Marine algal flora of Pico Island, Azores

Ana I. Azevedo Neto†, Afonso C. L. Prestes‡, Nuno V. Álvaro§, Roberto Resendes¶, Raul M. A. Neto‡, Ian Tittley#, Ignacio Moreu‡

† cE3c - Centre for Ecology, Evolution and Environmental Changes/Azorean Biodiversity Group & Faculdade de Ciências e Tecnologia, Departamento de Biologia, Universidade dos Açores, 9500-321 Ponta Delgada, São Miguel, Açores, Portugal
§ Universidade dos Açores, Faculdade de Ciências Agrárias, CCMGG (Centro do Clima Meteorologia e Mudanças Globais), IITA-A (Instituto de Investigação e Tecnologias Agrárias e do Ambiente), Angra do Heroísmo, Terceira, Portugal
¶ Universidade dos Açores, Faculdade de Ciências e Tecnologia, Departamento de Biologia, 9500-321 Ponta Delgada, São Miguel, Açores, Portugal
‡ N/A, Odivelas, Portugal
# Natural History Museum, Cromwell Road, London, United Kingdom

Corresponding author: Ana I. Azevedo Neto (ana.im.neto@uac.pt)
Academic editor: Paulo Borges
Received: 10 Aug 2020 | Accepted: 30 Aug 2020 | Published: 01 Oct 2020
Citation: Neto AIA, Prestes ACL, Álvaro NV, Resendes R, Neto RMA, Tittley I, Moreu I (2020) Marine algal flora of Pico Island, Azores. Biodiversity Data Journal 8: e57461. https://doi.org/10.3897/BDJ.8.e57461

Abstract

Background

The seaweed flora of Pico Island (central group of the Azores archipelago) has attracted interest of researchers on past occasions. Despite this, the macroalgal flora of the island cannot be considered well-known as published information reflects only occasional collections. To overcome this, a thorough investigation encompassing collections and presence data recording was undertaken. Research under the Campaigns “AÇORES/89”, “PICO/91”, “PICOBEL/2007” and “LAUMACAT/2011” covered a relatively large area (approximately 39 km²) around the island, encompassing the littoral and sublittoral levels down to about 40 m around the Island.

This paper improves the knowledge of the Azorean macroalgal flora at local and regional scales by listing taxonomic records and providing information on the ecology and occurrence of each species present on the Island’s littoral.
New information

A total of 4043 specimens (including taxa identified only to genus level) belonging to 303 taxa of macroalgae are registered, comprising 197 Rhodophyta, 53 Chlorophyta and 53 Ochrophyta (Phaeophyceae). From these, 225 were identified to species level (142 Rhodophyta, 41 Chlorophyta and 42 Ochrophyta), encompassing 110 new records for the island (69 Rhodophyta, 20 Chlorophyta and 21 Ochrophyta), three Macaronesian endemisms (*Botryocladia macaronesica* Afonso-Carillo, Sobrino, Tittley & Neto; *Laurencia viridis* Gil-Rodríguez & Haroun; *Codium elisabethiae* O. C. Schmidt), 14 introduced and 25 species with an uncertain status.

Keywords

Macroalgae, Azores, Pico Island, new records, endemism, native, introduced, uncertain, occurrence data.

Introduction

The Azorean algal flora, considered cosmopolitan with species shared with Macaronesia, North Africa, the Mediterranean Sea, Atlantic Europe and America (Tittley 2003, Tittley and Neto 2006Wallenstein et al. 2009), has been considered relatively rich when compared to that of other remote oceanic islands (Neto et al. 2005, Tittley and Neto 2005, Wallenstein et al. 2009). Even so, it is worth mentioning that the published information (approximately 400 species, Freitas et al. 2019) reflects data from only a few of the nine islands, since not all of them have been thoroughly investigated. To overcome this and improve the understanding of the archipelago’s seaweed flora, an effort has been made by local investigators over the past three decades and research on the marine macroalgae flora has been conducted on several of the less-studied Azorean islands. This paper comprises both physical and occurrence data and compiles the gathered information from macroalgae surveys developed in Pico Island mainly by the Island Aquatic Research Group of the University of the Azores (https://ce3c.ciencias.ulisboa.pt/sub-team/island-aquatic-ecology). It aims to constitute a practical resource for biological studies, such as systematics, diversity and conservation, biological monitoring, climate change and ecology and also for academics, students, government, private organisations and the general public.

General description

**Purpose:** By listing taxonomic records for Pico and presenting general information for each taxon occurrence on the Island’s littoral, this paper addresses several biodiversity shortfalls (see Cardoso et al. 2011, Hortal et al. 2015), namely the need to catalogue the Azorean macroalgae (Linnean shortfall) and improve the current information on their local and regional geographic distribution (Wallacean shortfall), as well as on species abundances and dynamics in space (Prestonian shortfall).
Project description

**Title:** Marine algal (seaweed) flora of Pico Island, Azores

**Personnel:** Collections were conducted and occurrence data recorded during several years (1989-2018) under the coordination of Ana I. Neto. Main collectors were Abel Sentiés, Ana Costa, Ana I Neto, André Amaral, António Brigos, Catarina Santos, Daniel Torrão, David Villegas, Edgar Rosas-Alquicira, Edward Hehre, Emanuel Xavier, Eunice Nogueira, Francisco Wallenstein, Gustavo Martins, Heather Baldwin, Inês Neto, José M. N. Azevedo, Ian Tittley, Karla Leon Cisneros, Leila Bagaço, Maria Machín-Sánchez, Marlene Terra, Mutue Toyota Fujii, Nuno Álvaro, Patricia Madeira, Raul Coma, Raul Neto, Richard Fralick, Rita Patarra, Ruben Afonso, Ruben Couto, Silvia Escarduça and Valeria Cassano.

Several taxonomists contributed for the species identification: Abel Sentiés, Ana I. Neto, Edgar Rosas-Alquicira, Edward Hehre, Francisco Wallenstein, Heather Baldwin, Karla Leon Cisneros, Ian Tittley, Maria Machín-Sánchez, Marlene Terra, Mutue Toyota Fujii, Richard Fralick, Ruben Couto and Valeria Cassano.

Voucher specimen management was mainly undertaken by Afonso Prestes, Ana I. Neto, Eunice Nogueira, Natália Cabral and Roberto Resendes.

**Study area description:** Located in the North Atlantic, roughly at 38°43′49″N, 27°19′10″W, the Azores comprise nine islands and several islets spread over 500 km, in a WNW direction (Fig. 1). The climate is temperate oceanic, with regular and abundant rainfall, high levels of relative humidity and persistent winds, mainly during the winter and autumn seasons (Morton et al. 1998). The islands lack a continental shelf, thus presenting a restricted coastal extension and deep waters occur within a few kilometres offshore. Shore geomorphology varies considerably with high cliffs in some places and rocky cobble/boulder beaches elsewhere (Borges 2004), the tidal range is small (< 2 m, see Hidrográfico 1981) and coasts are subjected to swell and surge most of the year.

Pico (in black in Fig. 1), of approximately 447 km² and dominated by its 2351 m tall mountain, is the second largest and the youngest island of the Azores archipelago, composed of basaltic volcanic deposits less than 300,000 years old (Cruz and Oliveira 2001). The Island's coastline is approximately 126 km long, generally devoid of high cliffs and consists mainly of irregular extensions of bedrock, presenting a variety of stack, arch and gully formations due to its recent volcanic origin. Intertidal platforms, occasionally dissected by channels and gullies, are mostly easily accessible by land and exhibit considerable variation in width (Wallenstein et al. 2009). Important features and habitats at this shore level are rock pools. These differ in shape and size and are a stressful environment due to the changes in salinity caused by either evaporation or dilution during low tides. They often recreate a shallow subtidal habitat and contain a rich diversity of marine life. A few shores consist of irregularly rounded boulders or cobles between which coarse sand or gravel may be retained. Sandy shores are rare (Neto pers. observ.).
The rocky-shore communities of Pico, like all over in the Azores, are dominated by macroalgae at both intertidal and shallow subtidal levels (Neto et al. 2005). At intertidal levels, a distinct zonation pattern is evident with a higher zone dominated by invertebrates (littorinids and chthamalid barnacles, in which patches or fringes of the algae Fucus spiralis Linnaeus and Gelidium microdon Kützing can occur (Fig. 2). This is followed by a mid-shore zone covered by algal turfs (growth forms of either diminutive algae or diminutive forms of larger species that create a dense, compact mat 20-30 mm thick, Fig. 3). Depending on the shore, turf can be monospecific (of either Caulacanthus ustulatus (Mertens ex Turner) Kützing, Centroceras clavulatum (C. Agardh) Montagne or Gymnogongrus) or multispecific and composed of soft algae (e.g. Centroceras clavulatum, Chondracanthus and Laurencia) usually growing as epiphytes over articulate calcareous forms (e.g. Ellisolandia and Jania). The lower zone is mainly dominated by calcareous crusts (first strata), covered by corticated macrophytes (e.g. Ellisolandia elongata (Fig. 4), Pterocladia capillacea, Treptacanth abies-marina (S.G.Gmelin) Kützing). Mainly during spring and summer, considerable amounts of the introduced Asparagopsis armata Harvey can be seen at this level. Subtidally, algal communities are mainly characterised associations of two or three frondose macrophytes, for example, Dictyota, Halopteris and Zonaria toumefortii (J.V.Lamouroux) Montagne (Fig. 5).
Littorinids, chthamalid barnacles and the algae *Fucus spiralis* and *Gelidium microdon* at the high intertidal (by the Island Aquatic Ecology Subgroup of cE3c-ABG).

Mid-shore intertidal levels covered by algal turfs (by the Island Aquatic Ecology Subgroup of cE3c-ABG).
Figure 4. *Ellisolandia elongata* at lower intertidal levels (by the Island Aquatic Ecology Subgroup of cE3c-ABG).

Figure 5. *Halopteris* spp., *Zonaria tournefortii* and *Dictyota* spp.) at the subtidal level (by the Island Aquatic Ecology Subgroup of cE3c-ABG).
**Design description:** The algae referred to in this paper were collected during field studies at littoral and sublittoral levels down to approximately 40 m around Pico Island. Each sampling location was visited several times and, on each occasion, a careful survey was made covering much of the area. Presence/absence data were recorded for all known species and whenever an unknown or potential new species was found, it was collected, assigned an individual registration number and vouchers were deposited at the AZB Herbarium Ruy Telles Palhinha, based at the Faculty of Sciences and Technology of the University of the Azores.

**Funding:** This study was mainly financed by the following projects/scientific expeditions:

- Campaign AÇORES/89, under the Expedition Acores/89, Departamento de Oceanografia e Pescas da Universidade dos Açores, July 1989;
- Expedition PICO/91, Ilha do Pico, Açores, Departamento de Biologia da Universidade dos Açores Ilha do Pico, Açores, June 1991;
- Campaign PICOBEL/2007, under the project “PICOBEL: Coastal benthic communities of Pico Island: characterization and monitoring”. 2007- 2008. The Azores Regional Government;
- Campaign LAUMACAT/2011 under the project “LAUMACAT: Diversity and phylogenetic relationships on the benthic marine algae with pharmacological potential: the Laurencia complex (Rhodophyta) in Macaronesian archipelagos, tropical and subtropical Atlantic”. Phase II. 2011 - 2014. General Direction for Research and Management: Research Projects. Spanish Government;
- Project “ACORES-01-0145-FEDER-000072 - AZORES BIOPORTAL – PORBIOTA. Operational Programme Acores 2020 (85% ERDF and 15% regional funds);
- Portuguese National Funds, through FCT – Fundação para a Ciência e a Tecnologia, within the projects UID/BIA/00329/2013, 2015 - 2018 and UID/BIA/00329/2019 and UID/BIA/00329/2020-2023;
- Portuguese Regional Funds, through DRCT – Direção Regional da Ciência e Tecnologia, within several projects, since 2013;
- CIRN/DB/UAc (Research Centre for Natural Resources, Universidade dos Açores, Departamento de Biologia);
- CIIIMAR (Interdisciplinary Centre of Marine and Environmental Research, Porto, Portugal).

**Sampling methods**

**Study extent:** This study covers a relatively large area, approximately 39 km², encompassing littoral and sublittoral levels down to approximately 40 m around the island (Table 1, Fig. 6).
Table 1.
Pico Island sampling sites information.

| Location No | Location ID | Municipality | Locality | Latitude / Longitude | Littoral zone |
|-------------|-------------|--------------|----------|----------------------|---------------|
| 1           | PIX_LP_LPlac| Lajes do Pico| Lajes do Pico| 38.398018, -28.254506 | Subtidal      |
| 2           | PIX_LP_LPMbsp| Lajes do Pico| Lajes do Pico| 38.391826, -28.251878 | Intertidal    |
| 3           | PIX_LP_LPMbsp| Lajes do Pico| Lajes do Pico| 38.391602, -28.251087 | Subtidal      |
| 4           | PIX_LP_LPMpb| Lajes do Pico| Lajes do Pico| 38.399773, -28.25225  | Intertidal    |
| 5           | PIX_SR_CPpi| São Roque    | Cais do Pico| 38.523888, -28.31165  | Intertidal    |
| 6           | PIX_LP_LPLa| Lajes do Pico| Lajes do Pico| 38.39961, -28.255085  | Intertidal    |
| 7           | PIX_LP_LPLa| Lajes do Pico| Lajes do Pico| 38.399708, -28.255538 | Subtidal      |
| 8           | PIX_LP_LPMbsp| Lajes do Pico| Lajes do Pico| 38.391602, -28.251087 | Subtidal      |
| 9           | PIX_LP_LPMpb| Lajes do Pico| Lajes do Pico| 38.390439, -28.251473 | Intertidal    |
| 10          | PIX_LP_LPMpp| Lajes do Pico| Lajes do Pico| 38.390439, -28.251473 | Intertidal    |
| 11          | PIX_LP_LPMpp| Lajes do Pico| Lajes do Pico| 38.390439, -28.251473 | Subtidal      |
| 12          | PIX_LP_CNpo| Calheta do Pico| Calheta do Pico| 38.402234, -28.078158 | Subtidal      |
| 13          | PIX_LP_SCp| Lajes do Pico| Santa Cruz| 38.405086, -28.185822 | Subtidal      |
| 14          | PIX_MA_SMp| São Mateus| São Mateus| 38.43023, -28.463406 | Subtidal      |
| 15          | PIX_LP_CNpo| Lajes do Pico| Calheta do Pico| 38.40219, -28.079374 | Intertidal    |
| 16          | PIX_LP_CNpo| Lajes do Pico| Calheta do Pico| 38.402234, -28.078158 | Subtidal      |
| Location N0 | Location ID | Municipality | Locality | Latitude / Longitude | Littoral zone |
|------------|-------------|--------------|----------|----------------------|---------------|
| 17         | PIX_LP_Fc   | Lajes do Pico| Feteira|Calheta              | Subtidal      |
| 18         | PIX_LP_LPc1 | Lajes do Pico| Lajes do Pico|Controlo 1 | Intertidal     |
| 19         | PIX_LP_LPc2 | Lajes do Pico| Lajes do Pico|Controlo 2 | Intertidal     |
| 20         | PIX_LP_LPc3 | Lajes do Pico| Lajes do Pico|Controlo 3 | Intertidal     |
| 21         | PIX_LP_LPc4 | Lajes do Pico| Lajes do Pico|Controlo 4 | Intertidal     |
| 22         | PIX_LP_LPc5 | Lajes do Pico| Lajes do Pico|Controlo 5 | Intertidal     |
| 23         | PIX_LP_LPc6 | Lajes do Pico| Lajes do Pico|Controlo 6 | Intertidal     |
| 24         | PIX_LP_LPfb | Lajes do Pico| Lajes do Pico|Fabrica baleia | Intertidal     |
| 25         | PIX_LP_LPLa | Lajes do Pico| Lajes do Pico|Lagido        | Intertidal     |
| 26         | PIX_LP_LPMpb| Lajes do Pico| Lajes do Pico|Maré|Ponta da Barra | Subtidal     |
| 27         | PIX_LP_LPMpp| Lajes do Pico| Lajes do Pico|Maré|Poça do Pano | Intertidal     |
| 28         | PIX_LP_LPpc | Lajes do Pico| Lajes do Pico|Ponta do Castelete | Subtidal     |
| 29         | PIX_LP_Pm   | Lajes do Pico| Piedade|Manhenha              | Intertidal     |
| 30         | PIX_LP_Pm   | Lajes do Pico| Piedade|Manhenha              | Subtidal     |
| 31         | PIX_LP_PN   | Lajes do Pico| Pontas Negras |              | Intertidal     |
| 32         | PIX_LP_PN   | Lajes do Pico| Pontas Negras |              | Subtidal     |
| 33         | PIX_LP_Ppc  | Lajes do Pico| Piedade|Porto do Calhau       | Intertidal     |
| Location N° | Location ID | Municipality | Locality | Latitude / Longitude | Littoral zone |
|-------------|-------------|--------------|----------|----------------------|---------------|
| 34          | PIX_LP_SB   | Lajes do Pico | Santa Bárbara | 38.394346, -28.198255 | Subtidal      |
| 35          | PIX_LP_Sbpa | Lajes do Pico | Santa Bárbara| Ponta do Arrife       | Subtidal      |
| 36          | PIX_LP_SCpi | Lajes do Pico | Santa Cruz| Piscinas              | Intertidal    |
| 37          | PIX_LP_Sf   | Lajes do Pico | Silveira| Fonte                 | Subtidal      |
| 38          | PIX_LP_Sf   | Lajes do Pico | Silveira| Fonte                 | Subtidal      |
| 39          | PIX_LP_SJp  | Lajes do Pico | São João| Porto                 | Intertidal    |
| 40          | PIX_LP_SJp  | Lajes do Pico | São João| Porto                 | Subtidal      |
| 41          | PIX_MA_CA   | Madalena      | Cabrito   | 38.55817, -28.390065  | Subtidal      |
| 42          | PIX_MA_CAC  | Madalena      | Cachorro  | 38.556193, -28.44759  | Subtidal      |
| 43          | PIX_MA_GU   | Madalena      | Guindaste | 38.445879, -28.502033 | Intertidal    |
| 44          | PIX_MA_MAc  | Madalena      | Madalena| Canal                 | Subtidal      |
| 45          | PIX_MA_MAcM | Madalena      | Madalena| Cais do Mourato       | Intertidal    |
| 46          | PIX_MA_MAi  | Madalena      | Madalena| Ilhéus                | Subtidal      |
| 47          | PIX_MA_MAP  | Madalena      | Madalena| Porto                 | Intertidal    |
| 48          | PIX_MA_MAPi | Madalena      | Madalena| Piscina               | Intertidal    |
| 49          | PIX_MA_mi   | Madalena      | Mirateca  | 38.448621, -28.511449 | Subtidal      |
| 50          | PIX_MA_MOpc | Madalena      | Monte| Porto do Calhau       | Intertidal    |
| Location N0 | Location ID   | Municipality       | Locality          | Latitude / Longitude       | Littoral zone |
|------------|--------------|--------------------|-------------------|---------------------------|---------------|
| 51         | PIX_MA_MOpo  | Madalena           | Monte|Pocinho         | 38.494812, -28.540192 | Intertidal    |
| 52         | PIX_MA_SCp   | Madalena           | São Caetano|Porto         | 38.425816, -28.421585 | Intertidal    |
| 53         | PIX_MA_SCp   | Madalena           | São Caetano|Porto         | 38.425656, -28.421382 | Subtidal      |
| 54         | PIX_MA_SMp   | Madalena           | São Mateus|Porto         | 38.430824, -28.462433 | Intertidal    |
| 55         | PIX_SR_CPpi  | São Roque          | Cais do Pico|Piscina       | 38.523888, -28.31165 | Intertidal    |
| 56         | PIX_SR_CPpi  | São Roque          | Cais do Pico|Piscina       | 38.52502, -28.312802 | Subtidal      |
| 57         | PIX_SR_PrN   | São Roque          | Prainha do Norte |             | 38.477785, -28.204158 | Intertidal    |
| 58         | PIX_SR_PrNbc | São Roque          | Prainha do Norte|Baia de Canas | 38.462872, -28.184805 | Intertidal    |
| 59         | PIX_SR_PrNca | São Roque          | Prainha do Norte|Canto da Areia | 38.462994, -28.19003 | Subtidal      |
| 60         | PIX_SR_SAbc  | São Roque          | Santo Amaro|Baía do Canto | 38.456384, -28.165936 | Intertidal    |
| 61         | PIX_SR_SAc   | São Roque          | Santo Amaro|Caisinho      | 38.456591, -28.16742 | Intertidal    |
| 62         | PIX_SR_SAnt  | São Roque          | Santo António    |             | 38.535259, -28.335402 | Intertidal    |
| 63         | PIX_SR_SAnt  | São Roque          | Santo António    |             | 38.537581, -28.334334 | Subtidal      |
| 64         | PIX_SR_SApm  | São Roque          | Santo Amaro|Ponta do Mistério | 38.45332, -28.120977 | Subtidal      |
| 65         | PIX_SR_SMA   | São Roque          | São Miguel Arcanjo|         | 38.509128, -28.288709 | Subtidal      |
| 66         | PIX_LP_LPMppb| Lajes do Pico      | Lajes do Pico|Maré|Ponta da poça da Baleia | 38.389725, -28.252395 | Intertidal    |
| 67         | PIX_LP_LPp   | Lajes do Pico      | Lajes do Pico|Portinho     | 38.400994, -28.25526 | Intertidal    |
| Location | Location ID | Municipality | Locality | Latitude / Longitude | Littoral zone |
|----------|-------------|--------------|----------|----------------------|--------------|
| 68       | PIX_LP_Pm   | Lajes do Pico | Piedade|Manhenha             | 38.410566,  -28.036926 | Intertidal  |
| 69       | PIX_LP_SCpi | Lajes do Pico | Santa Cruz|Piscinas            | 38.404764,  -28.187053 | Intertidal  |
| 70       | PIX_MA_MAb  | Madalena     | Madalena|Barca                | 38.540254,  -28.521195 | Intertidal  |
| 71       | PIX_MA_MOpo | Madalena     | Monte|Pocinho              | 38.494812,  -28.540192 | Intertidal  |
| 72       | PIX_SR_CPpov| São Roque    | Cais do Pico|Porto Velho       | 38.527148,  -28.319716 | Intertidal  |
| 73       | PIX_SR_PrN  | São Roque    | Prainha do Norte |                | 38.477785,  -28.204158 | Intertidal  |
| 74       | PIX_MA_MAb  | Madalena     | Madalena|Barca                | 38.540254,  -28.521195 | Intertidal  |

**Sampling description:** Intertidal collections were made at low tide by walking over the shores. Subtidal collections were made by scuba diving around the area. Sampling encompassed both physical collections and species presence recordings. For the former, in each sampling location, collections were made manually by scraping one or two specimens of species found into previously labelled bags (Fig. 7). Species recording data.
were gathered by registering all species present in the sampled locations visited (Fig. 8). Complementary data, for example, shore level (high, mid, low), orientation and type of substrate (bedrock, boulders, cobbles, mixed), habitat (tide pool, open rock, gully, crevice, cave) were also recorded.

Figure 7. Collecting macroalgae at the rocky intertidal (by the Island Aquatic Ecology Subgroup of cE3c-ABG).

Figure 8. Subtidal species recording data (by the Island Aquatic Ecology Subgroup of cE3c-ABG).
Quality control: Each sampled taxon was investigated by trained taxonomists with the help of keys and floras. This involved morphological and anatomical examination by eye or under dissecting and compound microscopes of an entire specimen or slide preparation. In difficult cases, specimens were sent to experts for identification.

Step description: In the laboratory, the specimens were sorted and studied following standard procedures used in macroalgae identification.

Species identification was based on morphological and anatomical characters and reproductive structures. For small and simple thalli, this required the observation of the entire thallus by eye and/or under dissecting or compound microscopes. For larger and more complex algae, the investigation of the thallus anatomy required histological work to obtain longitudinal and transverse sections needed for the observation of cells, reproductive structures and other diagnosing characters.

The Azorean algal flora has components from several geographical regions which makes for difficulties in identification. Floras and identification keys to macroalgae in the Atlantic and Western Mediterranean were used in species identification (e.g. Schmidt 1931, Taylor 1967, Taylor 1978, Levring 1974, Dixon and Irvine 1977, Lawson and John 1982, Irvine 1983, Irvine and Chamberlain 1994, Gayral and Cosson 1986, Fletcher 1987, Afonso-Carrillo and Sansón 1989, Burrows 1991, Boudouresque et al. 1992, Cabioc'h et al. 1992, Maggs and Hommersand 1993, Irvine and Chamberlain 1994, Irvine and Chamberlain 1994, Brodie et al. 2007, Lloréns et al. 2012, Rodríguez-Prieto et al. 2013).

For more critical and taxonomically-difficult taxa, specimens were taken to the Natural History Museum (London) for comparison with collections there or sent to appropriate specialists.

A reference collection was made for all collected specimens by assigning them a herbarium code number and depositing them at the AZB Herbarium Ruy Telles Palhinha, University of Azores. Depending on the species and on planned further research, different types of collections were made, namely (i) liquid collections using 5% buffered formaldehyde seawater and then replacing it by the fixing agent Kew (Bridsen and Forman 1999); (ii) dried collections, either by pressing the algae (most species) as described by Gayral and Cosson 1986) or by letting them air dry (calcareous species); (iii) silica collections for molecular studies.

Nomenclatural and taxonomic status used here follow Algaebase (Guiry and Guiry 2020). The database was organised on FileMaker Pro.

Geographic coverage

Description: Pico Island, Azores, Macaronesia, Portugal (approximately 38°34′02″N, 28°33′17″W).

Coordinates: 38.376 and 38.567 Latitude; -28.555 and -28.021 Longitude.
Taxonomic coverage

**Description:** All macroalgae were identified to genus or species. In total, 303 taxa were identified belonging to 30 orders and 67 families, distributed by the phyla Rhodophyta (15 orders and 39 families), Chlorophyta (3 orders and 10 families) and Ochrophyta (12 orders and 18 families).

**Taxa included:**

| Rank  | Scientific Name | Common Name  |
|-------|-----------------|--------------|
| phylum | Rhodophyta       | Red algae    |
| phylum | Chlorophyta      | Green algae  |
| phylum | Ochrophyta       | Brown algae  |

Temporal coverage

**Data range:** 1989-5-01 - 2018-9-30.

**Notes:** The sampling was performed on several occasions in the period between 1989 and 2018.

Collection data

**Collection name:** AZB | Marine macroalgae collection of Pico Island (Azores) – Expedition AZORES/89; AZB | Marine macroalgae collection of Pico Island (Azores) – Expedition PICO/91; AZB | Marine macroalgae collection of Pico Island (Azores) – Project PICOBEL; AZB | Marine macroalgae collection of Pico Island (Azores) – Project LAUMACAT; AZB | Marine macroalgae collection of Pico Island (Azores) – Occasional sampling; Marine macroalgae occurrence in Pico Island (Azores) – Expedition AZORES/89; Marine macroalgae occurrence in Pico Island (Azores) – Project PICOBEL; Marine macroalgae occurrence in Pico Island (Azores) – Project LAUMACAT.

**Collection identifier:** 4ea1e09c-13c8-4b8e-a28a-72c55bde8f66; 0f2368fa-0a53-43c5-9f19-b126260e4e83; 6163248c-236b-4778-99cf-39dbf28a9784; b4ed4e44-3e8f-42d4-a44b-d7855a8f8f0; acc4fc70-0cb6-496e-982c-9207d09b856a; 468e613d-1ce9-4a32-a5f9-c5a8b58545c1; a8405f3e-fdc6-452d-9dc9-ca1fd3abdf2c; 84ff06f5-8c7c-4c3c-9296-38ad24b347bd.

**Parent collection identifier:** AZB Herbarium Ruy Telles Palhinha, Faculty of Sciences and Technology of the University of the Azores.

**Specimen preservation method:** Air dry, Dried and pressed; Liquid (Formalin; fixing agent Kew), Silica.
Curatorial unit:  AZB Herbarium Ruy Telles Palhinha, Faculty of Sciences and Technology of the University of the Azores.

Usage rights

Use license:  Open Data Commons Attribution License

IP rights notes:  Creative Commons Attribution (CC-BY) 4.0 License

Data resources

Data package title:  Marine algal flora of Pico Island, Azores

Resource link:  http://ipt.gbif.pt/ipt/resource?r=pico_seaweed_flora&v=1.11

Alternative identifiers:  https://www.gbif.org/dataset/6af010f0-8238-4745-8309-21c3f82bd488

Number of data sets:  1

Data set name:  Marine algal (seaweed) flora of Pico Island, Azores

Download URL:  http://ipt.gbif.pt/ipt/resource?r=pico_seaweed_flora

Data format:  Darwin Core Archive

Data format version:  v1.11

Description:  This data paper presents physical and occurrence data from macroalgal surveys undertaken on Pico Island between 1989 and 2018. The dataset submitted to GBIF is structured as a sample event dataset, with two tables: event (as core) and occurrences (Neto et al. 2020). The data in this sampling event resource have been published as a Darwin Core Archive (DwCA), which is a standardised format for sharing biodiversity data as a set of one or more data tables. The core data table contains 74 records (eventID). The extension data table has 4043 occurrences. An extension record supplies extra information about a core record. The number of records in each extension data table is given in the IPT link. This IPT archives the data and thus serves as the data repository. The data and resource metadata are available for downloading in the downloads section.

| Column label         | Column description                                                                 |
|----------------------|------------------------------------------------------------------------------------|
| Table of Sampling Events | Table with sampling events data (beginning of table)                             |
| eventID              | Identifier of the event, unique for the dataset                                   |
| country              | Country of the sampling site                                                      |
| countryCode          | Code of the country where the event occurred                                       |
| Field                          | Description                                                                 |
|-------------------------------|-----------------------------------------------------------------------------|
| stateProvince                 | Name of the region                                                          |
| island                        | Name of the island                                                          |
| municipality                  | Name of the municipality                                                    |
| locality                      | Name of the locality                                                         |
| locationID                    | Identifier of the location                                                   |
| decimalLatitude               | The geographic latitude of the sampling site                                 |
| decimalLongitude              | The geographic longitude of the sampling site                                |
| geodeticDatum                 | The spatial reference system upon which the geographic coordinates are based |
| coordinateUncertaintyInMetres | The horizontal distance (in metres) from the given decimalLatitude and      |
|                               | decimalLongitude describing the smallest circle containing the whole of the  |
|                               | Location                                                                    |
| eventDate                     | Time interval when the event occurred                                        |
| year                          | The year of the event                                                       |
| samplingProtocol              | Sampling method used during an event                                         |
| locationRemarks               | Zonation level                                                              |
| minimumDepthInMetres          | The minimum depth in metres where the specimen was found                     |
| maximumDepthInMetres          | The maximum depth in metres where the specimen was found                     |
| eventRemarks                  | Notes about the event                                                       |
| Table of Species Occurrence   | Table with species occurrence data (beginning of new table)                |
| occurrenceID                  | Identifier of the record, coded as a global unique identifier               |
| institutionID                 | The identifier for the institution having custody of the object or information |
|                               | referred to in the record                                                   |
| institutionCode               | The acronym of the institution having custody of the object or information    |
|                               | referred to in the record                                                   |
| collectionID                  | An identifier of the collection to which the record belongs                 |
| collectionCode                | The name of the collection from which the record was derived                |
| datasetName                   | The name identifying the dataset from which the record was derived          |
| eventID                       | Identifier of the event, unique for the dataset                             |
| kingdom                       | Kingdom name                                                                |
| phylum                        | Phylum name                                                                 |
| class                         | Class name                                                                  |
| order                         | Order name                                                                  |
| family                        | Family name                                                                 |
Additional information

This paper accommodates the 4043 specimens of macroalgae recorded from Pico Island in 303 taxa comprising 225 confirmed species and 78 taxa identified only to genus level. The confirmed species (Tables 2, 3) include 142 Rhodophyta, 41 Chlorophyta and 42 Ochrophyta (Phaeophyceae). From these, 110 species are newly-recorded to the island (69 Rhodophyta, 20 Chlorophyta and 21 Ochrophyta), as, for example, *Laurencia pyramidalis* Bory ex Kützing (Fig. 9). Most species are native, including the three Macaronesian endemisms *Botryocladia macaronesica* Afonso-Carillo, Sobrino, Tittley & Neto, *Laurencia viridis* Gil-Rodríguez & Haroun and *Codium elisabethiae* O. C. Schmidt. Fourteen species represent introductions to the algal flora and 25 have an uncertain status.
### Table 2.
Macroalgae species from Pico Island, with information on number of records, biogeographic origin and occurrence remarks (A: abundant; C: common; R: rare).

| Phylum         | Species (Accepted Name)                                                                 | Number of records | Establishment Means | Occurrence Remarks |
|----------------|----------------------------------------------------------------------------------------|-------------------|---------------------|--------------------|
| Rhodophyta     | Acrosorium ciliolatum (Harvey) Kylin                                                   | 34                | Native              | New record         |
| Rhodophyta     | Aglaothamnion cordatum (Børgesen) Feldmann-Mazoyer                                     | 1                 | Introduced          | R                  |
| Rhodophyta     | Aglaothamnion tenuissimum (Bonnemaison) Feldmann-Mazoyer                               | 2                 | Uncertain           | R                  |
| Rhodophyta     | Ahnfeltiopsis devoniensis (Greville) P.C.Silva & DeCew                                  | 5                 | Native              | New record         |
| Rhodophyta     | Amphiroa beauvoisii J.V.Lamouroux                                                       | 11                | Native              | C                  |
| Rhodophyta     | Amphiroa fragilissima (Linnaeus) J.V.Lamouroux                                          | 2                 | Native              | New record         |
| Rhodophyta     | Amphiroa rigida J.V.Lamouroux                                                          | 4                 | Native              | New record         |
| Rhodophyta     | Anotrichium barbatum (C.Agardh) Nägeli                                                  | 1                 | Native              | New record         |
| Rhodophyta     | Anotrichium furcellatum (J.Agardh) Baldock                                              | 1                 | Uncertain           | R                  |
| Rhodophyta     | Antithamnion decipiens (J.Agardh) Athanasiadis                                          | 4                 | Native              | New record         |
| Rhodophyta     | Antithamnion diminutum Wollaston                                                       | 2                 | Introduced          | R                  |
| Rhodophyta     | Antithamnionella boergesenii (Cormaci & G.Fumari) Athanasiadis                           | 2                 | Uncertain           | R                  |
| Rhodophyta     | Aphanocladia stichidiosa (Funk) Ardré                                                   | 4                 | Native              | R                  |
| Rhodophyta     | Asparagopsis armata Harvey, phase Falkenbergia rufolanosa (Harvey) F.Schmitz            | 42                | Introduced          | New record A       |
| Rhodophyta     | Asparagopsis armata Harvey                                                              | 142               | Introduced          | C                  |
| Rhodophyta     | Asparagopsis taxiformis (Dellle) Trevisan                                              | 35                | Native              | C                  |
| Rhodophyta     | Asteromenia peltata (W.R.Taylor) Huisman & A.J.K.Millar                                 | 16                | Native              | New record C       |
| Rhodophyta     | Bornetia secundiflora (J.Agardh) Thuret                                                | 3                 | Native              | New record R       |
| Rhodophyta     | Botryocladia botryoides (Wulfen) Feldmann                                              | 3                 | Native              | New record R       |
| Rhodophyta     | Botryocladia macaronesica Afonso-Carillo, Sobrino, Tittley & Neto                       | 1                 | Macaronesian endemism | New record R   |
| Phylum   | Species (Accepted Name)                                                                 | Number of records | Establishment Means | Occurrence Remarks |
|----------|----------------------------------------------------------------------------------------|-------------------|---------------------|--------------------|
| Rhodophyta | *Callithamnion corymbosum* (Smith) Lyngbye                                              | 5                 | Native              | New record         |
| Rhodophyta | *Callithamnion granulatum* (Ducluzeau) C.Agardh                                          | 1                 | Native              | New record         |
| Rhodophyta | *Callithamnion tetragonum* (Withering) S.F.Gray                                         | 4                 | Native              |                    |
| Rhodophyta | *Carradoriella denudata* (Dillwyn) A.M.Savoie & G.W.Saunders                            | 20                | Uncertain           | C                  |
| Rhodophyta | *Carradoriella elongata* (Hudson) A.M.Savoie & G.W.Saunders                             | 9                 | Native              | New record         |
| Rhodophyta | *Catenella caespitosa* (Withering) L.M.Irvine in Parke & P.S.Dixon                      | 1                 | Native              | New record         |
| Rhodophyta | *Caulacanthus ustulatus* (Mertens ex Turner) Kützing                                    | 10                | Uncertain           | C                  |
| Rhodophyta | *Centroceras clavulatum* (C.Agardh) Montagne                                            | 57                | Native              | A                  |
| Rhodophyta | *Ceramium ciliatum* (J.Ellis) Ducluzeau                                                | 18                | Native              | C                  |
| Rhodophyta | *Ceramium cingulatum* Weber Bosse                                                      | 1                 | Introduced          | R                  |
| Rhodophyta | *Ceramium codiatum* (Kützing) J.Agardh                                                 | 1                 | Native              | New record         |
| Rhodophyta | *Ceramium diaphanum* (Lightfoot) Roth                                                  | 21                | Native              | C                  |
| Rhodophyta | *Ceramium echionotum* J.Agardh                                                         | 3                 | Native              | R                  |
| Rhodophyta | *Ceramium gaditanum* (Clemente) Cremades                                               | 4                 | Uncertain           | R                  |
| Rhodophyta | *Ceramium virgatum* Roth                                                               | 42                | Native              | C                  |
| Rhodophyta | *Champia parvula* (C.Agardh) Harvey                                                   | 3                 | Native              | R                  |
| Rhodophyta | *Chondracanthus acicularis* (Roth) Fredericq                                            | 58                | Native              | A                  |
| Rhodophyta | *Chondracanthus teedei* (Mertens ex Roth) Kützing                                       | 26                | Native              | New record         |
| Rhodophyta | *Chondria capillaris* (Hudson) M.J.Wynne                                               | 15                | Native              | New record         |
| Rhodophyta | *Chondria coerulescens* (J.Agardh) Sauvageau                                            | 1                 | Uncertain           | R                  |
| Rhodophyta | *Chondria dasypylla* (Woodward) C.Agardh                                                | 13                | Uncertain           | C                  |
| Rhodophyta | *Coelothrix irregularis* (Harvey) Børøgesen                                             | 1                 | Native              | R                  |
| Rhodophyta | *Corallina officinalis* Linnaeus                                                        | 5                 | Native              | R                  |
| Rhodophyta | *Cottoniella filamentosa* (M.Howe) Børøgesen                                            | 5                 | Native              | New record         |
| Rhodophyta | *Crouania attenuata* (C.Agardh) J.Agardh                                               | 11                | Native              | C                  |
| Rhodophyta | *Cryptopleura ramosa* (Hudson) L.Newton                                                | 6                 | Native              | R                  |
| Phylum | Species (Accepted Name)                                                                 | Number of records | Establishment Means | Occurrence Remarks |
|--------|----------------------------------------------------------------------------------------|-------------------|---------------------|--------------------|
| Rhodophyta | *Dasya corymbifera* J.Agardh                                                             | 7                 | Native              |                    |
| Rhodophyta | *Dasya rigidula* (Kützing) Ardissone                                                   | 2                 | Native              | New record         |
| Rhodophyta | *Dermocorynus dichotomus* (J.Agardh) Gargiulo, M.Morabito & Manghisi                   | 63                | Native              | A                  |
| Rhodophyta | *Diplothamnion jolyi* C.Hoek                                                           | 3                 | Native              | New record         |
| Rhodophyta | *Dudresnaya verticillata* (Withering) Le Jolis                                            | 1                 | Native              | New record         |
| Rhodophyta | *Ellisoldinia elongata* (J.Ellis & Solander) K.R.Hind & G.W.Saunders                    | 190               | Native              | A                  |
| Rhodophyta | *Erythrocytis montagnei* (Derbès & Solier) P.C.Silva                                   | 11                | Native              | New record         |
| Rhodophyta | *Gaillona hookeri* (Dillwyn) Athanasiadis                                                | 5                 | Native              | R                  |
| Rhodophyta | *Gastroclonium ovatum* (Hudson) Papenfuss                                              | 2                 | Native              | New record         |
| Rhodophyta | *Gastroclonium reflexum* (Chauvin) Kützing                                               | 20                | Native              | C                  |
| Rhodophyta | *Gaylella flaccida* (Harvey ex Kützing) T.O.Cho & L.J.McIvor                            | 4                 | Native              | R                  |
| Rhodophyta | *Gelidium arbuscula* Bory ex Børgeesen                                                 | 4                 | Native              | New record         |
| Rhodophyta | *Gelidium microdon* Kützing                                                             | 81                | Native              | A                  |
| Rhodophyta | *Gelidium pusillum* (Stackhouse) Le Jolis                                               | 76                | Native              | New record         |
| Rhodophyta | *Gelidium spinosum* (S.G.Gmelin) P.C.Silva                                             | 35                | Native              | C                  |
| Rhodophyta | *Gigartina pistillata* (S.G.Gmelin) Stackhouse                                         | 2                 | Native              | New record         |
| Rhodophyta | *Gracilariopsis longissima* (S.G.Gmelin) Steentoft, L.M.Irvine & Farnham                | 1                 | Native              | New record         |
| Rhodophyta | * Grateloupea filicina* (J.V.Lamoureux) C.Agardh                                       | 3                 | Native              | New record         |
| Rhodophyta | *Gymnogongrus crenulatus* (Turner) J.Agardh                                            | 38                | Native              | New record         |
| Rhodophyta | *Gymnogongrus griffithsiae* (Turner) C.Martius                                          | 37                | Native              | New record         |
| Rhodophyta | *Gymnothamnion elegans* (Schousboe ex C.Agardh) J.Agardh                               | 2                 | Native              | New record         |
| Rhodophyta | *Halarachnion ligulatum* (Woodward) Kützing                                             | 2                 | Native              | New record         |
| Phylum      | Species (Accepted Name)                                                                 | Number of records | Establishment Means | Occurrence Remarks |
|------------|---------------------------------------------------------------------------------------|-------------------|---------------------|--------------------|
| Rhodophyta | Herposiphonia secunda (C.Agardh) Ambronn                                             | 2                 | Native              |                    |
| Rhodophyta | Heterosiphonia crispella (C.Agardh) M.J.Wynne                                        | 5                 | Native              | New record         |
| Rhodophyta | Hildenbrandia crouaniorum J.Agardh                                                    | 2                 | Native              | New record         |
| Rhodophyta | Hypnea arbuscula P.J.L.Dangeard                                                       | 1                 | Native              |                    |
| Rhodophyta | Hypnea cervicornis J.Agardh                                                            | 2                 | Native              |                    |
| Rhodophyta | Hypnea flagelliformis Greville ex J.Agardh                                            | 8                 | Introduced          |                    |
| Rhodophyta | Hypnea musciformis (Wulfen) J.V.Lamouroux                                             | 97                | Uncertain           | A                  |
| Rhodophyta | Hypnea spinella (C.Agardh) Kützing                                                    | 25                | Native              | New record         |
| Rhodophyta | Hypoglossum hypoglossoides (Stackhouse) Collins & Hervey                              | 2                 | Native              | New record         |
| Rhodophyta | Jania capillacea Harvey                                                                | 16                | Native              | New record         |
| Rhodophyta | Jania longifurca Zanardini                                                             | 9                 | Uncertain           |                    |
| Rhodophyta | Jania pedunculata var. adhaerens (J.V.Lamouroux) A.S.Harvey, Woelkerling & Reviers    | 8                 | Native              | New record         |
| Rhodophyta | Jania pumila J.V.Lamouroux                                                             | 10                | Native              | New record         |
| Rhodophyta | Jania rubens (Linnaeus) J.V.Lamouroux                                                 | 43                | Native              |                    |
| Rhodophyta | Jania virgata (Zanardini) Montagne                                                    | 13                | Uncertain           |                    |
| Rhodophyta | Kallymenia reniformis (Turner) J.Agardh                                                | 1                 | Native              | New record         |
| Rhodophyta | Laurencia brongniartii J.Agardh                                                        | 3                 | Introduced          |                    |
| Rhodophyta | Laurencia chondrioides Børgesen                                                       | 11                | Introduced          |                    |
| Rhodophyta | Laurencia dendroidea J.Agardh                                                          | 10                | Introduced          |                    |
| Rhodophyta | Laurencia intricata J.V.Lamouroux                                                     | 2                 | Native              | New record         |
| Rhodophyta | Laurencia microcladia Kützing                                                          | 3                 | Native              | New record         |
| Rhodophyta | Laurencia minuta Vandermeulen, Garbary & Guiry                                        | 18                | Introduced          | New record         |
| Rhodophyta | Laurencia obtusa (Hudson) J.V.Lamouroux                                                | 2                 | Native              |                    |
| Rhodophyta | Laurencia pyramidalis Bory ex Kützing                                                  | 11                | Native              | New record         |
| Rhodophyta | Laurencia tenera C.K.Tseng                                                              | 17                | Native              | New record         |
| Phylum        | Species (Accepted Name)                                                                 | Number of records | Establishment Means          | Occurrence Remarks |
|--------------|----------------------------------------------------------------------------------------|-------------------|-----------------------------|--------------------|
| Rhodophyta   | Laurencia viridis Gil-Rodríguez & Haroun                                               | 4                 | Macaronesian endemism       | New record         |
| Rhodophyta   | Laurencia marilzae (Gill-Rodríguez, Senties, Díaz-Larrea, Cassano & M.T.Fuji) Gil-Rodríguez, Senties, Díaz-Larrea, Cassano & M.T.Fuji | 2                 | Native                      | New record         |
| Rhodophyta   | Lejolisia mediterranea Bornet                                                          | 1                 | Native                      | New record         |
| Rhodophyta   | Leptosiphonia brodiei (Dillwyn) A.M.Savoie & G.W.Saunders                              | 2                 | Uncertain                   | R                  |
| Rhodophyta   | Liagora viscida (Forsskál) C.Agardh                                                    | 8                 | Native                      | New record         |
| Rhodophyta   | Lithophyllum incrustans Philippi                                                       | 1                 | Native                      | R                  |
| Rhodophyta   | Lomentaria articulata (Hudson) Lyngbye                                                | 75                | Native                      | New record         |
| Rhodophyta   | Lomentaria clavellosa (Lightfoot ex Turner) Gaillon                                    | 1                 | Uncertain                   | R                  |
| Rhodophyta   | Lophosiphonia cristata Falkenberg                                                     | 13                | Native                      | C                  |
| Rhodophyta   | Meredithia microphylla (J.Agardh) J.Agardh                                             | 10                | Native                      | New record         |
| Rhodophyta   | Nemalion elminthoides (Velley) Batters                                                | 21                | Native                      | C                  |
| Rhodophyta   | Nitophyllum punctatum (Stackhouse) Greville                                            | 11                | Native                      | New record         |
| Rhodophyta   | Osmundea hybrida (A.P.de Candolle) K.W.Nam                                             | 5                 | Native                      | New record         |
| Rhodophyta   | Osmundea oederi (Gunnerus) G.Furnari                                                  | 3                 | Native                      | R                  |
| Rhodophyta   | Osmundea pinnatifida (Hudson) Stackhouse                                               | 23                | Native                      | C                  |
| Rhodophyta   | Osmundea truncata (Kützing) K.W.Nam & Maggs                                           | 24                | Native                      | New record         |
| Rhodophyta   | Peyssonellia squamaria (S.G.Gmelin) Decaisne ex J.Agardh                              | 8                 | Native                      | R                  |
| Rhodophyta   | Phyllophora gelidioides P.Crouan & H.Crouan ex Karsakoff                              | 1                 | Native                      | New record         |
| Rhodophyta   | Phymatolithon calcareum (Pallas) W.H.Adey & D.L.McKibbin ex Woelkering & L.M.Irving   | 1                 | Native                      | R                  |
| Rhodophyta   | Platoma cyclocolpum (Montagne) F.Schmitz                                               | 9                 | Native                      | R                  |
| Rhodophyta   | Plocamium cartilagineum (Linnaeus) P.S.Dixon                                            | 28                | Native                      | C                  |
| Rhodophyta   | Polysiphonia atlantica Kapraun & J.N.Norris                                            | 3                 | Native                      | New record         |
| Rhodophyta   | Polysiphonia ceramiiformis P.Crouan & H.Crouan                                         | 1                 | Native                      | New record         |
| Phylum       | Species (Accepted Name)                                      | Number of records | Establishment Means | Occurrence Remarks |
|--------------|-------------------------------------------------------------|-------------------|---------------------|--------------------|
| Rhodophyta   | *Polysiphonia havanensis* Montagne                          | 3                 | Native              | New record         |
| Rhodophyta   | *Polysiphonia opaca* (C.Agardh) Moris & De Notaris          | 3                 | Native              | R                   |
| Rhodophyta   | *Polysiphonia stricta* (Mertens ex Dillwyn) Greville       | 6                 | Native              | R                   |
| Rhodophyta   | *Porphyra umbilicalis* Kützing                              | 1                 | Native              | New record         |
| Rhodophyta   | *Pterocladiella capillacea* (S.G.Gmelin) Santelices & Hommersand | 131               | Native              | A                   |
| Rhodophyta   | *Rhodymenia holmesii* Ardissone                             | 22                | Native              | New record         |
| Rhodophyta   | *Rhodymenia pseudopalmata* (J.V.Lamouroux) P.C.Silva       | 9                 | Native              | New record         |
| Rhodophyta   | *Schizymenia apoda* (J.Agardh) J.Agardh                     | 1                 | Native              | R                   |
| Rhodophyta   | *Schottera nicaeensis* (J.V.Lamouroux ex Duby) Guiry & Hollenberg | 1                 | Uncertain           | R                   |
| Rhodophyta   | *Scinaia interrupta* (A.P.de Candolle) M.J.Wynne          | 2                 | Native              | R                   |
| Rhodophyta   | *Sebdenia dichotoma* Berthold                               | 7                 | Native              | R                   |
| Rhodophyta   | *Sebdenia rodrigueziana* (Feldmann) Codomier ex Parkinson  | 6                 | Native              | R                   |
| Rhodophyta   | *Spermothamnion repens* (Dillwyn) Magnus                   | 1                 | Native              | New record         |
| Rhodophyta   | *Sphaerococcus coronopifolius* Stackhouse                  | 16                | Native              | New record         |
| Rhodophyta   | *Spongoclonium caribaeum* (Børgesen) M.J.Wynne            | 4                 | Introduced         | R                   |
| Rhodophyta   | *Spyridia filamentosa* (Wulfen) Harvey                     | 2                 | Native              | New record         |
| Rhodophyta   | *Symphyocladia marchantioides* (Harvey) Falkenberg        | 44                | Introduced         | C                   |
| Rhodophyta   | *Taenioma nanum* (Kützing) Papenfuss                      | 3                 | Native              | R                   |
| Rhodophyta   | *Tenarea tortuosa* (Esper) Me.Lemoine                      | 1                 | Native              | R                   |
| Rhodophyta   | *Vertebrata fruticulosa* (Wulfen) Kuntze                   | 4                 | Native              | New record         |
| Rhodophyta   | *Vertebrata furcoides* (Hudson) Kuntze                     | 1                 | Uncertain           | New record         |
| Rhodophyta   | *Vertebrata furcellata* (C.Agardh) Kuntze                  | 1                 | Native              | R                   |
| Rhodophyta   | *Vertebrata reptabunda* (Suhr) Diaz-Tapia & Maggs          | 10                | Uncertain           | C                   |
| Rhodophyta   | *Vertebrata tripinnata* (Harvey) Kuntze                    | 1                 | Native              | R                   |
| Rhodophyta   | *Wrangelia penicillata* (C.Agardh) C.Agardh               | 3                 | Native              | New record         |
| Phylum          | Species (Accepted Name)                                                                 | Number of records | Establishment Means | Occurrence Remarks |
|-----------------|----------------------------------------------------------------------------------------|-------------------|---------------------|--------------------|
| Rhodophyta      | Yuzurua poiteaui (J.V.Lamouroux) Martin-Lescanne                                       | 4                 | Native              | New record         |
| Chlorophyta     | Anadyomene saldanhae A.B.Joly & E.C.Oliveira                                          | 94                | Native              | New record A       |
| Chlorophyta     | Anadyomene stellata (Wulfen) C.Agardh                                                  | 16                | Uncertain           | C                  |
| Chlorophyta     | Blidingia minima (Nägeli ex Kützing) Kylin                                              | 4                 | Native              | R                  |
| Chlorophyta     | Bryopsis cupressina J.V.Lamouroux                                                       | 4                 | Native              | New record R       |
| Chlorophyta     | Bryopsis pennata J.V.Lamouroux                                                         | 1                 | Native              | New record R       |
| Chlorophyta     | Bryopsis plumosa (Hudson) C.Agardh                                                     | 6                 | Native              | New record R       |
| Chlorophyta     | Chaetomorpha aerea (Dillwyn) Kützing                                                   | 8                 | Native              | New record R       |
| Chlorophyta     | Chaetomorpha ligustica (Kützing) Kützing                                               | 1                 | Native              | New record R       |
| Chlorophyta     | Chaetomorpha linum (O.F.Müller) Kützing                                                | 4                 | Native              | R                  |
| Chlorophyta     | Chaetomorpha pachynema (Montagne) Kützing                                              | 84                | Native              | A                  |
| Chlorophyta     | Cladophora albida (Nees) Kutzting                                                     | 6                 | Native              | New record R       |
| Chlorophyta     | Cladophora coelothrix Kützing                                                         | 32                | Native              | New record C       |
| Chlorophyta     | Cladophora conferta P.Crouan & H.Crouan                                               | 4                 | Native              | R                  |
| Chlorophyta     | Cladophora hutchinsiae (Dillwyn) Kützing                                               | 2                 | Native              | New record R       |
| Chlorophyta     | Cladophora laetevirens (Dillwyn) Kützing                                               | 7                 | Uncertain           | R                  |
| Chlorophyta     | Cladophora lehmanniana (Lindenberg) Kützing                                            | 8                 | Native              | New record R       |
| Chlorophyta     | Cladophora liebetruthii Grunow                                                        | 2                 | Native              | New record R       |
| Chlorophyta     | Cladophora prolifer (Roth) Kützing                                                    | 43                | Native              | C                  |
| Chlorophyta     | Cladoporhopsis macromeres W.R.Taylor                                                   | 2                 | Native              | New record R       |
| Chlorophyta     | Cladophoropsis membranacea (Hofman Bang ex C.Agardh) Bergesen                          | 6                 | Uncertain           | R                  |
| Chlorophyta     | Codium adhaerens C.Agardh                                                              | 101               | Native              | A                  |
| Chlorophyta     | Codium decorticatum (Woodward) M.Howe                                                 | 16                | Native              | C                  |
| Chlorophyta     | Codium effusum (Rafinesque) Delle Chiaje                                               | 22                | Uncertain           | C                  |
| Phylum          | Species (Accepted Name)                                      | Number of records | Establishment Means | Occurrence Remarks |
|-----------------|-------------------------------------------------------------|-------------------|---------------------|--------------------|
| Chlorophyta     | *Codium elisabethiae* O.C.Schmidt                           | 39                | Macaronesian endemism |                  |
| Chlorophyta     | *Codium fragile* subsp. *fragile* (Suringar) Hariot          | 4                 | Introduced          | New record         |
| Chlorophyta     | *Codium taylorii* P.C.Silva                                | 3                 | Native              | R                  |
| Chlorophyta     | *Codium vermiitaria* (Oliv) Delle Chiaje                    | 18                | Native              | New record         |
| Chlorophyta     | *Ernodesmis verticillata* (Kützing) Børgesen                | 2                 | Native              | New record         |
| Chlorophyta     | *Lychaete pellucida* (Hudson) M.J.Wynne                    | 10                | Native              | New record         |
| Chlorophyta     | *Microdictyon umbilicatum* (Velley) Zanardini               | 11                | Native              | New record         |
| Chlorophyta     | *Pseudorhizoclonium africanum* (Kützing) Boedeker          | 1                 | Native              | New record         |
| Chlorophyta     | *Ulva clathrata* (Roth) C.Agardh                           | 14                | Native              | C                  |
| Chlorophyta     | *Ulva compressa* Linnaeus                                   | 13                | Native              | C                  |
| Chlorophyta     | *Ulva intestinalis* Linnaeus                                | 13                | Native              | C                  |
| Chlorophyta     | *Ulva lactuca* Linnaeus                                     | 1                 | Uncertain           | R                  |
| Chlorophyta     | *Ulva linza* Linnaeus                                       | 3                 | Native              | R                  |
| Chlorophyta     | *Ulva polyclada* Kraft                                      | 5                 | Native              | R                  |
| Chlorophyta     | *Ulva prolifera* O.F.Müller                                | 3                 | Native              | R                  |
| Chlorophyta     | *Ulva rigida* C.Agardh                                      | 133               | Native              | A                  |
| Chlorophyta     | *Valonia macrophysa* Kützing                                | 1                 | Native              | New record         |
| Chlorophyta     | *Valonia utricularis* (Roth) C.Agardh                      | 7                 | Native              | New record         |
| Ochrophyta      | *Ascophyllum nodosum* (Linnaeus) Le Jolis                   | 4                 | Native              | R                  |
| Ochrophyta      | *Bachelotia antillarum* (Grunow) Gerloff                   | 4                 | Native              | R                  |
| Ochrophyta      | *Canistrocarpus cervicornis* (Kützing) De Paula & De Clerck | 1                 | Native              | New record         |
| Ochrophyta      | *Carpomitra costata* (Stackhouse) Batters                   | 4                 | Native              | New record         |
| Ochrophyta      | *Cladostephus spongiosum* (Hudson) C.Agardh                 | 6                 | Native              | New record         |
| Ochrophyta      | *Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier      | 98                | Native              | A                  |
| Phylum      | Species (Accepted Name)                                      | Number of records | Establishment Means | Occurrence Remarks |
|------------|-------------------------------------------------------------|-------------------|---------------------|--------------------|
| Ochrophyta | Cutleria multifida (Turner) Greville                       | 9                 | Uncertain           | R                  |
| Ochrophyta | Cutleria multifida (Turner) Greville, phase Aglaozonia parvula (Greville) Zanardini | 10                | Uncertain           | New record C       |
| Ochrophyta | Cystoseira compressa (Esper) Gerloff & Nizamuddin          | 23                | Native              | New record C       |
| Ochrophyta | Cystoseira foeniculacea (Linnaeus) Greville                | 2                 | Native              | New record R       |
| Ochrophyta | Cystoseira humilis Schousboe ex Kützing                    | 5                 | Native              | R                  |
| Ochrophyta | Dictyopteris polypodioides (A.P.de Candolle) J.V.Lamouroux | 1                 | Native              | New record R       |
| Ochrophyta | Dictyota bartayresiana J.V.Lamouroux                       | 3                 | Native              | New record R       |
| Ochrophyta | Dictyota cyanoloma Tronholm, De Clerck, A.Gómez-Garreta & Rull Lluch | 3                  | Native              | R                  |
| Ochrophyta | Dictyota dichotoma (Hudson) J.V.Lamouroux                  | 35                | Native              | C                  |
| Ochrophyta | Dictyota dichotoma var. intricata (C.Agardh) Greville      | 7                 | Native              | New record R       |
| Ochrophyta | Dictyota implexa (Desfontaines) J.V.Lamouroux              | 6                 | Native              | New record R       |
| Ochrophyta | Ectocarpus fasciculatus Harvey                             | 2                 | Native              | R                  |
| Ochrophyta | Fucus spiralis Linnaeus                                    | 32                | Uncertain           | C                  |
| Ochrophyta | Halopteris filicina (Grateloup) Kützing                    | 77                | Native              | A                  |
| Ochrophyta | Halopteris scoparia (Linnaeus) Sauvageau                   | 129               | Native              | A                  |
| Ochrophyta | Hincksia ovata (Kjellman) P.C.Silva                       | 1                 | Native              | R                  |
| Ochrophyta | Hydroclathrus clathratus (C.Agardh) M.Howe                 | 2                 | Native              | New record R       |
| Ochrophyta | Hydroclathrus tilesii (Endlicher) Santiañez & Wynne       | 15                | Introduced          | New record C       |
| Ochrophyta | Leathesia marina (Lyngbye) Decaisne                        | 2                 | Uncertain           | New record R       |
| Ochrophyta | Lobophora variegata (J.V.Lamouroux) Womersley ex E.C.Oliveira | 2                  | Native              | R                  |
| Ochrophyta | Microzonia floridana (E.C.Henry) Camacho & Fredericq      | 3                 | Native              | R                  |
| Ochrophyta | Myrionema strangulans Greville                            | 2                 | Native              | New record R       |
| Ochrophyta | Nemoderma tingitanum Schousboe ex Bornet                   | 39                | Native              | New record C       |
| Phylum    | Species (Accepted Name)                                      | Number of records | Establishment Means | Occurrence Remarks |
|-----------|-------------------------------------------------------------|-------------------|---------------------|--------------------|
| Ochrophyta| *Padina pavonica* (Linnaeus) Thivy                         | 91                | Native              | A                  |
| Ochrophyta| *Petalonia binghamiae* (J.Agardh) K.L.Vinogradova           | 10                | Introduced          | C                  |
| Ochrophyta| *Petrospongium berkeleyi* (Greville) Nägeli ex Kützing      | 1                 | Native              | New record         | R                  |
| Ochrophyta| *Sargassum cymosum* C.Agardh                                | 5                 | Native              | R                  |
| Ochrophyta| *Sargassum desfontainesii* (Turner) C.Agardh                 | 2                 | Native              | New record         | R                  |
| Ochrophyta| *Sargassum furcatum* Kützing                                 | 25                | Native              | New record         | C                  |
| Ochrophyta| *Sargassum vulgare* C.Agardh                                | 1                 | Native              | R                  |
| Ochrophyta| *Scytosiphon lomentaria* (Lyngbye) Link                     | 1                 | Native              | New record         | R                  |
| Ochrophyta| *Sphacelaria cirrosa* (Roth) C.Agardh                       | 2                 | Native              | R                  |
| Ochrophyta| *Sphacelaria tribuloides* Meneghini                         | 1                 | Uncertain           | R                  |
| Ochrophyta| *Spongonema tormentosum* (Hudson) Kützing                   | 1                 | Native              | New record         | R                  |
| Ochrophyta| *Taonia atomaria* (Woodward) J.Agardh                       | 2                 | Native              | New record         | R                  |
| Ochrophyta| *Treptacantha abies-marina* (S.G.Gmelin) Kützing            | 72                | Native              | New record         | A                  |
| Ochrophyta| *Zonaria tounefortii* (J.V.Lamouroux) Montagne              | 90                | Native              | A                  |

Table 3.
Main taxonomic figures with information on the species origin and status.

| Phylum    | Order | Family | Specimens Number | Total taxa | Total species | Native | Introduced | Uncertain | Macaronesian endemism | New record |
|-----------|-------|--------|------------------|------------|---------------|--------|------------|-----------|-----------------------|------------|
| Rhodophyta| 15    | 39     | 2404             | 197        | 142           | 113    | 11         | 16        | 2                     | 69         |
| Chlorophyta| 3     | 10     | 773              | 53         | 41            | 34     | 1          | 5         | 1                     | 20         |
| Ochrophyta| 12    | 18     | 866              | 53         | 42            | 36     | 2          | 4         | 3                     | 21         |
| Total     | 30    | 67     | 4043             | 303        | 225           | 183    | 14         | 25        | 3                     | 110        |

Many species were only sporadically recorded on Pico, but 11 were commonly found around the Island and occurred quite abundantly in some locations: the Rhodophyta *Asparagopsis armata* Harvey, *Ellisolania elongata* (J. Ellis & Solander) K. R. Hind & G. W. Saunders, *Hypnea musciformis* (Wulfen) J. V. Lamouroux and *Pterocladiella capillacea* (S. G. Gmelin) Santelices & Hommersand; the Chlorophyta *Anadyomene saldanhae* A. B. Joly & E. C. Oliveira, *Codium adhaerens* C. Agradh and *Ulva rigida* C. Agardh; the Ochrophyta
Colpomenia sinuosa (Mertens ex Roth) Derbès & Solier in Castagne, Halopteris scoparia (Linnaeus) Sauvageau, Padina pavonica (Linnaeus) Thivy and Zonaria tournefortii (J. V. Lamouroux) Montagne.

A mismatch regarding the GBIF backbone taxonomy of some of the macroalgae species names was identified as detailed in Suppl. material 1.

Acknowledgements

This research was supported by the project “PICOBEL: Coastal benthic communities of Pico Island: characterization and monitoring”, funded by the Azores Regional Government and lately by the project “ACORES-01-0145-FEDER-000072” funded the Operational Programme Azores 2020 (85% ERDF and 15% regional funds). We are grateful to the Municipality of Lajes do Pico and Escola Básica e Secundária de Lajes do Pico for their logistics support during the Campaign PICOBEL/2007. Thanks are due to the Campaign PICOBEL/2007 team (André Amaral, António Brigos, Catarina Santos, Daniel Torrão, David Villegas, Edgar Rosas-Alquicira, Eunice Nogueira, Francisco Wallenstein, Gustavo Martins, José M. N. Azevedo, Karla Leon Cisneros, Marlene Terra, Nuno Álvaro, Raul Coma, Rita Patarra, Ruben Couto and Silvia Escarduça), the team of the Campaign

Figure 9. doi

Laurencia pyramidalis, a new record for Pico Island (by the Island Aquatic Ecology Subgroup of cE3c-ABG).
LAUMACAT/2011 (Abel Sentiés, Eunice Nogueira, Maria Machín-Sánchez, Mutue Toyota Fujii, Valeria Cassano) and to Mrs Inês Melo Azevedo and her husband José A. Azevedo for providing free accommodation to some of the team members during the campaign periods. The occasional collections made by Edward Hehre, Heather Baldwin, Inês Neto, Leila Bagaço, Patrícia Madeira, Richard Fralick and Ruben Afonso are appreciated. Afonso Prestes was supported by a PhD grant (M3.1.a/F/083/2015) awarded by Fundo Regional da Ciência e Tecnologia (FRCT).

**Author contributions**

AIN: Conceptualisation; Methodology; Investigation (fieldwork and laboratory work); Resources; Data Curation; Formal analysis and interpretation; Paper writing

ACLP: Investigation (laboratory work); Resources; Paper writing

NVA: Investigation (field and laboratory work); Maps elaboration; Paper writing

RR: Resources; Data Curation

RMAN: Data Curation; Formal analysis and interpretation; Paper writing

IT: Methodology; Investigation (field and laboratory work); Data Curation; Paper writing

IM: Data Curation; Formal analysis and interpretation; Paper writing

**References**

- Afonso-Carrillo J, Sansón M (1989) Clave Ilustrada para la Determinación de los Macrófitos Marinas Bentónicos de las Islas Canarias. [Illustrated key for the determination of the Benthic Marine Macrophytes of the Canary Islands]. Departamento de Biología Vegetal (Botánica), Universidad de La Laguna, La Laguna, 55 pp.
- Borges PJA (2004) Ambientes litorais nos grupos Central e Oriental do arquipélago dos Açores - conteúdos e dinâmica de microescala. [Coastal environments in the Central and Eastern groups of the Azores archipelago - contents and microscale dynamics]. Universidade dos Açores, Ponta Delgada.
- Boudouresque C-F, Meinesz A, Verlaque M (1992) Méditerranée. In: Boudouresque C-F (Ed.) Guide des Algues des Mers d'Europe. Delachaux et Niestlé, Paris, 138-231 pp.
- Bridsen D, Forman L (1999) The Herbarium Handbook. 3rd. The Board of Trustees of the Royal Botanic Gardens, Kew, 334 pp. [ISBN 1-900347-43-1]
- Brodie J, Maggs C, John DM (2007) The green seaweeds of Britain and Ireland. British Phycological Society, Dunmurry, 242 pp.
- Burrows EM (1991) Seaweeds of the British Isles. Vol. 2. Chlorophyta . Natural History Museum, London, 238 pp.
- Cabioch J, Floch J-Y, Le Toquin A (1992) Manche et Atlantique. In: Boudouresque C-F, et al. (Ed.) Cuide des Algues des Mers d'Europe. Delachaux et Niestlé, Paris, 30-136 pp.
• Cardoso P, Erwin T, Borges PV, New T (2011) The seven impediments in invertebrate conservation and how to overcome them. Biological Conservation 144 (11): 2647-2655. https://doi.org/10.1016/j.biocon.2011.07.024
• Cruz VJ, Oliveira MS (2001) Hydrogeologic framework of Pico Island, Azores, Portugal. Hydrogeology Journal 9: 177-189. https://doi.org/10.1007/s100400000106
• Dixon SP, Irvine ML (1977) Seaweeds of the British Isles. Vol. I Rhodophyta. Part 1 Introduction, Nemaliales, Gigartinales . British Museum (Natural History), London, 252 pp.
• Fletcher RL (1987) Seaweeds of the British Isles. Vol. III. Fucophyceae (Phaeophyceae). Part 1. British Museum (Natural History), London, 359 pp.
• Freitas R, Romeiras M, Silva L, Cordeiro R, Madeira P, González JA, Wirtz P, Falcón J, Brito A, Floeter S, Afonso P, Porteiro F, Viera-Rodriguez MA, Neto Al, Haroun R, Farinha JM, Rebelo AC, Baptista L, Melo C, Martínez A, Núñez J, Berning B, Johnson M, Ávila S (2019) Restructuring of the 'Macaronesia' biogeographic unit: A marine multi-taxon biogeographical approach. Scientific Reports 9 (1). https://doi.org/10.1038/s41598-019-51786-6
• Gayral P, Cosson J (1986) Connaitre et reconnaitre les algues marines. Ouest France, 220 pp.
• Guiry MD, Guiry GM (2020) AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. https://www.algaebase.org. Accessed on: 2020-5-26.
• Hidrográfico I (1981) Roteiro do Arquipélago dos Açores. [Azores archipelago tour]. PUB. (N) -lli-128-SN, Lisboa.
• Hortal J, de Bello F, Diniz-Filho JAF, Lewinsohn TM, Lobo JM, Ladle RJ (2015) Seven shortfalls that beset large-scale knowledge of biodiversity. Annual Review of Ecology, Evolution, and Systematics 523-549. https://doi.org/10.1146/annurev-ecolsys-112414-054400
• Irvine ML (1983) Seaweeds of the British Isles. Vol. I Rhodophyta. Part 2A. Cryptonemiales (sensu stricto), Palmariales, Rhodymeniales . British Museum (Natural History), London, 115 pp.
• Irvine ML, Chamberlain YM (1994) Seaweeds of the British Isles. Vol. 1. Rhodophyta. Part 2B. Corallinales, Hildenbrandiales . Natural History Museum, London, 276 pp.
• Lawson GW, John DM (1982) The marine algae and coastal environment of Tropical West Africa. Beihefte zur Nova Hedwigia, J. Cramer, Vaduz, 455 pp.
• Levring T (1974) The marine algae of the archipelago of Madeira. Boletim do Museu Municipal do Funchal 28 (125): 5-111. URL: http://publications.cm-funchal.pt/jspui/handle/100/1231
• Lloréns JLP, Cabrero IH, Lacida RB, González GP, Murillo FGB, Oñate JJV (2012) Flora marina del litoral gaditano. Biologia, ecologia, usos y guía de identificación. mCN Monografías de Ciencias de la Naturaleza. [Marine flora of the Cadiz coast. Biology, ecology, uses and identification guide. mCN Nature Science Monographs]. Servicio de Publicaciones de la Universidad de Cadiz, Cadiz, 368 pp.
• Maggs CA, Hommersand MH (1993) Seaweeds of the British Isles. Vol. 1. Rhodophyta. Part 3A. Ceramiales . Natural History Museum, London, 444 pp.
• Morton B, Britton JC, Martins AMF (1998) Coastal Ecology of the Azores. Sociedade Afonso Chaves, Ponta Delgada, 249 pp.
Supplementary material

Suppl. material 1: DP-PIX-id_14106_normalized-redz.csv doi

Authors: Ana I. Neto
Data type: Macroalgae taxonomic mismatching
Brief description: GBIF does not have the more actualised nomenclature for some of the macroalgae species names. Therefore, the matching tools of its platform were applied to the species list, as required by Pensoft’s data auditor, to identify the problematic taxonomic situations. The resulting file (DP-PIX-id_14106_normalized-redz.csv) is included here, since the names will not be immediately updated in the GBIF Taxonomic Backbone. A request was already sent to GBIF helpdesk to resolve this situation.

Download file (4.37 kb)