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# Evidence of Warm Welcome From the Cymodocea nodosa (*Tracheophyta, Alismatales*) Meadow in the Seas of Taranto (Southern Italy, Mediterranean Sea)

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# Evidence of Warm Welcome from the *Cymodocea nodosa* (Tracheophyta, Alismatales) Meadow in the Seas of Taranto (Southern Italy, Mediterranean Sea)

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**Abstract:** The collection of photo shoots during the systematic monitoring activities is useful to witness the ecological role of marine phanerogams as hosts for a rich variety of organisms in coastal and transitional waters. *Cymodocea nodosa* is present in the Taranto seas. In the Mar Piccolo, it reached high covers in short times, up to 100%, due to the bettering of the environmental conditions. The most recent observations showed that it offers welcoming towards several vertebrates and invertebrates, native and non-indigenous, as well as to micro and macroalgae. The NPPR funded activities will make these observations more robust and structural.

**Keywords:** biodiversity; *Cymodocea nodosa*; ecosystem services; ITINERIS; LTER; Mar Piccolo of Taranto; Mediterranean Sea; non-indigenous species; NBFC

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Marine phanerogams are paramount for the structuring and functioning of marine coastal ecosystems. They are emblematic primary producers, protect shoreline from erosion, support high biodiversity offering food, refuge and nursey areas to invertebrates and vertebrates, such as fish and even migrant birds [1–4]. Their value in terms of ecosystem services, only in the Caribbean, was estimated at about 255 billion $ per year [5]. Marine phanerogams' abundance is a sign of excellent environmental conditions. So, they have been included among the primary species for the definition of priority habitat within the Habitat Directive (92/43/EEC), and used as bioindicators in the formulation of biotic indices for the assessment of the Good Environmental Status (GES) in coastal and transitional water systems, according to Water Framework Directive (2000/60/EC) and Marine Strategy Framework Directive (2008/56/EC) [6–8].

*Cymodocea nodosa* (Ucria) Ascherson is a plastic marine phanerogam, able to flourish into pristine environments, as well as to survive in stressed ones [9,10]. It is widely distributed into the Mediterranean coastal and transitional water systems, from East to West [9,11]. The articulated rhizome-root component with the dense slender leaves forms a robust grid, which stabilizes the substrate and welcomes the vagile fauna. Grazers find food also on the rich epiphytic community and often spawn among the shoots [2,3,12]. A value of about 3 million € per year was recently assessed for the commercial fish community housed by the *C. nodosa* meadows at Canary Islands [13]. Seahorses are joint guests of this marine plant [14,15], so as it earned the folk name of "seahorse grass" [16].

*Cymodocea nodosa* is present with a dense meadow along the south-eastern coast of the Mar Grande of Taranto [F. Rubino personal communication], where it sexually reproduces [E. Cecere personal communication]. Diving observations showed that it hosts a varied fauna from native seahorses *Hyppocampus hippocampus* (Linnaeus, 1758) and *H. guttulatus* (Cuvier 1829) to non-indigenous mollusks, such as *Pinctada radiata* (Leach, 1814) (Figure 1a, b).

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**(a)** **(b)**

**Figure 1.** Associated fauna to *Cymodocea nodosa* shoots in the Mar Grande of Taranto: (**a**) the seahorse *Hyppocampus guttulatus* takes refuge within the meadow; (**b**) aggregated specimens of *Pinctada radiata*.

In the Mar Piccolo, a transitional water system located in the Ionian Sea, after a consistent thinning in the 1980s and the 1990s, due to the presence of high eutrophication, *C. nodosa* is now flourishing again [17]. It is widely distributed along the basin coast, and in some zones, the meadow reaches a cover up to 100% [18], a sign of a high status, according to the MaQI index [6] (Figure 2).

The seasonal systematic observations carried out on the Mar Piccolo macrobenthos, mainly phytobenthos, since 2011, within the framework of long-term ecological research (LTER) activities, currently funded by the NRRP Project ITINERIS, allowed a visual assessment of the progressive recover of the meadow [17]. In addition, the activities performed within the framework of the Project "MIA Natura 2000", funded through POR PUGLIA FESR-FSE 2014/2020, led to the quantitative evaluation of the meadow's density as well as the structural descriptors [18]. The phenological monitoring is now continued within the National Recovery and Resilience Plan (NRRP), with the Project "National Biodiversity Future Center". The diving observations carried out in these years, for the collection of benthos samples, brought also to light the close relations of *C. nodosa* with the fauna and flora living in the basin.

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**Figure 2. A** dense meadow of *Cymodocea nodosa* onto the bottom of the Mar Piccolo basin (Photo credits: Gianni Squitieri).

For several years, starting from 2014, it was common to see specimens of the fan mussel *Pinna nobilis* (Linnaeus 1758) among the shoots of *C. nodosa* [19] (Figure 3). The big bivalve mollusk shows a marked preference for this phanerogam in transitional waters, mainly due to the close bonds produced among the rhizomes, the sediments, and the byssus filaments [20–23]. Also of paramount importance is the protective effect of leaves against the hydrodynamics, which fosters the mollusk's larvae settlement [23]. In Spain, in the transitional system of the Ebro River (NW Mediterranean), the highest density of *P. nobilis* specimens were measured in zones where the *C. nodosa* meadow reached a covering of 80-100% [21]. In the Venice Lagoon (Adriatic Sea, northern Italy), the fan mussel density was the highest at the highest cover of the phanerogam, and it was preferably located at the border of the meadow, where the filtering activity can be enhanced [23]. Unfortunately, Figure 3 represents an historical relic, since starting from 2018, *P. nobilis* underwent mass mortality in the Taranto seas, due to an infection of the protozoic parasite *Haplosporidium pinnae* [24]. This caused its disappearance from the basin, as already observed all around the Mediterranean Sea [25].

The Mar Piccolo of Taranto, like most of the transitional water systems, is subject to a high degree of biological pollution. At the moment, 22 non-indigenous invertebrates and 16 seaweeds have been recorded in the basin [26, A. Petrocelli unpublished data]. Generally, marine non-indigenous species (NIS) are considered a serious menace for the native communities, especially when they have a markedly invasive behavior, since they can cause strong alteration of ecosystem functions, reduction of biodiversity, damages to the economic activities [27,28]. *Caulerpa cylindracea* Sonder considerably spread along most of the coastal zone of the Mediterranean Sea in 1990s and 2000s, with a negative impact on both biodiversity and structure of the invaded ecosystems.

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**Figure 3.** *Pinna nobilis* among the leaves of *Cymodocea nodosa* in the Mar Piccolo of Taranto (Photo credits: Gianni Squitieri).

Within a mixed meadow of *C. nodosa* and *Nanozostera noltei* (Hornemann) Tomlinson & Posluszny (as *Zostera noltii* Hornemann) in the Tyrrhenian Sea, this invasive NIS considerably reduced the shoot density of the former [29] and altered the density of its flowering plants [30]. However, if the ecology of native species and NIS is significantly different, no interaction between the species can establish [28]. In the Mar Piccolo, no NIS caused serious damage to benthic populations to date [26]. Concerning seaweeds, the only species with an invasive behavior is *Hypnea corona* Huisman & Petrocelli, which is spreading into the basin since 2000, becoming the dominant species in summer, but without any evident disruption for both the macrophytobenthic communities and the native fauna [26]. Mixed communities with native species of seaweeds and invertebrates, and even *C. nodosa*, are observed in the basin (Figure 4a). Among NIS invertebrates, 7 molluscan species were recorded in the Mar Piccolo. The grazer *Bursatella leachii* Blainville 1817 and the carnivorous *Melibe viridis* (Kelaart, 1858) are frequently present in the *C. nodosa* meadow both in the Mar Piccolo and Mar Grande of Taranto [31] (Figure 4b), as reported also for other coastal Mediterranean environments [32–36]. Both species surely find refuge among the dense shoots, as well as their preferred meal. The former is primarily drawn to the rich epiphytic communities (e.g. diatoms, cyanobacteria) and the detritus, but sometimes does not mind associated seaweeds [35]. The latter finds several preys, such as microalgae herbivores, filter feeders, ectoparasites [12].

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(**a**) (**b**)

**Figure 4.** Alien organisms among *Cymodocea nodosa* shoots in the Mar Piccolo of Taranto: (**a**) Thalli of *Hypnea corona* intertwined with leaves (Photo credits: Giuseppe Portacci); (**b**) A specimen of *Melibe viridis* hidden within the dense meadow.

Once again, the effectiveness of LTER activities in the study of biodiversity in the Mar Piccolo of Taranto is made evident. The continuous monitoring and the availability of historical observations allow to follow the population development of species worth of protection (e.g., *Pinna nobilis*, *Cymodocea nodosa*). The NIS fate and every possible new introduction are continuously under surveillance. New technologies, such as the remote sensing and the eDNA, joined to the field activities and the classical taxonomy will surely lead to a more and more deep knowledge. In Italy, finally there was an awareness of this. The funding of the National Biodiversity Future Center can be an initial step and the fulfillment of its main task "*conserve, restore, monitor and enhance Italian and Mediterranean biodiversity*" is on track.

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