Aristotle, Taxonomy, and Traits

Internship Report

Vanessa Peña
Master Biology, Biodiversity: conservation and restoration, University of Antwerp
vanessa.pena@student.uantwerpen.be
6/8/2020

Abstract

Although Carolus Linneaus is seen as the start of western taxonomy, the traces of the biological works of Aristotle, the Greek philosopher, are still visible in current day taxonomy. Aristotle is recognized for his inventory of species and his ability to distinguish between organisms. He has contributed to the classification and distribution of marine organisms. He has provided significant information on ecological, biological, and distributional traits of marine organisms that are worth analyzing. During my internship program at the Flanders Marine Institute (VLIZ), I took part in an ongoing detailed analysis of all marine animals previously described by Aristotle. Information on previously described traits will be compared to the modern information on these species that can be found to this day.

Introduction

Linnaeus fathered western taxonomy. Though there has been research and discoveries made long before Linnaeus, that is of equal importance. Along with the famous Linnaeus, Aristotle is another well-known name in history who can be thanked for our current classification system we use today. Without him, the Linnaeus system might never exist at all. Aristotle (384 BC-323 BC) was a Greek philosopher born in Stagira, Greece (Voulusiadou *et al*., 2017). He developed his love for the study of nature while studying at Plato's Academy in Athens for 20 years. In 347 BC, after the death of his tutor Plato, he traveled to Asia Minor and Lesbos Island, where he took part in the origination of biology (Lennox, 2017). In 342 BC, Aristotle returned to Macedonia to tutor who we now know as Alexander the Great (Voulusiadou *et al*., 2017). He returned to Athens and established the 'Lyceum' school in 335 BC. When Aristotle retired, he stayed at Chalkis, his mother's place, on the island of Euboea until his passing in 323 BC. (Voulusiadou *et al*., 2017; Lennox, 2017). His zoological studies mostly took place during is stay in Kalloni Bay on Lesbos island. Though, it is believed that he continued his biological research until he retired from teachings at the Lyceum in Athens (Voulusiadou *et al*., 2017). Aristotle left us information on marine organisms. Information that sheds light on species biological, distributional, and ecological traits that were one of the first comprehensive studies of animals recorded at the time. Nothing similar had been done until the 16th century (Lennox, 2017).

Today we have access to endless scientific information that is provided by numerous databases. One of those databases is the World Register of Marine Species (WoRMS). WoRMS is a global species database that has been online since 2007. WoRMS is a part of the LifeWatch Species Information Backbone (Vandepitte et al., 2018). It is a free accessible global database containing information on marine species (Vandepitte et al., 2015). The European Register of Marine Species (ERMS) was founded in 1998 (MarBEF Data System, 2019; Costello, 2000) and became available through Aphia, the database behind WoRMS, in 2004 (Vandepitte et al., 2015). ERMS is a taxonomic list of species that occur in the European marine environment (Costello, 2000). ERMS was then developed into WoRMS. Currently, WoRMS gets funding primarily from the Flemish LifeWatch project and is managed by the Flanders Marine Institute (VLIZ) (World Register of Marine Species. 2019).

VLIZis the center for marine and coastal research in Belgium. It promotes and supports the (inter)national image of Flemish marine scientific research and (inter)national marine education while collaborating with different stakeholders. VLIZ is one of the Belgian partners in the European LifeWatch project and is collaborating with the Hellenic Centre for Marine Research (HCMR), a Greek LifeWatch partner, on a project that looks into modern databases and literature to see what trait information can be found on the same species Aristotle observed 25 centuries ago.

This ongoing project began with an updated version of Aristotle's books on the taxonomy of animal species, which was accomplished using WoRMS. A comparison of the taxa mentioned in his works, (Voulusiadou *et al*., 2017), was made with the currently available information on the same taxa. This comparison will help answer how much of a contribution Aristotle made to marine animal nomenclature (Voulusiadou *et al*., 2017). A review of this literature will explain how much of Aristotle's version of taxonomy still resonates in our current system. Voultsiadou *et al*. (2017) created a list of 89 marine species described by

Aristotle. They also collected the traits described by him. The focus of my internship was to look at the current data available to see what trait information can be found for Aristotle's 89 marine species.

Methodology: Description of Activities

Literature review of contributions by Aristotle

A background literature overview of Aristotle and the current project about his contribution to taxonomy was made. The recent publication (Voulusiadou et al., 2017) was the primary source used along with its most cited sources that summarized Aristotle's zoological works and informed me of what has been done so far by VLIZ and their partners in Greece.

Species Traits Spreadsheet

The ongoing project on Aristotle plans to compare traits of species initially described to the trait information found today. Current trait information for Aristotle's species is being arranged in a spreadsheet to give a clear overview of each species. This spreadsheet was started by a past intern, which I then added to that work. The spreadsheet was created containing Biological, Distributional, Ecological, and Importance to Society descriptors for 89 of Aristotle's previously described marine species. Appendix II contains an example of the species traits from *Anguilla anguilla* (Linnaeus, 1758). Definitions of the different descriptions can be found on the Marine Species Traits Wiki webpage (Marine Species Traits Wiki., 2020). This trait vocabulary has been developed within the EMODnet Biology project. VLIZ is the lead in the EMODnet Biology project, which is a European project that has several portals (e.g., biology, geology, chemistry) and is available through the LifeWatch Species Information Backbone. The traits vocabulary is currently under development, and not all the vocabulary is complete. Appendix I contains definitions later added to the original list of traits but are yet to be added on the webpage.

The "Species List," Appendix III, is included in the data file which contains the 89 marine species. Each species has its tab in the data file. Under the "species list," the legend can be found. The species are color-coded to organize the current state of each species tab to be able to identify which species are still incomplete or how much-collected information each species has. There is also a template tab with the complete table with all the descriptors which can be copy and pasted when a new species tab is opened. A few additional descriptors were added (grey cells) to adjust to all species on the list such as spawning, incubation period, gestation period, egg loss, hatching, live-bearing individuals, mating, molting, molt cycle, molting size, molting frequency, distribution, growth in captivity, growth in a natural environment, feeding, preyed upon by, preys on, activity, native range, range expansion, toxic/poisonous, human use, threats, and ecosystem services have been added. See Appendix I for definitions. When a descriptor did not apply to a specific species, it was noted as "Not Applicable."

The following steps were taken when searching trait information on each species.
The fish species on the 'species list' were all found in the SeaLifeBase database (SeaLifeBase, 2019), though when not much useful information was available; other databases were used. The WoRMS database (WoRMS Editorial Board., 2020) provided ecological information. Animal Diversity Web (Myers *et al.,* 2020) provided a vast amount of information about reproduction, habitat, ecology, and other biological traits of many species. The International

Union for the Conservation of Nature Red List of Threatened Species (IUCN 2020) provided information on threats, population size, and habitat/ecology, and social traits like the use of the species. The Invasive Species Compendium (Invasive Species Compendium., 2020), was helpful if humans introduced a species outside of their native range. The FAO Fisheries and Aquaculture Department (Fisheries and Aquaculture Department., 2017) provided most of the information needed for each specific species. Google Scholar was then used to conduct a literary search for papers containing the useful information needed for filling out as much correct information as possible for each fish species.

Results of Accomplished Work

Literature Review of contributions of Aristotle

Many people, including myself at the time of my internship, are unaware that Aristotle spent a considerable amount of his life studying marine species and can be regarded as a "father of biological classification." Following my literature review, I discovered to what extent Aristotle contributed to the classification and distribution of marine organisms.

In the section describing Aristotle's classification of marine animals, Voulusiadou *et al*. (2017) go into detail about how Aristotle developed rules to be followed to bring a degree of order to his classification of animals. A few of his ideas were as follows: 1) A dichotomous division of animal *genē* (genera = groups or taxa) should be avoided; 2) An animal *genē* should be defined by multiple characteristics; 3) The characteristics defined should group each *genē* in physical groups that are given specific name (ex. Fish or Birds) and grouping based on non-taxonomic characteristics (ex. Terrestrial or aquatic) are unspecified; 4) Animals are put in different *genē* when they differ by comparison such as a fish with scales and birds with feathers. Those can be more or less grouped when they differ just by having excess or reduced characteristic such as birds with long wings and birds with short wings.

All 181 species that Aristotle took note of were found in the Meditteranean Sea. His primary focus was marine fauna of the Aegean sea, but he also mentions other areas such as the Sea of Azov, the Black Sea, the Sea of Sicily, the Sea of Sardinia, and the Tyrrhenian Sea (Voulusiadou *et al*., 2017). Though 181 species may seem like a small number compared to the amount known today, it is known that Aristotle had a vast knowledge of the marine fauna in his area (Voultsiadou & Vafidis, 2007). Aristotle provided information on the distributions of species as well, especially marine animals of interest to humans. For example, the scallop was considered a prized delicacy at the time and, in turn, was Aristotle's second most frequently described animal in his texts. Aristotle reported in the Gulf of Kalloni that the population of smooth scallop stock had vanished due to intensive harvesting (Voultsiadou *et al*. 2010). Ganias *et al*., 2017 mention Aristotle's significant knowledge of fish migrations for feeding and reproduction between the Aegean to the Black Sea. He noted on annual fish migrations and was aware that some species spent part of their lives in rivers and estuaries. It is also mentioned that he discussed the variation in size and occurrence of species in different places.

During the time of Aristotle's descriptions, animal names that were used included some that were already being used by earlier authors. Although Aristotle invented several names, such as *dithyra* (bivalves) and *monothyra* (univalves), later taxonomists such as Linnaeus (1758-

1759) used the Greek language to develop scientific terminology which resulted in him latinizing many of Aristotle's Greek names. He created these names while establishing the binomial nomenclature, which included: *Asterias, Delphinus, Echinus, Muraena, Ostrea, Perca, Spongia, and Xiphias*. Most of the species described by Aristotle have an Aegean distribution, and many of the common Greek names of these animals are still used today, which assists identification (Voulusiadou *et al*., 2017).

An example of how Aristotle's work was used to settle a controversial deliberation was 'Aristotle's lantern.' The description given initially by Aristotle had specialists to believe it was the name of a jaw apparatus of the sea urchin. After examination using archeological findings from that period, the area in which he lived, and other classical texts, the term has been corrected, and now the lantern described the test (shell) of the sea urchin while the lamp inside resembles the jaw apparatus (Voultsiadou & Chintiroglou, 2008). Numerous examples and stories show that Aristotle clearly left a vast amount of information, inspired scientists that followed him, and lives on in marine nomenclature today. Voulusiadou *et al.* (2017) conclude by introducing that a detailed analysis of the marine animals described by Aristotle is the focus on an ongoing study, which is, in fact, the project subject that I contributed to during my time with VLIZ.

Species Traits Spreadsheet

During my twenty-day internship, I was able to gather information about the biological, ecological, distributional, and social importance traits of twenty-three different fish species. For twelve species, I was able to gather information for around 75% or more of the listed traits and marked as completed. Eight species were marked has half completed, and three species were marked as uncompleted due to the almost complete lack of available information for that species.

Discussion

During my four weeks at VLIZ, I collected information on 23 species, and though some species were completed before my arrival, the data-sheet is still incomplete. Previously, the intern that created the spreadsheet also added more descriptors and definitions for the spreadsheet (Appendix I), as well as collected information for 20 species. This collection of information will continue to be an ongoing research project for VLIZ, and HCMR is planning to analyze the results so meanwhile, no conclusions can be drawn yet for the comparison of species traits described by Aristotle with the information on those species today.

As mentioned before, depending on the information available for each species, different steps were taken to gather as much information on each trait as possible. One issue I kept experiencing was missing information on Habitat Directive, CITES, FAO-ASFIS, OSPAR, MSFD indicators, and most information on physiology. There seems to be insufficient knowledge and information for these descriptors. Before my time at VLIZ, new descriptors were added to the spreadsheet (Appendix I) to allow more information to be given to species that are not egg-bearing species. I did not add any new descriptors, but I do recommend that the Marine Species Traits Wiki expands their vocabulary with more descriptors to make it more universally relevant as more researchers begin to use the site. Species that were found to have a vast amount of information except for a group of descriptors such as feeding/diet or

Ecophysiology were noted so that others can know there is little or no information to be found on this subject for this particular species.

Assisting Conservation

The ocean is being affected by climate change at an alarming rate, and around 20% of marine species are threatened with extinction (Horton, Kroh & Vandepitte, 2017). Documentation of species and assessment of biodiversity is necessary for understanding the marine environmental processes that are essential for assessing the status of marine ecosystems (Dekeyzer *et al*., 2019). Going further with the project, the data I collected will help with possible projects such as developing ecological models for these species.

I consider zoological information that can be derived from older classical texts such as Aristotle's work can assist not just with conservation but other studies such as paleoecology, paleontology, and archaeology. Information like this helps with the reconstruction of past ecosystems, which in turn helps researchers gain more insight into our changing environments today.

WoRMS and Ocean Biodiversity Information System (OBIS) are two incredible databases for marine species but are limited to Taxonomic information and distribution (Costello *et al*., 2015). Providing more biological and ecological information to these databases multiply the benefits that they provide to new research. As I experienced, much information on traits and attributes were dispersed in the literature and took time to gather. However, having the terms available in the database and continuing to develop the classification of traits and a more extensive vocabulary will make WoRMS more valuable for users to answer their conservation questions.

References

Breed, M. D., & Moore, J. (2nd. ed.). (2016). Animal behavior Chapter 11 - Mating Systems,. Academic Press: London. p. 357-393

Birkhead, T. R., & Møller, A. P. (1998). Sperm Competition and sexual selection. New York: Academic press.

Collins. (2020). Definition of threat. Retrieved 18 March 2020, from https://www.collinsdictionary.com/dictionary/english/threat

Costello MJ, Claus S, Dekeyzer S, Vandepitte L, Tuama ÉÓ, Lear D, Tyler-Walters H. (2015). Biological and ecological traits of marine species. PeerJ 3:e1201 https://doi.org/10.7717/peerj.1201

Costello, M. (2000). Developing species information systems: The European Register of Marine Species (ERMS). Oceanography, 13(3), 48-55. Retrieved May 12, 2020, from www.jstor.org/stable/43924366

Dekeyzer S, Decock W, Verfaille K, Vanhoorne B, Lanssens T, Vandepitte L (2019) Marine Species Traits in the LifeWatch Taxonomic Backbone. Biodiversity Information Science and Standards 3: e37492.

Encyclopeadia Britannica. (2017). Molt biology. Retrieved 15 March 2020, from https://www.britannica.com/science/molt

European Commission. (2019). Captive Breeding and Artificial Propagation. Retrieved 15 March 2020, from https://ec.europa.eu/environment/cites/info_captive_en.htm

Fisheries and Aquaculture Department. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 17 March (2017). [Cited 14 March 2020]. http://www.fao.org/fishery/

Horton, T., Kroh, A., & Vandepitte, L. (2017). How many undiscovered creatures are there in the ocean. Retrieved on 25 March 2020, from http://theconversation.com/how-many-undiscovered-creatures-are-there-in-the-ocean-86705

Invasive Species Compendium. (2020). Invasive Species Compendium. Retrieved on 15 March 2020, from https://www.cabi.org/isc/

Lennox, J. (2017). *Aristotle's Biology*. Retrieved 20 March 2020, from https://plato.stanford.edu/entries/aristotle-biology/

LifeWatch. (2020). Currently in WoRMS. Retrieved 11 March 2020, from http://www.lifewatch.be /en/data

MarBEF Data System. (2019). The European Register of Marine Species. Retrieved 24 March 2020, from http://www.marbef.org/data/erms.php

Marine Species Traits editorial board (2020). Marine Species Traits. Accessed at http://www.marinespecies.org/traits on 2020-04-14

Marine Species Traits Wiki. (2020). Marine Species Traits. Retrieved on March 10 2020, from http://www.marinespecies.org/traits/wiki/

Merriam-Webster. (2020). Subspecies. Retrieved 14 March 2020, from https://www.merriam-webster.com/dictionary/subspecies

Myers, P., R. Espinosa, C. S. Parr, T. Jones, G. S. Hammond, and T. A. Dewey. 2020. The Animal Diversity Web (online). Accessed at https://animaldiversity.org.

Palomares, M.L.D. and D. Pauly. Editors. 2019. SeaLifeBase. World Wide Web electronic publication. www.sealifebase.org, version (12/2019).

Panawala, L. (2017). Difference between oviparous and viviparous. Retrieved 15 March 2020, from https://www.researchgate.net/publication/320516607_Difference_Between_Oviparous_and_Viviparous

Scottish Natural Heritage. (2019). Law on non-native species in Scotland. Retrieved 15 March 2020, from https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/protected-species/invasive-non-native-species/law-non-native-species-scotland

IUCN 2020. The IUCN Red List of Threatened Species. Version 2020-1. https://www.iucnredlist.org. Downloaded on 19 March 2020.

Vandepitte, L., Vanhoorne, B., Decock, W., Dekeyzer, S., Trias Verbeeck, A., Bovit, L., ... & Mees, J. (2015). How Aphia—The platform behind several online and taxonomically oriented databases—can serve both the taxonomic community and the field of biodiversity informatics. Journal of Marine Science and Engineering, 3(4), 1448-1473.

Vandepitte, L., Vanhoorne, B., Decock, W., Vranken, S., Lanssens, T., Dekeyzer, S., & Mees, J. (2018). A decade of the World Register of Marine Species–General insights and experiences from the Data Management Team: Where are we, what have we learned and how can we continue? PloS one, 13(4), e0194599.

Voultsiadou, Eleni & Chintiroglou, Chariton. (2008). Aristotle's lantern in echinoderms: An ancient riddle. Cahiers de Biologie Marine. 49. 299-302.

Voultsiadou, Eleni & Gerovasileiou, Vasilis & Vandepitte, Leen & Ganias, Konstantinos & Arvanitidis, Christos. (2017). Aristotle’s scientific contributions to the classification, nomenclature and distribution of marine organisms. Mediterranean Marine Science. 18. 468-478. 10.12681/mms.13874.

Voultsiadou, Eleni & Koutsoubas, Drosos & Achparaki, Maria. (2010). Bivalve mollusc exploitation in Mediterranean coastal communities: An historical approach. Journal of Biological Research. 13. 35-45.

Voultsiadou, E., Vafidis, D.,(2007). Marine invertebrate diversity in Aristotle’s zoology. Contributions to Zoology, 76, 103-120.

World Register of Marine Species. (2019). What is WoRMS? Retrieved 1 April 2020, from http://www.marinespecies.org/about.php

WoRMS Editorial Board (2020). World Register of Marine Species. Available from http://www.marinespecies.org at VLIZ. Accessed 2020-04-14. doi:10.14284/170

Appendix I: Definitions to the new descriptors added to the excel file that are currently excluded from the Marine Species Traits Wiki site

Descriptor	Definition
Spawning	Free spawning is defined as the release of sperm into the environment, whereas broadcast spawning is defined as the release of both eggs and sperm into the environment. Males can free spawn, pseudocopulate (release sperm directly on females or transfer a spermatophore), or copulate (release sperm within a female's reproductive tract). Females can broadcast spawn, brood eggs on an external surface, or brood eggs internally (after internal fertilization). By definition, broadcast spawning is always accompanied by free spawning but not vice versa; in many taxa males release sperm, but fertilization is either internal or on some external surface of the female (Birkhead & Mølle., 1998).
Incubation Period	Embryo development of egg-laying individuals
Gestation Period	Embryo development of life-bearing individuals
Egg Loss	Number of eggs lost during embryo development
Hatching	Hatching of egg-laying individuals
Live-Bearing	Viviparous animals refer to the animals that give girth to develop live young individuals. These animals possess specialized organs that supply nutrients for the development of the embryo (Panawala, 2017).
Mating	A mating system describes how male and female interactions are built around choosing mates (Breed & Moore, 2015).
Molting	The shedding or casting off of an outer layer or covering and the formation of its replacement (Encyclopedia Britannica, 2017).
Moult Cycle	A species can molt periodically (e.g., annually)
Molting Size	Species growth from the time before molting until after molting?
Molting Frequency	The number of times the species molt?
Distribution	Geographical distribution of occurrence of the species
Growth in Captivity	First-generation offspring (F1) means specimens produced in a controlled environment from parents of which at least one was conceived in or taken from the wild, most often called born in captivity. Second generation offspring (F2) and subsequent generation offspring (F3, F4, etc.) mean specimens produced in a controlled environment from parents that were also produced in a controlled environment, most often called born and bred in captivity. A controlled environment means an environment that is manipulated to produce animals of a particular species, that has boundaries designed to prevent animals, eggs or gametes of the species from entering or leaving the controlled environment, and the general characteristics of which may include, but are not limited to, artificial housing, waste removal, health care, protection from predators and the artificial supply of food (European Commission, 2019).
Growth in Natural Environment	Growth of species in the wild
Growth in Captivity	Growth of species while in captivity
Feeding	How does the species feed; feeding techniques?
Preyed Upon By	The species is eaten by which other species
Preys On	This species feeds on which other species; similar to food type/diet
Activity	The time of day the species is actively feeding or reproducing?
Native Range	The native range is defined in the 1981 act as the locality to which the animal or plant of that type is indigenous. It does not refer to any locality to which that type of animal or plant has been imported (whether intentionally or otherwise) by any person (Scottish Natural Heritage, 2019).
Range Expansion	Expansion of their natural geographical range. Can occur naturally or intentionally by humans
Toxic / Poisonous	Is the species toxic or poisonous for humans or other animals?
Human Use	Is it a human resource? What do we use it for or gain from it?
Threats	An indication of direct or indirect harm, danger, or pain (Collins, 2020).
Ecosystem Services	Ecosystem services are the direct and indirect contributions of ecosystems to human well-being (TEEB D0). They support directly or indirectly, our survival and quality of life. According to TEEB, ecosystem

	services can be categorized into four main types: Provisioning services are the products obtained from ecosystems such as food, fresh water, wood, fiber, genetic resources, and medicines. Regulating services are defined as the benefits obtained from the regulation of ecosystem processes such as climate regulation, natural hazard regulation, water purification, and waste management, pollination, or pest control. Habitat services highlight the importance of ecosystems to provide habitat for migratory species and to maintain the viability of gene-pools. Cultural services include non-material benefits that people obtain from ecosystems such as spiritual enrichment, intellectual development, recreation, and aesthetic values (Biodiversity Information System for Europe, n.d.).
Subspecies	A category in a biological classification that ranks immediately below a species and designates a population of a particular geographic region genetically distinguishable from other such populations of the same species and capable of interbreeding successfully with them where its range overlaps theirs (Merriam-Webster, 2020).

Appendix II: Species traits spreadsheet example for the species *Anguilla anguilla.*

Descriptors	LifeStage	Sex	Info_1	Source_1	Info_2	Source_2	Info_3	Source_3	NOTES - REMARKS
Biological descriptors:									
Body size	Adult	Female	To 137 cm, but usually 40-60 cm	Wheeler, A. - 1969. TI	Max Length: 122 cm with a c	https://www.fishbase.de/summary/Anguilla-anguilla.html			
Body size	Adult	Male	To 51 cm, but usually 30-40 cm	Wheeler, A. - 1969. TI	Max Length: 133 cm with a c	https://www.fishbase.de/summary/Anguilla-anguilla.html			
Maturity		Female	Highly variable, ranging from 6 to	van Ginneken, V.J.T.,					Maturation depends or
Maturity		Male	Mature at an age around 3-4 Yea	van Ginneken, V.J.T.,					Maturation depends or
Clutch size									
Dormant stage	Adult		Dormancy commenced in Octobe	Westerberg, H., & Sjöberg, N. (2015). Overwinterin					
Larval or juvenile dispersal									
Egg, egg mass or clutch location									
Egg or propagule size									
Fecundity			2,000,000 - 3,000,000	https://www.fishbase					
Fertilization			External	https://www.fishbase					
Spawning			Spawning depth of 100-200 m in	Deelder, C.L., 1984. S	Spawns primarily from Marc	van Ginneken, Vinc	Survey catches of lept	Jacoby, D. & Go	
Mating			Assortive mating	van Ginneken, V.J.T.,	Recent genomic DNA studies	https://www.fishE	Polygynandrous (prom	https://animald	A single random mating
Incubation period									
Gestation period			Not ApplicableNot ApplicableNot	ApplicableNot ApplicableNot Applicable					
Egg loss									
Hatching			Leptocephali of the European ee	Lecomte-Finiger, R. Growth history and age at recr					
Live-bearing			Not Applicable						
Gamete type									
Generation time			Generation time defined as the a	Convention on International Trade in Endagered Sp					
Larval and juvenile devolopment	Larva		Planktotrophic	Convention on International Trade in Endagered Sp					
Larval settlement period	larva		33 to 76 days	Lecomte-Finiger, R. Growth history and age at recr					
Duration of larval stage	larva		7 to 11 months	Lecomte-Finiger, R. G	leptocephali stage is very po	Feunteun, E. (2002	larvae spend only abo	Lecomte-Finige	Larval stage is spent mi
Larval settlement substratum	larva								
Life cycle			MetamorphosisMetamorphosis	https://animaldiversit					
Life span			Average life span is usually 15-20	Narberhaus, I., J. Krau	Can spawn as early as 7 year	https://animaldive			Die shortly after spawn
Reproductive frequency			Semelparous	http://www.fao.org/					
Reproductive season			Late winter to early spring	https://animaldiversit					
Reproductive type			Dioecism	https://www.fishbase					
Life stages	Larva		Leptocephali	https://animaldiversit					
Life stages	Juvinelle		Glass eel	https://animaldiversit					
Life stages	Juvinelle		Yellow eel	https://animaldiversit					
Life stages	Adult		Silver eel	https://animaldiversit					
Moulting			Not Applicable						
Moult cycle			Not Applicable						
Moulting size			Not Applicable						
Moult frequency			Not Applicable						
Physiology									
Distribution descriptors:									
Depth			Found in depths of 0-700 m, mos	https://animaldiversit	The species is found in all typ	Freyhof, J. & Kotte			
Elevation			Not Applicable						
Environment			Marine; freshwater; demersal; ca	https://www.fishbase					
Habitat: environmental position									
Habitat: physiography									
Habitat: salinity			Brackish						
Habitat: substratum			Coarse benthic habitats	Christoffersen M, Sve					
Habitat: tidal streams and water flow									
Habitat: tolerance									
Habitat: wave exposure									
Habitat preferences			The species is found in all types o	Freyhof, J. & Kottelat,	Depending on the lifestage o	https://animaldive			
Province			Neritic and Oceanic	https://www.fishbase					
Vertical biological zone or Zonation			Benthic and Littoral zones	Piper, Adam & Wright, R. & Kemp, Paul. (2012). The					
Distribution			Found in all European rivers drain	Freyhof, J. & Kottelat, M. 2010. Anguilla anguilla . T					
Ecological descriptors:									
Body shape			Body elongate, cylindrical anteriorly, somewhat compressed posteriorly						
Flexibility			Eels are extremely efficient swim	van Ginneken, Vincent & Maes, Gregory. (2005). Th					
Fragility									
Growth form									
Height (above substratum)									
Supporting structures and enclosures									
Ecological interactions			European eel is an important spe	Ogunola, Oluniyi & Or					
Ecophysiology: oxygenation tolerance			At a water temperature of 20-21	Molnár, Kálmán. (199					
Ecophysiology: growth rate			The calculated growth rate was C	van Ginneken, Vincen	Presuming that the larvae gre	Lecomte-Finiger, F			
Growth in captivity			Little to no information because	Jacoby, D. & Gollock,	The extreme blockage of ma	Palstra AP, van de			
Growth in natural environment			Eel growth increases with tempe	Jacoby, D. & Gollock,					
Ecophysiology: photosynthetic pigment(s)			Not Applicable						
Ecophysiology: temperature tolerated			Can survive, and even reproduce,	https://animaldiversit	Temperate; 4°C - 20°C	https://www.fishE			
Feeding			Carnivore	https://animaldiversit					
Feeding method/behaviour			Reported to leap out of the wate	https://animaldiversit					
Food type/diet	Larva		No food contents have ever beer	https://animaldiversit					
Food type/diet	Juvinelle		Insect larvae, dead fish, and smal	https://animaldiversit					
Food type/diet	Adult		Carnivore/ fish, eggs, carrion, ins	https://animaldiversit					
preyed upon by			Preyed upon by larger eels and ot	https://animaldiversit					
preys on			Preys on aquatic invertebrates, fr	https://animaldiversit					
Mode of life: dependency			Independent	https://animaldiversit					
Mode of life: sociability			Solitary species	https://www.fishbase					
Mode of life: support	Adult		Host	Jacoby, D. & Gollock,					Host to parasites partic
Movement: dispersal potential (adult)			Facultative Catadromous	Breve, Niels & Buijse,	Catadromous species	https://www.fishE			
Movement: migration	Larva		Larvae spend only about 1 yr in t	Lecomte-Finiger, R. G					
Movement: mobility	Adult		Spawning migrations occur mainl	Deelder, C.L., 1984. S					
Movement: mobility	Larva		We do not know whether the tra	van Ginneken, Vincen	Drifter : leaf-like larvae (lept	http://www.fao.o	Drift with the currents	Convention on	
Activity			Diurnal	https://animaldiversit					
Species importance to society:									
CITES			Appendix II	Convention on Intern					
FAO-ASFIS									
Habitat Directive			Habitats Directive does not cove	https://eunis.eea.eur					
IUCN Red list			Critically Endagered	Freyhof, J. & Kottelat,					
Native range			Palearctic, Atlantic ocean, Medit	https://animaldiversit					
Range expansion									
Invasive species			Not Invasive	https://www.cabi.org					
Abundance			Rare to Common	https://www.fishbase					
Impact			European eels are a popular food	https://animaldiversit					
Invasiveness			Not Invasive	https://www.cabi.org					
Location type			Introduced Countires: Iran, Israel	https://www.cabi.org	Native Countries: Albania; Al	Freyhof, J. & Kotte			
Occurrence									
Origin			Native-Non Endemic	Freyhof, J. & Kottelat,					
Pathways/vector									
MSFD Indicators			Environmental impacts in marine	The International Cou					
OSPAR			OSPAR Regions: I, II, III, IV & V	OSPAR Commission-					
Extra descriptors:									
Toxic/poisonous			The blood of the European eels i	https://nas.er.usgs.go					
Human use			Caught for eating, but most are u	Freyhof, J. & Kottelat,					
Threats			Habitat destruction and modifica	Freyhof, J. & Kottelat,					
Subspecies									
Ecosystem services									

Appendix III: Species List

Marine Species	
Actinia equina	*Oblada melanura*
Alcyonium palmatum	*Octopus vulgaris*
Anemonia viridis	*Ocypode cursor*
Anguilla anguilla	*Ostrea edulis*
Antedon mediterranea	*Pagellus erythrinus*
Anthias anthias	*Pagrus pagrus*
Argonauta argo	*Palinurus elephas*
Atherina hepsetus	*Paracentrotus lividus*
Balaenoptera physalus	*Patella caerulea*
Bonellia Viridis	*Pelagia noctiluca*
Brissus unicolor	*Perca fluviatilis*
Valappa granulata	*Phocoena phocoena relicta*
Carassius carassius	*Pholas dactylus*
Caretta caretta	*Phorcus turbinatus*
Cepola macrophthalma	*Phycis blennoides*
Cerithium vulgatum	*Physeter macrocephalus*
Charonia variegata	*Pinna nobilis*
Chromis chromis	*Pinnotheres pisum*
Cidaris cidaris	*Pontonia pinnophylax*
Conger conger	*Potamon fluviatile*
Coryphaena hippurus	*Sarcotragus foetidus*
Cyprinus carpio	*Sarda sarda*
Dicentrarchus labrax	*Sarpa salpa*
Diplodus sargus sargus	*Scomber colias*
Echeneis neucrates	*Scomber scombrus*
Eledone moschata	*Scyliorhinus canicula*
Eriphia verrucosa	*Scyliorhinus stellaris*
Haliotis tuberculata	*Scyllarus arctus*
Hermodice carunculata	*Sepia officinalis*
Hippospongia communis	*Silurus aristotelis*
Hirundichthys rondeletii	*Sparisoma cretense*
Homarus gammarus	*Sparus aurata*
Labrus mixtus	*Sphaerechinus granularis*
Liocarcinus depurator	*Spongia lamella*
Loligo vulgaris	*Spongia officinalis*
Maja squinado	*Spongia zimocca*
Microcosmus sabatieri	*Squalus acanthias*
Mobula mobular	*Squilla mantis*
Monachus monachus	*Syngnathus acus*
Mugil cephalus	*Todarodes sagittatus*
Mullus barbatus barbatus	*Trachinus draco*
Mullus surmuletus	*Uranoscopus scaber*
Muraena helena	*Xiphias gladius*
Mustelus mustelus	*Zeus faber*
Mytilus galloprovincialis	**Fish species in Blue***

Work Schedule (9:00h-17:00h)	
03/02/2020	Introduction to the project
04/02/2020	Literature review of Aristotle
05/02/2020	Collection of data for spreadsheet
06/02/2020	Collection of data for spreadsheet
07/02/2020	Collection of data for spreadsheet
10/02/2020	Collection of data for spreadsheet
11/02/2020	Collection of data for spreadsheet
12/02/2020	Collection of data for spreadsheet
13/02/2020	Collection of data for spreadsheet
14/02/2020	Collection of data for spreadsheet
17/02/2020	Collection of data for spreadsheet
18/02/2020	Collection of data for spreadsheet
19/02/2020	Collection of data for spreadsheet
20/02/2020	Collection of data for spreadsheet
21/02/2020	Collection of data for spreadsheet
24/02/2020	Collection of data for spreadsheet
25/02/2020	Collection of data for spreadsheet
26/02/2020	Collection of data for spreadsheet
27/02/2020	Collection of data for spreadsheet
28/02/2020	Collection of data for spreadsheet