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**RESEARCH ARTICLE**

# Seasonal trend of nudibranchs (Gastropoda, Heterobranchia) along the central-eastern coast of Sicily (Mediterranean Sea)

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**Abstract**

To date, specific studies on the seasonality of Mediterranean nudibranchs are still rather scarce. In the present study, we investigated the trend of seasonal variations in the number of nudibranch species from 2018 to 2021 in three sites located along the central-eastern coast of Sicily (Italy). Data on the seasonality were collected by photographing all nudibranch species encountered during the scuba dives performed in the study sites. Then, for each site, it was selected randomly one dive for every month, from which the number of found nudibranch species was counted. In all the examined sites, it was noted that the number of nudibranch species varies with a marked seasonal trend throughout the year: the number of species increases from mid-late autumn until spring (the season with the highest number of species). By contrast, between late spring and early summer this number begins to decline, decreasing considerably during summer and early autumn, the seasons in which there is the lowest value. This trend may be correlated with both the seasonality of sessile benthic suspension feeders, the main nudibranch preys, and the seasonal variations in the water column throughout the year.

**Keywords**: Marine Heterobranchia, Nudibranchia, seasonality, sessile benthic suspension feeders

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## Introduction

The term seasonality is generally intended as “the fact that something changes according to the time of the year” (Cambridge Dictionary 2022) or more precisely

"the property or feature of being dependent upon, related or restricted to, or varying with climatic seasons" (Hart 1985). Consequently, every event defined as seasonal is strictly correlated and dependent upon changes of various nature, which manifest during the year. In practice, each biotic and abiotic component of a certain ecosystem is subjected to seasonality. This latter is evident in almost everything around us and there are multiple examples of that: from viruses (Shek and Lee 2003) to cetaceans (Higdon *et al.* 2011), from rivers (Iglesias and Carballo 2011) to seas (Tziperman and Malanotte-Rizzoli 1991; Kahru *et al.* 2016).

Marine ecosystems do not constitute an exception to this. Indeed, these environments are prone to remarkable changes throughout the year, which consequently cause seasonality in the biological cycles of marine organisms (Coma *et al.* 2000). Probably, the marine invertebrates that suffer most from these variations are the sessile benthic suspension feeders (e.g., cnidarians, tunicates and sponges) (Coma *et al.* 2000).

In the Mediterranean Sea, these organisms generally show a seasonal cycle that involves high growth and reproduction rates during winter-spring and a marked decrease in life activities during the summer (aestivation) (Boero and Fresi 1986, Boero *et al.* 1986, Turon 1992, Turon and Becerro 1992, Coma *et al.* 1998, 2000). This seasonal cycle is caused by an ensemble of physical factors (light, temperature and seawater stratification) that overall, through a chain effect, produce a drastic fall of the organic suspended matter (on which these organisms feed) in summer (Coma *et al.* 2000). Nevertheless, it was highlighted that studies on the seasonality of marine Mediterranean ecosystems are still scarce and thus, although it is evident that sessile benthic suspension feeders present this seasonal pattern, there is a need for further research to understand if the aestivation is a diffuse phenomenon also in other organisms of warm-temperate waters (Coma *et al.* 2000).

The principal predators of sessile benthic suspension feeders are without any doubt the nudibranchs. Due to the flamboyant colours and shapes, this order of gastropod molluscs represents one of the most wanted groups of marine organisms by underwater photographers worldwide. This is evident due to the high number of books [e.g. (Valdés *et al.* 2006, Betti 2011, Trainito and Doneddu 2014, Burn 2015, Naya Garmendia 2016, Gosliner *et al.* 2018, Prkić *et al.* 2018, Ballesteros *et al.* 2019)] and websites [e.g. (Rudman 1998-2010, Ballesteros *et al.* 2012-2022)] dedicated to them. The order Nudibranchia, with about 3000 species (Valdés 2004, Goodheart 2017), is the most numerous and various group among marine heterobranchs (Willan 1998). All its members present generally the following four features (Wägele and Willan 2000): solid rhinophores, absence of shell (in the post-larval stage), pericardic complex longitudinally oriented and presence of a specialized vacuolized epithelium.

Nudibranchs are divided into two suborders: Cladobranchia and Doridina. The formers have the anus located along the right side of the body and "respiratory" structures produced by tegument eversions (generally called cerata) (Willan and Morton 1984). According to the group, cladobranchs can feed on anthozoans, hydrozoans, scyphozoans, bryozoans, molluscs (also nudibranchs) and other invertebrates (Thompson and Brown 1984, McDonald and Nybakken 1997). The members of Doridina have the notum that extends beneath the head, surrounding the rhinophores during animal development. Moreover, the anus, nephropore and gills are in postero-medial position (Wägele and Willan 2000). According to the group, dorids normally feed on sponges, bryozoans, barnacles, tunicates, polychaetes and other nudibranchs (Thompson and Brown 1984, McDonald and Nybakken 1997).

In recent years the east coast of Sicily (Italy) has been the subject of some seasonal and faunal studies on nudibranchs (Lombardo 2021, Lombardo and Marletta 2020a, 2022). Regarding the seasonality, in this area it was conducted a total of four studies on the abundance of individuals of the most common species along this coast throughout the seasons/months: the cladobranchs *Edmundsella pedata* (Montagu, 1816) (Lombardo *et al.* 2020), *Cratena peregrina* (Gmelin, 1791), *Flabellina affinis* (Gmelin, 1791) (Lombardo and Marletta 2020b), *Nemesignis banyulensis* (Portmann & Sandmeier, 1960) (Lombardo and Marletta 2021a) and the dorid *Peltodoris atromaculata* Bergh, 1880 (Lombardo and Marletta 2021b). Nevertheless, currently, in this area studies on the overall seasonality of the order Nudibranchia (which consider the total variation in the number of species throughout the year) have not yet been carried out. Consequently, the aim of the present paper was to highlight if this group is comprehensively characterized by an annual seasonal trend in the variation of the number of species and, whether this trend follows the general seasonal trend reported by Coma *et al.* (2000) for their preys, the sessile benthic suspension feeders.

**Materials and Methods**

The present study was carried out using part of data collected through a total of 221 scuba dives conducted from January 2018 to December 2021 in three sites located along the central-eastern coast of Sicily (Figure 1): Ognina (37°31'50.4"N – 15°07'10.8"E), Santa Maria La Scala (37°36'46.5"N – 15°10'31.4" E) and Scalo Pennisi (37°38'23.2"N – 15°11' 04.6"E).

The site of Ognina (the southernmost) is located within the municipality of Catania and is the most anthropized among the study areas. The coastal strip where this site falls presents a high number of apartment buildings, a harbor and a manifold. The northernmost site, Scalo Pennisi, is located within the hamlet of Santa Tecla, in the municipality of Acireale. This area shows the best environmental conditions among the study sites. Indeed, there are only a few residences and a small marina used exclusively during the summer. Finally, Santa

Maria La Scala, located, between the abovementioned sites, within the homonymous hamlet of the municipality of Acireale, presents intermediate environmental conditions. In this site, there is a marina and drainage pump releasing fresh water into the sea.

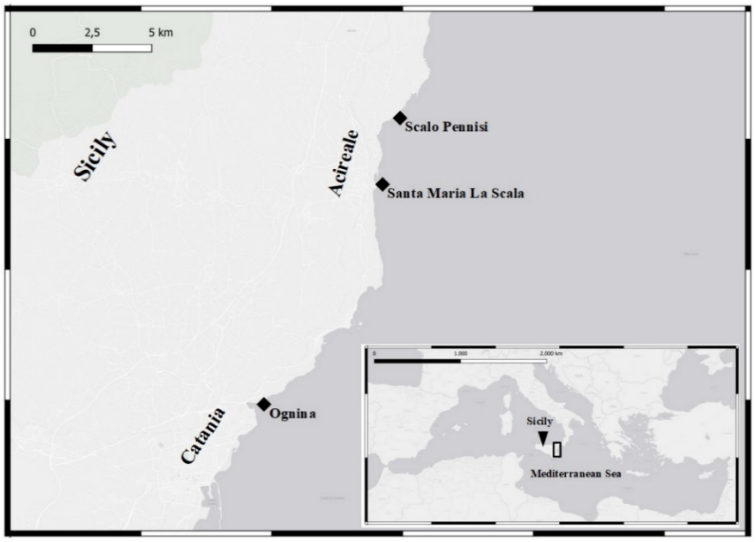


**Figure 1.** Geographical location of the study areas.

Data on the seasonality were collected by photographing all nudibranch species encountered during the scuba dives performed in the study sites (Figures 2 – 5) using the same technique described in Lombardo (2021) and Lombardo and Marletta (2022): scuba dives (87 at Ognina, 85 at Santa Maria La Scala and 49 at Scalo Pennisi), of the duration of 90 minutes, were performed between 9:00 and 11:30 a.m., twice a week (marine-weather conditions allowing). For each site, it was always conducted the same underwater path during which all the nudibranch specimens encountered were photographed through an Olympus TG-4 by one of the authors (A. Lombardo).

For the identification of nudibranch species, the following texts were mainly consulted: Schmekel and Portmann (1982), Trainito and Doneddu (2014). Subsequently, for each site, it was chosen randomly one dive for every month (in total 44 scuba dives for each study area), from which the number of found nudibranch species was counted.

The Analysis of Variance (ANOVA) was performed through Jamovi software version 2.3 to compare the number of species for every month, year and season at each site. Due to Covid-19 pandemic, it was not possible to perform scuba dives during April 2020, thus the values corresponding to this month for each site were calculated as the average value of April of the other years.

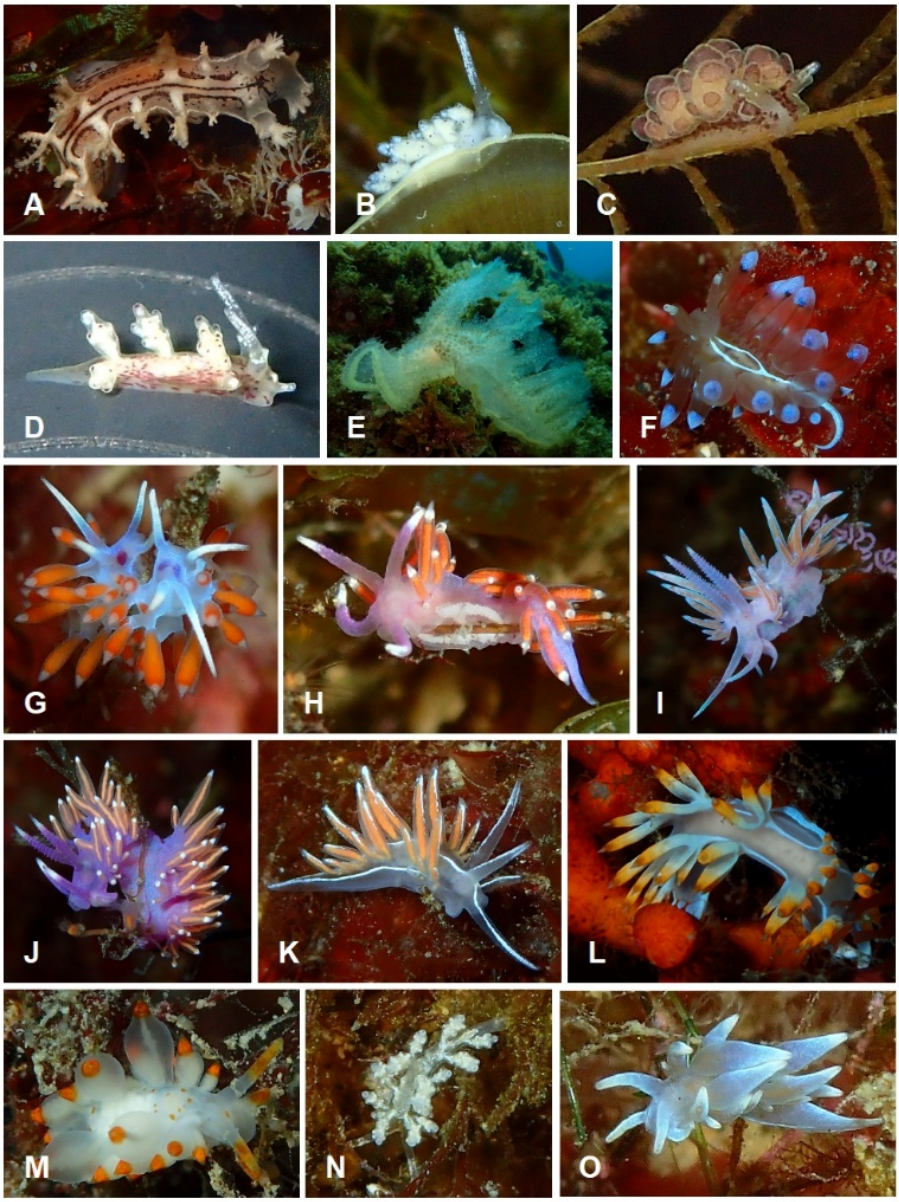


**Figure 2.** Photos of cladobranch nudibranch species I: (A) *Duvaucelia manicata*; (B) *Doto acuta*; (C) *D. floridicola*; (D) *D. maculata*; (E) *Melibe viridis*; (F) *Antiopella cristata*; (G) *Calmella* cf. *cavolini*; (H) *Edmundsella pedata*; (I) *Flabellina affinis*; (J) *Paraflabellina ischitana*; (K) *Coryphella lineata*; (L) *Luisella babai*; (M) *Amphorina farrani*; (N) *Capellinia doriae*; (O) *Eubranchus tricolor*


**Figure 3.** Photos of cladobranch nudibranch species II: (A) *Trinchesia caerulea*; (B) *T. foliata*; (C) *T. genovae*; (D) *T. morrowae*; (E) *T. ocellata*; (F) *Trinchesia* sp.; (G) *Embletonia pulchra*; (H) *Cratena peregrina*; (I) *Dicata odhneri*; (J) *Facelina annulicornis*; (K) *F. rubrovittata*; (L) *Facelinopsis marioni*; (M) *Favorinus branchialis*; (N) *Godiva quadricolor*; (O) *Nemesignis banyulensis*; (P) *Berghia coerulescens*; (Q) *Berghia* sp.; (R) *B. verrucicornis*; (S) *Limenandra nodosa*; (T) *Spurilla neapolitana*; (U) Eolid sp. 1.

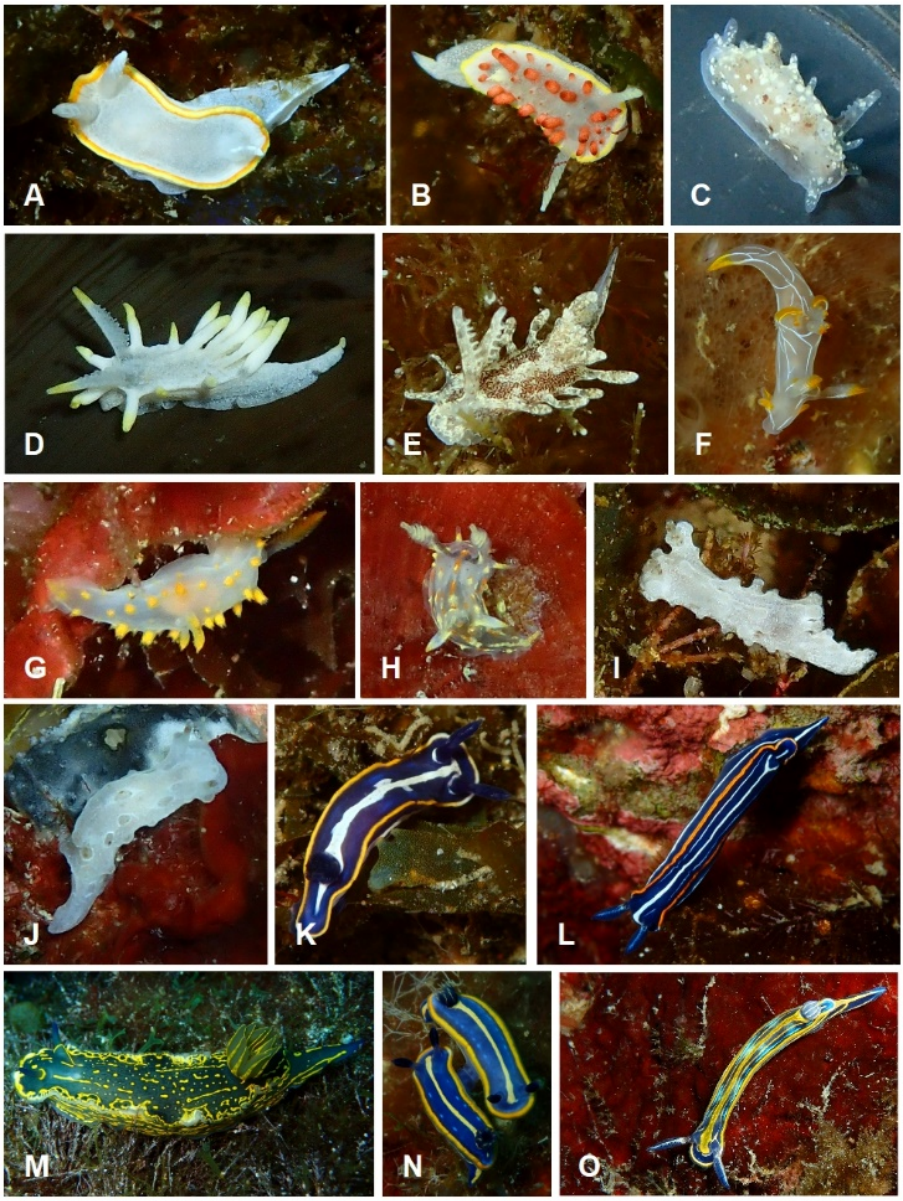


**Figure 4.** Photos of dorid nudibranch species I: (A) *Diaphorodoris alba*; (B) *D. papillata*; (C) *Okenia longiductis*; (D) *O. picoensis*; (E) *O. problematica*; (F) *Trapania lineata*; (G) *Crimora papillata*; (H) *Polycera quadrilineata*; (I) *Aegires leuckartii*; (J) *A. sublaevis*; (K) *Felimare fontandraui*; (L) *F. gasconi*; (M) *F. picta*; (N) *F. tricolor*; (O) *Felimare villafranca*

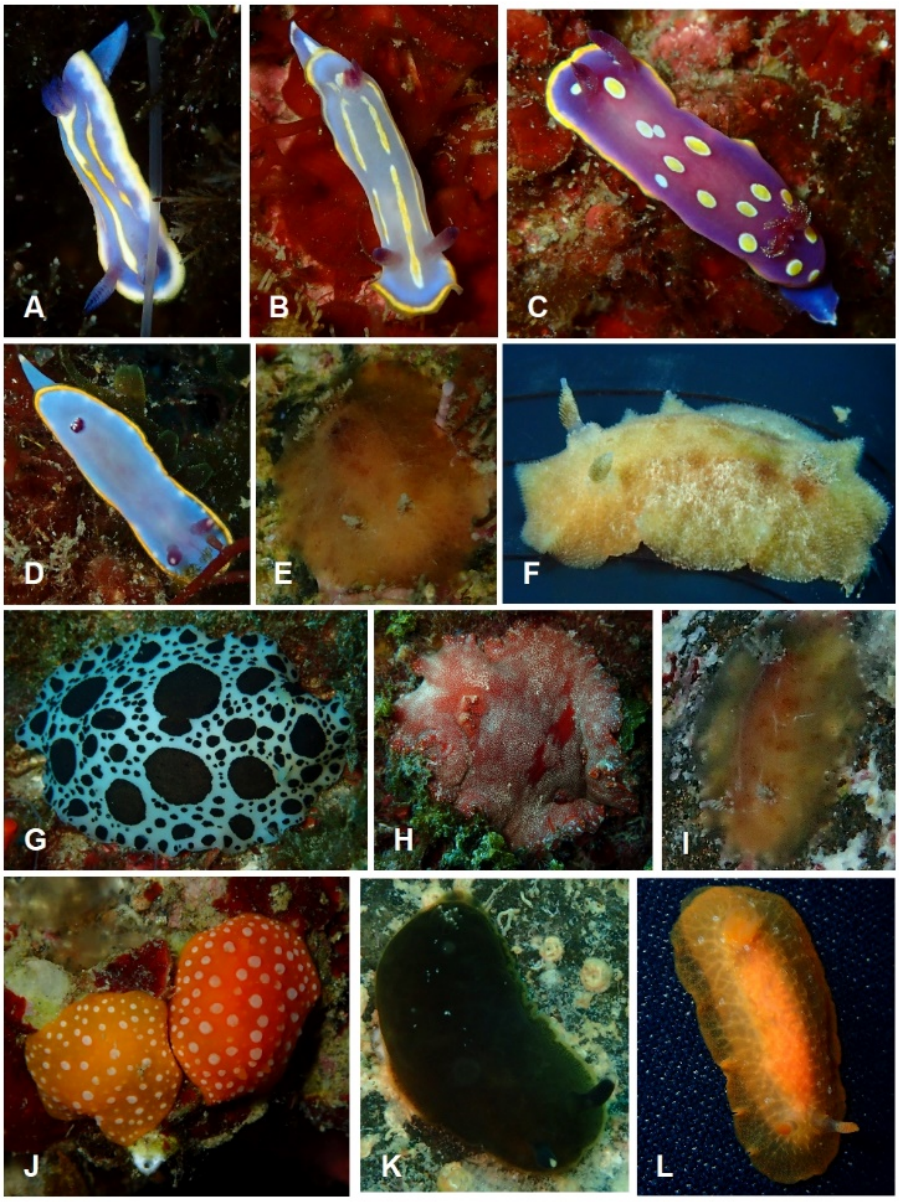


**Figure 5.** Photos of dorid nudibranch species II: (A) *Felimida binza*; (B) *F. krohni*; (C) *F. luteorosea*; (D) *F. purpurea*; (E) *Geitodoris portmanni*; (F) *Jorunna tomentosa*; (G) *Peltodoris atromaculata*; (H) *Platydoris argo*; (I) *Taringa tritorquis*; (J) *Phyllidia flava*; (K) *Dendrodoris limbata*; (L) *Doriopsilla rarispinosa*

## Results

For every site, it was produced a line chart (Figure 6, 8 and 10), which shows the seasonal trend in the number of species over the months of the years. Moreover, for each study area, it was also realized a bar plot (Figure 7, 9 and 11) depicting the trends of the number of species during the seasons of the years. For these plots, the seasons were considered as follows: winter (January + February + March), spring (April + May + June), summer (July + August + September) and autumn (October + November + December).

*Ognina*

At Ognina the variations in the number of nudibranch species showed almost the same trend among the years of study. Particularly in 2018 and 2021, the number of species increased from March to May and then dropped from June to November. In 2019, it was high in May and minorly also in August. Finally, during 2020, greater values were observed in April and June (Figure 6). Collectively, the highest number of species was always observed in all years during spring, while lower values were found in the other seasons. In particular, during each year the lowest number of nudibranch species was detected in autumn (Figure 7).

Through the ANOVA analysis, it was noted that at Ognina, the variations in the number of species observed over the months and seasons had a high statistical significance ($p<0.001$) while the differences observed over the years were not significant ($p=0.236$) (Table 1).

Table 4 reports the list of the species (42 in total) found at Ognina with the respective season/s of finding for each species.

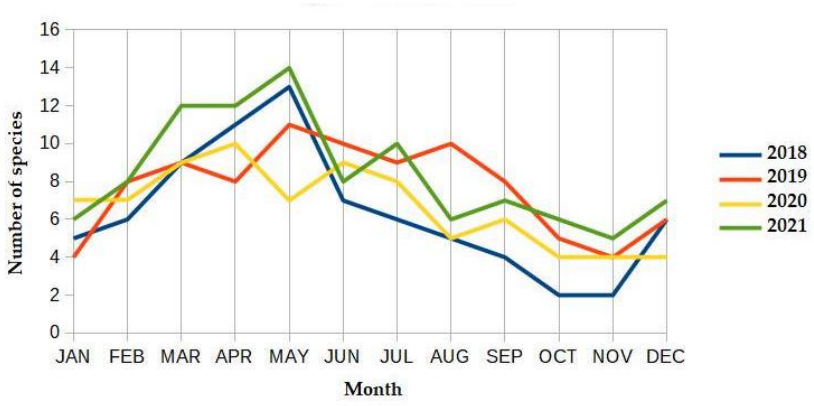


**Figure 6.** Variations in the number of nudibranch species over the months and the years at Ognina

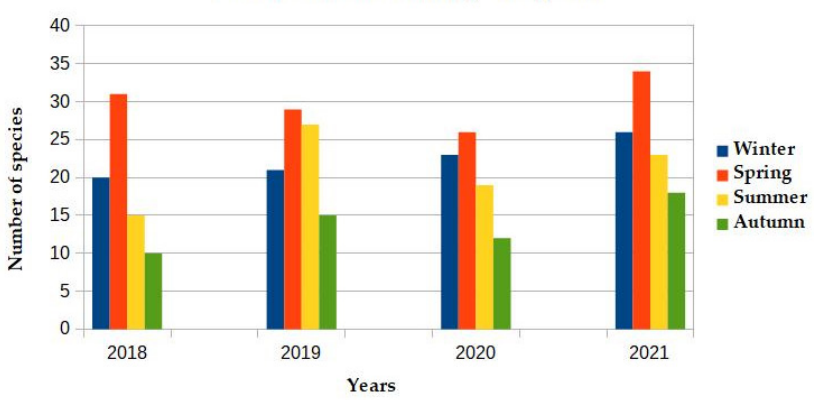


**Figure 7.** Variations in the number of species during the seasons from 2018 to 2021 at Ognina

**Table 1.** ANOVA for the number of species at Ognina

| | Sum of Squares | df | Mean Square | F | p |
|---|---|---|---|---|---|
| **Month** | 248 | 11 | 22.52 | 7.39 | <0.001 |
| **Year** | 32.6 | 3 | 10.85 | 1.47 | 0.236 |
| **Season** | 533 | 3 | 177.6 | 12.4 | <0.001 |

*Santa Maria La Scala*

In this site, the trends of variations in the number of nudibranch species during the months were comparable among years. Indeed, 2018, 2019 and 2021 showed an increment from January to May (which was the month with the highest number of species) and then a decline that started approximately from June and continued until October. In 2020, the variations in the number of species over the months were less evident than the other years, even though they followed the same trend (Figure 8). Overall, the season with the highest number of nudibranch species was spring during all the years of study, while it was noted a drop during summer and autumn (Figure 9).

The ANOVA analysis showed that at Santa Maria La Scala there were significant differences in the number of species over months and seasons ($p<0.001$), but not significant over the years ($p=0.659$) (Table 2).

Table 4 reports the list of the species (53 in total) found at Santa Maria La Scala with the respective season/s of finding for each species.

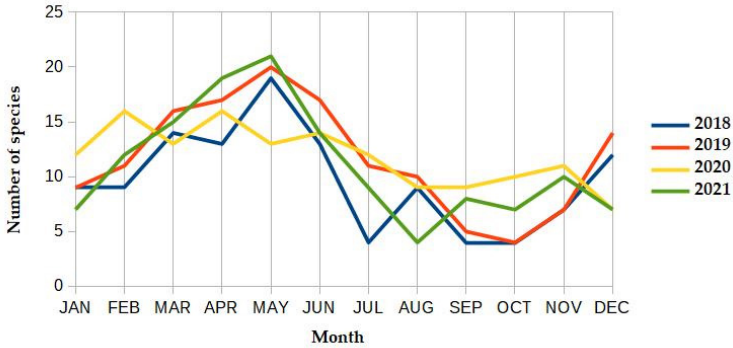


**Figure 8.** Variations in the number of nudibranch species over the months and the years at Santa Maria La Scala

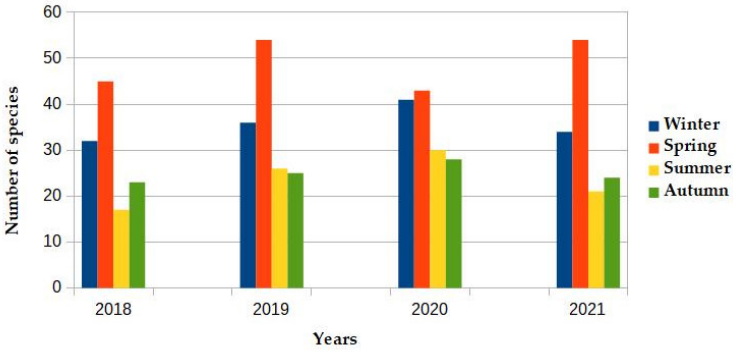


**Figure 9.** Variations in the number of species during the seasons from 2018 to 2021 at Santa Maria La Scala

**Table 2.** ANOVA for the number of species at Santa Maria La Scala

| | Sum of Squares | df | Mean Square | F | p |
|---|---|---|---|---|---|
| **Month** | 682 | 11 | 61.98 | 8.49 | <0.001 |
| **Year** | 33.4 | 3 | 11.1 | 0.538 | 0.659 |
| **Season** | 1670 | 3 | 556.6 | 25.9 | <0.001 |

*Scalo Pennisi*

At Scalo Pennisi, the variations in the number of nudibranch species during the months were similar among the years of study. The trends of 2018 and 2019 were almost identical with an increase from April to May (month presenting the highest number of species) and then a fall from June onwards. The trends of 2020 and 2021 were slightly different from the previous ones. Indeed, 2020 showed a remarkable number of species in February and June and then a decrease until September. In 2021, it was noted a high number of species between March and April, although the peak was observed in June, after which there was a decline

until October (Figure 10). Comprehensively, the season showing the highest number of species was spring. Only in 2020, a greater value was observed in winter, even though it was comparable to that of spring. Conversely, summer and autumn presented a lower number of species (Figure 11).

The ANOVA highlighted that at Scalo Pennisi there was a significant difference in the number of species over months ($p<0.001$) and seasons ($p = 0.005$) but it did not vary significantly over the years ($p = 0.083$) (Table 3).

Table 4 reports the list of the species (50 in total) found at Scalo Pennisi with the respective season/s of finding for each species.

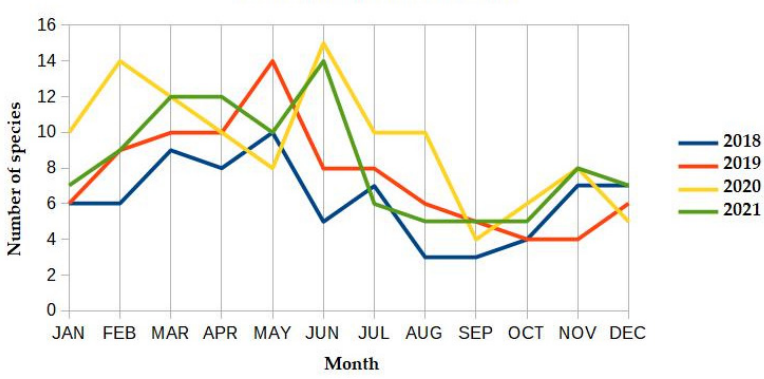


**Figure 10.** Variations in the number of nudibranch species over the months and the years at Scalo Pennisi

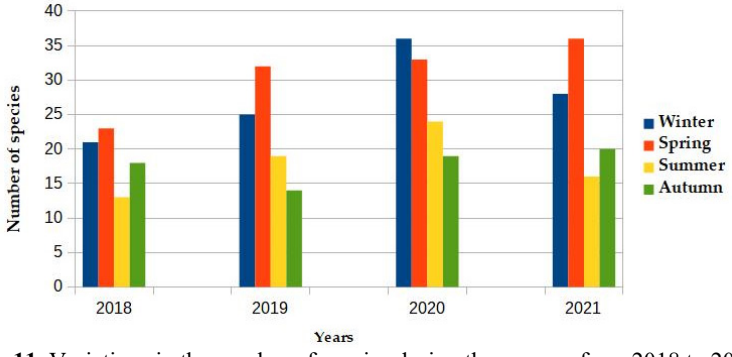


**Figure 11.** Variations in the number of species during the seasons from 2018 to 2021 at Scalo Pennisi

**Table 3.** ANOVA for the number of species at Scalo Pennisi

| | Sum of Squares | df | Mean Square | F | p |
|---|---|---|---|---|---|
| **Month** | 240 | 11 | 21.79 | 3.92 | <0.001 |
| **Year** | 61.4 | 3 | 20.47 | 2.38 | 0.083 |
| **Season** | 542 | 3 | 108.7 | 7.19 | 0.005 |

**Table 4.** List of the species found at Ognina, Santa Maria La Scala and Scalo Pennisi over the seasons (Win: Winter, Spr: Spring, Summ: Summer, Aut: Autumn)

| Species name | Ognina | | | | Santa Maria La Scala | | | | Scalo Pennisi | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Order Nudibranchia** | **Win** | **Spr** | **Summ** | **Aut** | **Win** | **Spr** | **Summ** | **Aut** | **Win** | **Spr** | **Summ** | **Aut** |
| **Suborder Cladobranchia** | | | | | | | | | | | | |
| **Family Tritoniidae Lamarck, 1809** | | | | | | | | | | | | |
| *Duvaucelia manicata* (Deshayes, 1853) | | | | | X | | | | | | | |
| **Family Dotidae Gray, 1853** | | | | | | | | | | | | |
| *Doto acuta* Schmekel & Kress, 1977 | X | X | | | | X | | | X | | | |
| *Doto cervicenigra* Ortea & Bouchet, 1989 | | | | | | | | | | X | | |
| *Doto floridicola* Simroth, 1888 | | | | | | X | | | | X | | |
| *Doto maculata* (Montagu, 1804) | | | | | | X | | | | | | |
| **Family Tethydidae Rafinesque,1815** | | | | | | | | | | | | |
| *Melibe viridis* (Kelaart, 1858) | | | | | | | | | | | X | |
| **Family Janolidae Pruvot-Fol, 1933** | | | | | | | | | | | | |
| *Antiopella cristata* (Delle Chiaje, 1841) | X | X | | X | X | | | | X | X | X | X |
| **Family Flabellinidae Bergh, 1889** | | | | | | | | | | | | |
| *Calmella* cf. *cavolini* (Vérany, 1846) | | X | | X | X | X | X | X | X | X | | |
| *Edmundsella pedata* (Montagu, 1816) | X | X | X | X | X | X | X | X | X | X | X | X |
| *Flabellina affinis* (Gmelin, 1791) | X | X | X | X | X | X | X | X | X | X | X | X |
| *Paraflabellina ischitana* (Hirano & T. E. Thompson, 1990) | X | | X | | X | X | X | X | X | | | X |
| **Family Coryphellidae Bergh, 1889** | | | | | | | | | | | | |
| *Coryphella lineata* (Lovén, 1846) | X | | | | X | X | | | | X | | |

**Table 4.** Continued

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Family Samlidae Korshunova, Martynov, Bakken *et al*. 2017** | | | | | | | | | | | | |
| *Luisella babai* (Schmekel, 1972) | | | | | X | X | X | X | | | | |
| **Family Eubranchidae Odhner, 1934** | | | | | | | | | | | | |
| *Amphorina farrani* (Alder & Hancock, 1844) | | X | | X | X | X | | X | X | X | | X |
| *Capellinia doriae* Trinchese, 1874 | | | | | | X | | | X | | | |
| *Eubranchus tricolor* Forbes, 1838 | X | | | | | | | | | | | |
| **Family Trinchesiidae F. Nordsieck, 1972** | | | | | | | | | | | | |
| *Trinchesia caerulea* (Montagu, 1804) | X | X | | | X | X | X | | | | | |
| *Trinchesia foliata* (Forbes & Goodsir, 1839) | X | X | X | | X | X | X | X | X | X | X | X |
| *Trinchesia genovae* (O'Donoghue, 1926) | X | X | X | | X | X | X | | X | X | | X |
| *Trinchesia morrowae* Korshunova, Picton, Furfaro *et al.* 2019 | | | | | X | X | X | X | X | | X | X |
| *Trinchesia ocellata* Schmekel, 1966 | X | | | | | X | | | X | | | |
| *Trinchesia* sp. | | X | | | | X | | | X | | | X |
| **Family Embletoniidae Pruvot-Fol, 1954** | | | | | | | | | | | | |
| *Embletonia pulchra* (Alder & Hancock, 1844) | | | | | | | | | | X | | |
| **Family Facelinidae Bergh, 1889** | | | | | | | | | | | | |
| *Cratena peregrina* (Gmelin, 1791) | X | X | X | X | X | X | X | X | X | X | X | X |
| *Dicata odhneri* Schmekel, 1967 | | X | X | X | | X | | | | X | X | X |
| *Facelina annulicornis* (Chamisso & Eysenhardt, 1821) | X | X | | | X | X | | X | X | | | |
| *Facelina rubrovittata* (Costa A., 1866) | X | X | X | | X | X | X | X | X | X | X | X |
| *Facelinopsis marioni* (Vayssière, 1888) | X | X | X | | X | X | X | X | X | X | X | X |

**Table 4.** Continued

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Favorinus branchialis* (Rathke, 1806) | | **X** | **X** | **X** | **X** | **X** | **X** | | **X** | **X** | **X** | |
| **Family Myrrhinidae Bergh, 1905** | | | | | | | | | | | | |
| *Godiva quadricolor* (Barnard, 1927) | | | | | | | | **X** | | | | |
| *Nemesignis banyulensis* (Portmann & Sandmeier, 1960) | **X** | | **X** | | **X** | **X** | **X** | **X** | **X** | **X** | | **X** |
| **Family Aeolidiidae Gray, 1827** | | | | | | | | | | | | |
| *Berghia coerulescens* (Laurillard, 1832) | | | **X** | | | **X** | | | **X** | **X** | **X** | |
| *Berghia* sp. | | | | | | **X** | | | | | | |
| *Berghia verrucicornis* (A. Costa, 1867) | | | **X** | | | | | | | | | |
| *Limenandra nodosa* Haefelfinger & Stamm, 1958 | | | | | | | **X** | | **X** | | **X** | |
| *Spurilla neapolitana* (Delle Chiaje, 1841) | | | | | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| Eolid sp. 1 | | | | | | | | **X** | | | | |
| **Suborder Doridina** | | | | | | | | | | | | |
| **Family Calycidorididae Roginskaya, 1972** | | | | | | | | | | | | |
| *Diaphorodoris alba* Portmann & Sandmeier, 1960 | **X** | **X** | **X** | | | **X** | **X** | **X** | **X** | **X** | **X** | |
| *Diaphorodoris papillata* Portmann & Sandmeier, 1960 | **X** | **X** | **X** | **X** | **X** | **X** | **X** | | **X** | **X** | **X** | **X** |
| **Family Goniodoridae H. Adams & A. Adams, 1854** | | | | | | | | | | | | |
| *Okenia longiductis* Pola, Pa-sedano, Macali *et al.* 2019 | | | | | | | **X** | | | | **X** | |
| *Okenia picoensis* Paz-Sedano, Ortigosa & Pola, 2017 | **X** | | | | | | | | | **X** | **X** | **X** |
| *Okenia problematica* Pola, Paz-Sedano, Macali *et al.* 2019 | | **X** | | | | | | | | | | |

**Table 4.** Continued

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Trapania lineata* Haefelfinger, 1960 | | | | | X | X | | | X | X | | |
| **Family Polyceridae Alder & Hancock, 1845** | | | | | | | | | | | | |
| *Crimora papillata* Alder & Hancock, 1862 | | | | | | | | | X | | | |
| *Polycera quadrilineata* (O.F. Müller, 1776) | X | X | | X | X | X | | X | X | X | | X |
| **Family Aegiridae P. Fischer, 1883** | | | | | | | | | | | | |
| *Aegires leuckartii* Vérany, 1853 | | | X | | X | X | X | | | X | | X |
| *Aegires sublaevis* Odhner, 1932 | X | | | | | | | | | | | |
| **Family Chromodorididae Bergh, 1891** | | | | | | | | | | | | |
| *Felimare fontandraui* (Pruvot-Fol, 1951) | X | X | X | | | X | X | | X | X | | X |
| *Felimare gasconi* (Ortea, 1996) | | | | X | X | X | | | | | | |
| *Felimare picta* (Philippi, 1836) | X | X | X | X | X | X | X | X | X | X | X | X |
| *Felimare tricolor* (Cantraine, 1835) | X | X | X | X | X | X | X | X | X | X | X | X |
| *Felimare villafranca* (Risso, 1818) | | | | | X | X | | X | | | | X |
| *Felimida binza* (Ev. Marcus & Er. Marcus, 1963) | | X | X | | X | X | X | | X | X | X | |
| *Felimida krohni* (Vérany, 1846) | X | X | X | X | X | X | X | X | X | X | X | |
| *Felimida luteorosea* (Rapp, 1827) | | | X | | X | X | | | | | X | |
| *Felimida purpurea* (Risso, 1831) | | | X | | | X | | X | X | X | | |
| **Family Discodorididae Bergh, 1891** | | | | | | | | | | | | |
| *Geitodoris portmanni* (Schmekel, 1972) | | | | | | | | | | | X | |
| *Jorunna tomentosa* (Cuvier, 1804) | | | | | | | | | | X | | |
| *Peltodoris atromaculata* Bergh, 1880 | X | X | X | X | X | X | X | X | X | | X | X |
| *Platydoris argo* (Linnaeus, 1767) | X | | X | | | X | X | | | X | | X |
| *Taringa tritorquis* Ortea, Perez & Llera, 1982 | | | | | | | X | | | | | |

**Table 4.** Continued

| | | | |
|---|---|---|---|
| **Family Phyllidiidae Rafinesque, 1814** | | | |
| *Phyllidia flava* Aradas, 1847 | **X** | **X** **X** | |
| **Family Dendrodoridae O'Donoghue, 1924 (1864)** | | | |
| *Dendrodoris limbata* (Cuvier, 1804) | **X** | **X** | **X** |
| *Doriopsilla rarispinosa* Pruvot-Fol, 1951 | | **X** | **X** |

## Discussion

Considering the differences in the number of species found in the three sites examined in this work, these do not seem to be significant. In fact, of the 65 nudibranch species (38 cladobranchs and 27 dorids), 42 were found at Ognina, 53 at Santa Maria La Scala and 50 at Scalo Pennisi. This similarity in the total number of species is in accordance with that noted by Lombardo and Marletta (2020a), who documented that there was not a marked difference in the number of species between the areas located at Catania (in this study represented by the site of Ognina), Santa Maria La Scala and Santa Tecla (here represented by Scalo Pennisi). Consequently, regarding this group of marine heterobranchs, there would appear to be no significant numerical differences between anthropized coastal areas and more natural ones. This is in accordance with Parera *et al.* (2020), which have documented an unexpectedly high level of diversity in strongly anthropized coastal areas.

Considering which species are present or not in the three sites here examined, it can be noted that, using also the data presented by Lombardo (2021) and Lombardo and Marletta (2022), far 44 nudibranchs species [24 cladobranchs (*Doto acuta*, *Antiopella cristata*, *Calmella* cf. *cavolini*, *Edmundsella pedata*, *Flabellina affinis*, *Paraflabellina ischitana*, *Coryphella lineata*, *Luisella babai*, *Amphorina farrani*, *Trinchesia foliata*, *T. genovae*, *T. morrowae*, *T. ocellata*, *Trinchesia* sp., *Embletonia pulchra*, *Cratena peregrina*, *Dicata odhneri*, *Facelina annulicornis*, *F. rubrovittata*, *Facelinopsis marioni*, *Favorinus branchialis*, *Nemesignis banyulensis*, *Berghia coerulescens* and *Spurilla neapolitana*) and 20 dorids (*Diaphorodoris alba*, *D. papillata*, *Okenia longiductis*, *O. picoensis*, *Trapania lineata*, *Polycera quadrilineata*, *Aegires leuckartii*, *Felimare fontandraui, F. picta*, *F. tricolor*, *F. villafranca*, *Felimida binza*, *F. krohni*, *F. luteorosea*, *F. purpurea*, *Taringa tritorquis*, *Peltodoris atromaculata*, *Platydoris argo*, *Phyllidia flava* and *Dendrodoris limbata*) are reported in all the three studied sites. Instead, 6 of the 65 species here reported (*Doto cervicenigra*, *Eubranchus tricolor, Trinchesia caerule*a (Montagu, 1804), *Berghia verrucicornis*, *Felimare gasconi* and *Jorunna tomentosa*) are not present in all three sites but are found both in Catania and Acireale waters. Instead, it is noteworthy that 5 nudibranch species (*Duvaucelia manicata*, *D. maculata*, *Doto floridicola*, *Melibe viridis*, *Capellinia doriae, Godiva quadricolor*, *Berghia* sp., *Limenandra nodosa*, Eolid sp. 1, *Crimora papillata, Geitodoris portmanni* and *Doriopsilla rarispinosa*) were documented exclusively in Acireale waters and others two (*Okenia problematica* and *Aegires sublaevis*) only in Catania. Nevertheless, with the present work data, it is difficult to make hypotheses about the reasons for the presence or absence of these latter species in their respective areas.

Through data analysis, it was highlighted that along the central-eastern coast of Sicily the number of nudibranch species varied with a marked seasonality

throughout the year. This number showed an increase from the mid-late autumn, which continued steadily until the spring, representing the season with the highest number of species. Between the end of spring and the beginning of summer, the number of species began to reduce, decreasing notably throughout the summer and early autumn, during which there was the lowest number of nudibranch species. In all examined sites this seasonal trend in the number of species was nearly identical. Therefore, in almost 14 km of coastline the variations of the number of species followed the same seasonal trend during the four years of study.

This trend may be related to both the seasonality of the sessile benthic suspension feeders (nudibranchs' preys), which in the Mediterranean present a marked summer inactivity, and to the seasonal cycle of Mediterranean waters. Indeed, the summer and the early autumn are characterised by the resources' reduction, seawater stratification and temperature increase (Margalef and Castellví 1967; Salat *et al.* 1978; Estrada 1996; Coma *et al.* 2000). On the contrary, from late autumn the seawater cooling begins, first weakening and then nullifying the summer seawater stratification during winter and spring. This cooling ensures the vertical mixing of waters and thus of nutritive substances and organic matter, deriving both from winter-spring planktonic blooms and upwelling of deep waters rich in nutrients, allowing the sessile benthic suspension feeders to feed and growth (Margalef and Castellví 1967, Salat *et al.* 1978, Estrada 1996, Coma *et al.* 2000). Moreover, the annulment in the seawater stratification in winter and spring would favour the vertical moving of nudibranchs' larvae, which are mainly of allochthonous origin (Clark 1975), ensuring the strong recruitment in these seasons. At the same time, most of nudibranchs' larvae [with planktotrophic development *sensu* Thompson (1976)], are forced to feed on planktonic microorganisms (generally phytoplankton), which generally bloom in winter-spring and in late autumn (Estrada 1996). Therefore, during summer and first autumn nudibranchs' larvae find probably a food shortage. Moreover, even the nudibranch adults (post-metamorphosed individuals) are subjected to a shortage of food during these last seasons. Indeed, their preys, the abovementioned sessile benthic suspension feeders, according to the belonging group, present a marked decrease in growth and reproduction rates during summer and first autumn, thus they have to implement various techniques to avoid this unfavourable period (Coma *et al.* 2000). For example, some groups decrease in abundance, others stop to feed and perform their normal metabolic functions and go into a period of dormancy (Boero and Fresi 1986, Coma *et al.* 1998, Garrabou 1999).

Consequently, overall, from the present study and the abovementioned literature, it would seem that summer and the first part of autumn are the least favourable seasons for the majority of nudibranch species in the Mediterranean Sea. The seasonal trend of nudibranch species found in this study fits perfectly with previous research on nudibranch seasonality in other Mediterranean areas, reporting a higher number of species in winter-spring (Ros 1978, Domenech *et*

*al.* 2002, Betti *et al.* 2017). In literature, the main causes that have been attributed to variations in the nudibranchs' assemblages of species are the temperature and food availability (e.g., Clark 1975, Betti *et al.* 2017).

The data showed in this study highlighted that the seasonal variations in the number of species belonging to this group of molluscs are probably caused by a concatenation of numerous factors ranging from the macro to the micro scale, which demonstrate that each component of an ecosystem is strictly interconnected. Consequently, being the nudibranchs the last part of this concatenation [since they are the predators at the top of this food chain (Trainito and Doneddu 2014)], analysing the seasonal variations of the number of species in a given area may provide important information on the temporal phytoplanktonic variations and at the same time on the seawater stratification. Therefore, these molluscs could be used as bioindicators to highlight and analyse such variations. Indeed, as already underlined by Betti *et al.* (2017), Goddard *et al.* (2016), Kurnianda *et al.* (2020), Parera *et al.* (2020) and Ah-Shee-Tee *et al.* (2022), nudibranchs can be used as sentinel organisms to understand ongoing environmental and climatic modifications.

The results presented in this work are clearly far from exhaustive, and it is recommended that in the near future the variation in the number of nudibranch species will be examined in other Mediterranean localities in order to highlight if the trends of nudibranchs are overall identical, similar or different to those observed in this study. Moreover, it would be useful that these types of empirical studies will be attended and supported by specialists in phytoplankton and seawater stratification to obtain a complete view of the realities of these processes.

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