# Rich and underreported: First integrated assessment of the diversity of mesopelagic fishes in the southwestern Tropical Atlantic

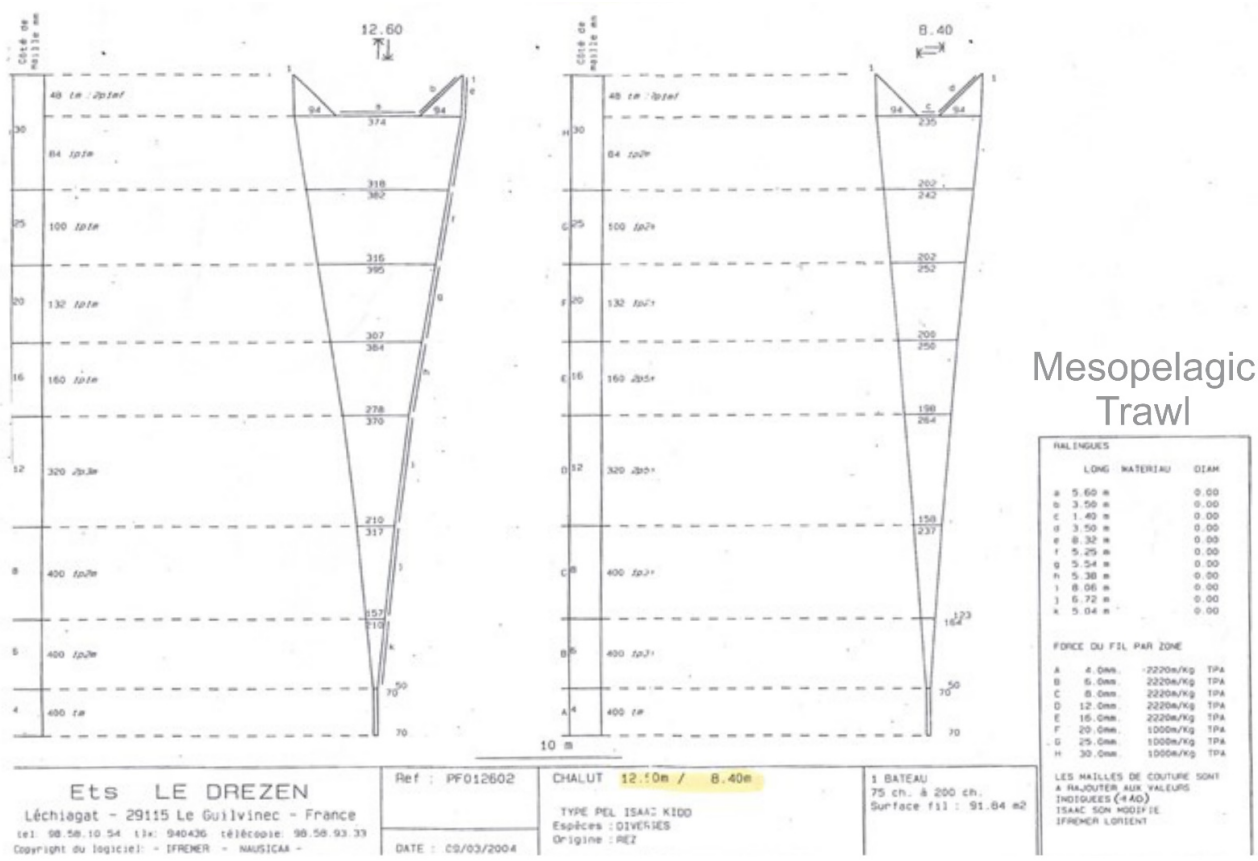
Leandro Nolé Eduardo[1,2], Arnaud Bertrand[1,2,3], Flávia Lucena-Frédou[1], Bárbara Teixeira Villarins[4], Júlia Rodrigues Martins[4], Gabriel Vinícius Felix Afonso[5], Theodore Wells Pietsch[6], Thierry Frédou[1], Fabio Di Dario[7], Michael Maia Mincarone[7]

[1] Universidade Federal Rural de Pernambuco (UFRPE), Departamento de Pesca e Aquicultura, Recife, PE, Brazil. [2] MARBEC, Univ. Montpellier, CNRS, Ifremer, IRD, Sète, France. [3] Universidade Federal de Pernambuco (UFPE), Departamento de Oceanografia, Recife, PE, Brazil. [4] Programa de Pós-Graduação em Ciências Ambientais e Conservação, Instituto de Biodiversidade e Sustentabilidade, Universidade Federal do Rio de Janeiro, Macaé, RJ, Brazil. [5] Programa de Pós-Graduação em Biologia Comparada, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Universidade de São Paulo (USP), Ribeirão Preto, SP, Brazil. [6] School of Aquatic and Fishery Sciences and Burke Museum of Natural History and Culture, University of Washington, Seattle, WA, United States. [7] Universidade Federal do Rio de Janeiro (UFRJ), Instituto de Biodiversidade e Sustentabilidade, Macaé, RJ, Brazil.

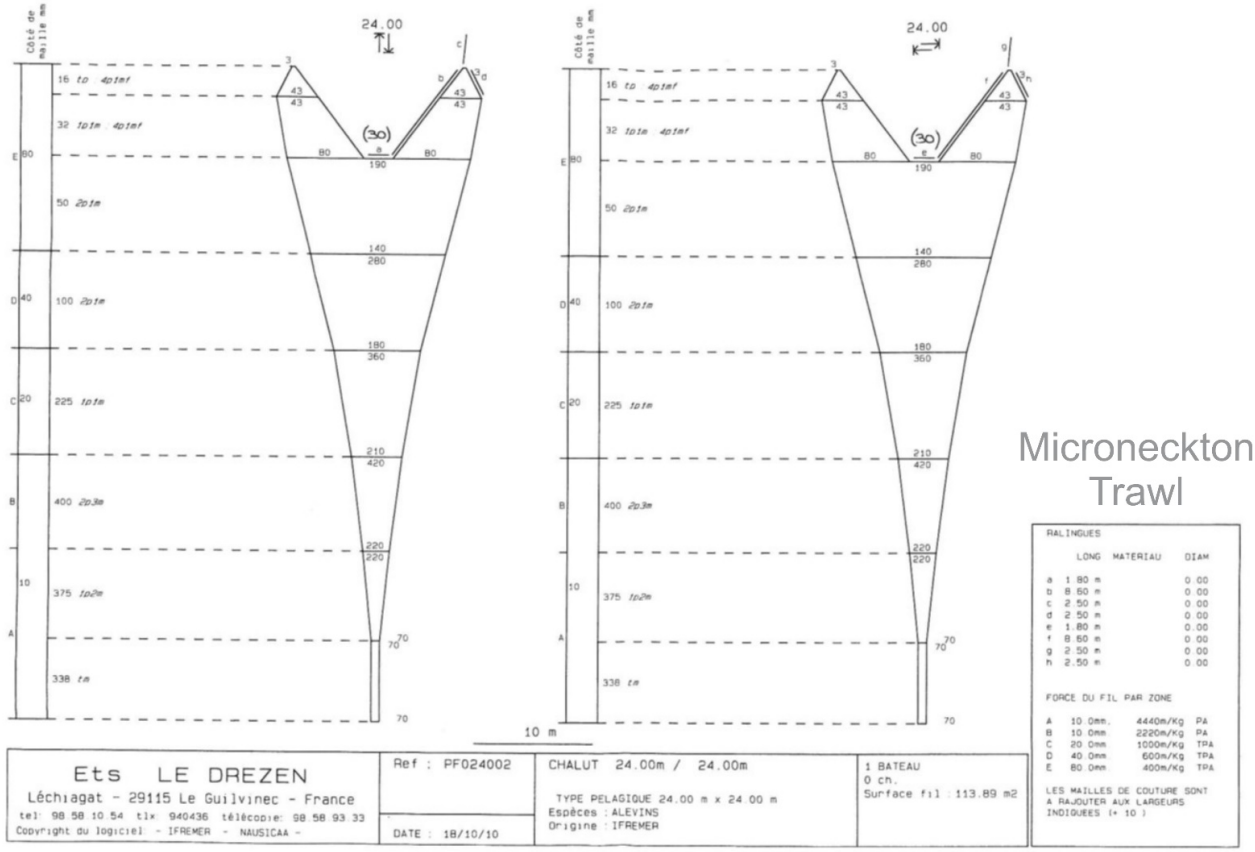
**Supplementary Material 1.** List of midwater trawls performed during the ABRACOS 1 (AB1) and ABRACOS 2 (AB2) expeditions. FNR: Fernando de Noronha Ridge. RN: Rio Grande do Norte, PB: Paraíba, PE: Pernambuco, and AL: Alagoas.

| Station | Site | Period | Latitude | Longitude | Depth | Station | Site | Period | Latitude | Longitude | Depth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AB1#1 | FNR | Night | -3.772 | -32.422 | 150 | AB2#22 | PB | Night | -6.888 | -34.762 | 10 |
| AB1#2 | FNR | Day | -3.661 | -32.218 | 110 | AB2#26 | RN | Day | -5.819 | -34.813 | 100 |
| AB1#3 | FNR | Night | -3.640 | -31.971 | 60 | AB2#28 | RN | Night | -5.617 | -34.785 | 130 |
| AB1#4 | FNR | Day | -3.908 | -32.340 | 90 | AB2#31 | RN | Day | -4.976 | -34.951 | 450 |
| AB1#5 | FNR | Night | -4.090 | -32.180 | 85 | AB2#35 | RN | Night | -4.327 | -35.497 | 630 |
| AB1#6 | FNR | Day | -4.243 | -32.613 | 85 | AB2#39 | FNR | Night | -4.874 | -34.059 | 800 |
| AB1#7 | FNR | Night | -3.960 | -32.532 | 58 | AB2#40A | FNR | Day | -3.523 | -32.528 | 440 |
| AB1#8 | FNR | Day | -3.736 | -32.895 | 100 | AB2#40B | FNR | Day | -3.520 | -32.530 | 230 |
| AB1#9 | FNR | Night | -3.471 | -32.759 | 105 | AB2#41A | FNR | Night | -3.333 | -32.412 | 430 |
| AB1#11 | FNR | Day | -3.750 | -33.230 | 40 | AB2#41B | FNR | Night | -3.321 | -32.428 | 25 |
| AB1#12 | FNR | Night | -3.939 | -33.511 | 130 | AB2#42A | FNR | Day | -3.258 | -31.808 | 780 |
| AB1#13 | FNR | Day | -3.917 | -33.848 | 110 | AB2#42B | FNR | Day | -3.262 | -31.817 | 50 |
| AB1#14 | FNR | Night | -3.983 | -34.056 | 510 | AB2#44A | FNR | Day | -3.881 | -32.293 | 850 |
| AB1#15 | FNR | Day | -3.734 | -34.000 | 537 | AB2#44B | FNR | Day | -3.872 | -32.300 | 130 |
| AB1#20 | FNR | Night | -3.761 | -33.880 | 60 | AB2#45A | FNR | Night | -4.237 | -32.035 | 30 |
| AB1#21 | FNR | Day | -3.657 | -33.692 | 100 | AB2#45B | FNR | Night | -4.239 | -32.021 | 50 |
| AB1#22 | FNR | Night | -4.129 | -33.790 | 525 | AB2#46A | FNR | Day | -4.142 | -32.304 | 360 |
| AB1#23 | RN | Day | -5.144 | -34.713 | 100 | AB2#46B | FNR | Day | -4.175 | -32.268 | 440 |
| AB1#26 | RN | Day | -6.154 | -34.576 | 560 | AB2#48A | FNR | Day | -4.418 | -32.964 | 505 |
| AB1#27 | RN | Night | -6.309 | -34.979 | 100 | AB2#48B | FNR | Day | -4.440 | -32.938 | 70 |
| AB1#29 | PB | Day | -6.621 | -34.760 | 15 | AB2#49A | FNR | Night | -4.177 | -33.269 | 1020 |
| AB1#31 | PB | Night | -6.734 | -34.440 | 50 | AB2#49B | FNR | Night | -4.176 | -33.259 | 90 |
| AB1#34 | PB | Night | -7.190 | -34.266 | 100 | AB2#50A | FNR | Day | -3.817 | -32.599 | 615 |
| AB1#35 | PB | Day | -7.486 | -34.425 | 250 | AB2#50B | FNR | Day | -3.812 | -32.640 | 115 |
| AB1#36 | PE | Night | -7.602 | -34.338 | 60 | AB2#50C | FNR | Day | -3.836 | -32.623 | 58 |
| AB1#37 | PE | Day | -7.867 | -34.495 | 25 | AB2#52A | FNR | Day | -3.721 | -33.419 | 984 |
| AB1#41 | PE | Day | -8.274 | -34.680 | 30 | AB2#52B | FNR | Day | -3.699 | -33.391 | 385 |
| AB1#43 | PE | Night | -8.415 | -34.844 | 12 | AB2#53A | FNR | Night | -3.816 | -33.988 | 610 |
| AB1#52 | AL | Day | -9.066 | -34.801 | 570 | AB2#53B | FNR | Night | -3.830 | -33.962 | 65 |
| AB1#25 | RN | Night | -5.803 | -34.951 | 75 | AB2#54A | FNR | Day | -3.771 | -34.727 | 95 |
| AB2#2 | PE | Night | -8.857 | -34.728 | 60 | AB2#54B | FNR | Day | -3.755 | -34.684 | 1030 |
| AB2#5 | AL | Night | -9.182 | -34.758 | 117 | AB2#56A | FNR | Day | -3.934 | -35.421 | 110 |
| AB2#6 | PE | Day | -8.873 | -34.599 | 240 | AB2#56B | FNR | Day | -3.962 | -35.406 | 260 |
| AB2#7 | PE | Day | -8.774 | -34.742 | 112 | AB2#58A | FNR | Day | -3.948 | -36.104 | 520 |
| AB2#8 | PE | Day | -8.758 | -34.785 | 17 | AB2#58B | FNR | Day | -3.949 | -36.155 | 90 |
| AB2#9 | PE | Night | -8.708 | -34.745 | 95 | AB2#58C | FNR | Day | -3.954 | -36.183 | 90 |
| AB2#10 | PE | Night | -8.659 | -34.761 | 15 | AB2#59A | FNR | Night | -3.634 | -36.053 | 1113 |
| AB2#13 | PE | Day | -8.317 | -34.428 | 445 | AB2#59B | FNR | Night | -3.643 | -36.038 | 110 |
| AB2#16 | PE | Night | -7.604 | -33.993 | 680 | AB2#60A | FNR | Day | -3.531 | -36.385 | 449 |
| AB2#21 | PB | Day | -6.841 | -34.306 | 800 | AB2#60B | FNR | Day | -3.529 | -36.356 | 700 |

**Supplementary Material 2.** Detailed design of the mesopelagic and micronekton trawls utilized in the campaigns ABRACOS 1 and ABRACOS 2.




Mesopelagic Trawl

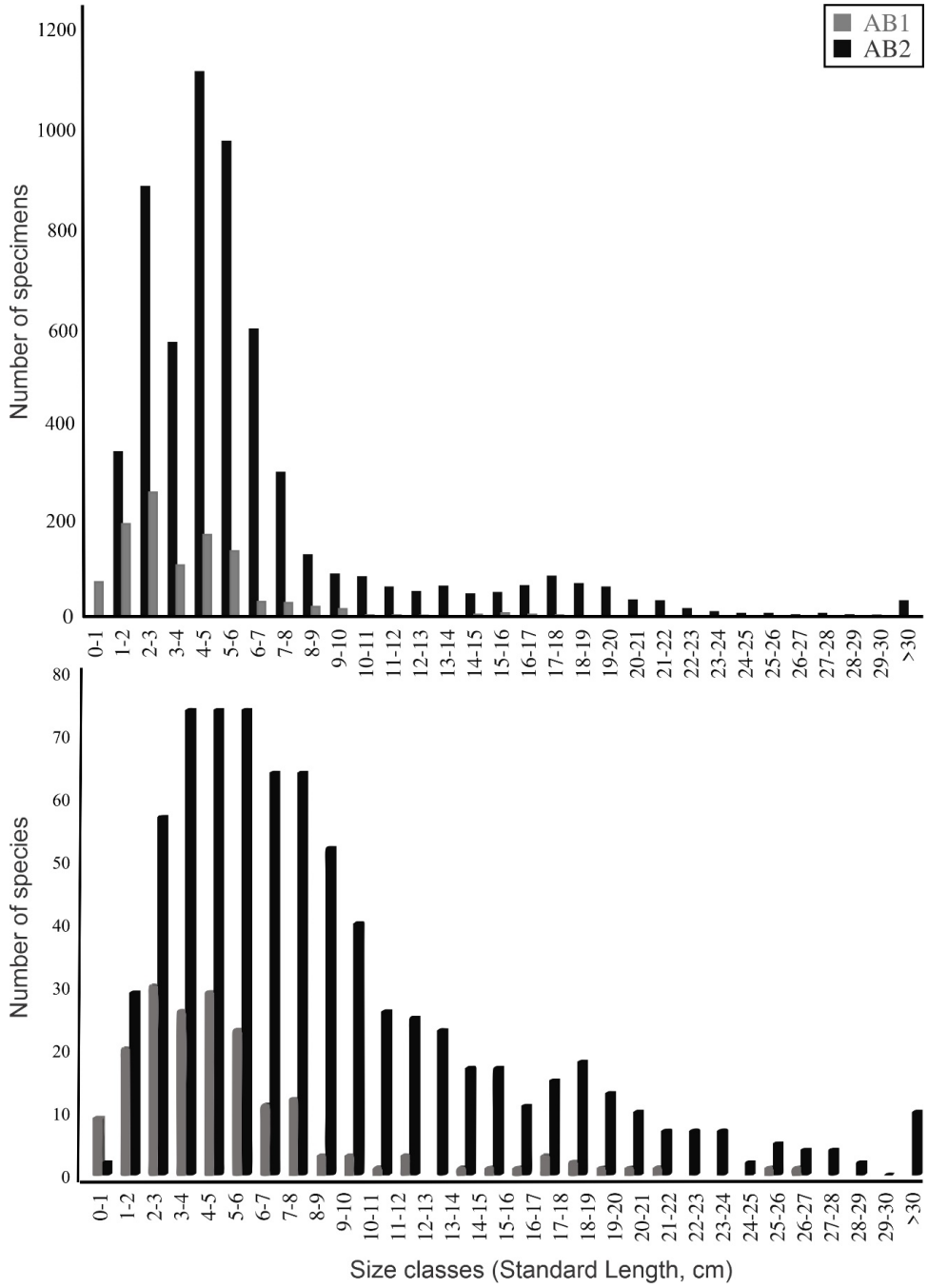



Microneckton Trawl

**Supplementary Material 3.** Mesopelagic fishes that could not be identified at species level due to their poor condition and/or extremely small size. Survey (1: ABRACOS 1; 2: ABRACOS 2), number of specimens (N), frequency of occurrence to overall samples (FO%) standard length (mean and range), total wet weight (mean and range), locality (PE: Pernambuco; PB: Paraíba; RN: Rio Grande do Norte; FNR: Fernando de Noronha Ridge), depth range, temperature range (T°C).

| Species | Survey | N | FO% | SL (mm) | TW (g) | Locality | Depth (m) | T (°C) |
|---|---|---|---|---|---|---|---|---|
| ANGUILLIFORMES | | | | | | | | |
| Nemichthyidae | | | | | | | | |
| Nemichthyidae sp. | 1-2 | 7 | 6.1 | 286(200–480) | 5.4(2.4–9.3) | FNR-PE | 40–800 | 4.7–26.6 |
| Serrivomeridae | | | | | | | | |
| *Serrivomer* sp. | 2 | 2 | 2.4 | 236 | 0.5 | FNR | 70–900 | 4.3–25.8 |
| ARGENTINIFORMES | | | | | | | | |
| Bathylagidae | | | | | | | | |
| Bathylagidae sp. | 2 | 5 | 3.7 | 79(63–98) | 3.3(1.2–4.7) | FNR | 430–800 | 4.6–8.54 |
| STOMIIFORMES | | | | | | | | |
| Gonostomatidae | | | | | | | | |
| *Gonostoma* sp. | 1-2 | 9 | 7.3 | 89(22–198) | 8.5(0.3–29.5) | FNR-PB-PE | 50–1000 | 4.3–27.6 |
| Gonostomatidae sp. | 2 | 3 | 2.4 | 27 | 1 | FNR | 720–780 | 4.6–4.9 |
| Sternoptychidae | | | | | | | | |
| *Sternoptyx* sp. | 2 | 72 | 1.2 | 25(14–34) | 1.6(0.4–4.8) | FNR | 110 | 24.1 |
| Phosichthyidae | | | | | | | | |
| Phosichthyidae sp. | 2 | 5 | 3.7 | 57 | – | FNR | 720–800 | 4.7–4.9 |
| Stomiidae | | | | | | | | |
| *Aristostomias* sp. | 1-2 | 22 | 17.1 | 85(32–151) | 6.3(1.0–19.5) | FNR-PB-PE | 60–1000 | 4.3–26.6 |
| *Astronesthes* sp. | 1-2 | 8 | 7.3 | 51(26–76) | 1.8(0.5–3) | FNR-PB | 50–900 | 4.3–26.5 |
| *Batophilus* sp. | 2 | 1 | 1.2 | 16 | 3.5 | FNR | 385 | 9.2 |
| *Eustomias* sp. | 1-2 | 12 | 13.4 | 84(63–134) | 3.6(0.6–7.9) | FNR-PB-PE | 65–1000 | 4.3–26.5 |
| *Leptostomias* sp. | 2 | 3 | 2.4 | 109(67–165) | 3.2(0.9–5.3) | FNR | 90–430 | 8.5–25.1 |
| *Melanostomias* sp. | 1-2 | 3 | 2.4 | 126(30–176) | 12.1(0.3–18.7) | PB-PE | 50–680 | 5.2–26.5 |
| *Photonectes* sp. | 2 | 2 | 1.2 | 33(28–37) | 0.04(0.04–0.05) | FNR | 780 | 4.6 |
| *Stomias* sp. | 2 | 1 | 1.2 | 107 | 3.3 | FNR | 610 | 5.6 |
| AULOPIFORMES | | | | | | | | |
| Notosudidae | | | | | | | | |
| *Scopelosaurus* sp. | 2 | 3 | 4.9 | 34(33–35) | 0.9(0.6–1.3) | FNR | 100–800 | 4.7–24.6 |
| Scopelarchidae | | | | | | | | |
| *Schopelarchoides* sp. | 2 | 1 | 1.2 | 75 | 2.8 | FNR | 610 | 5.6 |
| *Scopelarchus* sp. | 2 | 1 | 1.2 | 27 | – | FNR | 780 | 4.6 |
| Scopelarchidae sp. | 2 | 1 | 1.2 | 76 | 4.3 | FNR | 900 | 4.3 |
| Paralepididae | | | | | | | | |
| *Stemonosudis* sp. | 2 | 1 | 1.2 | 135 | 4.7 | FNR | 780 | 4.6 |
| Paralepidiidae sp. | 2 | 1 | 1.2 | 23 | 10.3 | FNR | 800 | 4.7 |
| MYCTOPHIFORMES | | | | | | | | |
| Myctophidae | | | | | | | | |
| *Bolinichthys* sp. | 2 | 20 | 6.1 | 43(25–76) | 4.1(0.5–24.5) | FNR-PB-RN | 630–900 | 4.3–5.6 |
| *Diaphus* sp. | 1-2 | 276 | 20.7 | 32(10–83) | 2.0(0.1–9.3) | FNR-PB-PE-RN | 60–900 | 4.3–26.6 |
| *Lampadena* sp. | 1-2 | 9 | 2.4 | 20(13–26) | 0.4(0.1–0.8) | FNR | 510–780 | 4.6–6.0 |
| *Lampanyctus* sp. | 1-2 | 93 | 19.5 | 46(21–125) | 2.4(0.3–12.6) | FNR-PE-RN | 25–900 | 4.3–28.8 |
| *Nannobrachium* sp. | 2 | 1 | 1.2 | 70 | 1.73 | FNR | 610 | 5.7 |
| *Taaningichthys* sp. | 2 | 7 | 6.1 | 53(43–72) | 1.3(0.5–3.6) | FNR | 720–800 | 4.6–4.98 |
| Myctophidae spp. | 1-2 | 138 | 35.4 | 40(14–135) | 3.0(0.1–25.3) | FNR-PB-PE-RN | 25–1000 | 4.3–28.8 |
| GADIFORMES | | | | | | | | |
| Macrouridae | | | | | | | | |
| Macrouridae sp. | 2 | 2 | 2.4 | 275 | 12.6(4.1–21.1) | FNR | 800–900 | 4.3–4.7 |
| BERYCIFORMES | | | | | | | | |
| Melamphaidae | | | | | | | | |
| *Scopeloberyx* sp. | 2 | 3 | 3.7 | 25(20–32) | 2.7(1.9–3.4) | FNR | 720–800 | 4.6–4.9 |
| PERCIFORMES | | | | | | | | |
| Bramidae | | | | | | | | |
| *Brama* sp. | 1 | 11 | 8.5 | 11(08–15) | 1.5(0.3–9) | FNR-PB | 58–130 | 15.0–26.6 |
| Caristiidae | | | | | | | | |
| *Platyberyx* sp. | 2 | 4 | 3.7 | 69(41–98) | 12.7(2.3–25.1) | FNR-RN | 450–720 | 4.9–8.5 |
| SCOMBRIFORMES | | | | | | | | |
| Gempylidae | | | | | | | | |
| Gempylidae sp. | 2 | 6 | 6.1 | 31(12–55) | 0.9(0.5–1.2) | FNR-PE | 70–800 | 4.7–25.8 |
| TRACHINIFORMES | | | | | | | | |
| Chiasmodontidae | | | | | | | | |
| *Chiasmodon* sp. | 2 | 9 | 8.5 | 31(16–46) | 1.9(0.5–4.4) | FNR-PE | 112–800 | 4.6–24.1 |
| LOPHIIFORMES | | | | | | | | |
| Melanocetidae | | | | | | | | |
| *Melanocetus* sp. | 2 | 6 | 6.1 | 49(20–88) | 11.6(2.1–33.2) | FNR-PE | 680–900 | 4.3–5.2 |
| Oneirodidae | | | | | | | | |
| *Chaenophryne* sp. | 1-2 | 2 | 2.4 | 22(17–28) | 0.8(0.8–0.8) | PE | 510–800 | 4.7–6.0 |
| *Oneirodes* sp. | 2 | 1 | 1.2 | 15 | 2.1 | FNR | 900 | 4.3 |
| Oneirodidae sp. | 1-2 | 3 | 3.7 | 80 | – | FNR | 40–780 | 4.6–26.6 |
| Ceratiidae | | | | | | | | |
| *Ceratias* sp. | 2 | 3 | 1.2 | 42(31–51) | 2.7(1.4–4.6) | FNR | 610–700 | 5.2–5.6 |
| Ceratiidae sp. | 1 | 1 | 1.2 | 30 | – | RN | 570 | 6.3 |
| Gigantactinidae | | | | | | | | |
| *Gigantactis* sp. | 1 | 1 | 1.2 | 60 | – | FNR | 100 | 24 |

**Supplementary Material 4.** Number of specimens and species per size class of mesopelagic species of fishes collected on the ABRACOS 1 (mesopelagic trawl) and ABRACOS 2 (micronekton trawl) expeditions.



**Supplementary Material 5.** Abundance (individuals.hour$^{-1}$), Biomass (Kg.hour-1x10$^{2}$), Number of species (N0), Margalef index, Hill's Shannon index (N1), and Hill's Simpson's index (N2) of mesopelagic species of fishes collected on the ABRACOS 1 (mesopelagic trawl) and ABRACOS 2 (micronekton trawl) expeditions. Stations with no collection of mesopelagic fishes were excluded.

| Station | Abundance | Biomass | N0 | Margalef | N1 | N2 |
|---|---|---|---|---|---|---|
| AB1#1 | 236.00 | 1.356 | 12 | 2.38 | 8.06 | 6.84 |
| AB1#2 | 4.00 | 0.021 | 2 | 1.44 | 2.00 | 2.00 |
| AB1#4 | 8.00 | 0.014 | 4 | 2.16 | 4.00 | 4.00 |
| AB1#5 | 102.00 | 0.195 | 12 | 2.84 | 5.14 | 2.92 |
| AB1#6 | 22.00 | 0.043 | 3 | 0.83 | 2.14 | 1.75 |
| AB1#7 | 10.00 | 0.024 | 3 | 1.24 | 2.87 | 2.78 |
| AB1#9 | 176.00 | 0.916 | 16 | 3.36 | 4.86 | 2.36 |
| AB1#11 | 6.00 | 0.000 | 2 | 1.44 | 2.00 | 2.00 |
| AB1#12 | 146.00 | 0.530 | 16 | 3.51 | 8.64 | 5.05 |
| AB1#13 | 4.00 | 0.007 | 2 | 1.44 | 2.00 | 2.00 |
| AB1#14 | 142.00 | 0.332 | 27 | 6.12 | 13.69 | 6.86 |
| AB1#15 | 100.00 | 0.097 | 9 | 2.08 | 5.45 | 3.73 |
| AB1#20 | 14.00 | 0.015 | 3 | 1.03 | 2.22 | 1.81 |
| AB1#21 | 8.00 | 0.005 | 4 | 2.16 | 4.00 | 4.00 |
| AB1#22 | 96.00 | 0.500 | 27 | 6.91 | 23.35 | 19.88 |
| AB1#23 | 12.00 | 0.014 | 5 | 2.23 | 4.76 | 4.50 |
| AB1#25 | 12.00 | 0.034 | 4 | 1.67 | 3.78 | 3.60 |
| AB1#26 | 32.00 | 0.032 | 4 | 1.08 | 2.50 | 1.94 |
| AB1#27 | 4.00 | 0.002 | 2 | 1.44 | 2.00 | 2.00 |
| AB1#31 | 46.00 | 0.019 | 6 | 2.28 | 5.35 | 4.76 |
| AB1#34 | 34.00 | 0.110 | 11 | 3.53 | 9.00 | 7.05 |
| AB1#36 | 42.00 | 0.070 | 4 | 1.30 | 2.56 | 1.92 |
| AB1#51 | 254.00 | 0.395 | 12 | 2.29 | 2.73 | 1.66 |
| AB1#52 | 192.00 | 0.051 | 4 | 0.74 | 1.45 | 1.19 |
| AB2#6 | 4.00 | 0.011 | 2 | 1.44 | 2.00 | 2.00 |
| AB2#7 | 13.85 | 0.021 | 5 | 2.23 | 4.76 | 4.50 |
| AB2#9 | 512.57 | 0.550 | 6 | 0.95 | 2.62 | 2.27 |
| AB2#16 | 289.79 | 1.315 | 43 | 7.75 | 14.86 | 7.98 |
| AB2#21 | 442.67 | 0.998 | 34 | 5.71 | 10.42 | 5.55 |
| AB2#28 | 420.00 | 1.061 | 25 | 4.40 | 9.84 | 6.46 |
| AB2#35 | 462.00 | 1.625 | 29 | 4.89 | 4.70 | 2.08 |
| AB2#39 | 1134.67 | 3.245 | 70 | 10.23 | 8.11 | 3.12 |
| AB2#40A | 769.09 | 2.766 | 30 | 5.30 | 13.05 | 7.62 |
| AB2#40B | 405.60 | 0.563 | 4 | 0.58 | 1.24 | 1.09 |
| AB2#41A | 771.82 | 4.230 | 59 | 10.29 | 25.52 | 15.28 |
| AB2#41B | 104.00 | 0.790 | 9 | 2.52 | 7.34 | 6.40 |
| AB2#42A | 7900.00 | 70.722 | 68 | 11.42 | 18.78 | 7.90 |
| AB2#42B | 7.83 | 0.005 | 4 | 0.87 | 1.51 | 1.21 |
| AB2#44A | 1704.00 | 19.201 | 75 | 11.86 | 24.65 | 12.48 |
| AB2#44B | 51.00 | 0.081 | 8 | 1.68 | 2.33 | 1.54 |
| AB2#45B | 453.00 | 0.829 | 15 | 2.97 | 7.30 | 5.34 |
| AB2#46A | 18.00 | 0.031 | 3 | 0.96 | 2.46 | 2.13 |
| AB2#46B | 19.20 | 0.039 | 5 | 2.06 | 4.37 | 3.77 |
| AB2#48A | 113.33 | 0.612 | 11 | 2.61 | 4.06 | 2.37 |
| AB2#48B | 83.57 | 0.140 | 8 | 1.86 | 3.30 | 2.09 |
| AB2#49A | 340.59 | 2.196 | 48 | 8.98 | 24.22 | 13.83 |
| AB2#49B | 950.40 | 2.166 | 33 | 5.36 | 10.11 | 5.57 |
| AB2#50A | 150.86 | 1.355 | 25 | 5.46 | 13.90 | 7.55 |
| AB2#52A | 408.00 | 2.361 | 57 | 10.57 | 25.41 | 10.89 |
| AB2#52B | 494.00 | 1.488 | 25 | 4.36 | 9.57 | 6.31 |
| AB2#53A | 994.00 | 6.474 | 55 | 8.73 | 13.86 | 6.07 |
| AB2#53B | 60.00 | 0.171 | 12 | 3.27 | 6.58 | 3.81 |
| AB2#54B | 826.00 | 3.804 | 61 | 10.04 | 21.42 | 10.55 |
| AB2#56B | 86.25 | 0.086 | 4 | 0.79 | 1.61 | 1.27 |
| AB2#56C | 146.00 | 0.531 | 17 | 3.74 | 8.95 | 5.63 |
| AB2#58A | 164.00 | 0.678 | 14 | 2.98 | 7.60 | 5.38 |
| AB2#59A | 373.50 | 1.772 | 40 | 7.14 | 10.81 | 5.11 |
| AB2#59B | 422.50 | 0.879 | 17 | 3.19 | 6.12 | 3.60 |
| AB2#60A | 6.00 | 0.013 | 2 | 0.91 | 1.89 | 1.80 |
| AB2#60B | 220.00 | 1.602 | 18 | 3.62 | 7.03 | 4.21 |