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*Même mer, captures différentes. Exploration des variations écologiques versus choix humains en Méditerranée préhistorique : le cas de la mer Égée*

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# SAME SEA, DIFFERENT CATCHES. EXPLORING ECOLOGICAL VARIATIONS VS. HUMAN CHOICES IN PREHISTORIC MEDITERRANEAN: THE AEGEAN CASE.

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Archeo-ichthyological and archaeo-malacological studies have increased in the last decades in the Mediterranean and cover almost all periods of Prehistory and Antiquity. Among other regions, the Aegean Sea offers a particularly diversified spatio-temporal panorama of the early Mediterranean History, which highlights the diversity of responses *vis-à-vis* the marine environment, omnipresent in the Aegean landscape. The rich dataset from this region has allowed addressing a number of themes touching upon all aspects of livelihood by the sea. However, what has been addressed to a lesser extent is the role of diachronic variations of Aegean prehistoric fish landings, namely in the turn from Mesolithic to Neolithic and to Bronze Age communities, and the potential impact of ecological fluctuations vs. that of human choices on fish catches. This paper briefly explores this specific research question by applying on a selection of Aegean prehistoric assemblages a methodological approach not commonly used in archeo-ichthyological research, namely a fundamental ecological model that seeks to assess how environmental and/or anthropogenic pressures impact the functioning of marine food webs and how societies adapt to these changes. This approach lies in the center of a newly launched ERC-CoG research program (MERMAID), that will improve and expand this exploratory application. Preliminary results show the potential of applying research questions and methodological tools from other disciplines in order to highlight tendencies and offer alternative interpretations that may add to the observations offered by standard approaches used in zooarchaeological research.

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**Même mer, captures différentes. Exploration des variations écologiques versus choix humains en Méditerranée préhistorique : le cas de la mer Égée**

Ces dernières années ont vu la multiplication des études archéo-ichtyologiques et archéo-malacologiques en Méditerranée, et ceci pour toutes les périodes de la Préhistoire et de l'Antiquité. Parmi les régions méditerranéennes, la mer Égée offre un panorama spatio-temporel particulièrement diversifié de l'histoire méditerranéenne des réponses adaptatives des humains vis-à-vis de l'environnement marin, omniprésent dans le paysage égéen. Ce riche jeu de données permet d'aborder une multitude de thèmes touchant aux relations entre les populations côtières et la mer. Parmi eux, les fluctuations dans les captures de pêche à travers les grandes périodes de la Préhistoire égéenne, notamment du Mésolithique au Néolithique et du Néolithique à l'âge du Bronze, ainsi que l'appréciation de l'impact écologique des choix humains sur les écosystèmes marins, restent moins explorées. Cet article présente une brève étude qui se propose d'appliquer à une sélection d'assemblages archéo-ichtyologiques égéens une approche méthodologique encore peu utilisée en archéo-ichtyologie, à savoir un modèle écologique qui essaie d'expliquer comment les pressions environnementales et anthropiques peuvent impacter le fonctionnement des réseaux trophiques marins et comment les sociétés humaines s'adaptent à ces changements. Cette approche est à la base d'un nouveau programme ERC-CoG (MERMAID), qui va explorer davantage ces questions et améliorer l'approche méthodologique. Les résultats préliminaires montrent le potentiel d'appliquer des questionnements et des outils méthodologiques issus d'autres disciplines dans le but de faire ressortir des tendances et offrir des interprétations alternatives qui s'ajoutent aux observations offertes par des approches plus couramment utilisées en archéozoologie.

**MOTS-CLÉS** Méditerranée, mer Égée, Mésolithique, Néolithique, Âge du Bronze, restes de poissons, pêcheries, niveaux trophiques, surpêche.

## INTRODUCTION

Aegean Prehistory affords us perhaps one of the richest records to understand the structure, operation, and evolution of the human-sea relationship in Mediterranean Prehistory. A growing and diversified faunal dataset from this region, covering several categories of remains from marine organisms, namely fish, molluscs, crustaceans, corals, occasionally also remains of other invertebrates (octopuses or cuttlefish), allows to address a number of themes touching upon all aspects of livelihood by the sea: exploited fishing grounds, year-round exploitation of marine resources, fishing methods and tackle, marine foodstuffs in the prehistoric diet and cuisine, trade of marine products, the role of marine animals in ritual, status, beliefs, and artistic expression. However, what has been addressed to a lesser extent is the role of diachronic variations of Aegean prehistoric fish landings, namely in the turn from Mesolithic to Neolithic and to Bronze Age communities, and the potential impact of ecological fluctuations vs. that of human choices on fish catches. In this paper, I briefly explore this specific research question by applying on the remains of fish from Aegean prehistoric sites a fundamental ecological model that seeks to assess how environmental and/or anthropogenic pressures impact the functioning of food webs and how societies adapt to these changes. This approach lies in the center of a newly launched ERC-CoG research program (MERMAID), that further expands this preliminary approach and which will also be briefly presented here.

## THE MEDITERRANEAN PREHISTORIC FISH RECORD. NEW QUESTIONS

Studies of fishing activities in the ancient Mediterranean have long time remained descriptive and often reproduced rather generalist visions of marine ecosystems and human-sea relations. If for other oceans it was generally admitted that they offer inexhaustible resources, the Mediterranean has often been considered as a rather poor sea in terms of biomass contribution of fisheries, albeit with a great diversity of marine species (e.g. Bianchi, Morri 2000; Coll *et al.* 2012; on historical views on the historical Mediterranean richness, e.g. Braudel 1966; on the ancient Aegean, Gallant 1985). Zooarchaeological research as well as other lines of evidence, such as work on ancient Mediterranean diets through isotope analysis of human bones, suggest a rather minor role of marine resources in most periods and areas studied (e.g. on W. Mediterranean Prehistory, Salazar-García *et al.* 2018; on a synthesis of studies for the Aegean and methodological constraints, Vika, Theodoropoulou 2012). The latter is also suggested for periods in Prehistory, such as the Mesolithic, which have nevertheless been characterized more "marine-oriented" in the Atlantic counterparts of Europe (e.g. Dupont *et al.* 2009). Although the Mediterranean prehistoric record offers examples of marine exploitation, the significance of the latter with respect to other subsistence activities as well as relative importance compared to other periods is not well understood.

Indeed, the importance of fishing/collecting activities in earlier periods of human history is now considered greater than previously believed (e.g. Rick, Erlandson 2008, 2009; Saporiti *et al.* 2014; Schwerdtner Mânez, Poulsen 2015; Orton 2016). As demonstrated in other parts of the world, the earlier belief that the ecological impact of pre-industrial societies on nature was negligible, based on the assumption that « the ancient peoples were not sophisticated or numerous enough to significantly modify their marine environment, (...) largely inaccessible » (Erlandson, Rick 2010), has given way to the observation that the populations of the past not only were the witnesses of environmental changes, to which they adapted in a variable manner, but that they were also active agents of exploitation and transformation of marine resources. Thus, a multi-factorial reassessment of the precise conditions and impacts of fishing/collecting activities in earlier periods of the human history is needed.

The above questioning is one of the research questions included in the ERC-CoG program MERMAID<sup>1</sup>. The latter will explore available zooarchaeological records from this region, what could be described as “archaeo-fisheries” archives, in order to follow variations through time and space. The project proposes to understand: a) how marine resources have been influenced by environmental/human pressures, b) when human impact can first be identified, and c) the ways ancient societies depended on these resources and adapted their exploitation strategies. With respect to the earlier periods in the Mediterranean, the project aspires to gain an insight into pristine conditions of marine ecosystems and study the environmental pressures but also potential first impacts of human activities on natural stocks, by exploring the idea of *shifting baselines*, i.e., the shift of marine ecosystem states through time as reflected in the fish catches of different periods.

In this paper we present a preliminary study that lied in the building of this project, which served to identify potential and constraints of the approach and better define our methodology for the program at the time of submission. It was applied on a restricted case study, the prehistoric fish record from the Aegean. Among other regions in the Mediterranean, the Aegean Sea offers a particularly diversified spatiotemporal panorama of early Mediterranean history that highlights the diversity of responses *vis-à-vis* the marine environment. Among other approaches, regarded as more traditional in the zooarchaeological discipline, it was decided to exploit available data from this region by applying an “external” conceptual approach and methodology, namely borrowed by the fisheries science.

As demonstrated by marine ecologists, the fishing pressure exerted by human activities differs radically from natural predation, due to the combination of direct and indirect effects (synthesised in Pauly *et al.* 1998). Overfishing is a form of overexploitation in which fish

stocks are depleted to critical levels for the sustainability of both fisheries and the ecosystem structure, regardless of water body size. The direct fishing effect of reducing the abundance of marine populations is often enough for them to collapse. Overexploited areas also exhibit strong reductions of mean size in the species landed, reflecting similar reductions of size in the ecosystems. Overfishing has not only proved disastrous to fish stocks in areas where it has occurred but also to the fishing communities relying on the harvest (overview for the Mediterranean in Coll *et al.* 2012). An indirect result of overfishing is what has been explicitly entitled “fishing down the food web” by Pauly *et al.* (1998). This is the process whereby fisheries in a given ecosystem, “having depleted the large predatory fish on top of the food web, turn to increasingly smaller species, finally ending up with previously spurned small fish and invertebrates” (Pauly *et al.* 1998). The exploration of this anthropological observation in archaeology might help us gain a better understanding of fish assemblages.

Although overfishing is not acknowledged as a large-scale phenomenon in Prehistory, the hypothesis of over-exploitation of specific resources in specific time periods has been advanced (various case studies in Rick, Erlandson 2008). The working hypothesis for prehistoric fishing pressure was that its effect on ecosystems, being highly localized, would probably resemble the effect of natural predation. Pauly’s model has been tested on several archaeological fish assemblages with promising results (one of the pioneer applications in Reitz 2004; among an increasing bibliography, see for instance for the Mediterranean Prehistory Morales-Muñiz, Roselló-Izquierdo 2004, 2008), despite several drawbacks in the application of the method in archaeofaunas, which will be discussed in the present paper.

In the following, we offer an insight into the catch composition and mean trophic level of Aegean prehistoric fisheries. We also explore issues of size exploitation compared to modern values, with the aim of highlighting potential shifts in prehistoric fish catches that might be further explored within the new research program described above.

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## THE AEGEAN CASE. MATERIAL AND METHODS

For the purposes of this paper, data available from published prehistoric sites from the Aegean have been selected on the basis of their chronological coverage, ranging from the Mesolithic to the Bronze Age<sup>2</sup>, in order to follow potential diachronic divergences throughout Prehistory in the species presence and their relative frequencies, as well as overall trophic identity of catches. Seven sites cover a total time span of c. nine millennia, namely the Mesolithic/Neolithic site of Cyclops on Youra (Sporades), the Neolithic site of Limenaria (Thasos), the Bronze Age sites of Archontiko, Toumba Thessaloniki (Central Macedonia), Mikro Vouni (Samothraki), Koukonisi (Lemnos) and Troy (Aegean Minor Asia) (**fig. 1**)<sup>3</sup>. However,

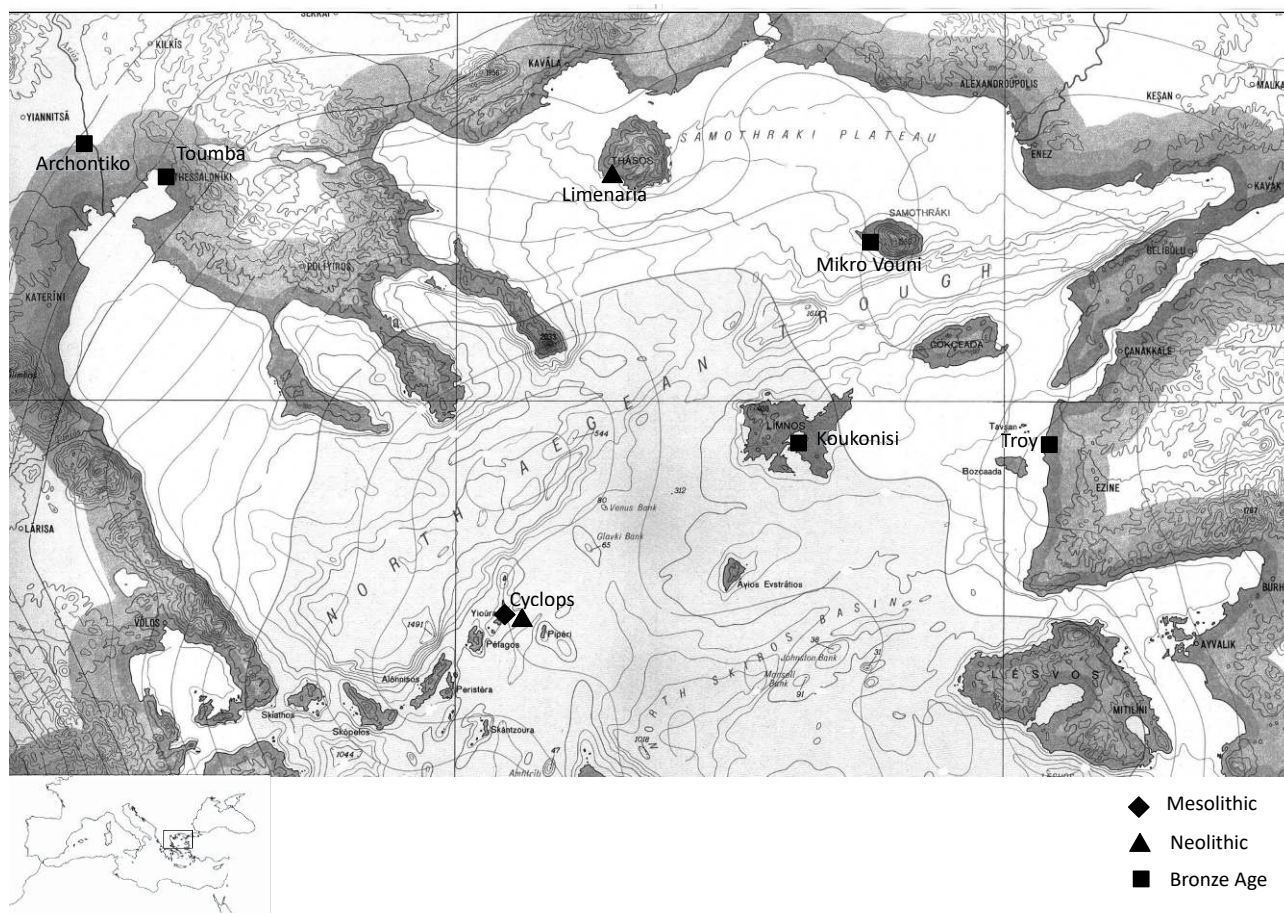
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[1] MERMAID - Marine Ecosystems, Animal Resources and Human Strategies in Ancient Mediterranean: Integrated Studies on Natural and Societal Resilience (CNRS, France, 2021-2026). The project has received funding from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation program (Grant Agreement n°. 01002721).

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[2] It should be noted that sites antedating the Mesolithic are rare in the Aegean, especially the Northern Aegean region, which has been selected for this study.

[3] The Aegean Mesolithic broadly spans between 10,000-6500 BC, the Neolithic between 6500-3200 BC, and the Bronze Age between 3200-1100 BC.



— FIGURE 1 —

Bathymetric map of Northern Aegean with prehistoric sites selected for this study.

Carte bathymétrique de l'Égée du Nord avec les sites préhistoriques sélectionnés pour cette étude.

only some of these sites offer a large intra-site chronological sequence or statistically reliable samples from all strata. It is thus difficult to compare data for a same site through distinct chronological phases (see exceptions in the results).

The selected dataset was deliberately chosen from a relatively limited marine zone, namely the North Aegean basin, coherent in hydrological and ecological terms, as biogeographical conditions in the northern parts of the Aegean Sea are distinct from those in the southern parts (the distinction between the two basins being south of the Pagasetic Gulf, between Euboea and the island of Psara, Papaconstantinou 1988 p. 14; Papageorgiou 1997 p. 424-442; Legakis, Sfendourakis 1999; Coll *et al.* 2010). The archaeological hazard of finds does not make it possible to work on a more restricted sub-area, e.g. one gulf or one island, which would allow to follow both faunistic and environmental changes at a more refined biogeographical level.

Finally, the sites were selected on the basis that they offer a reliable faunal record thanks to systematic excavations and detailed sampling protocols –i.e., water-sieving–, that minimises the problem of the loss of smaller taxa or small

and more fragile anatomical parts<sup>4</sup>. The latter is particularly significant with respect to zooarchaeological methods that try to investigate animal resource management and potential pressure of natural populations, as they rely on a highly vulnerable archaeological record, highly subjected to preservation and recovery biases which may distort the sample upon which estimations are made. Among known assemblages, only those that were quantitatively significant for statistical analysis were used in the study.

In order to investigate potential pressures or even shifts at a long timescale in Aegean Prehistory, a method similar to the one proposed by Pauly *et al.* (1998) was adopted. Pauly *et al.* (1998) have introduced a method for documenting secular changes in world fisheries, based on the trophic level (TL) values of marine organisms (on the concept, Lindeman 1942). The mean TL is calculated by assigning each fish or invertebrate species a number based on its trophic level. The TL is a measure of the position of an organism in a food web, starting at level 1

[4] Within this short study only the remains of cartilaginous and bony fishes have been taken into account. Harvesting of shells was an important part of coastal exploitation in the prehistoric Aegean (for an overview, Theodoropoulou 2008). Shell-harvesting on the shore has its own socio-economic implications, but also different ecological impact.

with primary producers, such as phytoplankton and seaweed, then moving through the primary consumers at level 2 that eat the primary producers, to the secondary consumers at level 3 that eat the primary consumers, and so on. The fishing pressure exerted by modern industrial fleets differs radically from natural predation, due to the combination of direct and indirect effects. According to the model, any mean TL change in a fishery of an order of magnitude of 0,1 or larger is significant and often accompanied by rearrangements of the taxa (elements) constituting the cropped ecosystem. Under « pristine » conditions (the state of the ecosystem before fishing made strong impact), reflected in the mean TL value of a fishery when first cropped, the model sets values of around 3 that climb to 3,4 or 3,5 during the peak of the fishing activity but eventually settles down to values of 2,9 or less as the highest TL value species become depleted and overfishing sets on the whole fishery. One of the ways to calculate the mean TL in modern fisheries is by averaging trophic levels for the overall catch using the datasets for commercial fish landings. It is recommended that these estimations are combined with survey-based and model-based indicators, as they reflect more globally both the human and environmental impact on the entire marine ecosystem (e.g. Branch *et al.* 2010; Shannon *et al.* 2014).

As stated above, the archaeofaunal material represents ancient fish landings. Thus, it does not directly provide data on general ecosystem composition, as it is biased by human selection. A method to remedy for this partial image is proposed by the MERMAID ERC program and is presented at the end of the paper, but was not applied on this previously conducted pilot study. The mean TL estimated for each studied period of the Aegean Prehistory was based on the represented identified fish taxa from each archaeological sequence. For each one, its TL value was attributed using data from the Fishbase database (Froese, Pauly 2022). Then, a formula proposed by Reitz (2004), adapted to zooarchaeological remains, was used ( $TL_i = \sum (TL_{ij})(NISP_{ij}) / \sum NISP_{ij}$ , where  $i$ =specific time period,  $j$ =each taxon, NISP=Number of Identifiable Specimens<sup>5</sup>) in order to estimate the mean TL for each spatiotemporal group considered in this paper. The derived values were then compared with values from modern Aegean fisheries.

Before presenting the results of these estimations, a general evaluation of the prehistoric fish landings is useful.

## DIACHRONIC VARIATIONS OF AEGEAN PREHISTORIC CATCHES. SOME RESULTS

The fish assemblages produced in the selected sites offer a more or less rich spectrum, varying from 6 to 49 species depending on the site and/or locality<sup>6</sup>.

[5] NISP counts were used for this paper, as they represent an absolute calibration and are used in most archaeoichthyological studies.

[6] In the following, we did not take into account sites from this region/periods that yielded less than 30 NISP. However, these are briefly presented in footnotes. It is interesting to observe that most of the spectra present the same taxa as those in sites that yielded more voluminous assemblages.

Although data for the Mesolithic remain scarce to this day in the area, the single site dated to this period from the studied area, the Cyclops cave, produced a voluminous sample (Mylona 2011; Powell 2011) (fig. 2, tabl. 1). The Mesolithic layers of the site produced at least 31 taxa<sup>7</sup>, mostly sea breams (Sparidae), scorpionfish (Scorpaenidae), various scombrids (Scombridae), groupers (Serranidae), morays (Muraenidae) and seabasses (*Dicentrarchus labrax*). The Lower Mesolithic is dominated by scorpionfish accounting for 25% of NISP, followed by breams and groupers. On the contrary, sea breams, especially the saddled bream and the two-banded sea-bream become dominant (29% and 12% of NISP respectively) during the Upper Mesolithic, which is the best represented phase (at least 1290 NISP of remains identified to genus/species level).

The Neolithic period in the Northern Aegean is represented in this study by the Early Neolithic layers of Cyclops, and by the insular Limenaria for the Middle-Late Neolithic period (fig. 2, tabl. 2). The Early Neolithic layers of Cyclops were quite rich (fig. 2, tabl. 2a)<sup>8</sup>. They produced more than 50% of sea breams (Sparidae), as well as scorpion fish (Scorpaenidae, 9 %) and groupers (Serranidae). The late Middle-Late Neolithic layers of the site of Limenaria (fig. 2, tabl. 2b) on the island of Thasos contained a restricted variety of fish families, largely dominated by scombrids (Scombridae, 65% of NISP), followed by grey mullets (Mugilidae, 16%), and small numbers of sea breams (Sparidae), eels (Anguillidae), meagres (Sciaenidae) and stargazers (Uranoscopidae) (Theodoropoulou 2007, v.2 - p. 293-327)<sup>9</sup>. Despite the insular location of the site and sieving during excavation, the later layers (Early Bronze Age) did not produce any fish remains.

More robust data are available for the Bronze Age (fig. 2, tabl. 3). The Early Bronze Age is represented in this study by layers I-III in Troy (fig. 2, tabl. 3a)<sup>10</sup>. They produced a quite rich and diversified assemblage (240 NISP), including mostly sea breams (Sparidae) and bluefish (*Pomatomus saltatrix*), as well as mullets (Mugilidae) and tunas (*Thunnus thynnus*), followed by minor other species, namely angel sharks (Squatinae), meagres (Sciaenidae), gurnards (Carangidae), amberjacks (*Seriola dumerili*), little tunnies (*Euthynnus alletteratus*), seabasses (*Dicentrarchus labrax*) (Uerpmann, Van Neer 2000). The end of Early-beginning of Middle Bronze Age layers from Archontiko in

[7] Most vertebral remains were identified to family level (Mylona 2011), more precise identifications were possible for cranial elements (Powell 2011).

[8] The Early Neolithic site of Ayios Petros in the Sporades yielded a restricted fish assemblage (eight NISP), including groupers, amberjacks and mackerels, for which no detailed NISP is given, though (Schwarz 1985). Other Early Neolithic sites from the North Aegean mostly exploited freshwater fish, thus they are not taken into account in this paper (Theodoropoulou 2007, v. 1 - p. 205-213).

[9] For this period, the site of Ayios Petros yielded six fish bones from the Middle-Late Neolithic layers, belonging to the same species reported for the previous period (see above), again without specific NISP/species. Thus, those data could not be exploited. The late Middle-Late Neolithic coastal site of Makri (Alexandroupoli, Western Thrace) yielded a restricted fish assemblage (42 NISP) of which only 11 bones were identified, and include five sea breams of which one *Sparus aurata*, three meagres (Sciaenidae) of which one *Sciaena umbra* and one dogfish (*Squalus acanthias*) (Curci, Tagliacozzo 2003).

[10] 31 more fish bones were retrieved from the Early Bronze layers of Archontiko, mostly freshwater fish (Theodoropoulou 2007, v. 1 - p. 239). Six *Sparus aurata*, five *Dicentrarchus labrax* and one *Mugil capito* were also identified, but they are not included in this paper due to the statistically not reliable sample. For the same period, the site of Toumba Thessaloniki also yielded a limited fish sample (11 NISP), of which only three could be identified (Theodoropoulou 2007, v. 1 - p. 239).

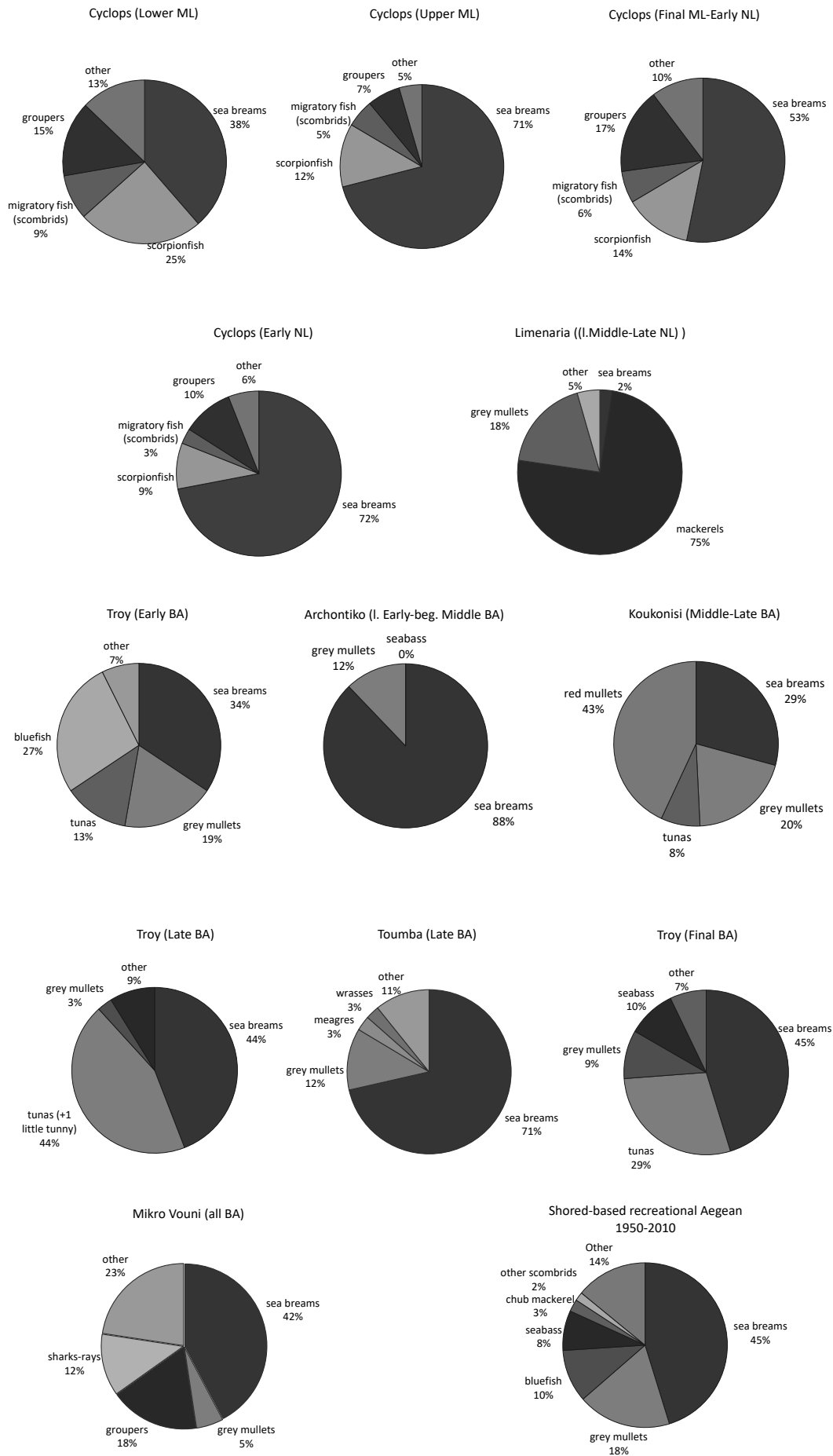


FIGURE 2

Relative frequencies of main fish groups by site and period, and relative frequencies of main fish groups in modern shore-based recreational Aegean fisheries (from Moutopoulos *et al.* 2013, **tabl. 1**).

*Fréquences relatives des principaux groupes de poissons par site et par période, et fréquences relatives des principaux groupes de poissons dans les pêches récréatives modernes à terre dans la mer Égée. (d'après Moutopoulos *et al.* 2013, **tabl. 1**).*



Common name	Scientific name	Lower Mesolithic	Upper Mesolithic	Final Mesolithic- Early Neolithic
moray	<i>Muraena helena</i>	2	10	1
hake	<i>Merluccius merluccius</i>	1	2	1
john dory	<i>Zeus faber</i>	4	18	1
white grouper	<i>Epinephelus aeneus</i>	1	10	2
golden grouper	<i>Epinephelus alexandrinus</i>	1	6	1
grouper	<i>Epinephelus</i> sp.	33	62	20
conger	<i>Serranus cabrilla</i>	1	5	2
sea bass	<i>Dicentrarchus labrax</i>	3	7	3
bluefish	<i>Pomatomus saltatrix</i>	4	9	1
red mullet	<i>Mullus</i> sp.		3	
bogue	<i>Boops boops</i>		5	2
dentex	<i>Dentex dentex</i>	5	18	14
dentex	<i>Dentex macrophthalmus</i>	2	64	22
dentex	<i>Dentex maroccanus</i>	1	11	3
dentex	<i>Dentex</i> sp.	3	17	
two banded sea-bream	<i>Diplodus vulgaris</i>	14	149	16
saddled bream	<i>Oblada melanura</i>	9	380	6
axillary sea-bream	<i>Pagellus acarne</i>	4	60	2
common pandora	<i>Pagellus erythrinus</i>	4	35	5
pandora	<i>Pagellus</i> sp.	1	10	1
blue spotted bream	<i>Pagrus caerulostictus</i>	34	61	10
salema	<i>Sarpa salpa</i>	2	25	1
gilt-head sea-bream	<i>Sparus aurata</i>	8	33	2
black sea-bream	<i>Spondyliosoma cantharus</i>	3	13	
wrasse	<i>Labrus</i> sp.	7	17	7
weever	<i>Trachinus</i> sp.	5	13	1
bullet tuna	<i>Auxis rochei</i>	6	18	4
atlantic bonito	<i>Sarda sarda</i>	7	7	2
chub mackerel	<i>Scomber japonicus</i>	7	43	4
albacore	<i>Thunnus</i> sp.		3	
grey mullet	<i>Liza aurata</i>	1	4	3
scorpion fish	<i>Scorpaena scrofa</i>	57	161	21
angler fish	<i>Lophius piscatorius</i>	2	3	
picarel	<i>Maena smarlis</i>		8	
Total NISP marine Cyclops		232	1290	158

— TABLE 1 —

List of taxa/families in the Mesolithic site of Cyclops.

Liste des taxons/familles dans le site mésolithique de Cyclops.

Central Macedonia<sup>[11]</sup> produced a mixed spectrum of marine and freshwater fish species (Theodoropoulou 2007, v. 2 - p. 91-135) (fig. 2, tabl. 3b). Among the marine/euryhaline taxa, sea breams (Sparidae, mostly *Sparus aurata*) and grey mullets (Mugilidae) are dominant (more than 10% and 6,5% of NISP respectively), followed by seabasses (*Dicentrarchus labrax*). The insular Middle-Late Bronze Age layers of Koukonisi on the island of Lemnos (fig. 2, tabl. 3c) produced a limited size of fish remains, mostly constituted of various

grey mullets (Mugilidae) and sea breams (Sparidae), occasionally also little tunnies (*Euthynnus alletteratus*) (Theodoropoulou 2007, v. 2 - p. 239-266)<sup>[12]</sup>. For Late Bronze Age<sup>[13]</sup>, the layers of Toumba Thessaloniki produced a great

[12] The Middle Bronze Age layers from Troy (IV-V) yielded a small fish assemblage (eight bones) due to the specific context of discovery but also sampling methods, of which five Mugilidae, one *Sparus aurata*, one *Sparisoma cretense* and one Chondrichthyes (Uerpman, Van Neer 2000). They cannot be statistically compared with earlier and later phases within the site.

[13] For the Late Bronze Age, Archontiko yielded again a small fish marine record of 12 marine NISP (Theodoropoulou 2007, v. 1 - p. 257). The same is valid for Troy, with eight NISP (Uerpman et al. 1992). Neither of the two is considered in this study.

[11] The site was situated closer to the shore at the time of its occupation.

a.

Common name	Scientific name	Early Neolithic
morray	<i>Muraena helena</i>	17
hake	<i>Merluccius merluccius</i>	5
white grouper	<i>Epinephelus aeneus</i>	4
golden grouper	<i>Epinephelus alexandrinus</i>	7
grouper	<i>Epinephelus</i> sp.	71
conger	<i>Serranus cabrilla</i>	6
sea bass	<i>Dicentrarchus labrax</i>	2
bluefish	<i>Pomatomus saltatrix</i>	2
dentex	<i>Dentex dentex</i>	1
dentex	<i>Dentex macrophthalmus</i>	27
dentex	<i>Dentex maroccanus</i>	1
two banded sea-bream	<i>Diplodus vulgaris</i>	231
striped sea-bream	<i>Lithognathus mormyrus</i>	1
saddled bream	<i>Oblada melanura</i>	195
axilliary sea-bream	<i>Pagellus acarne</i>	94
common pandora	<i>Pagellus erythrinus</i>	29
blue spotted bream	<i>Pagrus caerulostictus</i>	27
salema	<i>Sarpa salpa</i>	36
gilt-head sea-bream	<i>Sparus aurata</i>	8
black sea-bream	<i>Spondyliosoma cantharus</i>	21
wrasse	<i>Labrus</i> sp.	17
bullet tuna	<i>Auxis rochei</i>	5
atlantic bonito	<i>Sarda sarda</i>	11
chub mackerel	<i>Scomber japonicus</i>	5
grey mullet	<i>Liza aurata</i>	3
scorpion fish	<i>Scorpaena scrofa</i>	83
Total NISP marine Cyclops		909

b.

Common name	Scientific name	late Middle-Late Neolithic
horse mackerel	<i>Scomber japonicus</i>	180
grey mullet	<i>Mugil</i> sp.	45
eel	<i>Anguilla anguilla</i>	6
little tunny	<i>Euthynnus alletteratus</i>	5
meagre	<i>Argyrosomus regius</i>	4
gilthead seabream	<i>Sparus aurata</i>	3
common seabream	<i>Pagrus</i> sp.	2
stargazer	<i>Uranoscopus scaber</i>	1
sea breams	Sparidae	1
Total NISP marine Limenaria		247

TABLE 2

List of taxa/families in the Neolithic sites: (a) Early Neolithic of Cyclops, (b) late Middle-Late Neolithic of Limenaria.

Liste des taxons/familles dans les sites néolithiques : (a) Néolithique précoce de Cyclops, (b) Néolithique moyen-tardif de Limenaria.

variety of marine fish (fig. 2, tabl. 3d), mostly sparids (Sparidae, more than 30% of NISP of which mostly *Sparus aurata* with 14,5%) and grey mullets (Mugilidae, c. 6% NISP), followed by seabasses (*Dicentrarchus labrax*), meagres (Sciaenidae), red mullets (Mullidae), wrasses (Labridae), garfish (Belonidae), gadids (Gadidae), groupers (Serranidae), gurnards (*Trigla* sp.), pompano fish (*Trachinotus* sp.), sharks (*Squatina squatina*, *Galeorhinus* sp.), plaice (*Pleuronectes platessa*), scorpionfish (*Scorpaena scrofa*), barracuda (*Sphyraena barracuda*), whiting (*Merlangius merlangius*), and

pickarels (Centracanthidae) (Theodoropoulou 2007, v. 2 - p. 407-445). The Late and Final Bronze Age is also represented in Troy (VI-VII) (fig. 2, tabl. 3e) by small quantities of fish bones (35 and 49 respectively), both dominated by *Sparus aurata* (32% and 28% of NISP) and *Thunnus thynnus* (34% and 24% of NISP). A notable increase in the diversity of species is observed in the Final Bronze Age (fig. 2, tabl. 3f), namely with grey mullets (Mugilidae), other sparids, and other minor families (Uerpmann, Van Neer, 2000). Finally, one of the richest assemblages from the

a.

Common name	Scientific name	Early Bronze Age
gilthead seabream	<i>Sparus aurata</i>	49
bluefish	<i>Pomatomus saltatrix</i>	44
grey mullets	Mugilidae	30
Atlantic bluefin tuna	<i>Thunnus thynnus</i>	20
sea breams	Sparidae	7
angelshark	<i>Squatina squatina</i>	4
meagre	<i>Argyrosomus</i> sp.	2
gurnards	Triglidae	2
jacks/pompanos	Carangidae	1
greater amberjack	<i>Seriola dumerili</i>	1
littly tunny	<i>Euthynnus alletteratus</i>	1
seabass	<i>Dicentrarchus labrax</i>	1
cownose ray	<i>Rhinoptera marginata</i>	1
Total NISP marine Troy		163

b.

Common name	Scientific name	late Early-beginning Middle Bronze Age
gilthead seabream	<i>Sparus aurata</i>	536
thinlip mullet	<i>Chelon ramada</i>	238
seabass	<i>Dicentrarchus labrax</i>	31
salema	<i>Sarpa salpa</i>	7
common seabream	<i>Pagrus pagrus</i>	6
striped seabream	<i>Lithognathus mormurus</i>	5
common two-banded bream	<i>Diplodus vulgaris</i>	3
golden grey mullet	<i>Chelon auratus</i>	3
saddled seabream	<i>Oblada melanoura</i>	3
common pandora	<i>Pagellus erythrinus</i>	2
black seabream	<i>Spondyliosoma cantharus</i>	1
Total NISP marine Archontiko		835

c.

Common name	Scientific name	Middle-Late Bronze Age
red mullet	<i>Mullus</i> sp.	28
gilthead seabream	<i>Sparus aurata</i>	18
grey mullet	<i>Mugil</i> sp.	13
mackerel tuna	<i>Euthynnus affinis</i>	3
littly tuny	<i>Euthynnus</i> sp.	2
common seabream	<i>Pagrus pagrus</i>	1
Total NISP marine Koukonisi		65

TABLE 3

List of taxa/families in the Bronze Age sites: (a) Early Bronze Age of Troy, (b) late Early-beginning Middle Bronze Age of Archontiko, (c) Middle-Late Bronze Age of Koukonisi.

Liste des taxons/familles dans les sites de l'âge du Bronze : (a) âge du Bronze ancien de Troie, (b) fin de l'âge du bronze ancien-début de l'âge du Bronze moyen d'Archontiko, (c) âge du Bronze moyen-ancien de Koukonisi.

North Aegean covering most of the Bronze Age comes from the site of Mikro Vouni on the island of Samothraki (Theodoropoulou 2007, v. 2 - p. 329-389) (fig. 2, tabl. 3g). The site provided a large variety of taxa, among which sparids (Sparidae), groupers (Serranidae) and various sharks/rays are dominant. Other species complete this diversified spectrum, namely mullets (Mugilidae), mackerels and tunas (Scombridae), wrasses (Labridae), hakes (*Merluccius merluccius*), morays (Muraenidae), and meagres (Sciaenidae). To this day, stratigraphic study is ongoing and it is therefore not possible to further refine sub-periods.

Overall, sea breams, mullets, seabasses, groupers, meagres, scorpionfish and other inshore demersal taxa, make up most of the reconstructed catches. Groupers and scorpionfish are more present in the Mesolithic. A significant fluctuation is to be observed for sparids (mostly other than *Sparus aurata*, which is poorly represented) and for scorpionfish throughout this period. For later periods, the two major resources become the gilthead sea bream and grey mullets, which are constantly dominant in all assemblages in %NISP. Their presence is more important in sites that can be qualified as 'hinge' or transition locations, i.e., coastal/insular sites in proximity of rivers or

d.

Common name	Scientific name	Late Bronze Age
gilthead seabream	<i>Sparus aurata</i>	235
sea breams	Sparidae	90
saddled seabream	<i>Oblada melanoura</i>	72
common pandora	<i>Pagellus erythinus</i>	66
thinlip mullet	<i>Chelon ramada</i>	54
meagre	<i>Argyrosomus regius</i>	25
golden grey mullet	<i>Chelon auratus</i>	27
brown wrasse	<i>Labrus merula</i>	23
common two-banded seabream	<i>Diplodus</i> sp.	19
grey mullets	Mugilidae	21
seabass	<i>Dicentrarchus labrax</i>	16
white seabream	<i>Diplodus sargus</i>	17
common seabream	<i>Pagrus pagrus</i>	15
pandora	<i>Pagellus</i> sp.	15
striped seabream	<i>Lithognathus mormurus</i>	15
bogue	<i>Boops boops</i>	15
pink dentex	<i>Dentex gibbosus</i>	14
common dentex	<i>Dentex dentex</i>	12
black seabream	<i>Spondyliosoma cantharus</i>	13
brown meagre	<i>Sciaena umbra</i>	10
ray	<i>Raia</i> sp.	8
angelshark	<i>Squatina squatina</i>	7
boxlip mullet	<i>Oedalichus labeo</i>	7
spanish bream	<i>Pagellus acarne</i>	5
red mullet	<i>Mullus barbatus</i>	4
little tunny	<i>Euthynnus alletteratus</i>	4
grouper	<i>Epinephelus</i> sp.	4
garfish	<i>Belone belone</i>	10
pickarels	Centracanthidae	6
dentex	<i>Dentex</i> sp.	3
whiting	<i>Merlangius merlangius</i>	3
common seabream	<i>Pagrus</i> sp.	3
cod	<i>Gadus</i> sp.	2
gurnard	<i>Trigla</i> sp.	1
pompano	<i>Trachynotus</i> sp.	1
pompano	<i>Trachynotus ovatus</i>	1
great barracuda	<i>Sphyræna barracuda</i>	1
scorpionfish	<i>Scorpaena scrofa</i>	1
European plaice	<i>Pleuronectes platessa</i>	1
thicklip mullet	<i>Chelon labrosus</i>	1
golden grey mullet	<i>Mugil aurata</i>	1
golden grouper	<i>Epinephelus alexandrinus</i>	1
white grouper	<i>Epinephelus aeneus</i>	1
common two-banded seabream	<i>Diplodus vulgaris</i>	1
eel	<i>Anguilla anguilla</i>	1
salema	<i>Sarpa salpa</i>	1
red mullet	<i>Mullus surmuletus</i>	1
tope shark	<i>Galeorhinus</i> sp.	1
Total NISP marine Toumba		855

**TABLE 3**

(Continuing). List of taxa/families in the Bronze Age sites: (d) Late Bronze Age of Toumba.

(Suite). Liste des taxons/familles dans les sites de l'âge du Bronze : (d) Âge du Bronze tardif de Toumba.

e.

Common name	Scientific name	Late Bronze Age
gilthead seabream	<i>Sparus aurata</i>	13
grey mullet	Mugilidae	1
Atlantic bluefin tuna	<i>Thunnus thynnus</i>	14
sea bream	Sparidae	2
angelshark	<i>Squatina squatina</i>	1
littly tunny	<i>Eythunnus alletteratus</i>	1
scorpionfish	<i>Scorpaena sp.</i>	1
eagly ray	<i>Myliobatis sp.</i>	1
Total NISP marine Troy		34

f.

Common name	Scientific name	Final Bronze Age
gilthead seabream	<i>Sparus aurata</i>	14
grey mullet	Mugilidae	4
Atlantic bluefin tuna	<i>Thunnus thynnus</i>	12
Atlantic horse mackerel	<i>Trachurus sp.</i>	1
sea bream	Sparidae	4
pandora	<i>Pagellus sp.</i>	1
seabass	<i>Dicentrarchus labrax</i>	4
sardines	<i>Sardina pilchardus</i>	1
ray	<i>Raja sp.</i>	1
Total NISP marine Troy		42

**TABLE 3**

(Continuing). List of taxa/families in the Bronze Age sites: (e) Late Bronze Age, (f) final Bronze Age of Troy.

(Suite). Liste des taxons/familles dans les sites de l'âge du Bronze : (e) âge du Bronze tardif, (f) âge du Bronze final de Troie.

estuaries/bays with low salinity levels (fig. 3). These locations have experienced important geomorphological changes from the Neolithic to the Bronze Age in the North Aegean coasts (Ghilardi *et al.* 2008, Psychoyos 1988), and it has been suggested elsewhere that fishing communities adapted to these changing mixed environments (Theodoropoulou 2008). Nevertheless, other parameters might also be taken into account in a more long-scale perspective.

Tunas, mackerels, as well as little sharks and rays, are also found in Aegean contexts of all periods, but only occasionally in significant numbers. Their presence as early as the Lower Mesolithic is interesting from a technological and a social organisational point of view. The fishing of tunas, especially in the Mesolithic and the Bronze Age, could be related to local variations, namely to tuna migration routes through the Aegean (namely valid for Thasos, the Sporades, and Troy; on the biology/migration of tunas and archaeological implications, Mylona 2021), or to human choices. At Cyclops their presence remains relatively constant. For the Neolithic, the increased presence of migratory fish at the site of Limenaria on the island of Thasos reflects a more focused, potentially seasonal, i.e., organised, fishing activity targeting smaller fish, completed by occasional larger. However, this sample should be interpreted with caution as the high numbers of small mackerels, all retrieved from a single stratigraphic horizon, probably reflect a single seasonal catch. For the Bronze Age, Troy is a site that could have potentially relied more on this type of resource, in Early and especially in Late Bronze Age. Although absolute numbers of tunas are not particularly high for each sub-period represented at the site, the constant presence of tunas suggests a well-established orientation and, more significantly, good

social organisation and technological expertise to efficiently capture this resource. It could also suggest an organised transformation circuit and even, potentially, trade networks.

The general image provided seems to be, in most cases, in accordance with the typical image of a wide spectrum of inshore species exploited by recent-year traditional near-shore subsistence and recreational fisheries in the Aegean and other Mediterranean regions (for the Aegean, Moutopoulos *et al.* 2013, tabl. 1) (tabl. 4, fig. 2), with the exception of tuna landings. The species that dominate modern landings may vary with area. Yet, three species or groups of species, the gilthead sea-bream (*Sparus aurata*), various mullets (Mugilidae) and the annular sea-bream (*Diplodus spp.*) make up more than 48% of the total catch, while for the shore-based recreational angling catches the European seabass (*Dicentrarchus labrax*) and the white seabream (*Diplodus sargus*) should be added. Based on this general qualitative comparison with traditional and recreational fisheries from the Aegean, it can be suggested that fishing strategies in the prehistoric Aegean formed a near-shore activity throughout this considerably long period with occasional exploitation of seasonal resources. However, it may be observed that fishing of tunas and other migration species was in certain periods and sites an important activity. The discrepancy with modern-day artisanal fisheries values is explained by the fact that tuna-fishing is a distinct professional activity that does not appear on the shore-based catches counts.

The constant presence of the two key families, sea breams and grey mullets, offers the possibility to explore the hypothesis of a human pressure through an evaluation of

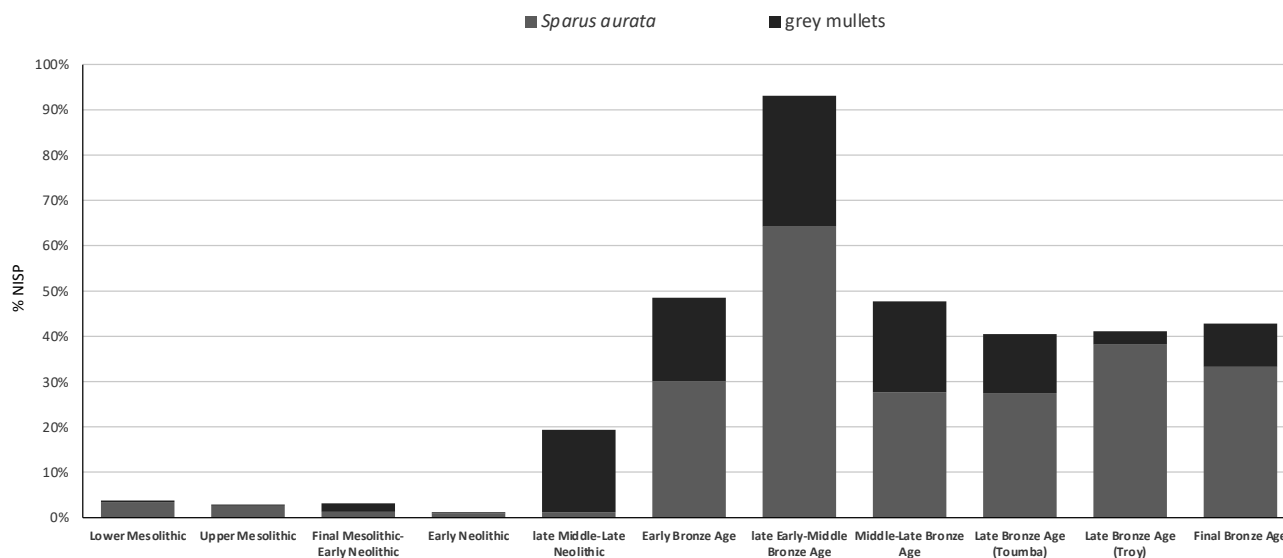
g.

Common name	Scientific name	Bronze Age
gilthead seabream	<i>Sparus aurata</i>	49
sea breams	Sparidae	42
common seabream	<i>Pagrus pagrus</i>	30
dusky grouper	<i>Epinephelus marginatus</i>	24
white grouper	<i>Epinephelus aeneus</i>	23
grouper	<i>Epinephelus</i> sp.	22
white seabream	<i>Diplodus sargus</i>	20
black seabream	<i>Spondyliosoma cantharus</i>	15
thinlip mullet	<i>Chelon ramada</i>	10
herring hake	<i>Merluccius merluccius</i>	10
pink dentex	<i>Dentex gibbosus</i>	10
saddled seabream	<i>Oblada melanoura</i>	9
cods	Gadidae	7
seabass	<i>Dicentrarchus labrax</i>	7
brown meagre	<i>Sciaena umbra</i>	6
moray	<i>Muraena helena</i>	6
thicklip grey mullet	<i>Chelon labrosus</i>	6
dentex	<i>Dentex</i> sp.	5
bogue	<i>Boops boops</i>	5
stargazer	<i>Uranoscopus scaber</i>	4
chub mackerel	<i>Scomber japonicus</i>	3
thicklip grey mullet	<i>Chelon labrosus</i>	3
whiting	<i>Merlangius merlangius</i>	3
striped seabream	<i>Lithognathus mormurus</i>	3
sardine	<i>Sardina pilchardus</i>	2
pandora	<i>Pagellus</i> sp.	2
spanish bream	<i>Pagellus acarne</i>	2
grey mullet	<i>Mugil</i> sp.	2
albacore	<i>Thunnus alalunga</i>	1
salema	<i>Sarpa salpa</i>	1
common bonito	<i>Sarda sarda</i>	1
common pandora	<i>Pagellus erythrinus</i>	1
brown wrasse	<i>Labrus merula</i>	1
wrasses	Labridae	1
tunny	<i>Euthynnus</i> sp.	1
little tunny	<i>Euthynnus alletteratus</i>	1
European anchovy	<i>Engraulis encrasicolus</i>	1
smooth-hound shark	<i>Mustelus</i> sp.	17
tope shark or spinner shark	<i>Galeorhinus galeus</i> or <i>Carcharias brevipinna</i>	6
spinner shark	<i>Carcharias brevipinna</i>	5
sandbar shark	<i>Carcharhinus plumbeus</i>	1
great white shark	<i>Carcharodon carcharias</i>	1
angel shark	<i>Squatina squatina</i>	15
ray	<i>Raja</i> sp.	7
common eagle ray or sting ray	<i>Myliobatis</i> sp. or <i>Dasyatis</i> sp.	1
torpedo	<i>Torpedo</i> sp.	1
Total marine Mikro Vouni		393

TABLE 3

(Continuing). List of taxa/families in the Bronze Age sites: (g) Bronze Age of Mikro Vouni.

(Suite). Liste des taxons/familles dans les sites de l'âge du Bronze : (g) Âge du Bronze de Mikro Vouni.



— FIGURE 3 —

Change in relative frequencies of two main families exploited in Aegean prehistory, sea breams and grey mullets (100% = total %NISP species composition/site).

Changement dans les fréquences relatives des deux principales familles exploitées au cours de la préhistoire égéenne, les daurades et les rougets (100 % = % total de la composition en espèces du PNIS/site).

reconstructed sizes of individuals throughout the chronological sequence studied. Moreover, the presence of these resources can be compared to the presence of other taxa, more pronounced at the two ends of our chronological time span (Mesolithic, end of Bronze Age), which represent higher TL values (big solitary inshore fish, such as the grouper or the seabass, as well as pelagic taxa). In the following, we explore the possibility of a potentially more significant fishing activity of one or the other group that would on its turn be visible on the landings mean TL or size of individuals.

## A DISCUSSION ON THE INTENSITY OF FISHING ACTIVITIES IN THE PREHISTORIC AEGEAN

As stated above, the working hypothesis of this paper for a non-significant prehistoric fishing activity is that its effect on ecosystems would probably stay stable and resemble the effect of natural predation. The reconstructed TL values for the various prehistoric samples are presented in **fig. 4a**. The values are plotted on the theoretical value limits for increasing harvesting/peak of fishing activity/depleted ecosystem provided by the model. For comparison, we estimated the mean TL of modern artisanal, shore-based, and recreational fisheries reported for the Aegean based on published % species composition (Moutopoulos *et al.* 2013, **tabl. 1**) (**tabl. 4**), as the latter is estimated closer to the initial hypothesis of a less engaged fishing activity exercised by coastal Aegean prehistoric populations. Prehistoric values cannot be compared with modern professional fishing, which implies

different tackle, targeting not just the continental shelf, and results to considerably more increased quantities of catches<sup>14</sup>.

Given the limited sample of sites available for each period as well as the limited sample of bones for some sites, it is difficult to pronounce a general evolution (**fig. 4a**). All the archaeological values are far from the depletion threshold, based on modern values. On the contrary, most sites are within the threshold of an increased fishing activity but are still situated lower than the modern values of shore-based recreational fishing reported in the Aegean that targets large fish. However, some sites — or phases within sites — exhibit particularly high mean TL values. This is the case of Mesolithic Cyclops, for which however we do not have contemporary sites from the region to compare with. For other periods, namely the Bronze Age, particularly high values are observed, which are nevertheless not aligned with TL values of other sites within the same period. It seems that values vary depending on the geographical area within each period, or the subsistence strategies of each site. This seems to be the case of the two Late Bronze Age sites of Toumba and Troy. Although both share similar biogeographical conditions, situated in mixed environments in closed bays, they present different strategies. Toumba exploits a great variety of fish, mostly inshore taxa of medium trophic values, such as sparids (with the exception of higher TL *Sparus aurata* or *Pagrus pagrus*) and grey mullets. Troy presents a mixed pattern between local high TL gilthead breams and even higher tunas, which contribute to the highest mean TL observed throughout the Aegean

[14] It has been estimated that 1,5% of the coastal population in the Aegean fishes recreationally, and this is a general percentage in the Eastern Mediterranean. Although recreational fishing theoretically has a lower impact on fisheries, the expansion of fishing for subsistence purposes, not only for personal consumption but also to generate income for the households during periods of financial turmoil, may lead to the increase of unrecorded biomass removal. Intensification of shore-based recreational fishing may thus also enhance pressure on coastal ecosystems and their fauna.

Family/Species	% shore-based recreational catches (1950-2010)	Family/Species	% shore-based recreational catches (1950-2010)
Mugilidae	15,7	<i>Coryphaena spp.</i>	0,5
<i>Sparus aurata</i>	15,3	<i>Dentex dentex</i>	0,4
<i>Diplodus annularis</i>	11,3	<i>Sarda sarda</i>	0,4
<i>Pomatomus saltatrix</i>	10,3	<i>Lichia amia</i>	0,3
<i>Dicentrarchus labrax</i>	7,8	Gobiidae	0,3
<i>Diplodus sargus</i>	4,5	<i>Sphyraena sphyraena</i>	0,2
<i>Pagellus erythrinus</i>	3,1	<i>Trachinus spp.</i>	0,2
<i>Spicara flexuosa</i>	2,9	<i>Sciaena umbra</i>	0,2
<i>Liza spp.</i>	2,6	<i>Spondyliosoma cantharus</i>	0,2
<i>Scomber japonicus</i>	2,4	<i>Mullus barbatus</i>	0,1
<i>Lithognathus mormyrus</i>	2,2	<i>Thunnus spp.</i>	0,1
<i>Trachurus mediterraneus</i>	2,1	<i>Merluccius merluccius</i>	0,1
<i>Oblada melanura</i>	2,0	<i>Dentex gibbosus</i>	0,1
<i>Pagellus bogaraveo</i>	1,9	<i>Epinephelus aeneus</i>	0,1
<i>Diplodus vulgaris</i>	1,5	<i>Epinephelus alexandrinus</i>	0,1
<i>Spicara maena</i>	1,1	<i>Epinephelus marginatus</i>	0,1
<i>Pagellus acarne</i>	1,1	<i>Mullus surmuletus</i>	0,1
<i>Sarpa salpa</i>	0,8	Labridae	0,1
<i>Caranx sp.</i>	0,7	<i>Serranus spp.</i>	0,1
<i>Boops boops</i>	0,6	<i>Spicara smaris</i>	0,1
<i>Euthynnus sp.</i>	0,6	<i>Umbrina cirrhosa</i>	0,1
<i>Belone belone</i>	0,6	<i>Cephalopods</i>	4,3
<i>Auxis thazard</i>	0,6	Total % species composition recreational fisheries Aegean	100,0

— TABLE 4 —

Percentages of species composition of shore-based recreational fisheries in the Aegean (1950-2010), taken from Moutopoulos *et al.* 2013.

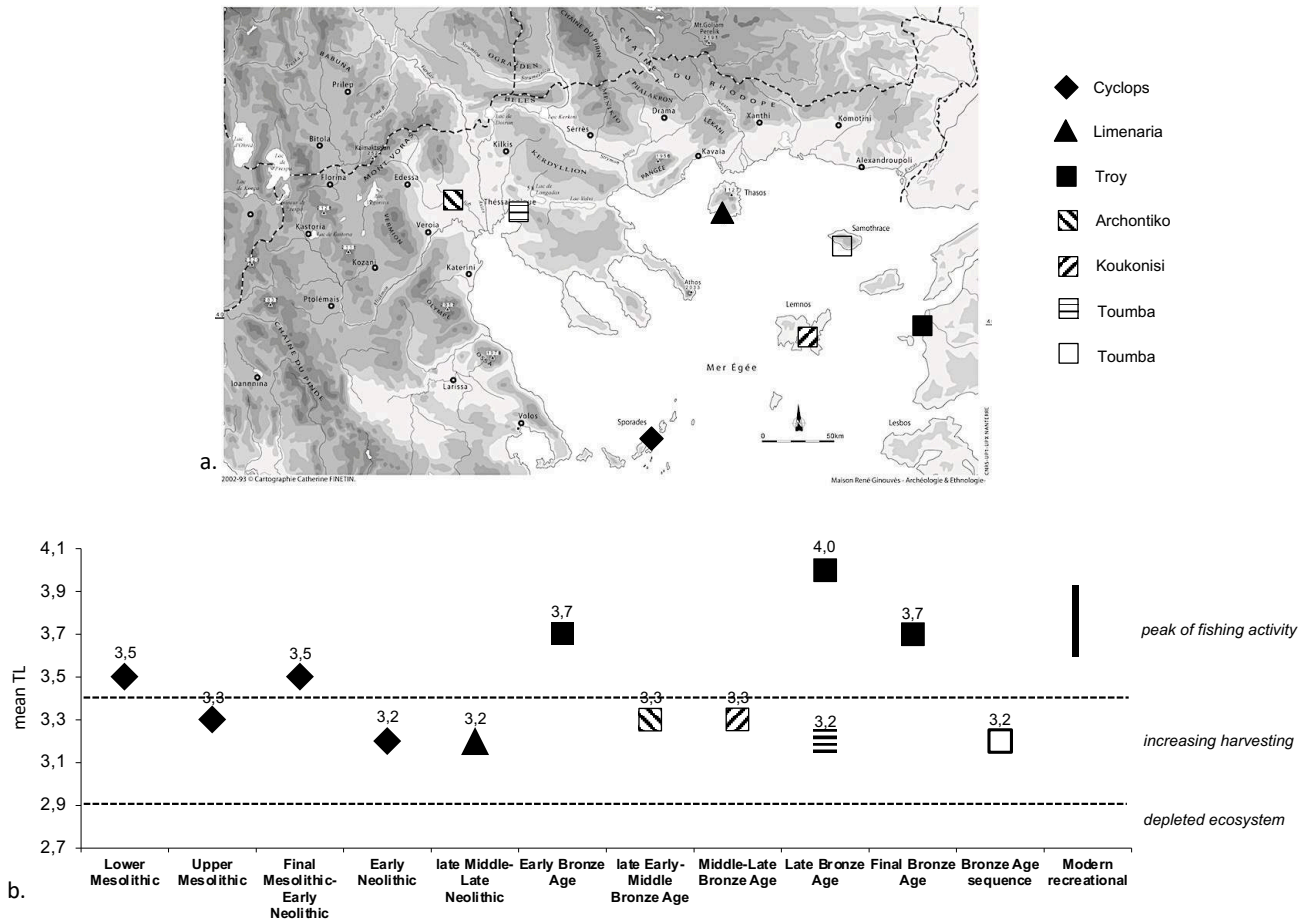
Pourcentages de la composition des espèces de la pêche récréative à terre dans la mer Égée (1950-2010), d'après Moutopoulos *et al.* 2013.

Prehistory thus far. The latter could be interpreted by the localisation of Troy on the return migration route of these fish.

As underlined above, an intra-region comparison of contemporary sites would be more meaningful, but the archaeological record lacks sufficient information. Another interpretational approach is even more relevant, the evolution of mean TL values within the phases of a site. Again, few sites have produced enough data from each sub-period to allow for such comparisons, and an even more refined stratigraphical level would not be meaningful or statistically solid. However, two sites offer the possibility for a long-term diachronical perspective. The Cyclops cave covers the entire Mesolithic period and Early Neolithic. Mean values at the site fluctuate between an increased fishing activity (3.2 to 3.3) that reaches at times a peak (3.6). This fluctuation could be related to rarefaction of more intensively exploited large taxa which leads to a reorientation of targeted species, albeit from the same

ecological zones. More specifically, the increased values especially concern the less voluminous assemblages of the Lower Mesolithic (232 NISP), and of the Final Mesolithic-Early Neolithic (158 NISP), which targets large fish, such as groupers, scorpionfish and large breams. They are recurrently followed by periods of increased catches (i.e., 1290 NISP in the Upper Mesolithic, 909 NISP in the Early Neolithic), which exhibit lower TL values, mainly focusing on lower TL sparids. Another important site that offers the possibility to follow intra-site TL fluctuation is Troy, which covers the entire Bronze Age period. Although not all sub-periods were considered in this paper for statistical reasons (i.e., the small assemblage from the Middle Bronze Age), data from the other phases present a fluctuating pattern within the highest levels of fishing activity, starting at 3.7 mean TL in the Early Bronze Age to reach 4 mean TL in the Late Bronze Age and settle again at 3.7 in the Final Bronze Age. As mentioned above, the site exhibits a double fishing orientation to two different types of resources. The absolute numbers of the two prevalent





— FIGURE 4 —

a. Location of sites per sub-period, b. mean reconstructed TL by site and sub-period.

a. Localisation des sites par sous-période, b. TL moyenne reconstituée par site et sous-période.

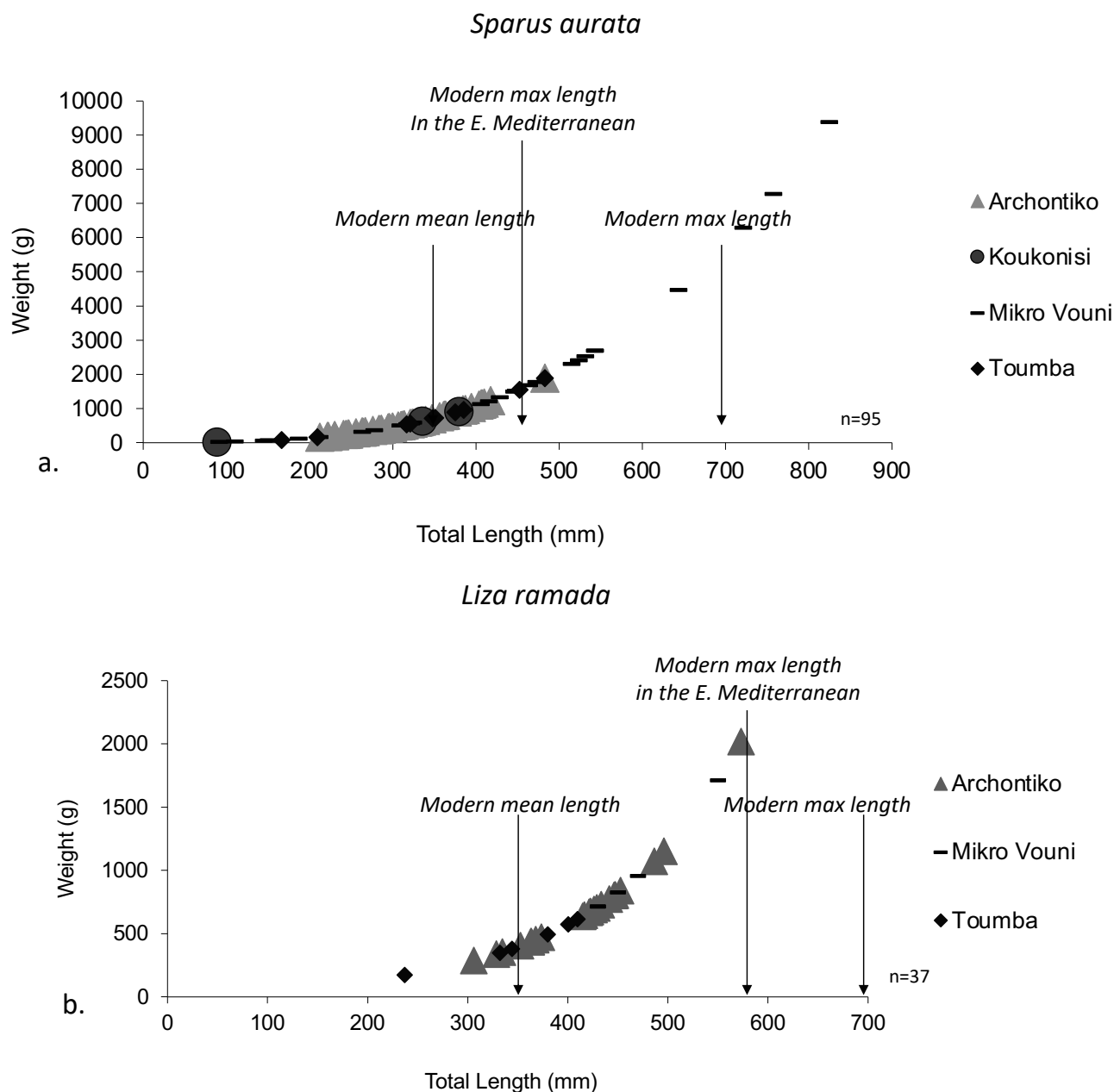
taxa remain the same through different sub-periods and at any rate are not important enough to suggest a massive fishing activity, which would have led to overfishing pressure. Fluctuation of mean TL values should be interpreted more in terms of the fishing strategy adopted, namely a more diversified fishing in the Early and Final Bronze Age which contributes to a lower mean TL, and an activity more targeted on high TL taxa in the Late Bronze. The latter seems to coincide with an important period of the site, thus cultural rather than ecological reasons could be reflected in these numbers.

If we try to synthesise the above and provide a general scheme, despite the limited sample available of sites available for each period—and even more sub-period—, there may be observed some fluctuation (fig. 4). Fishing activity in the Aegean looks quite intensive and reaches a peak during the Mesolithic, targeting larger fish of higher trophic value in the beginning of the Mesolithic, and settled down to more discrete values throughout the period. Values drop in the Early Neolithic, although it is not clear whether this is due to the previously intensive fishing activity or, more probably, to the advent of the Neolithic lifestyle. The second hypothesis seems to be supported by the more variable pattern in later phases of the Neolithic, both in terms of TL and in terms of actual catches. Overall,

values remain the same throughout the next period, the Bronze Age, with the exception of a highly specialised site, Troy. The latter site supports the idea of a non-impacted environment during this period, as it presents a quasi-constant exploitation of two major Mediterranean resources, the gilthead sea bream and the tuna.

The aforescribed pattern of a fishing activity that was not expanded enough to considerably impact fisheries, might also be supported by a more traditional approach used in zooarchaeology, namely size reconstruction. Within the limits of this short study, only the two recurrent species in Aegean Prehistory, the gilthead sea bream and the grey mullet, were taken into account, as they offered reliable metrical and quantitative data, at least for the two periods considered here, the Neolithic and the Bronze Age. Reconstructed lengths of both studied species compared to modern data indicate the presence of bigger sizes of individuals (fig. 5a-b)<sup>15</sup>. This observation is interesting in

[15] The addition of relevant data from the Mesolithic Cyclops would help complete the above general image, however given the already large individuals reconstructed for succeeding sites, it is not expected that sizes should indicate an inverse tendency. However, given the fluctuations in mean TL values throughout the Mesolithic-Early Neolithic, as well as the important numbers in the presence of sparids, reconstructed sizes would be very helpful in exploring potential pressure of fishing at a micro-region level.



— FIGURE 5 —

Reconstructed sizes of two main taxa exploited in Aegean Prehistory, a. the gilthead sea-bream and b. the grey mullet.

Tailles reconstruites des deux principaux taxons exploités dans la préhistoire égéenne, a. la dorade et b. le mullet.

that it affirms two tendencies: a) from an ecological point of view, a still non-depleted natural environment that presented the entire size spectrum<sup>16</sup>, and b) from a social perspective, a choice to target larger individuals, thus potentially investing on a more profitable activity, in terms of the ratio effort/return for prehistoric fishermen, even within the general consensus of fishing being a

complementary activity from the Neolithic onwards<sup>17</sup>. Moreover, we observe that both taxa show larger individuals in the beginning of the Bronze Age (Archontiko) than in the Late Bronze Age (Toumba) within the same area, i.e., the Thermaic Gulf. Although the latter could be indicative of an overfishing pressure on larger fish, more data –both intra-site and across different sites of the same area– are needed to confirm this, as this observation is based on only two sites.

[16] This is the case of Mikro Vouni, which presents the whole range of sizes, but data from this site should be taken with caution as they concern the entire Bronze Age sequence of the site. Further refinement of the stratigraphic data should allow a more secure exploitation of the faunal data.

[17] Similar targeting of larger individuals has been observed both by myself and other colleagues working on prehistoric Aegean with respect to the most common shell exploited in Northern Greece, the cockle *Cerastoderma glaucum*. In the case of cockles, however, in some stratigraphical sequences we do observe a gradual reduction of sizes through time.

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## AN EVALUATION OF THE METHOD AND PERSPECTIVES

The attempt to reconstruct ancient TL values as an additional means to interpret fishing strategies and, most important, potential pressure on fish populations is inevitably based on fish bones found in archaeological sites, which should be seen as 'ancient catch data', i.e., the remains of fish caught by ancient Mediterranean fishermen. However, this record hurts upon two major drawbacks.

First, it offers a partial representation of a given ecosystem, as it is biased by human selection as well as pre- or post-depositional losses inherent in any archaeological record. To the previous, we should consider the sampling strategy applied for the recovery of each archaeofaunal material. The preliminary study presented in this paper highlighted the need to work with statistically exploitable assemblages, comparable in size, for each chronological period studied, and at the scale of a single site or a locality. Then, inter-site comparisons will be possible for a regional approach.

From an ecological point of view, the problem remains of how to move from ancient catch data to marine biodiversity data, as it has already been suggested by marine ecologists in regard to modern TL reconstructions solely based on catch-data (e.g., Shannon *et al.* 2014). Fisheries, either modern or—even more significantly—ancient, should be observed as a highly skewed sampling of the marine biodiversity. Their landings greatly vary according to the fishing grounds exploited, the season of capture, or the techniques used, which are all included in a certain human strategy. Subsistence fishing can be more generalist, including a greater variety of taxa, but can never be as representative as ecological surveys. Professional fishing, although not entirely relevant to the reconstruction of ancient fishing activities—at least for the Prehistory—, relies on the specialised exploitation and sale of cost-effective commercial fish, such as tuna or groupers in the Mediterranean. Recent approaches suggest a combination of data, including survey-based and catch-based indicators, cross-checked with model-derived data.

All the aforementioned render this type of record methodologically vulnerable. Despite these drawbacks, the Mediterranean offers a unique record of 'ancient catch data', as exemplified through the Aegean case study presented in this paper, which remains the only tangible archaeological record for some periods such as Prehistory. The archaeo-ichthyological record offers the possibility to not only reconstruct human-sea relationships from the earliest periods of human occupation in the basin, but also the resilience of both marine ecosystems and human societies through time.

The newly launched ERC program MERMAID thus primarily relies on these ancient fish landings. Among other research goals, the program aims to further refine the approach presented in this paper and to remedy for methodological weaknesses underlined. We will calculate TL indicators based on the general methodological framework explained above. In order to overcome the problem of the absence of the whole set of organisms that build ancient marine ecosystems, we will use multiple methodological approaches. The zooarchaeological record

generally provides evidence of ancient primary and secondary consumers. It is possible to suggest the presence of other organisms on which they depend for nutrition (producers) by using a combined ecological and isotopic approach. This will allow us to reconstruct precise trophic chains based on the actual isotopic value of the remains of ancient marine organisms, and thus compare ancient values with modern ones, as well as follow potential evolution of trophic values in different periods of Prehistory–History. As briefly presented in the present study, we will also use osteometry to provide metrical data on selected species, commonly exploited in all studied periods, in order to explore potential change in size over long time spans. On a larger scale, we will reconstruct trophic spectra in the Mediterranean past through the use of ecological modelling (Ecological Niche Modeling-ENM), which will allow to: a) correlate the presence of species (Species Distribution Model-SDM) with different ecological and environmental parameters available (either through modelling or through actual palaeo-climatic records), and b) correct pseudo-absences linked to human selection or ancient technological constraints. This innovative approach is particularly important as it will provide for the first time insights into past ecosystems and, more relevant to the core question of this paper, an estimation of potential fishing impacts on the whole ecosystem.

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## CONCLUSION

This short paper does not in any case imply that pressure on stocks led to overfishing phenomena in prehistoric Aegean. What is mostly to be highlighted through is the different ways of reading data on prehistoric fisheries in an attempt to provide a more refined answer regarding the actual engagement of prehistoric groups with marine resources.

As Morales Muñoz and Roselló Izquierdo (2004) have underlined elsewhere, it would be a mistake to think that trophic level analysis holds the key for spotting, let alone understanding pressure events in the archaeological record. The combination of methodological tools, and always in keeping in mind the restrictions of any faunal material, may further highlight aspects of the human-sea relationship in the past.

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## REFERENCES

- BIANCHI C.N., MORRI C. 2000 - Marine biodiversity of the Mediterranean Sea: situation, problems and prospects for future research. *Marine Pollution Bulletin*, 40, p. 367-376.
- BRANCH T., WATSON R., FULTON E., JENNINGS S., MCGIL 2010 - The trophic fingerprint of marine fisheries. *Nature* 468, 431-435. <https://doi.org/10.1038/nature09528>
- BRAUDEL F. 1966 - *La Méditerranée et le monde méditerranéen à l'époque de Philippe II*, Paris : Armand Colin.
- COLL M. et al. (+15 authors) 2010 - The biodiversity of the Mediterranean Sea: estimates, patterns and threats. *PLoS ONE*, 5, e11842.
- COLL M. et al. (+15 authors) 2012 - The Mediterranean Sea under siege: spatial overlap between marine biodiversity, cumulative threats and marine reserves. *Global Ecology and Biogeography*, 21, p. 465-480.
- CURCI A., TAGLIACCOZZO A. 2003 - Economic and ecological evidence from the vertebrate remains of the Neolithic site of Makri (Thrace-Greece). In: E. KOTJABOPOULOU, Y. HAMILAKIS, P. HALSTEAD, C. GAMBLE, P. ELEFANTI (Éds.), *Zooarchaeology in Greece. Recent Advances*, The British School at Athens, p. 123-131 (Studies 9).
- DUPONT C., TRESSET A., DESSE-BERSET N., GRUET Y., MARCHAND G., SCHULTING R.R. 2009 - Harvesting the seashores in the Late Mesolithic of north-western Europe. *Journal of World Prehistory*, 22, p. 93-111.
- ERLANDSON J.M., RICK T.C. 2010 - Archaeology meets marine ecology: the antiquity of maritime cultures and human Impacts on marine fisheries and ecosystems. *Annual Review of Marine Science*, 2, p. 165-185.
- GALLANT T.W. 1985 - *A fisherman's tale*. *Miscellanea Graeca*, 7, Belgian Archaeological Mission in Greece, Gent.
- GHILARDI M., FOUACHE E., QUEYREL F., SYRIDES G., VOUVALIDIS K., KUNESCH S., STYLLAS M., STIROUS S. 2008 - Human occupation and geomorphological evolution of the Thessaloniki Plain (Greece) since Mid Holocene. *Journal of Archaeological Science*, 35(1), p. 111-125.
- FROESE R., PAULY D. 2022 - *FishBase. World Wide Web electronic publication*. [www.fishbase.org](http://www.fishbase.org), version (02/2022).
- LEGAKIS A., SFENDOURAKIS S. 1999 - *Η βιοποικιλότητα της Ελλάδας (The biodiversity of Greece)*. Σύμβαση Ευρωπαϊκής Ένωσης για τη Βιολογική Ποικιλότητα στην Ελλάδα, Ζωολογικό Μουσείο και Υ.Πε.Χω.Δ.Ε., Αθήνα.
- LINDEMAN R.L. 1942 - The trophic-dynamic aspect of ecology. *Ecology*, 23(4), p. 399-417.
- MORALES-MUÑIZ A., ROSELLÓ-IZQUIERDO E. 2004 - Fishing down the food web in Iberian prehistory? A new look at the fishes from Cueva de Nerja (Malaga, Spain). In: J.-P. BRUGAL, J. DESSE (Éds.), *Petits animaux et sociétés humaines. Du complément alimentaire aux ressources utilitaires*. XXIV<sup>e</sup> rencontres internationales d'archéologie et d'histoire d'Antibes, Juan-les-Pins : Editions APDCA, p. 111-123.
- MORALES-MUÑIZ A., ROSELLÓ-IZQUIERDO E. 2008 - Twenty thousand years of fishing in the Strait: archaeological fish and shellfish assemblages from Southern Iberia. In: T.C. RICK, J.M. ERLANDSON (Éds.), *Human impacts on ancient marine ecosystems: a global perspective*. California : University of California Press, p. 243-278.
- MOUTOPOULOS D.K., TSIKLIRAS A.C., KATSELIS C., STERGIU K.I. 2013 - Estimation and reconstruction of shore-based recreational angling fisheries catches in the Greek Seas (1950-2010). *Journal of Biological Research-Thessaloniki*, 20, p. 376-381.
- MYLONA D. 2011 - Fish vertebrae. In: A. Sampson (Éd.) *The cave of Cyclops. Mesolithic and Neolithic networks in the Northern Aegean, Greece*, vol. II. *Bone tool industry, dietary resources and the paleoenvironment, and archaeometrical studies*. Philadelphia, INSTAP Academic Press, p. 237-268 (Prehistory Monographs 31).
- MYLONA D. 2021 - Catching tuna in the Aegean: biological background of tuna fisheries and the archaeological implications. *Anthropozoologica*, 56, p. 23-37.
- ORTON D. 2016 - Archaeology as a tool for understanding past marine resource use and its impact. In: K. SCHWERDTNER MÁNEZ, B. POULSEN (Éds.), *Perspectives on oceans past. A handbook of Marine Environmental History*, Dordrecht, Springer, p. 47-70.
- PAPACONSTANTINO C. 1988 - Faunae Graeciae. Check-List of Marine Fishes of Greece, National Centre for Marine Research and Hellenic Zoological Society, Athens.
- PAPAGEORGIOU D.K. 1997 - Ρεύματα και άνεμοι στο Βόρειο Αιγαίο. In: CH. DOUMAS, V. LA ROSA (Éds.), *Η Πολιόχνη και η Πρώιμη Εποχή του Χαλκού στο Βόρειο Αιγαίο, Διεθνές Συνέδριο Αθήνα, 22-25 Απριλίου 1996*, Scuola Archeologica Italiana di Atene, Πανεπιστήμιο Αθηνών, Αθήνα, p. 424-442.
- PAULY D., CHRISTENSEN V., DALSGAARD J., FROESE R., TORRES F.C. 1998 - Fishing down marine food webs. *Science*, 279, p. 860-863.
- PAULY D. 1999 - Fishing down marine food webs as an integrative concept. In: D. PAULY, V. CHRISTENSEN, L. COELHO (Éds.), *Proceedings of the '98 EXPO conference on ocean food webs and economic productivity, Lisbon, Portugal, 1-3 July 1998*. ACP-EU Fisheries Research Report, 5, p. 4-6.
- POWELL J. 2011 - Non-vertebral fish bones. In: A. SAMPSON (Éd.), *The cave of Cyclops. Mesolithic and Neolithic networks in the Northern Aegean, Greece*, vol. II. *Bone tool industry, dietary resources and the paleoenvironment, and archaeometrical studies*. Philadelphia, INSTAP Academic Press, p. 151-236 (Prehistory Monographs 31).
- PSYCHOYOS O. 1988 - *Déplacements de la ligne de rivage et sites archéologiques dans les régions côtières de la mer Égée, au Néolithique et à l'âge du Bronze*. *Studies in Mediterranean Archaeology and Literature*, Pocket Book 92, Paul Åströms Vörlag, Jonsered.
- REITZ E.J. 2004 - Fishing down the web: A case study from St. Augustine, Florida, USA. *American Antiquity*, 69, p. 63-83.

RICK T.C., ERLANDSON J.M. (Éds.) 2008 - *Human impacts on ancient marine ecosystems: a global perspective*. California : University of California Press,

RICK T.C., ERLANDSON J.M. 2009 - Coastal Exploitation. *Science*, 325, p. 952-953.

SALAZAR-GARCIA D.C., FONTANALS-COLL M., GOUDE G., SUBIRA M.E. 2018 - "To 'seafood' or not to 'seafood'?" An isotopic perspective on dietary preferences at the Mesolithic-Neolithic transition in the Western Mediterranean. *Quaternary International*, 470, p. 497-510.

SAPORITI F., BEARHOP S., SILVA L., VALES D.G., ZENTENO L., CRESPO E.A, AGUILAR A., CARDONA L. 2014 - Longer and less overlapping food webs in anthropogenically disturbed marine ecosystems: confirmations from the past. *PLoS ONE*, 9(7), e103132.

SCHWARTZ C.A. 1985 - The vertebrate and molluscan fauna. Final report (Appendix II). In: N. EFSTRATIOU (Éd.), *Ayios Petros, A Neolithic site in the Northern Sporades*, BAR International Series, 241, Oxford : Archaeopress, p. 151-160.

SCHWERDTNER MÁNEZ, POULSEN B. (Éds.) 2015 - *Perspectives on oceans past. A handbook of Marine Environmental History*, Dordrecht, Springer,

SHANNON L., COLL M., BUNDY A., GASCUEL D., HEYMANS J.J., KLEISNER K., LYNAM C., PIRODDI C., TAM J., TRAVERS-TROLET M., SHIN Y. 2014 - Trophic level-based indicators to track fishing impacts across marine ecosystems. *Marine Ecology Progress Series*, 512, 115-140. <https://doi.org/10.3354/meps10821>

THEODOROPOULOU T. 2007 - *L'exploitation des faunes aquatiques en Égée septentrionale aux périodes pré- et protohistoriques*. Université de Paris 1 Panthéon-Sorbonne, Thèse de doctorat, 2 volumes (unpublished).

THEODOROPOULOU T. 2008 - Stratégies de pêche en Égée septentrionale au Néolithique et à l'âge du Bronze : paramètres environnementaux et culturels. In: P. BÉAREZ, S. GROUARD, B. CLAVEL (Éds.), *Archéologie du poisson, 30 ans d'Archéo-ichthyologie, Hommage aux travaux de Jean Desse et de Nathalie Desse-Berset*. Actes des XXVIII<sup>e</sup> rencontres d'archéologie et d'histoire d'Antibes, 18-20 octobre 2007, Juan-les-Pins : Editions APDCA, p. 347-358.

UERPMANN H.-P., KÖHLER K., STEPHAN E. 1992 - Tierreste aus den neuen Grabungen in Troia. Erster Bericht. *Studia Troica*, 2, p. 105-121.

UERPMANN M., VAN NEER W. 2000 - Fischreste aus den neuen Grabungen in Troia (1989-1999). *Studia Troica*, 10, p. 145-179.

VIKA E., THEODOROPOULOU T. 2012 - Re-investigating fish consumption in Greek antiquity: results from  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  analysis from fish bone collagen. *Journal of Archaeological Science*, 39, p. 1618-1627.