36	6.5
AEJ 404	1	35 "	35	.7
AEJ 405	10	21 "	37	5.2
AEJ 406	8	22 "	37	4.0
AEJ 407	5	23 "	32	2.0
AEJ 502	8	26 "	36	5.6
AEJ 503	10	20 "	37	7.2
AEJ 504	10	21 "	39	5.4
AEJ 505	6	16 "	37	2.8
AEJ 506	1	20 "	20	.1
AEJ 507	9	20 "	36	5.0
AEJ 509	1	32 "	32	.4
AEJ 703	6	14 "	32	1.0
AEJ 705	1	25 "	25	.3
AEJ 707	2	25 "	27	.5
AEJ 708	1	25 "	25	.2
RHB2701	5	17 "	27	.9
RHB2702	9	27 "	37	5.4
RHB2703	9	24 "	37	5.3
TOTAL	194	13 "	39	87.0
SCOPELOBERYX		ROBUSTUS		
AEJ 6	1	11 "	11	.1
AEJ 11	1	15 "	15	.1

SYSTEMATIC LIST OF SPECIES DATA

STATION	QUANTITY	SIZE (MM)		VOLUME (CC)
		MIN	MAX	
AEJ 101	1	15 "	15	0.1
AEJ 505	1	15 "	15	0.1
AEJ 703	1	17 "	17	0.1
AEJ 705	1	13 "	13	0.1
AEJ 706	2	13 "	14	0.1
RHB2702	1	15 "	15	0.1
RHB2703	4	14 "	19	0.5
TOTAL	13	11 "	19	1.3

SCOPELEGGADUS		BEANII		
AEJ 2	2	28 "	96	35.0
AEJ 5	1	104 "	104	28.0
AEJ 8	1	32 "	32	0.5
AEJ 11	1	34 "	34	0.6
AEJ 100	1	38 "	38	1.0
AEJ 401	3	36 "	42	3.6
AEJ 406	4	32 "	105	40.0
AEJ 407	2	46 "	78	12.0
AEJ 502	1	19 "	19	0.2
AEJ 503	1	20 "	20	0.2
AEJ 509	6	16 "	116	64.0
AEJ 706	1	51 "	51	2.5
AEJ 707	3	105 "	109	89.0
AEJ 708	1	59 "	59	4.1
RHB2701	3	35 "	76	12.5
RHB2702	6	30 "	88	26.0
RHB2703	7	37 "	108	174.0
TOTAL	44	16 "	116	492.2

SCOPELEGGADUS		MIZBLEPIS		
AEJ 34	1	46 "	46	1.3
TOTAL	1	46 "	46	1.3