

How many seas must a nudibranch sail? *Okenia picoensis* (Mollusca: Nudibranchia: Goniodorididae) conquering the Mediterranean

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ABSTRACT

The genus *Okenia* is undergoing a singular evolution in the last 20 years, with the description of new species and the rapid diffusion into new biogeographical compartments. Described only in 2017, from specimens collected in 2013 at the Azores islands, *Okenia picoensis* in the span of five years has been observed in the Mediterranean from east to west and north in the Gulf of Lion. The first observations for Sardinia are reported here and its current diffusion is mapped, mainly based on data mining, and discussed.

Keywords: Sea slug, Goniodorididae, *Okenia picoensis*, diffusion, Atlantic, Mediterranean

INTRODUCTION

Towards the end of 1962, a very young Bob Dylan offered to the world his most famous song: "Blowing in the wind", more than a (beautiful) song, a sequence of unanswered questions, then as now.

Years later, in 2013, Justin Hart collected along the shores of Pico Island, in the Azores, some specimens of a very small nudibranch with a very particular appearance, difficult to confuse with other species of the same genus. In 2017, those tiny sea slugs became a new species with the name of *Okenia picoensis*

Paz-Sedano, Ortigosa & Pola, 2017 (Paz-Sedano et al., 2017).

17 years earlier, Ortea & Espinosa (2000) had described the new species *Okenia miramarae*, based on two 4.5 mm long specimens collected in La Habana, Cuba. In 2016, Ortea, together with Moro and Bacallado, also reported this species for the island of Gran Canaria: the images attached to this report, however, lack the characteristic of the most conspicuous external morphology of *O. miramarae*, that is, they do not have the two

peribranchial processes so long as to go beyond the end of the tail (Moro et al., 2016).

So far, an absolutely normal story unfolds: in the absence of new findings of *O. miramarae* and in the absence of genetic data, Paz-Sedano et al. (2017) kept the two species distinct and entrusted the evaluation of the relationship between the two species to future new findings.

Three years after its description, in 2020, *O. picoensis*, is observed in the Mediterranean and reported as an alien species (Orfanidis et al., 2021). Afterwards, a sequence of observations begins in the Mediterranean: it continues to this days, involving the whole basin, with the sole exclusion of the Adriatic Sea.

The aim of this communication is: i) to report the first observations of *O. picoensis* along the coasts of Sardinia and in the central Tyrrhenian Sea; ii) to reconstruct the current presence of the species in the Mediterranean through scientific publications and data mining on the web; iii) to discuss the possible hypotheses of such a large and rapid dispersion and the opportunity to consider it an Atlantic species introduced in the Mediterranean or instead an autochthonous species of the entire Atlantic-Mediterranean range.

MATERIALS AND METHODS

The observations in Sardinia took place first on 10 April 2022 during an exploratory dive at Capo Figari (Golfo Aranci, Italy) and the specimen was photographed in situ with Olympus TG6: it was 34 m deep and the temperature of the water was 13° C. A second specimen was observed on 13 May 2022 in Tavolara MPA at the depth of 25 m and the temperature of the water was 16° C: it was photographed in situ, collected, photographed in laboratory with a Nikon D3X, measured (7

mm), then preserved in 96% ethanol for future analyses and provisionally stored in the authors's collection (Fig. 1).

The other data were collected in the scientific literature and, predominantly through research on the web and in social media, using the keywords *Okenia* and *Okenia picoensis*. Each result that contained an image was validated through the analysis of external morphological characters and, where possible, verified with the observer. The observations known to date for the species are summarized in Table 1 and in Fig. 2 and 3.

RESULTS

If we exclude the data relating to the description of the species, the survey through scientific literature and World Wide Web made it possible to find 30 reports of observations in the Mediterranean, between 2020, when the first report occurred in Malta, and 2022 with the discoveries in Sardinia. All images have been validated and the external morphology was always consistent with the original description and in particular with the white morphotype. To the Mediterranean reports must be added one record of a specimen on the Island of Saba (Dutch Caribbean) (Tab. 1).

DISCUSSION

The three scientific communications that reported observations of *Okenia picoensis* in the Mediterranean considered it an alien species and argued about the possible ways of spreading and the possible link with the warming of Mediterranean waters (Orfanidis et al., 2021; Crocetta et al., 2021; Lombardo & Marletta, 2021). Anyway, while in the first occasion, which dealt with the first finding in

Table 1. Observations known to date for the species

Site	X	Y	Month	Year	Author	Observer
Porto do Calhau, Pico island, Azores, Portugal	-28.540045	38.486735	11	2013	Paz-Sedano S., Ortigosa D. & Pola M. 2017	Justin Hart
Rozi wreck, Ċirkewwa, Malta	14.3286	35.9878	11	2020	Orfanidis et al., 2021	Kristaps Dzonsons
Um El Faroud wreck, Wied iż-Żurrieq, Malta	14.4498	35.8191	11	2020	Orfanidis et al., 2021	Kristaps Dzonsons
Ċirkewwa arch, Malta	14.3286	35.9878	11	2020	Orfanidis et al., 2021	Kristaps Dzonsons
Um El Faroud wreck, Wied iż-Żurrieq, Malta	14.4498	35.8191	1	2021	Orfanidis et al., 2021	Kristaps Dzonsons
La Piedra del Hombre, Almunecar, Granada, Spain	-3.7375	36.7231	3	2021	Orfanidis et al., 2021	David Ballesteros
Acque Fredde, Santa Tecla, Italy	15.1811	37.637	3	2021	Crocetta et al., 2021	Lombardo & Marletta
Ognina, Italy	15.119666	37.530666	3	2021	Lombardo & Marletta 2021	
Scalo Pennisi, Italy	15.126444	37.639777	3	2021	Lombardo & Marletta 2021	
Santa Maria La Scala, Italy	15.175388	37.612916	3	2021	Lombardo & Marletta 2021	
La Chiatta, Genova, Italy	8.86597	44.35528	3	2021	Facebook	Virginia Picco
Villefranche-sur-Mer, France	7.321386	43.686791	4	2021	https://doris.ffessm.fr/Especies/Okenia-picoensis-Okenia-de-Pico-5585	Sylvain Le Bris
Bellatrix , Italy	15.126444	37.534222	5	2021	Lombardo & Marletta 2021	
Summeil, Tel Aviv, Israel	34.768708	32.082587	5	2021	iNaturalist	Rafi Amar
Achziv, Israel	35.102177	33.048379	5	2021	YOU TUBE	Joseph Elayani
Castellammare del Golfo, Italy	12.819000	38.084622	5	2021	Present paper	Elisa Manganelli
Ustica, Italy	13.153954	38.695133	5	2021	Present paper	Elisa Manganelli
Agay, Saint-Raphael, France	6.864769	43.42761	6	2021	iNaturalist	Sylvain Le Bris

Ustica, Italy	13.183170	38.724344	6	2021	Present paper	Elisa Manganelli
Formica, Porticello, Sicily, Italy	13.55962	38.08364	6	2021	Facebook	Santo Tirnetta, Giovanni Ombrello
Lampedusa, Italy	12.631251	35.513329	7	2021	Present paper	Elisa Manganelli
Saba, St Thomas. Dutch Caribbean	-63.253528	17.640523	9	2021	iNaturalist	Terence Zahner
Tamariu, Costa Brava, Spain	3.207670	41.917868		2021	Pontes et al., 2022; https://opistobranquis.info/	Maria Pilchmaier
Santa Maria al Bagno, Lecce, Italy	17.992324	40.128835	3	2022	Facebook	Cesare Petrelli Andrea Astore
Franata dei Mufloni, Capo Figari, Sardinia, Italy	9.658725	40.991848	4	2022	Present paper	Valentina Migliore
Isola delle Femmine, Sicily, Italy	13,232500	38,209444	4	2022	Facebook	Giovanni Ombrello
Capo Noli, Italy	8.421641	44.199031	5	2022	Facebook	Ilaria Mg. Rizzuto
Civitavecchia, Italy	11.800333	40.074400	5	2022	Facebook	Mariele Crispino
Stavros, Crete, Greece	24.07779	35.592993	5	2022	https://greece.inaturalist.org/taxa/902114-Okenia-picoensis	Emmanouil Darakis
AMP Tavolara, Sardinia, Italy	9.707200	40.896533	5	2022	Present paper	Maria Agostini

the Mediterranean, this approach could be justified, at that time, by the incomplete knowledge of the real diffusion of the species in the Mediterranean, in our opinion persisting in considering it an alien species after the subsequent finds is an error.

Indeed, after two years it is possible to develop new considerations. If you type three keywords "alien, Nudibranchia and Mediterranean" on Google Scholar, 805 results appear. This is a confirmation not so much and

not only of the consistency of the phenomena of change taking place in the Mediterranean, but also of a cultural propensity to deepen this aspect. By the way, aliens are very profitable from the point of view of the visibility of publications and impact they have within the scientific community. To put it in simpler terms, a fad has developed that involves researchers and enthusiasts and occupies the entire schedule of some scientific journals.

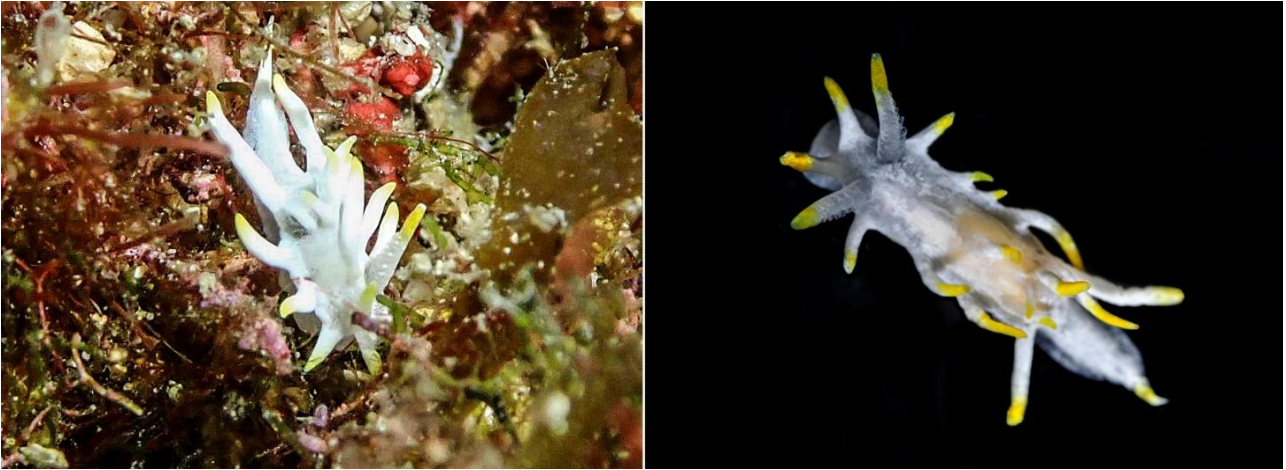


Figure 1. The individuals observed in NE Sardinia, Italy: left, at Capo Figari, right at Tavolara MPA

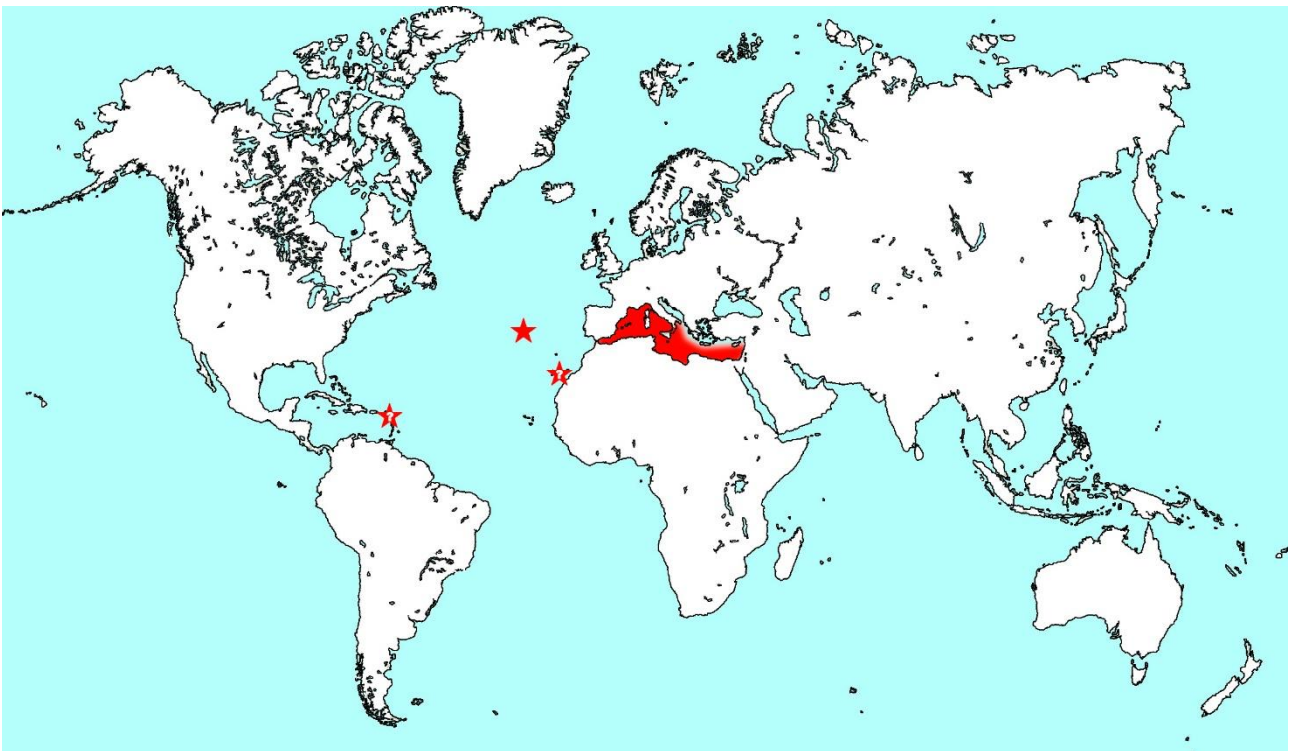


Figure 2. The hypotetic global distribution of *Okenia picoensis*: the solid star indicates *locus typicus*, outlined stars the controversial findings at Saba and Gran Canaria.

Over time, the "race to the alien" has encountered various stumbles linked to the scarcity of data relating to the diffusion and the equally scarce data relating to genetics that may allow for the discrimination of apparently unitary populations. Thus, terms such as "introduced" or "cryptogenic" have entered the

scientific language. The first in turn is divided between "voluntarily introduced species", generally farmed, and "unintentionally introduced species", generally attributed to organisms found in environments where the importation of non-native species is known. When it is not known how to define the species

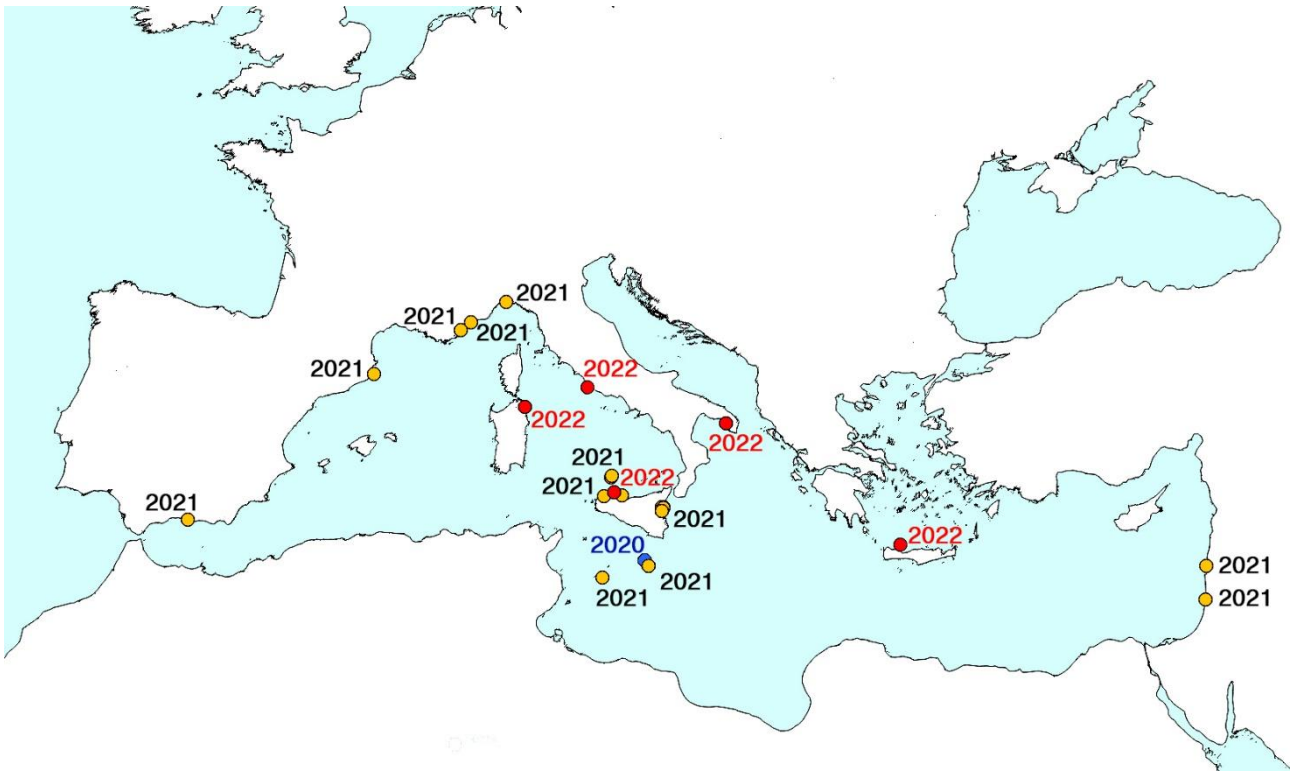


Figure 3. The distribution of records in the Mediterranean

based on its origin, the term "cryptogenic" settles things once and for all: it is a spare admission of not knowing, following the Socratic method.

The case of *O. picoensis* is particularly interesting because 5 years after its description the context has completely changed. In 2017 the only element of uncertainty concerned the possibility that the specimens from the Azores were to be attributed to *O. miramarae*, described in 2000 from Cuba (Ortea & Espinosa, 2000): a question still unresolved in the absence of possible genetic evidence, given the weakness of the distinctions on a morphological basis.

Today the centre of gravity of the species seems to have shifted to the Mediterranean, considering that most of the observations available today concern this basin, and they are distributed throughout it. To complicate the picture, there was a report of a specimen in Saba in the Netherlands Antilles (Table 1). In summary: may a species that does not exceed 8 mm in length, but generally much smaller,

have a distribution range that develops over a span of about 6800 nautical miles? May it appear to be an amphi-atlantic and Mediterranean species (Fig. 2)?

If a species is found in hundreds of specimens and for decades only in the Atlantic and never in the Mediterranean, it can be assumed that it is an Atlantic species. So, if after a certain period of time some specimens are also found in the Mediterranean, it can be hazarded that it is an "alien" species for the Mediterranean that came from the Atlantic.

Other considerations should be drawn for a species, never found either in the Atlantic or in the Mediterranean until 2013, which in the course of 3 years after its description is reported both in the Atlantic and in the Mediterranean. In the balance of the years since the marine fauna has been studied (that is about three centuries), for a span of 3 years one can reasonably speak of simultaneity.

So the reality is that it is a species, never seen before, which simultaneously appears both in the Atlantic and in the Mediterranean.

It would be specious to argue that, only because the first report is from the Atlantic and the next in the Mediterranean, it is a species initially present only in the Atlantic and subsequently spread also in the Mediterranean. To explain this concept, a trivial consideration is enough: if on that day in 2013 Justin Hart had preferred a trip to the countryside rather than an underwater dive, the species in question would have never been found in the Azores. As a consequence, its first discovery would have been in Malta, and when Terence Zahner would have found specimens in St. Thomas, someone would have written that a species “native to the Mediterranean” had introduced itself, as an alien, to the Caribbean. Therefore, in conclusion, the geographic origin of a species could be defined on the basis of an enthusiast’s decision whether to pursue her/his hobby or to devote her/himself to something else. This is hardly acceptable in science.

A first important step forward could be given by genetic analyses that certify the actual conspecificity of the Mediterranean specimens with those of the Azores and Saba (and of the Canaries, considering the evaluations previously expressed).

The other question that arises is how it can happen that a species, never reported before, becomes, in the course of about 2 years, the object of simultaneous observations throughout the Mediterranean basin (Fig. 3), from east to west, from south to north and in the Caribbean. Undoubtedly, considering that almost all of the observations are not to be attributed to targeted research, but from documented reports by non-specialists, it is evident that this group of organisms, generally called sea slugs, has become an actively sought target for underwater photography enthusiasts. Probably the causes of this success are linked to the shapes and colours of these organisms, in synthesis to their beauty; certainly their popularity is also due to the non-obviousness

of their discovery, which requires attention, curiosity and a little basic knowledge. In addition, for fans, their discovery and sharing on social media are a source of satisfaction and, for those who care, of likes and other emoticons.

From a scientific point of view, in addition to taking note of the data and the need for verification to which they must be subjected, it is at least risky to think that *O. picoensis* appeared in the Mediterranean in 2020 and that it has traveled thousands of miles across the Atlantic in a such a short time frame. It would not be the first case of dispersion of a non-native species. To name just a couple, *Aplysia dactylomela* Rang 1828 (Fig. 4) and *Lamprohaminoea ovalis* (Pease, 1868) took 17 years to colonize the basin from the moment of their first report (Valdes et al. 2013; Moles et al., 2017; Azzola et al., in press). For further comparison, a much more dynamic species being a fish, *Fistularia commersonii* (Rüppel, 1835) took 7 years to fulfill the same task (Mas et al. 2009; Sanna et al., 2015) (Fig. 5).

It is very likely that *O. picoensis*, in addition to being considered a cryptogenic species, must have been present in the Mediterranean basin, before its discovery in the Azores.

In conclusion, we think that it is reasonable to consider it as a native species of the entire Atlanto-Mediterranean region, which only recently, after its demographic explosion, has come to be observed. Speculating whether it was present before in the Atlantic or in the Mediterranean is reminiscent of the classic hen/egg dilemma. We should instead ask ourselves why a species never noticed until 2013 appears in a few years everywhere.

A good explanation could be that this species has experienced a demographic explosion, after being very rare and hardly noticed, even if distributed from the Caribbean

to the eastern Mediterranean.

But this would only move one step further up the unsolved doubt, which would become: "Why has it experienced a population explosion that had never happened before in its entire history?" We do not even have an hypothesis.

Only the collection of samples from sites relevant to the species, in particular from the

Caribbean, Gran Canaria and the Mediterranean, will be able to initiate the investigations to understand how many miles a nudibranch (his larvae) can travel.

But currently, paraphrasing Bob Dylan, all that we can say is: "the answer my friend is flowing in the stream, the answer is flowing in the stream".

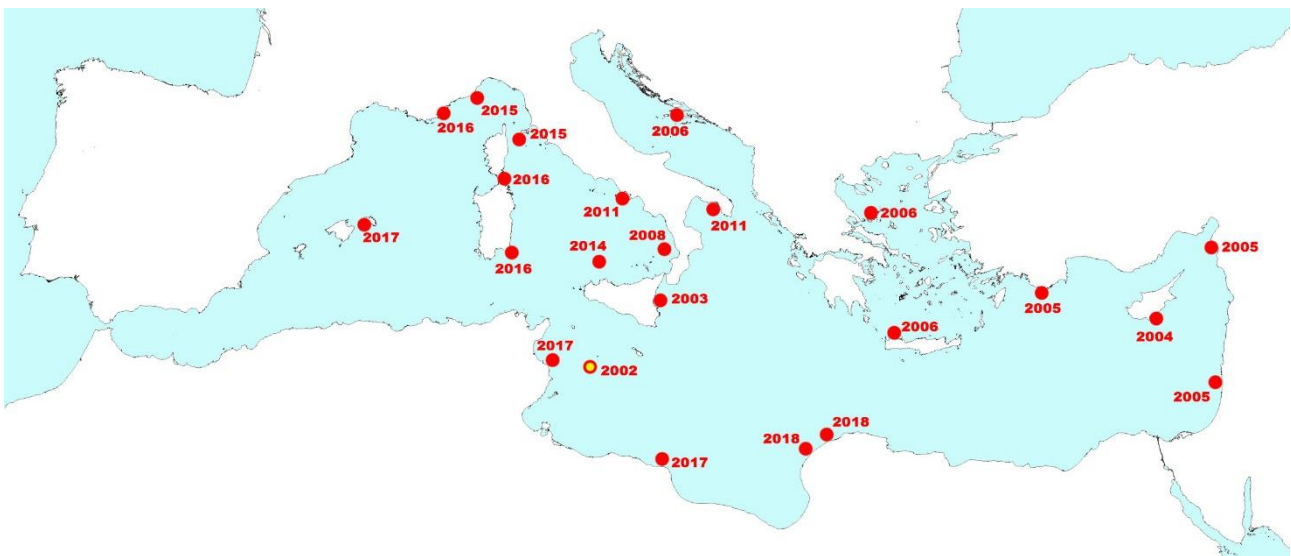


Figure 4. The dispersion of *Aplysia dactylomela* in the Mediterranean based on bibliography



Figure 5. The dispersion of *Fistularia commersonii* in the Mediterranean based on bibliography

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Koliko mora puž golać treba da preplovi? *Okenia picoensis* (Mollusca: Nudibranchia: Goniodorididae) osvajajući Sredozemno more

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SAŽETAK

Rod *Okenia*, s opisom novih vrsta i brzim širenjem u nova biogeografska područja, prolazi kroz jedinstvenu evoluciju u poslednjih 20 godina. Opisana tek 2017. g. na osnovu primjeraka prikupljenih 2013. g. na Azorskim ostrvima, *Okenia picoensis* je u periodu od pet godina primjećena u Sredozemlju od istoka do zapadu i na sjeveru u Lavljem zalivu. Ovdje su prikazana prva zapažanja za Sardiniju i mapirana je njena trenutna rasprostranjenost, uglavnom zasnovana na pretraživanju različitih tipova baza podataka, koji su diskutovani.

Ključne riječi: morski puž, Goniodorididae, *Okenia picoensis*, rasprostranjenje, Atlantik, Sredozemno more