

SHORT COMMUNICATION

# Much can happen in three months: The proliferation of the bigfin reef squid (*Sepioteuthis lessoniana* Lesson, 1831) within Maltese coastal waters since its first record

Alan Deidun<sup>1</sup>, Laura Prieto Gomez<sup>1</sup>, Adam Gauci<sup>1</sup>, Bruno Zava<sup>2</sup>, Maria Corsini-Foka<sup>3</sup> and Alessio Marrone<sup>1</sup>

<sup>1</sup> Oceanography Malta Research Group, Department of Geosciences, Faculty of Science, University of Malta, Malta

<sup>2</sup> Wilderness Studi Ambientali, Palermo, Italy

<sup>3</sup> Institute of Oceanography, Hellenic Centre for Marine Research. Hydrobiological Station of Rhodes, Greece

**Abstract:** The rapid colonisation of Maltese coastal waters by the non-indigenous *Sepioteuthis lessoniana* Lesson, 1831 is hereby documented through the ‘Spot the Alien’ citizen science campaign, to which a considerable number of catches and sightings of the species were submitted in rapid sequence over a three-month timeframe. The study also compares sea surface temperature values for the July-December period of 2015, 2020 and 2025 for the same waters, in order to explore the putative influence that sea temperatures might have on the observed rapid expansion of this non-indigenous species (NIS). The findings of this study highlight both the notable spread of the species across local waters and the important role of citizen science in early detection and monitoring of non-indigenous species.

**Keywords:** non-indigenous species; Mediterranean Sea; Malta; citizen science; invasive alien species

**Sažetak:** MNOGO SE TOGA MOŽE DOGODITI U TRI MJESECA: UBRZANO ŠIRENJE VELIKOPERAJNE SIPOLIGNJE (*SEPIOTEUTHIS LESSONIANA* LESSON, 1831) U OBALNIM VODAMA MALTE OD NJEZINA PRVOG ZABILJEŽENOG NALAZA. Brza kolonizacija obalnih voda Malte od strane velikoperajne sipolignje *Sepioteuthis lessoniana* Lesson, 1831, dokumentirana je kroz “Spot the Alien” kampanju usmjerenu na građansku znanost, u sklopu koje je značajan broj ulova i viđenja ove vrste, u brzom slijedu, dojavljen unutar razdoblja od 3 mjeseca. Studija nadalje uspoređuje vrijednosti površinske temperature mora za 2015., 2020. i 2025. godinu, od srpnja do prosinca u istim vodama, s ciljem istraživanja mogućeg utjecaja temperature mora na uočeno ubrzano širenje ove alohtone vrste (NIS). Rezultati ovog rada ističu značajnu rasprostranjenost vrste u lokalnim vodama, kao i važnu ulogu građanske znanosti u ranom otkrivanju i praćenju alohtonih vrsta.

**Ključne riječi:** alohtone vrste; Sredozemno more; Malta; građanska znanost; invazivne strane vrste

## INTRODUCTION

*Sepioteuthis lessoniana* Lesson, 1831 is one of the eight cephalopod NIS (non-indigenous species) recorded to date within the Mediterranean, where it is considered to be a Lessepsian migrant of an Indo-Pacific origin (Jereb and Roper, 2010; Bello *et al.*, 2020; Marrone *et al.*, 2025). The species was first recorded in the basin off the Turkish coast in 2002 (Salman, 2002) and since then has spread as far west as the island of Lampedusa (Marrone *et al.*, 2025) and Tunisian coast and as far north as Montenegro in the Adriatic (Bello *et al.*, 2020). The proliferation of this invasive species is such that its commercial exploitation is documented within the Levantine Basin (Kleitou *et al.*, 2022).

The bigfin reef squid *S. lessoniana* was first recorded from Maltese waters in July 2025 (Marrone *et al.*, 2025), through the collection of a single individual along the north-east coast of Malta. Since then, the species has ex-

hibited a rapid proliferation in Maltese coastal waters, mainly along the northern and eastern coastline of the island of Malta, over a six-month timeframe extending between October 2025 and early January 2026.

## MATERIAL AND METHODS

The ‘Spot the Alien’ citizen science campaign (campaigns.ocean.mt) has been implemented in the Maltese Islands since 2016 by the Oceanography Malta Research Group (OMRG) of the Department of Geosciences at the University of Malta. Through this campaign, sea users can submit records of non-indigenous marine species, supported by photographic and/or video documentation, through a number of different platforms, including the campaign website, social media accounts and email address. Submitted reports are validated by OMRG staff and all associated metadata is streamlined within the campaign records matrix. Over the years, the campaign

has proven effective in documenting new NIS records from Maltese waters and in monitoring their spread (e.g., Deidun *et al.*, 2021).

The 'Spot the Alien' campaign database was consulted in order to extract the metadata associated with all the *Sepioteuthis lessoniana* records made over the October 2025-January 2026 period. To our knowledge, these database entries represent all or, at least, the vast majority of records pertaining to *S. lessoniana* made in Maltese waters over the same timeframe. The sex of the recorded specimens was inferred visually from the submitted photographs by using the criteria listed in Sivashanthini *et al.* (2010), whilst the approximate dimensions of the photographed individuals (mantle length and total length, inclusive of tentacles) were estimated through the use of the ImageJ software (Schneider *et al.*, 2012) for six out of the twelve individuals only (objects of known dimensions which could be adopted as a 'scalebar' when operating the sizing software were only present within six of the provided photographs). Unfortunately, none of the collected specimens could be weighed, given that these were either promptly consumed by the fishers in question or not caught and only observed.

Daily sea surface temperature (SST) data were obtained from the Mediterranean Sea Physics Reanalysis numerical model provided by the Copernicus Marine Service (Escudier *et al.*, 2020). Three representative points were selected along the coast of Malta for further analysis. Given that records of *S. lessoniana* come from the eastern Maltese coast, the points were chosen to represent the northern, central and southern areas of the eastern part of the archipelago: one point to the north of the island of Gozo (36° 5' 50.78" N, 14° 15' 21.12" E), one off the north-east coast of the island of Malta (35° 59' 56.97" N, 14° 24' 57.78" E) as well as a third location off the south-east coast of the island of Malta (35° 54' 18.45" N, 14° 33' 56.04" E), encompassing the entire eastern flank of the Maltese archipelago, from where the full cohort of *S. lessoniana* records were reported. Each dataset consists of daily SST data for the years 2015, 2020, and 2025. These years were selected arbitrarily in order to represent regular (5-year-long) temporal intervals for comparative purposes. Data processing was conducted using Python (Python Software Foundation, 2024), with the datasets combined by calculating the daily mean across the three locations, resulting in a single consolidated daily SST time series for each year. Daily values corresponding to the months of July through December were then extracted for each year. These subsets were plotted to examine seasonal variations in SST along the eastern Maltese coast over the three-year period. This exercise was conducted given that a number of studies (e.g., Jackson and Moltschanivskyj, 2002) suggest that tropical squids exposed to prolonged periods of warming water temperatures might grow faster than squids growing through periods of cool water temperatures.

## RESULTS AND DISCUSSION

A total of 11 separate citizen science records of *Sepioteuthis lessoniana*, corresponding to a total of 14 individuals of the species, were received between the 25<sup>th</sup> October 2025 and the 10<sup>th</sup> January 2026 and these are collated in Fig. 1. Such an upsurge in validated reports of this NIS was deemed anomalous given that the species had only been recorded for the first time from Maltese waters just three months earlier, on the 15<sup>th</sup> July 2025.

The majority of the records (9 out of 11) putatively referred to male specimens, and all individuals were caught or observed in very shallow, coastal waters characterised by a rocky or heterogeneous seabed. Four of the reports refer to locations within harbours, as shown in Fig. 2.

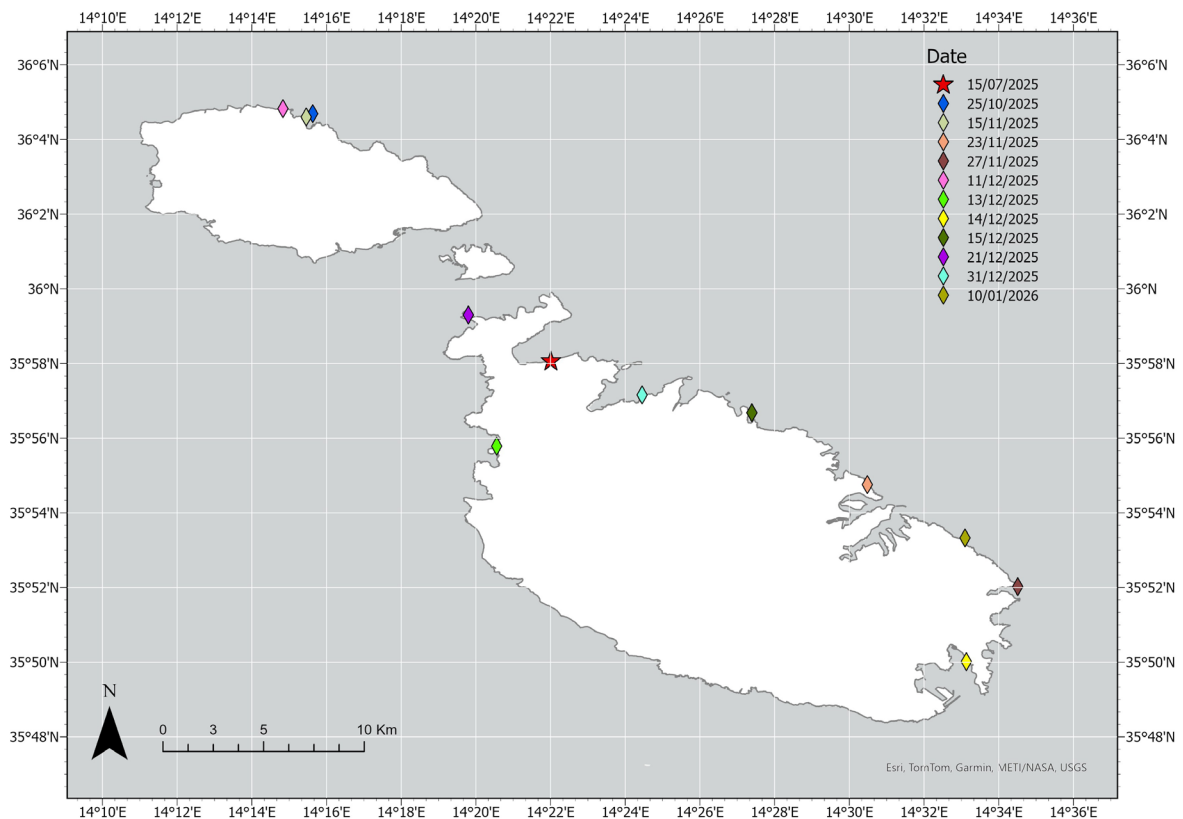
The data for these records is summarised in Table 1, which indicates that the majority (10 out of 11) of the records consisted of catches made from shore through angling by recreational fishers practicing the popular fishing technique called "eging", whilst the remaining two records consisted of an observation made from land as well as a catch by a spear-fisher. The first record included in Table 1 has been published in Marrone *et al.* (2025).

The mantle length ranged between 10.6 cm and 26.0 cm, suggesting that the recorded individuals were either adults or sub-adults, but not juveniles, according to the morphometric data collected for the species by Jackson and Moltschanivskyj (2002). Applying the age-length relationships provided by the same authors, the tentative age of the smallest and largest *S. lessoniana* specimens recorded in the present study is estimated to range approximately between 50 days and 150 days, respectively, suggesting an inseminating spawning episode taking place in late spring or early summer in Maltese or in contiguous waters already colonised by the species. This hypothesis is consistent with the multiple spawning nature of *S. lessoniana* (Sivashanthini *et al.*, 2010). One must recommend caution, however, in applying these relationships given that they were computed on the basis of *S. lessoniana* individuals sampled within tropical waters off Queensland, Australia and off Thailand, where sea temperatures ranged between 23 °C and 30 °C (these are higher values than autumn sea temperature values recorded off Malta) and whose productivity is notoriously higher than that of Mediterranean waters.

The comparative SST analysis for the waters off the eastern coast of Malta for the summer of 2015, 2020 and 2025 tentatively reveals a warming signal in the most recent years, with mean sea surface temperatures in 2020 and 2025 being generally higher than those recorded in 2015. This difference is particularly evident during the months of September, early October, and December, when SST values in 2020 and 2025 were approximately 1 °C higher than in 2015 (Fig. 3). These observations are consistent with the widely-reported warming trend for the Mediterranean Sea (e.g., Pastor *et al.*, 2020).



**Fig. 1.** Photographs pertaining to all eleven *Sepioteuthis lessoniana* citizen science reports included in this study: 15/07/2025 first documented record in Malta (see Marrone *et al.*, 2025) (A); 25/10/2025 (B); 15/11/2025 (C); 23/11/2025 (D); 27/11/2025 (E); 11/12/2025 (F); 13/12/2025 (G); 14/12/2025 (H); 15/12/2025 (I); 21/12/2025 (J); 31/12/2025 (K); 10/01/2026 (L). Details in Table 1.



**Fig. 2.** Map of the records of *Sepioteuthis lessoniana* in the Maltese archipelago with the related date of capture. The star represents the first record reported in Marrone et al. (2025).

Such elevated late-summer and autumn temperatures are noteworthy in the context of the present records of *S. lessoniana*, given that the species is of tropical Indo-Pacific origin and is known to exhibit enhanced growth rates and prolonged activity periods under warmer thermal regimes (Jackson and Moltschanivskyj, 2002). While the present study does not attempt to establish a direct causal relationship between increased SST and the observed rapid increase in records, the persistence of warmer conditions into early autumn and winter may have contributed to extending the temporal window of habitat suitability for the species within Maltese coastal waters.

Martínez et al. (2024) recently provided a synthesis of Mediterranean Sea surface currents. This study indicates a high degree of confluence of surface waters between the south Adriatic, waters off the eastern coast of Malta (i.e., in the western Ionian) and waters off Libya and Tunisia, both in the months of July and in December. This high degree of hydrodynamic connectivity suggests that the prevailing direction of sea surface currents could have facilitated the colonisation of Maltese waters by a pelagic species such as *S. lessoniana*. An alternative hypothesised introduction pathway for the species to Maltese waters could be shipping, with larval and juvenile stages possibly transported within ship ballast tanks. This pathway cannot be completely discounted given the status of the Malta-Sicily Channel (Mizzi et

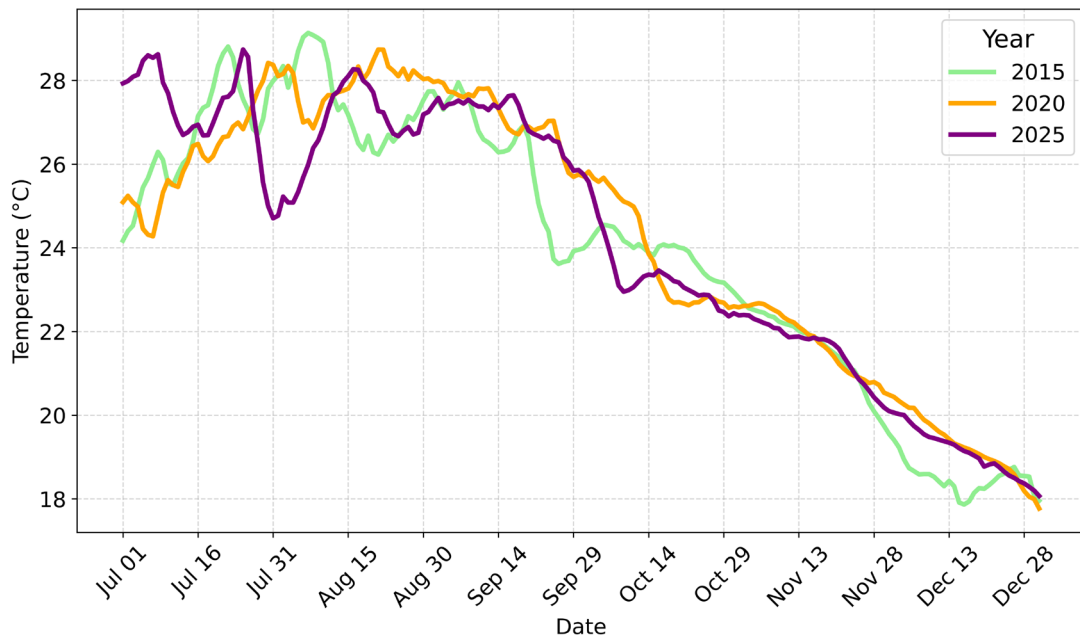
al., 2024) as a key shipping corridor, putatively including shipping traffic of an Erythrean or an Indo-Pacific provenance.

The present study also highlights the critical role of citizen science in the early detection and documentation of rapid non-indigenous species proliferation events, with this role being underscored within a substantial number of publications (e.g., Earp and Liconti, 2019; Kousteni et al., 2022). Citizen science has already been deployed on a number of occasions for documenting the expansion of a number of non-indigenous fish species, including *Fistularia commersonii* (Deidun and Germanà, 2011), *Stephanolepis diaspros* (Deidun et al., 2015) and *Lagocephalus guentheri* (Deidun et al., 2024) as well as of non-indigenous scyphozoans such as *Cassiopea andromeda* (Deidun et al., 2018).

The dense temporal clustering of *S. lessoniana* records within a three-month timeframe would have been extremely unlikely to emerge through conventional scientific monitoring programmes alone, particularly given the species' relatively short life cycle and shallow coastal habitat use. The 'Spot the Alien' campaign effectively functioned as an early-warning system, allowing the transition from a single first record to the recognition of a widespread coastal presence to be documented in near real time, witnessing the potential of a NIS to further establish itself within an invaded area.

**Table 1.** Data for all the Maltese *Sepioteuthis lessoniana* reports included in this study (July 2025-January 2026). N: number of individuals; TL: total length, including tentacles; ML: mantle length; NP: measurement not feasible. (See Fig. 1).

Photo ref.	Coordinates of the site of the report	Date of observation	N	Method of capture or observation	TL (cm)	ML (cm)
A	35° 58' 04.80" N 14° 22' 00.60" E	15/07/2025	2	spearfishing	65.4	26.0
B	36° 04' 41.64" N 14° 15' 34.68" E	25/10/2025	2	observed from land	NP	NP
C	36° 04' 36.25" N 14° 15' 27.42" E	15/11/2025	2	angling	NP	NP
D	35° 54' 45.40" N 14° 30' 28.99" E	23/11/2025	1	angling	16.3	11.7
E	35° 52' 01.45" N 14° 34' 30.60" E	27/11/2025	1	angling	39.4	16.7
F	36° 04' 49.61" N 14° 14' 50.04" E	11/12/2025	1	angling	NP	NP
G	35° 55' 47.30" N 14° 20' 33.43" E	13/12/2025	1	angling	NP	NP
H	35° 50' 00.88" N 14° 33' 08.05" E	14/12/2025	1	angling	NP	NP
I	35° 56' 40.93" N 14° 27' 23.46" E	15/12/2025	2	angling	NP	NP
J	35° 59' 18.09" N 14° 19' 47.91" E	21/12/2025	1	angling	41.4	22.8
K	35° 57' 09.55" N 14° 24' 27.08" E	31/12/2025	1	angling	17.5	10.6
L	35° 53' 19.68" N 14° 33' 05.92" E	10/01/2026	1	angling	24.5	16.4



**Fig. 3.** Daily average sea surface temperature (SST) for the years 2015 (green), 2020 (orange) and 2025 (purple) for the time frames July-December.

## CONCLUSIONS

The anomalously rapid proliferation along the entire length of the eastern Maltese Islands coastline (along with a single location along the western coastline of the island of Malta) should serve as an early-warning signal to national environmental management and fisheries authorities by virtue of the implicit fast establishment of the species at the local level. The present study further demonstrates that sustained citizen science programmes, such as ‘Spot the Alien’, are essential tools for the early detection, tracking, and assessment of non-indigenous marine species in the rapidly changing Mediterranean Sea.

## ACKNOWLEDGEMENTS

The authors are indebted to the citizen scientists who have contributed to this study through the submission of their reports.

## REFERENCES

- Bello, G., Andaloro, F., Battaglia, P. 2020. Non-indigenous cephalopods in the Mediterranean Sea: A review. *Acta Adriatica*, 61(2), 113-134. <https://doi.org/10.32582/aa.61.2.1>
- Deidun, A., Germanà, A. 2011. On the increasing occurrence of the bluespotted cornetfish *Fistularia commersonii* (Rüppel, 1838) in the central Mediterranean (Osteichthyes, Fistulariidae). *Biodiversity Journal*, 2(1), 19-26.
- Deidun, A., Castriota, L., Falautano, M. 2015. Documenting the occurrence of the Lessepsian fish *Stephanolepis diaspros* within the Strait of Sicily, Central Mediterranean. *Journal of Black Sea/Mediterranean Environment*, 21(1), 1-11.
- Deidun, A., Gauci, A., Sciberras, A., Piraino, S. 2018. Back with a bang—an unexpected massive bloom of *Cassiopea andromeda* (Forsk., 1775) in the Maltese Islands, nine years after its first appearance. *BioInvasions Records*, 7(4), 399-404. <https://doi.org/10.3391/bir.2018.7.4.07>
- Deidun, A., Insacco, G., Galdies, J., Balistreri, P., Zava, B. 2021. Tapping into hard-to-get information: The contribution of citizen science campaigns for updating knowledge on range-expanding, introduced and rare native marine species in the Malta-Sicily Channel. *BioInvasions Records*, 10(2), 257-269.
- Deidun, A., Corsini-Foka, M., Marrone, A., Galdies, J., Zava, B., Crobe, V., Tinti, F. 2024. Yet another non-indigenous fish from Maltese waters, central Mediterranean: A first record of *Lagocephalus guentheri* Miranda Ribeiro, 1915 (Tetraodontiformes, Tetraodontidae). *BioInvasions Records*, 13(3), 777-786. <https://doi.org/10.3391/bir.2024.13.3.16>
- Earp, H.S., Liconti, A. 2019. Science for the future: The use of citizen science in marine research and conservation. *In* YOU MARES 9 - The oceans: Our research, our future (eds. S. Jungblut, V. Liebich, M. Bode-Dalby). Springer, Cham. pp. 1-19. [https://doi.org/10.1007/978-3-030-20389-4\\_1](https://doi.org/10.1007/978-3-030-20389-4_1)
- Escudier, R., Clementi, E., Omar, M., Cipollone, A., Pistoia, J., Aydogdu, A., Drudi, M., et al. 2020. Mediterranean Sea physical reanalysis (CMEMS MED-Currents) (Version 1) [Data set]. Copernicus Monitoring Environment Marine Service (CMEMS). [https://doi.org/10.25423/CMCC/MEDSEA\\_MULTIYEAR\\_PHY\\_006\\_004\\_E3R1](https://doi.org/10.25423/CMCC/MEDSEA_MULTIYEAR_PHY_006_004_E3R1)
- Jackson, G., Moltschanivskyj, N. 2002. Spatial and temporal variation in growth rates and maturity in the Indo-Pacific squid *Sepioteuthis lessoniana* (Cephalopoda: Loliginidae). *Marine Biology*, 140(4), 747-754. <https://doi.org/10.1007/s00227-001-0746-9>
- Jereb, P., Roper, C.F.E. (Eds.) 2010. Cephalopods of the world: An annotated and illustrated catalogue of cephalopod species known to date; Myopsid and Oegopsid squids. FAO Species Catalogue for Fishery Purposes. FAO, 605 pp.
- Kleitou, P., Moutopoulos, D.K., Giovos, I., Kletou, D., Savva, I., Cai, L.L., Hall-Spencer, J.M., et al. 2022. Conflicting interests and growing importance of non-indigenous species in commercial and recreational fisheries of the Mediterranean Sea. *Fisheries Management and Ecology*, 29(2), 169-182. <https://doi.org/10.1111/fme.12531>
- Kousteni, V., Tsiamis, K., Gervasini, E., Zenetos, A., Karachle, P.K., Cardoso, A.C. 2022. Citizen scientists contributing to alien species detection: The case of fishes and mollusks in European marine waters. *Ecosphere*, 13(1), e03875. <https://doi.org/10.1002/ecs2.3875>
- Marrone, A., Deidun, A., Corsini-Foka, M., Zava, B., Tinto, E., Rizzo, C., Battaglia, P. 2025. First record of *Sepioteuthis lessoniana* from the Maltese archipelago, with further notes on its occurrence in the Central Mediterranean Sea. *Journal of Marine Science and Engineering*, 13(9), 1783. <https://doi.org/10.3390/jmse13091783>
- Martínez, J., García-Ladona, E., Ballabrera-Poy, J., Isern-Fontanet, J., González-Motos, S., Allegue, J.M., González-Haro, C. 2024. Atlas of surface currents in the Mediterranean and Canary-Iberian-Biscay waters. *Journal of Operational Oceanography*, 17(1), 40-62. <https://doi.org/10.1080/1755876X.2022.2102357>
- Mizzi, M., Deidun, A., Gauci, A., Gauci, R. 2024. The impact of anchoring on seafloor integrity: An integrated assessment within a major bunkering area of the Maltese Islands. *Geographies*, 4(4), 612-629. <https://doi.org/10.3390/geographies4040033>
- Pastor, F., Valiente, J.A., Khodayar, S. 2020. A warming Mediterranean: 38 years of increasing sea surface temperature. *Remote Sensing*, 12(17), 2687. <https://doi.org/10.3390/rs12172687>
- Python Software Foundation. 2024. Python (Version 3.x) [Computer software]. <https://www.python.org/>
- Salman, A. 2002. New report of the loliginid squid *Sepioteuthis lessoniana* Lesson, 1830 in the Mediterranean. *Israel Journal of Zoology*, 48, 249-250.
- Schneider, C.A., Rasband, W.S., Eliceiri, K.W. 2012. NIH Image to ImageJ: 25 years of image analysis. *Nature Methods*, 9(7), 671-675. <https://doi.org/10.1038/nmeth.2089>
- Sivashanthini, K., Thulasitha, W.S., Charles, G.A. 2010. Reproductive characteristics of squid *Sepioteuthis lessoniana* (Lesson, 1830) from the northern coast of Sri Lanka. *Journal of Fisheries and Aquatic Science*, 5(1), 12-22. <https://doi.org/10.3923/jfas.2010.12.22>