Data Article

Contribution to Mediterranean medieval dietary studies: Stable carbon and nitrogen isotope data of marine and catadromous fish from Provence (9th–14th CE)

Leïa Mion, Tatiana André, Anne Mailloux, Myriam Sternberg, Arturo Morales Muniz, Eufrasia Rosello-Izquierdo, Laura Llorente Rodríguez, Estelle Herrscher

Aix Marseille University, CNRS, Minist Culture, LAMPEA, Aix-en-Provence, France
Aix Marseille University, CNRS, LA3M, Aix-en-Provence, France
Aix Marseille University, CNRS, Minist Culture, CCJ, Aix-en-Provence, France
Laboratorio de Arqueozoología, Universidad Autónoma de Madrid, Spain
Laboratory for Archaeozoological Studies, Faculty of Archaeology, Universiteit Leiden, Leiden, the Netherlands

ABSTRACT

Whilst marine resources are one of the pillars of the Mediterranean diet, their mode of acquisition and subsequent consumption by medieval populations in southern France are still not well known. Throughout Europe, bioarchaeological techniques, however, are beginning to reveal hitherto unknown aspects of these practices both dating to the medieval period as well as other periods of history and prehistory. This study involved the stable isotope analysis of five marine and catadromous taxa from three medieval sites in Provence, France: "rue Frédéric Mistral" at Fos-sur-Mer, "le Château" at Hyères and "Couvent des Dominicaines - Parking/Collegé Mignet" at Aix-en-Provence. In total, 127 specimens, including Anguilla anguilla, Dicentrarchus labrax, Sparus aurata, Diplodus sargus and Mugilidae were subjected to car-

* Corresponding author.
E-mail address: leia.mion@univ-amu.fr (L. Mion).

https://doi.org/10.1016/j.dib.2022.108016
2352-3409/© 2022 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)
The study provides a crucial and unprecedented point of reference of the carbon and nitrogen isotopic variability of one of the main dietary resources in the Mediterranean world, fish.

© 2022 The Authors. Published by Elsevier Inc.
This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

---

**Specifications Table**

| Subject | Archaeology |
|---------|-------------|
| Specific subject area | Stable carbon and nitrogen isotopes analysis of bone collagen in archaeological and palaeoecological studies. |
| Type of data | Table |
| How data were acquired | Carbon (δ¹³C) and nitrogen (δ¹⁵N) stable isotope measurements were acquired using an Isotope Ratio Mass Spectrometer (IRMS). |
| Data format | Table |
| Parameters for data collection | Vertebrals from five taxa *Anguilla anguilla* (n = 53), *Dicentrarchus labrax* (n = 29), *Sparus aurata* (n = 4), *Diplodus sargus* (n = 7) and Mugilidae (n = 34) were sampled for collagen extraction (total n = 127). Four samples did not provide enough material for EA-IRMS measurements. The remaining 123 samples were analysed by EA-IRMS at Iso-Analytical Limited (United Kingdom). One in five samples was measured in duplicate for better analytical reliability when enough material was available (extracted weight > 2 mg, n = 23). |
| Description of data collection | Samples were ultrasonicated in MilliQ water for 15 min until clean. Collagen was then extracted following a modified ABA protocol [1]. 0.13–1.1 mg of each extracted bone collagen sample were measured by EA-IRMS. |
| Data source location | All sampled skeletal collections are kept in the LA3M UMR 7298, MMSH at Aix Marseille University, Aix-en-Provence, France. The collection comes from the medieval archaeological sites of “rue Frédéric Mistral” at Fos-sur-Mer, “le Château” at Hyères and “Couvent des Dominicaines - Parking/Collège Mignet” at Aix-en-Provence, Provence, France. |
| Data accessibility | Repository: IsoArch (www.isoarch.eu) [2] |
| Data identification number | 10.48530/isoarch.2021.012 |
| Direct URL | https://doi.org/isoarch.2021.012 |
| Data is available under the Creative Commons BY-NC-SA 4.0 license. |

---

**Value of the Data**

- This dataset can benefit archaeologists, anthropologists, and zooarchaeologists interested in palaeodiets reconstruction and past fish acquisition practices and palaeoecology.
- This dataset is useful to reconstruct the consumption and acquisition of marine resources by medieval communities of the Western Mediterranean Basin.
- The dataset provided can be used to explore the changes of those practices and their affiliated environments during medieval times.
- This dataset enlightens the interest and the necessity of building archaeologically documented datasets of the isotopic variability of this key dietary resource to better assess its importance in the Mediterranean diet through time.
1. Data Description

The data comprise of elemental and isotope values of 127 vertebrae of marine and catadromous fish specimens (53 Anguilla anguilla, 29 Dicentrarchus labrax, 4 Sparus aurata, 7 Diplodus sargus and 34 Mugilidae). This dataset is the result of a research project (Icht’Isomed2 https://www.univ-amu.fr/fr/public/icthisomed2) which combined an archaeo-ichthyological approach and an analysis of the carbon and nitrogen isotope values of 5 key fish species of three medieval archaeological sites in Provence, South of France. The objective is to reconstruct the environments used for foraging marine resources Table 1. present sample data by specimen, providing site, taxon and sampled bone of the specimens analysed, collagen extraction data (Initial weight of the prepared sample, amount of extracted collagen and associated yield), elemental values (carbon and nitrogen contents expressed in percentage, atomic C/N ratio) and carbon and nitrogen isotope values (δ13C and δ15N) using delta notation (δ) in per mil increments (‰).

The samples come from three sites located along the Mediterranean seashore of Provence in South-East France: “rue Frédéric Mistral” at Fos-sur-Mer (Bouches-du-Rhône, France), “le Château” at Hyères (Var, France) and “Couvent des Dominicaines - Parking/Collège Mignet” at Aix-en-Provence (Bouches-du-Rhône, France) (Fig. 1). The samples from “le Château” at Hyères come from a dump layer dated between the end of the 8th and the middle of the 10th century AD [3]. The ones from the "rue Frédéric Mistral" habitat site in Fos-sur-Mer are from occupation levels dated between the 10th and the end of the 14th centuries AD [4]. The samples from “Couvent des Dominicaines - Parking/Collège Mignet” at Aix-en-Provence originate from a deposit pit used for consumption wastes and dated from the early 14th century AD [5].

Fig. 1. Location of the three sites in southern France.
Table 1
Elemental and isotopic data (carbon and nitrogen) of the fish samples analysed with related skeletal and archaeological information. Abbreviations: FOS= "rue Frédéric Mistral", Foss-sur-Mer, Bouches-du-Rhône, France, HYERES="le Château", Hyères, Var, France, AIX=“Couvent des Dominicaines – Parking/Collège Mignet”, Aix-en-Provence, Bouches-du-Rhône, France, VTC= caudal vertebra, VTPC= precaudal vertebra, VTT= thoracic vertebra. UND undetermined vertebra,"samples did not provid enough collagen for EA-IRMS analyses or do not met the minimum thresholds for carbon and nitrogen contents (%C>13% and%N > 5% [10]) or atomic C:N ratio (between 2.9 and 3.6 [11]).

| LabCode | Site  | Taxon         | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N | δ¹³C (‰) | δ¹⁵N (‰) |
|---------|------|---------------|--------------|--------------------|------------------------|-------------|-----------------------|-------------------|---------------------|-----|-----------|-----------|
| AIX_F01 | AIX  | Anguilla anguilla | VTC          | 16.11              | 2.9                    | 180.0       | 0.92                  | 24.43             | 9.40                | 3.03 | -9.98     | 10.64     |
| AIX_F02 | AIX  | Anguilla anguilla | VTPC         | 18.66              | 3.4                    | 182.2       | 1.02                  | 16.22             | 5.63                | 3.36 | -12.79    | 14.19     |
| AIX_F03*| AIX  | Anguilla anguilla | VTPC         | 23.89              | 5.2                    | 217.7       | 0.99                  | 8.59              | 2.93                | 3.42 | -11.81    | 10.66     |
|         |      |               | Duplicate values | 0.96               | 8.85                 | 2.99        | 3.45                  |                   |                     |      |           |           |
| AIX_F04 | AIX  | Anguilla anguilla | VTPC         | 11.11              | 2.2                    | 198.0       | 0.71                  | 26.61             | 10.11               | 3.07 | -11.57    | 11.06     |
| AIX_F05*| AIX  | Anguilla anguilla | VTPC         | 24.52              | 5.9                    | 240.6       | 0.96                  | 9.94              | 3.54                | 3.27 | -11.05    | 10.98     |
| AIX_F06 | AIX  | Anguilla anguilla | VTPC         | 16.37              | 3.0                    | 183.2       | 1.02                  | 30.51             | 11.75               | 3.03 | -13.53    | 16.14     |
| AIX_F07*| AIX  | Anguilla anguilla | VTPC         | 12.16              | 1.7                    | 139.8       | 0.14                  | 22.84             | 7.21                | 3.70 | -15.12    | 14.23     |
| AIX_F08 | AIX  | Anguilla anguilla | VTPC         | 12.26              | 2.4                    | 195.8       | 0.56                  | 23.15             | 9.22                | 2.93 | -9.16     | 10.71     |
| AIX_F09*| AIX  | Anguilla anguilla | UND          | 3.01               | <1                     | >10         |                      |                   |                     |      |           |           |
| AIX_F10*| AIX  | Mugilidae       | VTC          | 80.01              | 9.3                    | 116.2       | 1.10                  | 12.11             | 4.42                | 3.19 | -11.99    | 9.10      |
| AIX_F11*| AIX  | Mugilidae       | VTC          | 52.76              | 7.0                    | 132.7       | 0.97                  | 12.77             | 4.58                | 3.25 | -16.65    | 13.06     |
|         |      |               | Duplicate values | 1.00               | 12.75                | 4.54        | 3.28                  |                   |                     |      | -16.55    | 13.32     |
| AIX_F12*| AIX  | Mugilidae       | VTC          | 28.68              | 8.9                    | 310.4       | 0.97                  | 6.90              | 2.33                | 3.46 | -14.77    | 13.98     |
|         |      |               | Duplicate values | 0.96               | 6.79                 | 2.34        | 3.39                  |                   |                     |      | -14.55    | 13.90     |
| FOS_F01 | FOS  | Anguilla anguilla | VTC          | 58.40              | 9.8                    | 167.8       | 1.06                  | 41.96             | 15.85               | 3.09 | -10.62    | 14.15     |
|         |      |               | Duplicate values | 0.92               | 40.11                | 15.22       | 3.08                  |                   |                     |      | -10.56    | 14.10     |
| FOS_F02 | FOS  | Anguilla anguilla | VTC          | 15.50              | 3.0                    | 193.5       | 1.01                  | 38.76             | 14.52               | 3.11 | -11.39    | 16.99     |
| FOS_F03 | FOS  | Anguilla anguilla | VTC          | 26.30              | 4.2                    | 159.7       | 1.03                  | 41.96             | 15.48               | 3.16 | -25.94    | 9.47      |
| FOS_F04 | FOS  | Anguilla anguilla | VTC          | 33.20              | 4.4                    | 132.5       | 0.99                  | 41.77             | 15.56               | 3.13 | -26.28    | 10.65     |
| FOS_F05 | FOS  | Anguilla anguilla | VTC          | 51.40              | 7.4                    | 144.0       | 0.96                  | 43.56             | 16.33               | 3.11 | -21.69    | 9.84      |
| FOS_F06 | FOS  | Anguilla anguilla | VTC          | 72.40              | 10.6                   | 146.4       | 0.95                  | 40.58             | 15.32               | 3.09 | -20.77    | 11.66     |
| FOS_F07 | FOS  | Anguilla anguilla | VTPC         | 47.60              | 6.5                    | 136.6       | 1.00                  | 41.12             | 15.52               | 3.09 | -9.62     | 13.41     |
|         |      |               | Duplicate values | 1.02               | 41.57                | 15.59       | 3.11                  |                   |                     |      | -9.60     | 13.44     |
| FOS_F08 | FOS  | Anguilla anguilla | VTPC         | 74.30              | 10.0                   | 134.6       | 0.97                  | 42.75             | 15.92               | 3.13 | -9.94     | 13.48     |

(continued on next page)
| LabCode | Site | Taxon           | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N | δ¹³C (%) | δ¹⁵N (%) |
|---------|------|-----------------|--------------|--------------------|-----------------------|-------------|----------------------|-------------------|---------------------|-----|---------|---------|
| FOS_F09 | FOS  | Anguilla anguilla | VTC          | 63.00              | 9.2                   | 146.0       | 1.10                 | 38.13             | 14.35               | 3.10 | −9.80   | 12.99   |
| FOS_F10 | FOS  | Anguilla anguilla | VTC          | 30.80              | 5.2                   | 168.8       | 1.01                 | 41.87             | 15.44               | 3.16 | −9.54   | 13.24   |
| FOS_F11 | FOS  | Anguilla anguilla | VTC          | 177.90             | 18.8                  | 105.7       | 0.97                 | 22.28             | 8.36                | 3.11 | −21.79  | 9.07    |
| FOS_F12 | FOS  | Anguilla anguilla | VTC          | 111.60             | 11.8                  | 105.7       | 1.04                 | 43.36             | 16.11               | 3.14 | −9.93   | 17.32   |

**Duplicate values**

| LabCode | Site | Taxon           | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N | δ¹³C (%) | δ¹⁵N (%) |
|---------|------|-----------------|--------------|--------------------|-----------------------|-------------|----------------------|-------------------|---------------------|-----|---------|---------|
| FOS_F13 | FOS  | Anguilla anguilla | VTC          | 68.40              | 8.0                   | 117.0       | 1.10                 | 42.48             | 15.86               | 3.12 | −9.09   | 16.04   |
| FOS_F14 | FOS  | Anguilla anguilla | VTC          | 18.90              | 3.7                   | 195.8       | 1.02                 | 39.17             | 14.46               | 3.16 | −9.65   | 12.36   |
| FOS_F15 | FOS  | Anguilla anguilla | VTC          | 109.00             | 9.5                   | 87.2        | 1.00                 | 43.81             | 16.06               | 3.18 | −20.52  | 10.64   |
| FOS_F16 | FOS  | Anguilla anguilla | VTC          | 134.20             | 20.1                  | 149.8       | 0.99                 | 44.84             | 16.89               | 3.10 | −10.68  | 15.97   |
| FOS_F17 | FOS  | Anguilla anguilla | VTC          | 59.30              | 3.9                   | 65.8        | 1.07                 | 43.02             | 16.20               | 3.10 | −10.86  | 15.85   |

**Duplicate values**

| LabCode | Site | Taxon           | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N | δ¹³C (%) | δ¹⁵N (%) |
|---------|------|-----------------|--------------|--------------------|-----------------------|-------------|----------------------|-------------------|---------------------|-----|---------|---------|
| FOS_F18 | FOS  | Anguilla anguilla | VTC          | 90.00              | 1.7                   | 18.9        | 0.94                 | 37.13             | 13.85               | 3.13 | −27.74  | 9.95    |
| FOS_F19 | FOS  | Anguilla anguilla | VTC          | 56.40              | 6.4                   | 113.5       | 0.99                 | 43.22             | 16.28               | 3.10 | −9.10   | 11.99   |
| FOS_F20 | FOS  | Anguilla anguilla | VTC          | 12.86              | 14.8                  | 115.1       | 0.98                 | 42.39             | 16.07               | 3.08 | −10.88  | 13.90   |
| FOS_F21 | FOS  | Anguilla anguilla | VTC          | 111.70             | 15.2                  | 136.1       | 1.10                 | 44.70             | 16.83               | 3.10 | −19.58  | 11.25   |
| FOS_F22 | FOS  | Anguilla anguilla | VTC          | 49.10              | 6.3                   | 128.3       | 1.07                 | 44.32             | 16.58               | 3.12 | −24.01  | 12.57   |

**Duplicate values**

| LabCode | Site | Taxon           | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N | δ¹³C (%) | δ¹⁵N (%) |
|---------|------|-----------------|--------------|--------------------|-----------------------|-------------|----------------------|-------------------|---------------------|-----|---------|---------|
| FOS_F23 | FOS  | Anguilla anguilla | VTC          | 60.60              | 9.8                   | 161.7       | 0.96                 | 45.87             | 17.34               | 3.09 | −11.22  | 11.93   |
| FOS_F24 | FOS  | Anguilla anguilla | VTC          | 66.50              | 0.7                   | 10.5        | 0.54                 | 32.47             | 12.36               | 3.07 | −9.35   | 12.39   |
| FOS_F25 | FOS  | Dicentrarchus labrax | VTC          | 285.00             | 26.7                  | 93.7        | 1.00                 | 44.79             | 17.01               | 3.07 | −9.72   | 11.54   |
| FOS_F26 | FOS  | Dicentrarchus labrax | VTC          | 243.90             | 26.5                  | 108.7       | 1.10                 | 46.06             | 17.35               | 3.10 | −9.75   | 11.46   |
| FOS_F27 | FOS  | Dicentrarchus labrax | VTC          | 197.30             | 19.8                  | 100.4       | 1.08                 | 45.87             | 17.18               | 3.12 | −9.80   | 11.45   |
| FOS_F28 | FOS  | Dicentrarchus labrax | VTC          | 111.80             | 8.1                   | 72.5        | 0.95                 | 44.25             | 16.15               | 3.20 | −11.05  | 12.58   |

**Duplicate values**

| LabCode | Site | Taxon           | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N | δ¹³C (%) | δ¹⁵N (%) |
|---------|------|-----------------|--------------|--------------------|-----------------------|-------------|----------------------|-------------------|---------------------|-----|---------|---------|
| FOS_F29 | FOS  | Dicentrarchus labrax | VTC          | 165.30             | 15.9                  | 96.2        | 1.10                 | 42.08             | 15.76               | 3.12 | −8.78   | 11.32   |
| FOS_F30 | FOS  | Dicentrarchus labrax | VTC          | 239.30             | 17.1                  | 71.5        | 0.96                 | 45.09             | 17.08               | 3.08 | −10.06  | 13.54   |

(continued on next page)
| LabCode | Site | Taxon | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N | δ¹³C (%) | δ¹⁵N (%) |
|---------|------|-------|--------------|--------------------|----------------------|-------------|---------------------|--------------------|---------------------|-----|----------|----------|
| FOS_F31 | FOS  | Dicentrarchus labrax | VTC | 161.40 | 26.1 | 617.0 | 1.05 | 49.45 | 18.48 | 3.12 | −10.19 | 13.58 |
| FOS_F32 | FOS  | Dicentrarchus labrax | VTPC | 307.80 | 30.8 | 100.1 | 1.00 | 32.40 | 12.17 | 3.11 | −10.75 | 10.15 |
| FOS_F33 | FOS  | Dicentrarchus labrax | VTC | 93.80 | 14.9 | 158.8 | 1.10 | 43.68 | 15.46 | 3.30 | −11.03 | 12.39 |
| FOS_F34 | FOS  | Dicentrarchus labrax | VTC | 43.30 | 6.3 | 145.5 | 0.96 | 40.04 | 15.29 | 3.06 | −11.67 | 11.28 |
| FOS_F35 | FOS  | Dicentrarchus labrax | VTPC | 275.50 | 26.9 | 97.6 | 1.06 | 42.87 | 15.37 | 3.25 | −11.54 | 13.39 |
| FOS_F36 | FOS  | Dicentrarchus labrax | VTPC | 87.40 | 9.7 | 111.0 | 1.07 | 38.82 | 14.67 | 3.09 | −8.74 | 13.87 |
| FOS_F37 | FOS  | Dicentrarchus labrax | VTPC | 113.00 | 11.2 | 99.1 | 0.91 | 41.36 | 15.43 | 3.13 | −8.80 | 13.92 |
| FOS_F38 | FOS  | Dicentrarchus labrax | VTPC | 111.60 | 9.4 | 84.2 | 1.00 | 41.99 | 15.58 | 3.14 | −13.10 | 11.28 |
| FOS_F39 | FOS  | Dicentrarchus labrax | VTC | 290.20 | 36.1 | 124.4 | 1.04 | 35.42 | 13.14 | 3.15 | −9.52 | 13.34 |
| FOS_F40 | FOS  | Dicentrarchus labrax | VTC | 122.60 | 15.1 | 123.2 | 1.00 | 41.99 | 15.92 | 3.08 | −13.38 | 6.55 |
| FOS_F41 | FOS  | Dicentrarchus labrax | VTC | 254.70 | 32.1 | 126.0 | 1.01 | 43.62 | 16.54 | 3.08 | −12.57 | 14.24 |
| FOS_F42 | FOS  | Dicentrarchus labrax | VTC | 74.10 | 10.8 | 145.7 | 0.91 | 41.61 | 15.80 | 3.07 | −9.33 | 11.36 |
| FOS_F43 | FOS  | Dicentrarchus labrax | VTC | 200.60 | 13.1 | 65.3 | 0.95 | 40.94 | 15.29 | 3.12 | −10.46 | 10.03 |
| FOS_F44 | FOS  | Dicentrarchus labrax | VTPC | 197.20 | 23.5 | 119.2 | 1.05 | 41.31 | 14.91 | 3.23 | −10.49 | 13.56 |
| FOS_F45 | FOS  | Dicentrarchus labrax | VTC | 204.70 | 9.3 | 45.4 | 0.99 | 39.41 | 14.25 | 3.23 | −11.99 | 11.65 |
| FOS_F46 | FOS  | Dicentrarchus labrax | VTPC | 286.60 | 28.8 | 100.5 | 0.91 | 40.60 | 15.34 | 3.09 | −10.81 | 10.35 |
| FOS_F47 | FOS  | Dicentrarchus labrax | VTPC | 132.70 | 17.3 | 130.4 | 0.93 | 43.43 | 16.23 | 3.12 | −11.65 | 13.43 |
| FOS_F48 | FOS  | Dicentrarchus labrax | VTPC | 199.40 | 24.0 | 120.4 | 0.93 | 41.95 | 15.82 | 3.09 | −9.95 | 11.82 |
| FOS_F49 | FOS  | Diplodus sargus | VTC | 26.60 | 4.3 | 161.7 | 0.96 | 38.96 | 14.74 | 3.08 | −6.80 | 9.68 |
| FOS_F50 | FOS  | Diplodus sargus | VTC | 32.20 | 4.4 | 136.6 | 0.99 | 39.54 | 14.85 | 3.11 | −8.32 | 10.43 |
| FOS_F51 | FOS  | Diplodus sargus | VTC | 27.20 | 3.2 | 117.6 | 1.08 | 40.69 | 15.40 | 3.08 | −7.65 | 7.83 |

(continued on next page)
Table 1 (continued)

| LabCode | Site | Taxon       | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N  | δ¹³C (‰) | δ¹⁵N (‰) |
|---------|------|-------------|--------------|--------------------|----------------------|-------------|---------------------|-------------------|---------------------|-------|----------|----------|
| FOS_F52 | FOS  | Diplodus sargus | VTPC         | 52.70              | 6.6                  | 125.2       | 1.05                | 41.09             | 15.38               | 3.12  | −6.84    | 8.82     |
| FOS_F53 | FOS  | Diplodus sargus | VTPC         | 27.20              | 3.7                  | 136.0       | 0.99                | 38.54             | 14.54               | 3.09  | −9.44    | 12.56    |
| FOS_F54 | FOS  | Diplodus sargus | VTPC         | 122.90             | 15.0                 | 122.1       | 0.95                | 42.51             | 16.16               | 3.07  | −6.59    | 9.15     |
| FOS_F55 | FOS  | Diplodus sargus | VTC          | 38.50              | 7.3                  | 189.6       | 1.10                | 30.08             | 11.43               | 3.07  | −6.41    | 8.66     |

Duplicate values

| LabCode | Site | Taxon       | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N  | δ¹³C (‰) | δ¹⁵N (‰) |
|---------|------|-------------|--------------|--------------------|----------------------|-------------|---------------------|-------------------|---------------------|-------|----------|----------|
| FOS_F56 | FOS  | Mugilidae   | VTPC         | 311.50             | 21.7                 | 69.7        | 0.91                | 40.85             | 15.14               | 3.15  | −15.93   | 6.59     |
| FOS_F57 | FOS  | Mugilidae   | VTPC         | 247.40             | 20.8                 | 84.1        | 1.08                | 42.07             | 15.63               | 3.14  | −11.35   | 8.39     |
| FOS_F58 | FOS  | Mugilidae   | VTPC         | 179.90             | 17.5                 | 97.3        | 1.07                | 43.86             | 16.55               | 3.09  | −8.72    | 9.88     |
| FOS_F59 | FOS  | Mugilidae   | VTC          | 190.70             | 19.1                 | 100.2       | 0.99                | 43.06             | 15.55               | 3.23  | −5.87    | 7.90     |
| FOS_F60 | FOS  | Mugilidae   | VTC          | 190.10             | 13.4                 | 70.5        | 1.00                | 41.91             | 15.70               | 3.11  | −22.46   | 9.06     |
| FOS_F61 | FOS  | Mugilidae   | VTC          | 206.40             | 18.9                 | 91.6        | 0.97                | 42.10             | 15.51               | 3.17  | −12.96   | 12.82    |

Duplicate values

| LabCode | Site | Taxon       | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N  | δ¹³C (‰) | δ¹⁵N (‰) |
|---------|------|-------------|--------------|--------------------|----------------------|-------------|---------------------|-------------------|---------------------|-------|----------|----------|
| FOS_F62 | FOS  | Mugilidae   | VTC          | 353.70             | 27.5                 | 77.7        | 1.05                | 41.96             | 15.36               | 3.19  | −6.60    | 9.14     |
| FOS_F63 | FOS  | Mugilidae   | VTPC         | 196.80             | 19.0                 | 96.5        | 1.08                | 43.78             | 16.54               | 3.09  | −9.88    | 11.45    |
| FOS_F64 | FOS  | Mugilidae   | VTPC         | 197.40             | 11.0                 | 55.7        | 1.03                | 39.07             | 14.60               | 3.12  | −10.52   | 11.23    |
| FOS_F65 | FOS  | Mugilidae   | VTC          | 110.00             | 9.4                  | 85.5        | 1.05                | 42.87             | 15.87               | 3.15  | −19.19   | 12.99    |
| FOS_F66 | FOS  | Mugilidae   | VTPC         | 303.80             | 35.7                 | 117.5       | 1.03                | 44.75             | 16.48               | 3.17  | −13.64   | 9.56     |

Duplicate values

| LabCode | Site | Taxon       | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N  | δ¹³C (‰) | δ¹⁵N (‰) |
|---------|------|-------------|--------------|--------------------|----------------------|-------------|---------------------|-------------------|---------------------|-------|----------|----------|
| FOS_F67 | FOS  | Mugilidae   | VTPC         | 227.60             | 18.4                 | 80.8        | 0.95                | 42.11             | 15.55               | 3.16  | −12.55   | 9.55     |
| FOS_F68 | FOS  | Mugilidae   | VTPC         | 195.40             | 25.5                 | 130.5       | 0.96                | 33.46             | 12.50               | 3.12  | −6.54    | 9.18     |
| FOS_F69 | FOS  | Mugilidae   | VTPC         | 362.40             | 29.3                 | 80.8        | 1.01                | 43.75             | 15.55               | 3.28  | −6.01    | 7.85     |
| FOS_F70 | FOS  | Mugilidae   | VTC          | 182.70             | 15.0                 | 82.1        | 0.95                | 42.99             | 15.92               | 3.15  | −6.45    | 9.01     |

(continued on next page)
| LabCode  | Site | Taxon         | Sampled bone | Sampled weight (mg) | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Weight content (%) | Carbon content (%) | Nitrogen content (%) | C:N | δ\(^{13}\)C (%o) | δ\(^{15}\)N (%o) |
|---------|------|---------------|--------------|---------------------|---------------------|-----------------------|--------------|----------------------|--------------------|---------------------|---------------------|------|------------------|------------------|
| FOS_F71 | FOS  | Mugilidae     | VTC          | 84.10               | 9.8                 | 116.5                 | 1.05         | 42.08                | 14.80              | 3.32                | −6.73              | 6.95 |
| FOS_F72 | FOS  | Mugilidae     | VTC          | 89.80               | 10.1                | 112.5                 | 1.03         | 38.82                | 14.08              | 3.22                | −6.97              | 6.99 |
| FOS_F73 | FOS  | Mugilidae     | VTC          | 162.40              | 9.3                 | 57.3                  | 0.93         | 39.50                | 14.61              | 3.15                | −13.86             | 8.07 |
| FOS_F74 | FOS  | Mugilidae     | VTC          | 212.70              | 23.4                | 110.0                 | 1.05         | 44.59                | 16.48              | 3.16                | −10.29             | 11.02|
| FOS_F75 | FOS  | Sparus aurata | VTC          | 44.40               | 6.6                 | 148.6                 | 1.02         | 36.34                | 13.75              | 3.08                | −6.59              | 8.78 |
| FOS_F76 | FOS  | Sparus aurata | VTC          | 86.20               | 10.4                | 120.6                 | 1.00         | 41.50                | 15.51              | 3.12                | −12.00             | 14.50|

**Duplicate values**

| LabCode | Site | Taxon         | Sampled bone | Sampled weight (mg) | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Weight content (%) | Carbon content (%) | Nitrogen content (%) | C:N | δ\(^{13}\)C (%o) | δ\(^{15}\)N (%o) |
|---------|------|---------------|--------------|---------------------|---------------------|-----------------------|--------------|----------------------|--------------------|---------------------|---------------------|------|------------------|------------------|
| FOS_F77 | FOS  | Sparus aurata | VTPC         | 277.40              | 35.1                | 126.5                 | 0.97         | 39.83                | 15.14              | 3.07                | −8.65              | 10.13|
| FOS_F78 | FOS  | Sparus aurata | VTC          | 164.20              | 14.1                | 85.9                  | 1.10         | 43.48                | 16.13              | 3.14                | −7.22              | 9.86 |
| Hy_F01  | HYERES | Anguilla anguilla | VTC         | 12.40               | 1.3                 | 104.8                 | 0.30         | 25.60                | 9.34               | 3.20                | −15.43             | 8.02 |
| Hy_F02  | HYERES | Anguilla anguilla | VTC         | 10.20               | 2.4                 | 235.3                 | 0.97         | 34.63                | 12.92              | 3.13                | −11.41             | 11.43|
| Hy_F03  | HYERES | Dicentrarchus labrax | VTPC     | 33.80               | 7.1                 | 210.1                 | 0.97         | 15.53                | 5.72               | 3.17                | −13.01             | 7.26 |

**Duplicate values**

| LabCode | Site | Taxon         | Sampled bone | Sampled weight (mg) | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Weight content (%) | Carbon content (%) | Nitrogen content (%) | C:N | δ\(^{13}\)C (%o) | δ\(^{15}\)N (%o) |
|---------|------|---------------|--------------|---------------------|---------------------|-----------------------|--------------|----------------------|--------------------|---------------------|---------------------|------|------------------|------------------|
| Hy_F04  | HYERES | Dicentrarchus labrax | VTC         | 18.10               | 2.8                 | 154.7                 | 0.95         | 37.55                | 13.78              | 3.18                | −12.82             | 7.13 |
| Hy_F05  | HYERES | Dicentrarchus labrax | VTC         | 18.90               | 2.7                 | 142.9                 | 0.93         | 35.22                | 12.76              | 3.22                | −15.13             | 11.51|
| Hy_F06  | HYERES | Dicentrarchus labrax | VTC         | 13.20               | 1.9                 | 143.9                 | 0.83         | 35.71                | 12.92              | 3.23                | −12.96             | 6.00 |
| Hy_F07  | HYERES | Mugilidae     | VTPC         | 22.40               | 5.2                 | 232.1                 | 1.03         | 21.85                | 8.04               | 3.17                | −12.33             | 11.74|

**Duplicate values**

| LabCode | Site | Taxon         | Sampled bone | Sampled weight (mg) | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Weight content (%) | Carbon content (%) | Nitrogen content (%) | C:N | δ\(^{13}\)C (%o) | δ\(^{15}\)N (%o) |
|---------|------|---------------|--------------|---------------------|---------------------|-----------------------|--------------|----------------------|--------------------|---------------------|---------------------|------|------------------|------------------|
| Hy_F08  | HYERES | Mugilidae     | VTC          | 12.10               | 1.8                 | 148.8                 | 0.98         | 36.91                | 13.32              | 3.23                | −12.24             | 9.64 |
| Hy_F09  | HYERES | Mugilidae     | VTC          | 19.10               | 2.4                 | 125.7                 | 1.01         | 35.22                | 12.76              | 3.22                | −12.53             | 6.98 |
| Hy_F10  | HYERES | Mugilidae     | VTPC         | 45.30               | 4.1                 | 90.5                  | 1.09         | 40.07                | 14.90              | 3.14                | −12.35             | 13.02|
| Hy_F11  | HYERES | Mugilidae     | VTPC         | 10.00               | 1.2                 | 120.0                 | 0.41         | 31.86                | 11.54              | 3.22                | −12.68             | 6.90 |

(continued on next page)
| LabCode   | Site     | Taxon         | Sampled bone | Initial weight (mg) | Extracted weight (mg) | Yield (mg/g) | Weight analysed (mg) | Carbon content (%) | Nitrogen content (%) | C:N | δ¹³C (%) | δ¹⁵N (%) |
|-----------|----------|---------------|--------------|--------------------|-----------------------|--------------|----------------------|-------------------|---------------------|-----|----------|----------|
| Hy_F12*   | HYERES   | Mugilidae     | VTPC         | 25.70              | 5.1                   | 198.4        | 1.10                 | 8.03              | 2.57                | 3.65 | −18.49   | 8.26     |
|           |          |               |              | 1.03               | 7.45                  | 2.42         | 3.60                 | −18.37            | 8.19                |
| Hy_F13    | HYERES   | Mugilidae     | VTPC         | 19.30              | 2.6                   | 134.7        | 1.09                 | 37.43             | 13.85               | 3.15 | −11.11   | 8.74     |
| Hy_F14    | HYERES   | Mugilidae     | VTPC         | 92.50              | 8.6                   | 93.0         | 0.98                 | 38.63             | 14.31               | 3.15 | −14.60   | 14.90    |
| Hy_F15    | HYERES   | Anguilla anguilla | VTC         | 7.80               | 1.3                   | 166.7        | 0.49                 | 34.66             | 12.47               | 3.24 | −10.29   | 14.16    |
| Hy_F16    | HYERES   | Anguilla anguilla | VTC         | 6.80               | 1.6                   | 235.3        | 0.38                 | 34.19             | 12.21               | 3.27 | −18.34   | 10.10    |
| Hy_F17    | HYERES   | Anguilla anguilla | VTPC         | 7.00               | 1.6                   | 228.6        | 0.28                 | 30.07             | 10.07               | 3.49 | −12.61   | 12.85    |
| Hy_F18    | HYERES   | Anguilla anguilla | VTT         | 7.50               | 2.2                   | 293.3        | 0.57                 | 36.35             | 12.79               | 3.32 | −13.90   | 14.09    |
|Hy_F19     | HYERES   | Anguilla anguilla | VTC         | 7.70               | 1.4                   | 181.8        | 0.75                 | 33.63             | 11.72               | 3.35 | −13.31   | 13.94    |
|Hy_F20     | HYERES   | Anguilla anguilla | VTC         | 5.50               | 1.4                   | 254.5        | 0.24                 | 28.01             | 9.48                | 3.45 | −16.53   | 12.62    |
|Hy_F21     | HYERES   | Anguilla anguilla | VTC         | 5.00               | 1.4                   | 280.0        | 0.52                 | 27.25             | 9.17                | 3.47 | −13.64   | 12.14    |
|Hy_F22     | HYERES   | Dicentrarchus labrax | VTC         | 6.80               | 1.6                   | 235.3        | 0.66                 | 31.52             | 11.41               | 3.22 | −12.70   | 8.25     |
|Hy_F23     | HYERES   | Mugilidae     | VTPC         | 6.30               | 1.2                   | 190.5        | 0.50                 | 27.33             | 9.38                | 3.40 | −12.87   | 8.70     |
|Hy_F24     | HYERES   | Mugilidae     | VTPC         | 6.10               | 1.1                   | 180.3        | 0.36                 | 28.47             | 10.00               | 3.32 | −13.22   | 7.16     |
|Hy_F25     | HYERES   | Anguilla anguilla | VTC         | 3.80               | 1.3                   | 342.1        | 0.31                 | 28.17             | 9.83                | 3.34 | −15.61   | 13.98    |
|Hy_F26     | HYERES   | Anguilla anguilla | VTC         | 4.10               | 1.2                   | 292.7        | 0.24                 | 29.56             | 9.86                | 3.50 | −11.31   | 8.95     |
|Hy_F27*    | HYERES   | Anguilla anguilla | VTC         | 4.10               | 0.5                   | 122.0        | 0.44                 | 30.60             | 9.41                | 3.79 | −13.59   | 11.68    |
|Hy_F28*    | HYERES   | Anguilla anguilla | VTC         | 3.00               | <1                    | >10          | >10                  | >10               | >10                 | >10 | >10      | >10      |
|Hy_F29     | HYERES   | Anguilla anguilla | VTC         | 3.50               | 0.5                   | 142.9        | 0.30                 | 26.39             | 9.15                | 3.37 | −10.20   | 12.90    |
|Hy_F30*    | HYERES   | Anguilla anguilla | VTT         | 2.40               | 0.7                   | 291.7        | 0.15                 | 26.60             | 11.59               | 2.68 | −14.06   | 6.33     |
|Hy_F31*    | HYERES   | Anguilla anguilla | VTC         | 20.00              | <1                    | >10          | >10                  | >10               | >10                 | >10 | >10      | >10      |
|Hy_F32*    | HYERES   | Anguilla anguilla | VTC         | 7.00               | <1                    | >10          | >10                  | >10               | >10                 | >10 | >10      | >10      |
|Hy_F33*    | HYERES   | Anguilla anguilla | VTC         | 5.10               | 1.0                   | 196.1        | 0.14                 | 28.71             | 9.07                | 3.69 | −15.50   | 11.16    |
|Hy_F34*    | HYERES   | Anguilla anguilla | VTC         | 4.70               | 1.0                   | 212.8        | 0.18                 | 26.01             | 8.39                | 3.62 | −13.87   | 11.85    |
|Hy_F35*    | HYERES   | Anguilla anguilla | VTC         | 4.30               | 1.0                   | 232.6        | 0.15                 | 18.89             | 5.60                | 3.94 | −12.54   | 11.32    |
|Hy_F36*    | HYERES   | Mugilidae     | VTPC         | 4.30               | 0.9                   | 209.3        | 0.13                 | 25.43             | 7.58                | 3.91 | −14.04   | 7.03     |
|Hy_F37*    | HYERES   | Mugilidae     | VTPC         | 3.10               | 0.7                   | 225.8        | 0.16                 | 22.23             | 6.58                | 3.94 | −13.81   | 7.42     |
The quality of the extracted collagen was measured according to their collagen yield (higher than 10 mg/g [9]), their carbon and nitrogen contents (%C > 13% and %N > 5% [10]) and their atomic C:N ratio (between 2.9 and 3.6 [11]). All samples met the minimum thresholds for collagen yield but 4 did not yield enough material to allowed EA analysis. 9 samples had atomic C:N outside the accepted values and 5 more did not reach the minimum amount of carbon and nitrogen contents. In total 109 samples (86%) met the thresholds for collagen preservation. 50 of them (39%) have carbon and nitrogen contents in collagen higher than 30 and 11%, respectively and C:N ratio lower than 3.2, more restrictive criteria pointed out by van Klinken and Guiry & Szpak for very good collagen conservation [9,12]. There is no strong correlation between the isotopic signatures of the remaining 109 samples and their yield (Spearman tests, $S_{\delta^13C} = 262,024, p = 0.34 \rho -0.09$ for C; $S_{\delta^15N} = 210,146, p = 0.18 \rho 0.13$ for N), their atomic C:N ($S_{\delta^13C} = 310,344, p = 0.001 \rho -0.29$ for C; $S_{\delta^15N} = 264,148, p = 0.30 \rho -0.10$ for N), their carbon contents ($S_{\delta^13C} = 197,040, p = 0.06 \rho 0.18$ for C; $S_{\delta^15N} = 200,611, p = 0.08 \rho 0.17$ for N) and their nitrogen content ($S_{\delta^13C} = 199,024, p = 0.07 \rho 0.17$ for C; $S_{\delta^15N} = 194,772, p = 0.04 \rho 0.19$ for N).

A significant alteration of the isotopic information for the remaining samples can therefore be ruled out [11]. In total, 109 samples are then exploitable for isotopic interpretation. Isotopic data of those samples are summarized by site and taxa in Table 2. A scatterplot of $\delta^{13}C$ and $\delta^{15}N$ data according to site and taxa is presented in Fig. 2.

![Fig. 2. $\delta^{13}C$ and $\delta^{15}N$ values obtained from the fish remains analysed in this study. The data have been disaggregated according to species and site.](image-url)
Table 2
Summary of the isotopic data (carbon and nitrogen) of the fish samples analysed by taxa and site.

| Site                                           | Datation   | Taxon                  | n  | δ13C (‰)   | δ15N (‰)   |
|------------------------------------------------|------------|------------------------|----|------------|------------|
|                                                |            |                        |    | Min        | Max        | Mean±SD    | Min        | Max        | Mean±SD    |
| Fos-sur-Mer rue Frédéric Mistral               | 10–14th    | Anguilla anguilla      | 24 | −27.7      | −9.1       | −15.0 ± 6.7 | 9.1        | 17.3       | 12.8 ± 2.4 |
|                                                |            | Dicentrarchus labrax   | 24 | −13.4      | −8.7       | −10.6 ± 1.3 | 6.6        | 14.2       | 12.0 ± 1.7 |
|                                                |            | Diplodus sargus        | 7  | −9.4       | −6.4       | −7.4 ± 1.1  | 7.8        | 12.6       | 9.6 ± 1.5  |
|                                                |            | Mugilidae              | 19 | −22.5      | −5.9       | −10.9 ± 4.7 | 6.6        | 13.0       | 9.5 ± 2.0  |
|                                                |            | Sparus aurata          | 4  | −12.0      | −6.6       | −8.6 ± 2.4  | 8.8        | 14.5       | 10.8 ± 2.5 |
| Hyères le Château                              | 8–10th     | Anguilla anguilla      | 12 | −18.3      | −10.2      | −13.5 ± 2.6 | 8.0        | 14.2       | 12.1 ± 2.1 |
|                                                |            | Dicentrarchus labrax   | 5  | −15.1      | −12.7      | −13.3 ± 1.0 | 6.0        | 11.5       | 8.0 ± 2.1  |
|                                                |            | Mugilidae              | 9  | −14.6      | −11.1      | −12.7 ± 0.9 | 6.9        | 14.9       | 9.8 ± 2.9  |
| Aix-en-Provence Couvent des Dominicaines -     | 14th       | Anguilla anguilla      | 5  | −13.5      | −9.2       | −11.4 ± 1.8 | 10.6       | 16.1       | 12.5 ± 2.5 |
| Parking/Collège Mignet                         |            |                        |    |            |            |            |            |            |            |
2. Experimental Design, Materials and Methods

Prior to the extraction of collagen, the collected bone remains were subjected to a standard procedure: codified taxonomic nominations and standardised measurements were carried out with the help of the referential collections of the LA3M and CCJ osteological platforms [6–8,14–18]. Every vertebra sampled was then photographed using a 2D-3D digital microscope Hirox™.

Collagen extraction was performed at UMR 7269 LAMPEA (France), following a modified ABA method that acknowledges the fragility of the material [1]. Fish vertebrae were kept complete and first washed using successive bath of MilliQ water in an ultrasonic tank until the liquid remained clear. Samples were then demineralised at ca. 4 °C in 12 ml of either 0.1 M (samples weighing less than 100 mg) or 0.5 M HCl (samples weighing more than 100 mg) depending upon the weight of the sample. Solution was changed daily until bones were fully demineralised. Once demineralised, the samples were rinsed five times with MilliQ water. Demineralised bones were then placed in a 0.125 M NaOH solution at room temperature for successive 30 min sessions (until solution stopped changing colour). The samples were finally rinsed 5 times with MilliQ water and then gelatinised in a pH3 solution (10−3 M HCl) at 75°C for 48 h. The resultant soluble collagen was filtered with Ezee filters™, frozen, and subsequently freeze-dried.

After being weighed into tin capsules (between 0.13 and 1.1 mg), collagen samples were analysed by EA-IRMS on a Europa Scientific Elemental analyser coupled with a Europa Scientific 20-20 continuous flow isotope ratio Mass Spectrometer at Iso-Analytical Limited (United Kingdom). The analysis was conducted in a batch process by which a reference is analysed followed by several samples and then another reference. One in five samples were measured in duplicate when enough material was available to check analytical reliability.

The reference material used for δ13C and δ15N analysis was IA-R068 (soy protein, δ13C_{V-PDB} = −25.22 ‰, δ15N_{AIR} = +0.99 ‰), IA-R068, IA-R038 (L-alanine, δ13C_{V-PDB} = −24.99 ‰, δ15N_{AIR} = −0.65 ‰), IA-R069 (tuna protein, δ13C_{V-PDB} = −18.88 ‰, δ15N_{AIR} = +11.60 ‰) and a mixture of IAEA-C7 (oxalic acid, δ13C_{V-PDB} = +14.48 ‰) and IA-R046 (ammonium sulphate, δ15N_{AIR} = +22.04 ‰) were run as quality control check samples during analysis. IA-R068, IA-R038 and IA-R069 are calibrated against and traceable to IAEA-CH-6 (sucrose, δ13C_{V-PDB} = −10.449 ‰) and IAEA-N-1 (ammonium sulphate, δ15N_{AIR} = +0.40 ‰). IA-R046 is calibrated against and traceable to IAEA-N-1. IAEA-C7, IAEA-CH-6 and IAEA-N-1 are inter-laboratory comparison standards distributed by the International Atomic Energy Agency, Vienna (Austria).

Following recommendations by Szpak et al [13], based on repeated measurements of calibration standards, check standards, and sample replicates, precision was determined to be ± 0.07 ‰, ± 0.06 ‰, and ± 0.06 ‰ for δ13C and δ15N, respectively. Based on the difference between the observed and known δ values of the check standards and the long-term standard deviations of these check standards, accuracy or systematic error was determined to be ± 0.17 and ± 0.12 for δ13C and δ15N, respectively. The total analytical uncertainties were estimated to be ± 0.17 for δ13C, ± 0.13 for δ15N.

Ethics Statement

Not applicable.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that have or could be perceived to have influenced the data reported in this article.
CRediT Author Statement

Leïa Mion: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing; Tatiana André: Conceptualization, Data curation, Investigation, Writing – review & editing; Anne Mailloux: Conceptualization, Funding acquisition, Supervision, Writing – review & editing; Myriam Sternberg: Conceptualization, Funding acquisition, Supervision, Writing – review & editing; Arturo Morales Muniz: Conceptualization, Writing – review & editing; Eufrasia Rosello-Izquierdo: Conceptualization, Writing – review & editing; Laura Llorente Rodriguez: Writing – review & editing; Estelle Herrscher: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

Acknowledgments

The project leading to this publication has received funding from Excellence Initiative of Aix-Marseille University – A*MIDEX, a French "Investissements d’Avenir" programme - Institute for Mediterranean Archaeology ARKAIA (AMX-19-IET-003-projet AMORCE 2020 Icht’IsoMed2). Ongoing research of A. Morales Muniz, E. Rosello-Izquierdo, L. Llorente Rodriguez, L. Mion and T. André is now being sponsored by Grant number: PID2020–118662GB–100 of the Spanish Ministry of Science and Innovation. We thank D. Ollivier, N. Nin, L. Nanthavongdouangsy, J.P. Lagrue and F. Marty for access to the archaeological collections. S. Chevallier and M. Farese for their help concerning the photographic record and collagen extraction. Finally, we thank the three anonymous reviewers for their suggestions and corrections.

References

[1] S. Cersoy, A. Zazzo, M. Lebon, J. Refos, S. Zirah, Collagen extraction and stable isotope analysis of small vertebrate bones: a comparative approach, Radiocarbon 59 (2017) 679–694, doi:10.1017/RDC.2016.82.
[2] K. Salesse, R. Fernandes, X. de Rochefort, J. Brüzek, D. Castex, É. Dufour, IsoArchEu: an open-access and collaborative isotope database for bioarchaeological samples from the Graeco-Roman world and its margins, J. Archaeol. Sci. Rep. 19 (2019) 1050–1055, doi: 10.1016/j.jasrep.2017.07.030.
[3] D. Ollivier, T. André, C. Denizeau, C. Cenzo-Salvaivre. Le château d’Hyères, Hyères (83). Rapport Final d’Opération, LA3M UMR 7298 AMU-CNRS. 2020, pp. 210
[4] J.-P. Lagrue, M. Del Corso, Fos-sur-Mer, rue Frédéric Mistral, Document final de synthèse, Service Régional d’Archéologie de Provence-Alpes-Côte d’Azur, 1999, pp. 70.
[5] S. Bonnet, S. Claude, M. El Amouri, C. Méla, N. Nin, D. Pesesse, N. Portalier, A. Ratsimba. Aix-en-Provence – Collège Mignet Extension du parc de stationnement. Rapport Final d’Opération, Direction Générale des Services Techniques de la Ville d’Aix-en-Provence. 2009, pp. 181.
[6] A. Morales-Muñiz, K. Rosenlund, in: Fish Bone Measurements. An Attempt to Standardize the Measurement of Fish Bones from Archaeological Sites, Stenstrupsia, 1979, pp. 1–48. Spec. Issue.
[7] Els Thieren, Wim Wouters, Wim Van Neer, Anton Ervynck, Body length estimation of the European eel Anguilla anguilla on the basis of isolated skeletal elements, Cybium Int. J. Ichthyl. 36 (2012) 551–562.
[8] D. Patón, E. Roselló, A computerized procedure for the classification of Mugil remains from archaeological sites, Ofa 51 (1994) 394–400.
[9] G.J. van Klinken, Bone collagen quality indicators for palaeodietary and radiocarbon measurements, J. Archaeol. Sci. 26 (1999) 687–695, doi: 10.1006/jasc.1998.0385.
[10] S.H. Ambrose, Preparation and characterization of bone and tooth collagen for isotopic analysis, J. Archaeol. Sci. 17 (1990) 431–451, doi:10.1016/0305-4403(90)90007-R.
[11] M.J. DeNiro, Postmortem preservation and alteration of in vivo bone collagen isotope ratios in relation to palaeodietary reconstruction, Nature 317 (1985) 806–809, doi:10.1038/317806a0.
[12] E.J. Guiry, P. Szpak, Improved quality control criteria for stable carbon and nitrogen isotope measurements of ancient bone collagen, J. Archaeol. Sci. 132 (2021) 105416, doi:10.1016/j.jas.2021.105416.
[13] P. Brufau, R.P. Macdonald, Best practices for calibrating and reporting stable isotope measurements in archaeology, J. Archaeol. Sci. Rep. 13 (2017) 609–616, doi: 10.1016/j.jasrep.2017.05.007.
[14] M. Courtemanche, V. Legendre, in: Os de poissons: Nomenclature codifiée, noms français et anglais, Rapport technique 06-38., Gouvernement du Québec, Ministère du Loisir, de la Chasse, et de la Pêche, Montréal, 1985, p. 61.
[15] J. Desse, N. Desse Berset, M. Rochetteau, Contribution à l’ostéométrie du mulet Liza (Liza) ramada Risso, 1826 (=Mugil capito Cuvier, 1829), Fiches d’ostéologie animale pour l’archéologie. Série A - Poissons 2 (1987) 3–25.
[16] R. Libois, C. Hallet Libois, R. Rosoux, Éléments pour l’identification des restes crânien s des poissons dulçaquicoles de Belgique et du Nord de la France. 1. Anguilliformes, Gasterosteiformes, Cyprinodontiformes et Perciformes, Fiches d’ostéologie animale pour l’archéologie. Série A - Poissons 3 (1987) 2–15.
[17] M. Sternberg, Ostéologie du loup. *Dicentrarchus labrax* (Linnaeus, 1758) = *Labrax lupus* (Cuvier, 1828), Fiches d’ostéologie animale pour l’archéologie. Série A - Poissons 7 (1992) 3–25.

[18] J. Desse, N. Desse Berset, Ostéométrie et archéologie de la daurade royale (*Sparus aurata*, Linné 1758), Fiches d’ostéologie animale pour l’archéologie. Série A - Poissons 9 (1996) 3–31.