Discovering marine and terrestrial biota on Pico (Azores) 2018

From whaling to whale watching

L. Wälter, M. Funken, L. Brackelmann, L. Lies, P. Zahn

Department of Biology and Chemistry

Dipl.-Biol. Peter Zahn, University of Hildesheim (pzahn@uni-hildesheim.de)

Lara Wälter, University of Hildesheim (waelter@uni-hildesheim.de)

Maren Funken, University of Hildesheim (funken@uni-hildesheim.de)

Lina Brackelmann, University of Hildesheim (brackelm@uni-hildesheim.de)

Laura Lies, University of Hildesheim (liesla@uni-hildesheim.de)

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THE AZORES

The Azores are an archipelago composed of nine volcanic islands in the North Atlantic Ocean (see Figure 1). They are one of the two autonomous regions of Portugal. Santa Maria, one of the eastern islands of the Azores, is about 1360 km away from the mainland of Portugal. The westernmost island is Flores. Flores is 1860 km away from the mainland (WAKONIGG 2008:18).

Figure 1: Location of the Azores in the Atlantic Ocean (GOOGLEEARTH 2018).

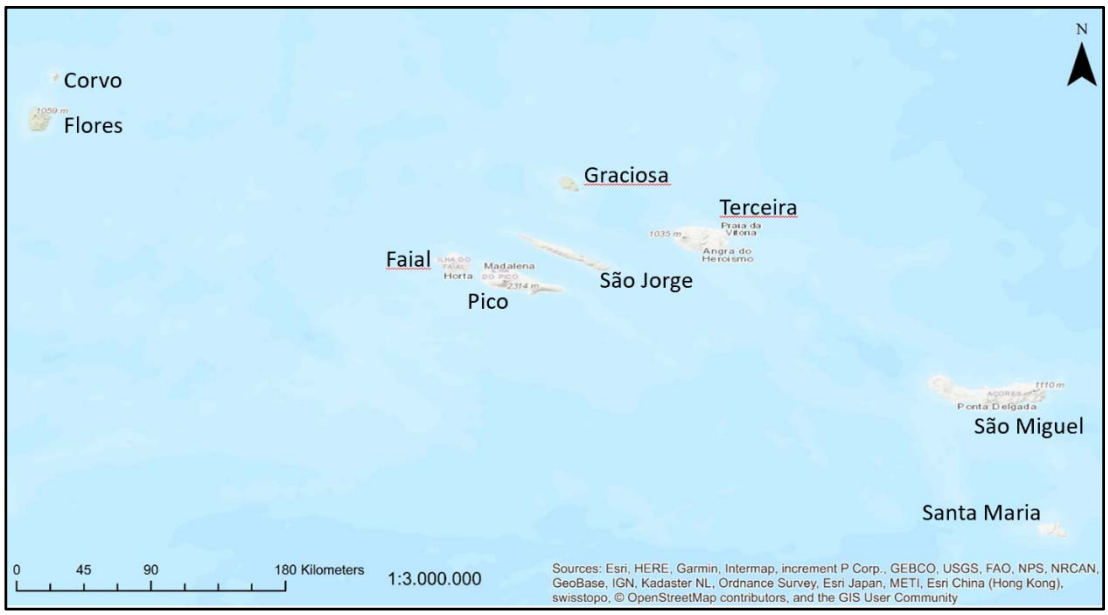


Figure 2: Overwiev of the archipelago (GOOGLE EARTH 2018).

The nine volcanic islands are all inhabited. The archipelago is split in three groups: The western islands are Flores and Corvo, the center islands are Faial, São Jorge, Terceira, Pico and Graciosa and the eastern islands are São Miguel and Santa Maria (see Figure 2). The archipelago of the Azores extends along a west-northwest to east-southeast orientation (More than 600 km between 36.5°-40° North latitudes and 24.5°-31.5° West latitudes). Mount Pico, on the island Pico, is the highest point in Portugal, at 2.351 m over sea level (WAKONIGG 2008:18). The number of inhabitants of the Azores is 247.000 (Effective: 2012) (AZOREN.NET 2017).

The name of the archipelago is inferred from the Portuguese word “Açores”, which means hawk. It originated from the fact that the first sailors, who visited the Azores, confused the buzzards on the island with the hawks (WAKONIGG 2008:18).

The Climate

Climatically, the Azores are located in the winter-moist subtropics (WAKONIGG 2008:86). Based on the low mean temperature of 22 °C in August and at least four months with a mean temperature about 10 °C, the Azores are related to warm, summer dry climate according to KÖPPEN and GEIGER (1930).

The climate of the Azores is very mild. It is influenced by the distance from the continents and by the passing Gulf Stream. Because of the marine influences, temperatures remain mild throughout the year. It is also generally wet and cloudy. Figure 3 shows the climate graph of the rural community Lajes do Pico. Here the excursion took place for the most part. The annual mean temperature in Lajes do Pico accounts for 16,9 °C and the annual precipitation accounts for 1012 mm (see Figure 3).

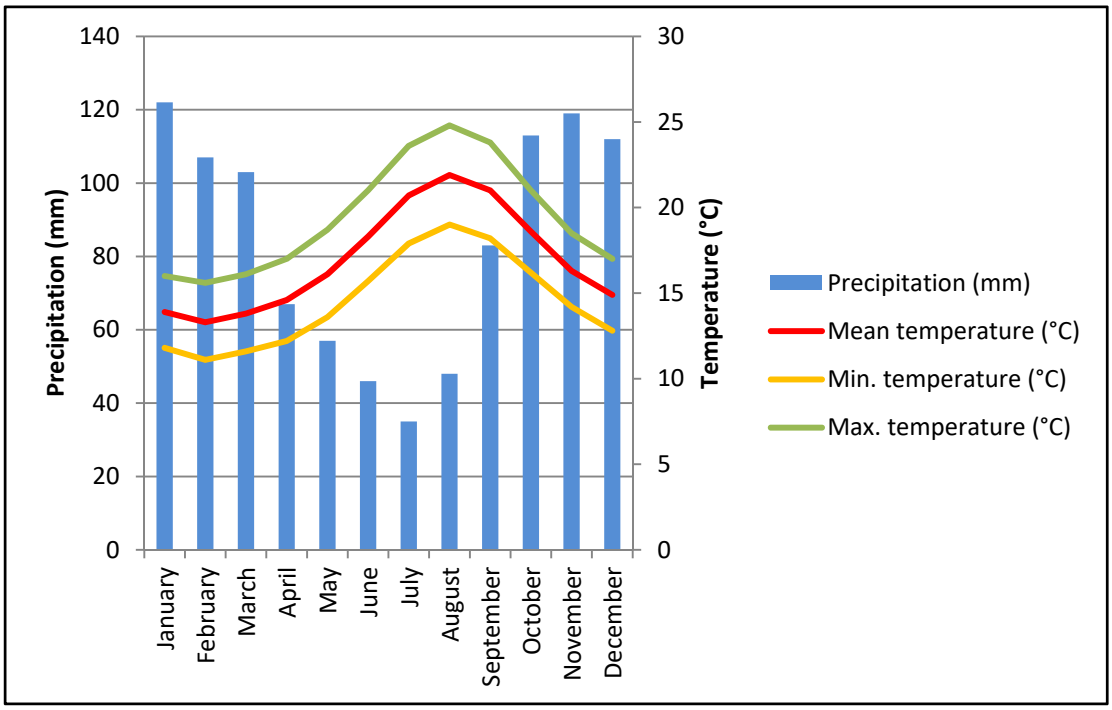


Figure 3: Climate graph of Lajes do Pico. Altutude: 121 m; Climate: Csb; Mean temperature: 16.9°C; Mean precipitation: 1012 mm (modified on CLIMATE DATA.ORG w.J.).

The Azores High, an area with high atmospheric pressure, has a special influence in the European climate. It was named after the archipelago. In summer the center of the Azores High is located over the archipelago. Therefore, the islands receive only little precipation (between a maximum of 35 to 50 mm per month). During the course of the year the center of the Azores High shifts, so that it is located in the south of the archipelago. As a result of the move a depression is generated in the north over the Azores. It implies more rainfall in winter (max. 122 mm per month). This also entails that the mean temperature fluctuates within the year (see Figure 3; STIEGLITZ 2009:9f.; WAKONIGG 2008:62).

The Primary Origin and Geology of the Azores

The Azores belongs with the archipelago of Madeira, the Canary Islands, the Ilhas Selvagens and the Cape Verde islands to the Eastern Atlantic islands (also called Macaronesia). The whole macaronesian region has a volcanic origin. No other rocks are found in the Azores. There is recent volcanism on the macaronesian islands with 26 active volcanoes (WAKONIGG 2008:31ff.).

The Azores archipelago is located on an irregular triangular shaped plateau. "This plateau is the result of magmatic activity related to a hot spot close to the triple junction between the Eurasian, Nubian, and North American plates. The plateau extends beyond the Mid-Atlantic Ridges […]" (MADEIRA 2015:1402). The age of the islands falls from east to west with the eastern island being the oldest and the western islands the youngest of the Azores (WAKONIGG 2008:40). A chronology of the making from east to west can also be seen on the Azorean island Pico (see Figure 4).

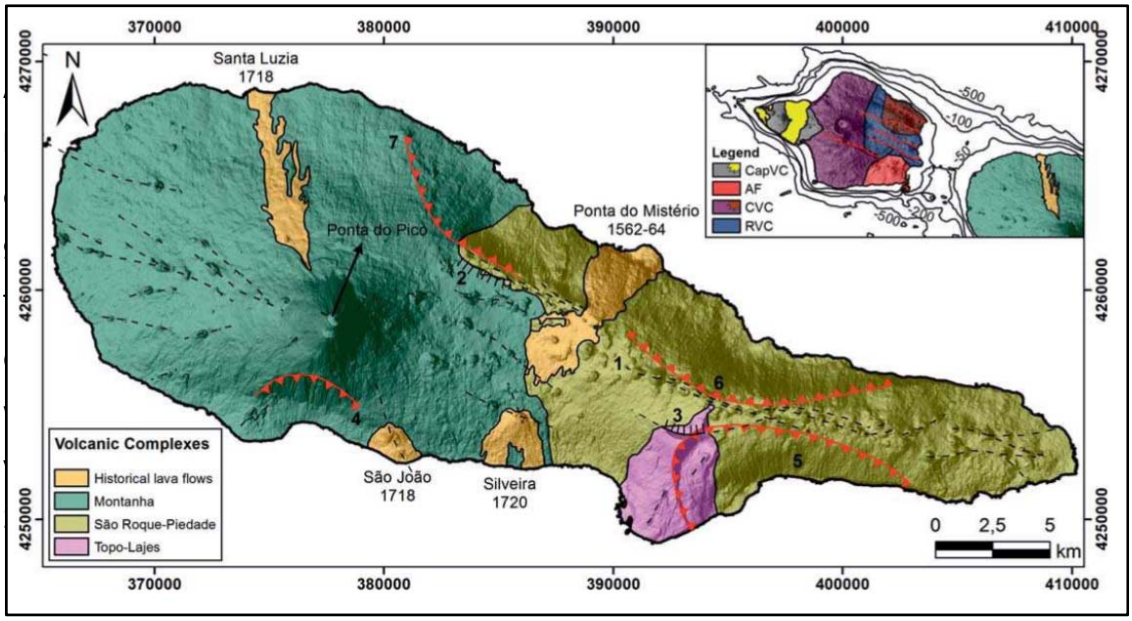
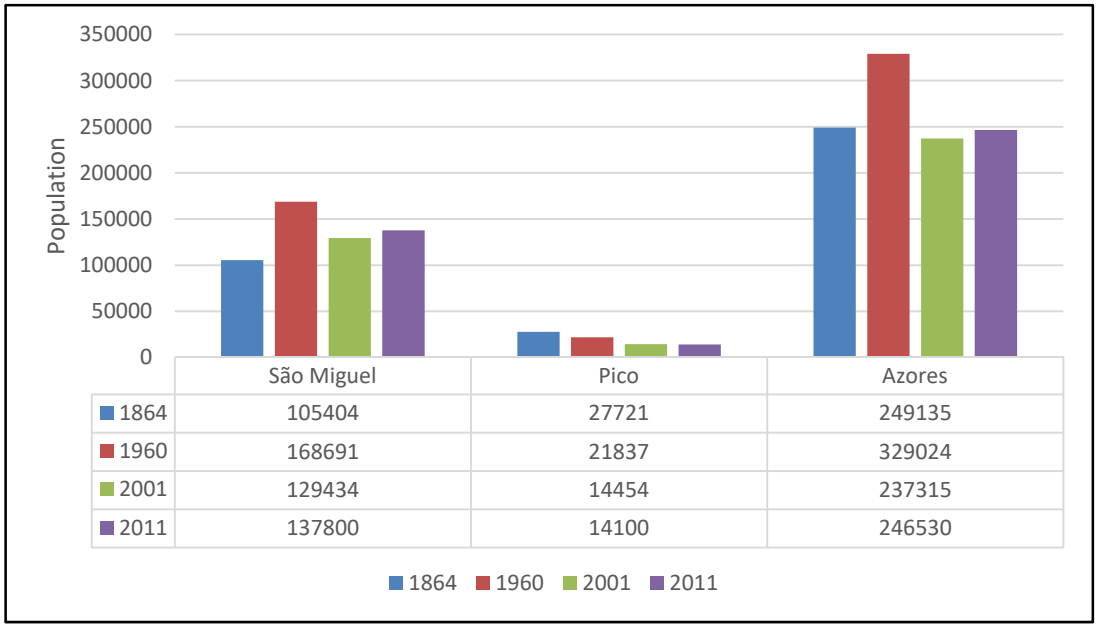


Figure 4: Simplified geologic map of Pico Island (MADEIRA 2015:1403).

Above sea level, Pico Islands is 46 km in length and has a maximum width of 15.8 km. The highest point is the Ponta do Pico (2351 m above the sea level). It rises in the eastern part of the island above a highland with many volcanic cones and small crater lakes (between 800 m and 900 m above sea level). The highland plunges abruptly to the coast (WAKONIGG 2008:54). The oldest part of the island (Topo-Lajes) lies in the south-east of the island. São Roque-Piedade is the second oldest part of the island. It constitutes the eastern half of the island. The western part of Pico arose during a volcanic eruption of the Pico 220,000 years ago. The youngest rocks descend from historical volcanic eruptions between 1562 and 1720 (MADEIRA 2015:1403).



	São Miguel	Pico	Azores
1864	105404	27721	249135
1960	168691	21837	329024
2001	129434	14454	237315
2011	137800	14100	246530

Figure 5: change in population on São Miguel, Pico and the Azores in the years 1864, 1960, 2001 and 2011 (After SAYERS 2013:24; WAKONIGG 2008;133).

The Discovery and Colonization of the Azores

The Azores were recorded Already on charts of the 13th century. But they were not settled until the reign of the Portuguese King Henrique es Navegador ("Henry the Navigator"). Beginning in 1439 the Portuguese populated the eastern island Santa Maria and São Miguel. The middle and western island were discovered between 1452 and 1466. The Azores remained always in Portuguese property, apart from the personal union with Spain (WAKONIGG 2008:122).

There are parallels to the demographic development between Madeira and the Azores. Already in the 16th century a first emigration wave to Brazil took place. In the following centuries further emigration waves ensued. Probable reasons are overpopulation, volcanic eruptions, piracy, social discrimination and economic crises. Since the 18th century most of the people emigrated to the United States. From 1960 to 2001 the total population of the Azores has decreased by 40% (see Figure 5). This results in empty houses, overageing and fallow farmland (WAKONIGG 2008:133f.).

The Soils

The soil conditions on the Azores are researched sparsely. It can be assumed that there are mainly loose and profound andosols in form of red earth and brown earth. These soils are more humus-rich and less degraded than the soil on the other Macaronesia islands (see Figure 6). The pH value of the soil is in the acidic range (WAKONIGG 2008:112). Intensive monocultures have led to considerable exploitation of the soil (SCHÄFER 2005:5).

Figure 6: Soil profile of Pico (Picture: MOLLENHAUER 2016).

The Agriculture

The agriculture of the Azores is determined by the climate. The subtropical-oceanic, consistently frost-free cold with many precipitations is profitable for the cultivation of crops. Based on the landscape structure and isolation from mainland, the traditional agriculture predominates (WAKONIGG 2008:195). There is no current data on area distribution and exploitation. In the 1990s, 15% was used as farmland, 20% as pastureland, and 5% as permanent crops. The farming land is increasingly disappearing in favor of pasture economy. In 2008, 52% of the total area was declared to be used for agricultural purposes. As a consequence of this declaration, three quarters are used as pastureland and only one quarter for farmland and permanent crops (WAKONIGG 2008:196).

Pineapple, tea and tobacco are the most important crops of the Azores. Pineapple is cultivated in glasshouse cultures and exported to the mainland. Per annum the Azores export 1500 to 2000 tons of fruits. The cultivation of tea (on São Miguel) is unique in Europe. It can produce about 40 t of tea per annum. In addition, two cigarette factories on the mainland produce cigarettes. The need of basic foods (e.g. bread cereals) is higher than the number of crops harvested on the Azores (WAKONIGG 2008:196f). Export of agricultural goods has always been very important in the Azorean economy. “This orientation led to a series of colonial exports monocultures, which caused several famines and other problems for people and nature in the past.” (SCHÄFER 2005:5). After the colonization, the islands were one of the most important granaries for Portugal. In the 17th century, corn (*Zea mays*), sweet potatoes (*Ipomoea batatas*), and yams (*Colocasia esculenta*) were introduced into the Azores (SCHÄFER 2005:5). In favor of agriculture, the previously extensive laurel forest was cleared and is currently only existing in smaller stocks (WAKONIGG 2008:197).

WHALE HUNT

Whale hunt is traceable to the 12th century in Portugal. Not until the end of the 18th century the commercial hunt for sperm whales (*Physeter macrocephalus*) commenced in the Azorean waters. The first statistics on successfully hunted whales and the oil gained from it are based in the year 1896. However, it isn´t documented which cetacean species was hunted. It can be concluded that most of the killed whales were sperm whales based on the significant blow and the characteristic that the animals are drifting on the surface after killing. The reason for floating is because of the abundance of precious spermaceti in the heads of *Physeter macrocephalus* which made them more attractive to whalers. Whale oil and spermaceti are used in the textile and chemical industries since 1930. Furthermore, the sperm whales are slow swimmers compared to other species (KOEHLER 2014:24ff).

Figure 7:"Canoa" Azorean whaling boat (Picture: MOLLENHAUER 2016).

Around 1875, the Azorean people started to equip their own boats for hunting. The process was delayed due to limited financial resources, though. Till the end of the 19th century, American boats were still being used. The development of an Azorean boat construction based on the knowledge of the American boats (KOEHLER 2014:24ff).

The Azorean boats are called "Canoas" (KOEHLER 2014:24ff). The whaler and boat builder José Machado from Pico was involved in the development of the Azorean constructions. From 1900, whalers used almost only products of the Azores to build boats for the hunt. One of these boats is exhibited in the whaling museum in Lajes do Pico (see Figure 7; KOEHLER 2014:24ff).

In 1910 a modernization of whale hunting followed. Motorboats and radios were introduced. Through the change more whales could be hunted in a shorter time. Via radio the boats could be navigated to the whales more exactly. With the new equipment, the sales opportunities and export increased. From 1896 to 1924, a total amount of 23.525 whales were caught in the Azorean waters but only 1.171 around the Portuguese mainland. The whale hunting around the Azores played an important role in the Portuguese industry due to processing the whale carcasses to produce Whale oil and spermaceti (KOEHLER 2014:24ff).

The Important Artifacts of Whale Hunt

Figure 8: Harpoon tip with foldable barb (Picture: ZAHN 2016).

For centuries, many harpoons have been developed and tested in America and other countries. Tips with one and two barbs, electric-powered or harpoon heads charged with explosive were used. However, on the Azores the two last-named forms weren´t deployed. In 1858 Lewis Temple invented a new Harpoon method which seemed to be a breakthrough in the Harpoon technology. He developed a harpoon with a big, foldable tip made of solid steel. It was secured with a strait peg at the head of the harpoon (see Figure 8). If the whale tried to free itself from the harpoon, the peg broke with the result that the tip (with a length of up to 20 cm) grounded. The whale could not free itself any longer (KOEHLER 2014:72ff). The technical development of harpoons is presented in an exhibition the whaling museum (Museu dos Baleeiros) in Lajes do Pico.

WHALE WATCHING

Whale watching is the practice of observing cetaceans in their natural habitat. It can include - besides the observation by boat - feeding, touching and swimming with the animals. In the Azores, whale watching tourism is economically important and secures many jobs. Nowadays, many whalers work for whale watching stations. Because of this the whaling ban in 1982 had only little impact on the level of employment of the Azorean people (HIGHAM et al. 2012:2f.).

Positive Impacts of Whale Watching

As a result of whale watching, the observation of the animals in their natural habitat became a trend. It either can be done from a boat or the coastline including beaches. Instead of whaling or watching whales in captivity, it is possible to see whales and dolphins in their natural environment (ZEPPEL & MOLOIN 2012:110). 1990 2 million people participated in the new observation program. In 2012, the attendance per year estimated at 13 million. In addition, the whale watching tourism secured 13.000 jobs and generated 2.1 billion US-Dollars per annum (HIGHAM et al. 2012:2). Whale watching studies have been conducted to assess the positive impact in relation to environmental education and also the education for sustainable development. As part of the studies participants were asked about their perception of the marine

environment as well as their own way of dealing with it. The main focus was based on marine learning programs that bring visitors closer to the world of cetaceans. It is based on a direct transfer of information regarding biology, ecology and the behavior of the whales. During these boat trips the tourists are accompanied by experienced guides. Many studies demonstrate that intensive educational focus of marine wildlife tours can change the tourist´s views on the environment and species protection. The attention to whales and the marine life is increased by the direct contact between humans and animals. In addition, the gained impressions are consolidated by important facts and information about the animals, but also about the anthropogenic influences (ZEPPEL & MOLOIN 2012:113f). On the excursion, the study group was also accompanied by expert guides during the boat trips.

Negative Impacts of Whale Watching

Several studies have suggested that the senses of the cetaceans were disturbed by whale watching. The impact on the cetaceans is partitioned into two effects: horizontal and vertical effects. The horizontal effects are e.g. that the animals spend less time on the sea surface and dive for a longer time. Vertical avoidance might increase the swimming speed and repeated changes in direction (CHRISTIANSEN & LUSSEAU 2012:177f).

The research of long-term effects is difficult, therefore the data is still meager. Probably the increased stress causes a decline in the reproduction rate for the female cetaceans. However, the survival of an adult whale isn´t endangered (CHRISTIANSEN & LUSSEAU 2012:178). In addition, it is assumed that whale watching leads to changes in habitat selection due to vessels that chases them within their chosen habitat. The change of a living environment may result in an increasing risk potential for the individual whale. In addition to a higher rate of natural predators, there could be an increasing intraspecific competition for food, which also has negative impacts on the population dynamics (CHRISTIANSEN & LUSSEAU 2012:184).

Regulation of Whale Watching

The aim is to reduce the negative impact of whale watching on the cetaceans to a minimum. In recent decades, there has been a progressive development of policies and regulations. These policies and regulations are recognized by over 100 countries and organization (NEW et al. 2015:1). However, these are usually anchored only as a suggestion in the laws of the individual countries. In some regions of the world, the clash between humans and cetaceans aren´t regulated (LUDWIG & WILLIAMS-GREY 2016:15). The major impact on the cetaceans are the vessels (see Figure 9). In most cases, economic interests are in conflict with the conservation of nature, especially when it comes to an increase in the number of in attendants

which accompany whale watching trips (LUDEWIG & WILLIAMS-GREY 2016:19). Unfortunately, there is still no control of the specifications (NEW et al. 2015:7). Meanwhile, the ignorance of these regulations is the cause of observed behavioral changes. In order to counteract, the social awareness of the participating parties must empower, so that at whale watching tours a less aggressive and more sustainable approach is enforced in the future (NEW et al. 2015:6).

Figure 9: Whale-watching Boats (Picture: MOLLENHAUER 2016).

Espaço Talassa

The whale watching station Espaço Talassa was founded in 1989 by Serge Viallelle, the former whaler João Gonçalves and Alexandra Teles. The station advocates for the protection of the marine environment and for the education of the public. Since this year Espaço Talassa doesn´t provide swimming with dolphins, because of the deleterious influences on the dolphins. A relatively smooth and gentle observation of whales is very important for the station and the researcher. The whales are discovered only via an observation tower on the coast called “vigia” in Portuguese and hydrophones. Echo sounders aren´t used as they have a negative impact on the whales and their social behavior. When the look-out of the observation tower has seen a blow of a whale, he navigates the boats (see Figure 9) to the position of the whale. With decreasing distance to the whale, the speed of the boat is reduced to protect the whales from the noise. A maximum of three boats may approach a group of animals at the same time. When the whales show indication of escape behavior, the skippers are encouraged to remove with the boats (ESPAÇO TALASSA 2018).

Beside the whale watching tours, Espaço Talassa offers the opportunity to participate in different presentations every evening at 7pm. These lectures given by the employees of Espaço Talassa or invited experts deal with the issues of the ocean as a biotope and its pollution, the life on and around Pico and different kinds of animals or vegetation. Thus, the presentations provide earth care education as well. At the end of every week the skippers show their own best taken pictures of the season. After every presentation the possibility is given to ask

questions and to discuss with the audience about the provided information. During the research project in April and the excursions in May and August 2018 presentations about ocean issues, the world of sea turtles, Pico Island, the photo ID project and moths (Lepidoptera) of the Azores were held. The topic: Moths of the Azores, was presented by Peter Zahn. Furthermore, the photo ID project is used to distinguish which individual whale crosses Pico Island on its way to other feeding grounds as well as where the whale was seen elsewhere. The project obtains knowledge about the age and the size of the species. For the successful Identification it is necessary to take different pictures of the various whales. In many countries different whale-watching and research stations around the oceans take part in this project.

Sightings on the Whale Watching Tours with Espaço Talassa

The University of Hildesheim offered two excursions to the Azores in 2018. The first travel period was from the 18th - 27th of May and the second from the 3rd - 12th of August. Furthermore Peter Zahn attended in a research project in April (20th – 27th) with the topic „photo-identification of blue whales (*Balaenoptera musculus*). The results of this jouney are shown in this report as well.

Every group went on five whale watching tours which took always three hours. The purpose of every tour was the observation of marine mammals in their natural environment. In addition to whales and dolphins, it was possible to disvover occasionally fishes, turtles, jellyfish and sea-birds. Due to the different time periods of these excursions the groups have seen various species during their trips. The amount of sighted species during the excursions in 2016, 2017 and 2018 is listed below (see table 1). Furthermore, the tables 7 - 16 in the appendix contain the sighted marine species of each day in 2018 and also the complete list of all seen marine species around Pico in April, May and August 2018 (see tables 17).

Table 1: Amount of sighted marine species during the excursions from 2016 to 2018 (self-description).

Period	Amount of seen species
2016	15
2017	27
2018	29

12 whale species were observed in 2018, not counting the *Mesoplodon spec*. in April. Besides the cetaceans, 17 other species of marine wildlife were disvorered. This includes five different species of fishes, two Crustaceans, the Loggerhead sea turtles (*Caretta caretta*), one Cnidarian, the Portuguese man o´war (*Physalia physalis*), one Tunicate, the Pyrosome (*Pyrosama atlanticum*) and 7 species of sea birds. During the journey the skippers explained detailed

knowledge about the behaviour and important facts about the seen animals. After the return to Lajes do Pico a short briefing for every detected whale species was included. Furthermore, the skippers picked up detected plastic and garbage from the ocean surface to dispose it afterwards to keep the ocean clean and to save the environment of the marine animals.

THE BIRDS OF THE AZORES

Less than 200 species of birds are known on the Azores. Most of them are seasonal. The migratory birds visit the archipelago regularly in spring and autumn. Sometimes a few birds bear away from their actual migration routes and land on the islands. Due to the central location of the Azores in the Atlantic, it is not uncommon for such migratory species to deviate from their migratory routes because of extreme weather conditions. Thus, they can be observed, especially on the western Azores islands Flores and Corvo. Most of them are American bird species which land on the Azores during their migration. On Flores, near the Lagoa Branca (a crater lake), an obervatory was constructed. The primary purpose is to watch the migration of Nearctic birds. The total number of all discovered, even occasionally recorded species, approaches 400. These include some extremely rare spotted birds in the Western Palearctic (VISIT PORTUGAL 2013).

About 30 to 36 breeding bird species are found on the Azores including nesting seabirds. The Roseate tern (*Sterna dougallii*) is found on the Islands. They are rare in Europe, because they are in a long term decline. The archipelago is of outstanding importance for the Cory's shearwater (*Calonectris diomedea*). With estimated 180,000 breeding pairs, they are the dominating species on the Azores. That's approximately about 80% of the whole European population (STIEGLITZ 2013:21). In addition, some endemic species can be observed as well. The Monteiro's storm petrel (*Oceanodroma monteiroi*) is the rarest seabird in Europe. It's only to be found on the rocky island's northeast of Pico. The most endangered species in Europe is the Azorean bullfinch (*Pyrrhulapyrrhula murina*). As a specialized inhabitant of the laurel forests, it is greatly decimated by the destruction of the primary forests. Previously, it was considered as an agricultural pest. Flower buds served as a food source which has been the reason for the severely persecution of this species. In 1930 it was considered as extinct before it was rediscovered around 1968. Today the bird is under strict protection. In the east of São Miguel, it inhabits two areas, the rough mountainous terrain of the Serra da Tronqueira and the Pico da Vara, a 6000-ha protected area. It is estimated that about 40 to 80 breeding pairs live there. Other endemic subspecies can be identified by their names, such as the Azorean chaffinch (*Fringilla coelebs moreletti*) and the Azorean wood pigeon (*Columba palumbus azorica*) (STIEGLITZ 2013:22).

The Birds on Pico

Between the individual Islands of the Azores only little differences in the variety of species exist. Frequently observed species are e.g. the Common buzzard (*Buteo buteo rothschildi*), the Goldcrest (*Regulus regulus*), the Wild canary (*Serinus canaria*), the European robin (*Erithacus rebecula*), the Common blackbird (*Turdus merula*), and the Starling (*Sturnus vulgaris*). The Eurasian woodcock (*Scolopax rusticola*) and the Great snipe (*Gallinago media*) occur more often on Pico than on the other Islands. They are found in the higher altitude of the Island (MOORE et al., 2014:159f.). Occasionally the American charadriiforms can also be observed e.g. the White-rumped sandpiper (*Calidris fuscicollis*) and the Spotted sandpiper (*Actitis macularius*). However, the number of seabirds on Pico is lower than on the other islands but Pico harbors Arctic birds, such as the American wigeon (*Anas americana*), the Blue-winged teal (*Anas discors*), the Ring-necked duck (*Aythya collaris*), the Little blue heron (*Egretta caerulea*), the American bittern (*Botaurus lentiginosus*) and the American coot (*Fulica americana*) (MOORE et al., 2014:159f.). The different species which were spotted during the excursions in April, May and August are listed in table 18 in the appendix (see table 18). Several lakes are spread over Pico where many species of birds can be observed. Charadriiforms are spotted in Lajes do Pico due to the flat coast which represents a good feeding ground for them (MOORE et al., 2014:159f.). The amount of sighted species during the excursions in 2018 is listed below (see table 2).

Table 2: Amount of sighted bird species during the excursions in 2018 (self-description).

Period	Days	Amount of seen species
April 2018	7	22
May 2018	7	15
August 2018	7	14

In 2018 as many as 26 species were seen altogether including the Manx shearwater (*Puffinus puffinus*), the Great skua (*Stercorairus skua*), the Parasitic jaeger (*Stercorarius parasiticus*), the American wigeon (*Anas americana*) and the Roseate tern (*Sterna dougallii*). But the most spotted species was the Cory's shearwater (*Calonectris diomedea*) (see fig. 10). During the day, it was seen in high numbers on the ocean searching for food. In the evening after sunset, its pithy calls were heard, when the animals approached their breeding caves.

Figure 10: A group of Cory's shearwater (Picture: ZAHN 2016).

A FAUNISTIC EXAMINATION OF THE MOTHS OF THE AZORES

The butterfly fauna of the Azores has been studied since the 1850th. Not every Azorean archipelago Island is exanimated well. Most butterfly species of the Azores show more similarities with the European lepidoptera than with the lepidoptera from North- or Southamerica. Especially the endemic species are Palaearctic. Many butterflies have a wide distribution through a good flight capability or were brought to the Azores by the introduction of imported plants. Overall, there are 151 confirmed species on the Azores (see table 3) from which 10 are related to the butterflies (*Papilionoidea*), 38 are endemic species, of these 34 are related to moths (BORGES ET. AL. 2010; REGO ET. AL. 2015).

Table 3: Number of Lepidoptera-species on the Azores and Pico divided in total and endemic species (Borges, P.A.V., A. Costa, R. Cunha, R. Gabriel, V. Goncalves, A.F. Martins, I. Melo, M. Parente, P. Raposeiro, P. Rodrigues, R.S. Santos, L. Silva, P. Vieira, E. Mendoca & M. Boieiro 2010. Description of the terrestrial and marine biodiversity of the Azores. Pp. 9-33. In: P.A.V. Borges, A. Costa, R. Cunha, R. Gabriel, V. Goncalves, A.F. Martins, I. Melo, M. Parente, P. Raposeiro, P. Rodrigues. R.S. Santos, L. Silva, P. Vieira & V. Vieira (Eds)).

Lepidoptera	Total on the Azores	Endemic on the Azores	Total on Pico	Endemic on Pico
Papilionoidea	10	4	8	2
Moths	141	34	88	25
Total	**151**	**38**	**96**	**27**

With 35 different species the family of the owlet moths (Noctuidae) is the most represented family of moths on the Azores. The grass moth family (Crambidae) on the other hand is represented with 16 species, the tortrix moths (Tortricidae) family with 14 species and the pyralid moths (Pyralidae) with 13 species. The family of the geometer moth (Geometridae) has only nine confirmed species. A quarter of the species are endemic on the Azores (see table 2). On Pico, the second largest island of the Azores, 96 species exist, 88 of them are moths and only eight species belong to superfamily of Papilionoidea (BORGES ET. AL. 2010).

The Method of the Identification of Species

The town Lajes do Pico is located on the south of the island and is surround by grass- and pastureland. The natural vegetation of the Island is sparse. The Casa do Flores is a house which is situated at the border of Lajes do Pico. The garden of the house served as the location where the pictures of the moths were taken in April, May and August 2018. With the taken pictures, the identification oft moths species was possible, with the help of the identification key Steiner et al (2014) as well as the internet portals "lepiforum.de" and „Portal da Biodiversidade dos Acores". The following table shows the period in which pictures of moths were taken in 2018 (see table 4).

Table 4.: Duration of the faunistic examination (self-description).

Period	Days	Amount of seen species
April 2018	4	15
May 2018	4	26
August 2018	5	28

To be able to take photographs of moths it is necessary to attract these by light. For this purpose, a 180 cm high and 70 cm diameter wide Diolen-mesh with 1x1 mm squares - which was invented by R. Müller - was hung up at the garden of the Casa do Flores (see Figure 11). The entomological net is closed at the top and the bottom to ensure the saftey of the moths, by inhibiting them to get close to the lamps inside and don´t get burned. The methodology takes advantage of the fact that most moth species are attracted by light. The table below gives a view of the sightings in April, May and August (see table 5). Table 19 in the appendix shows all sighted species during the excursions in 2018 (see table 19).

Figure 11: Luring place in the garden of Casa do Flores (Picture: ZAHN 2016).

Table 5: Overview of the sighted moths on Pico confirmed in April, May and August 2018 (self-description).

Family	Amount of species in April	Amount of species in May	Amount of species in August
Tineidae	2	3	2
Gracillariidae	1	1	1
Bedelliidae		1	
Blastobasidae	1		2
Gelechiidae		2	2
Epermeniidae	1	1	
Choreutidae			1
Tortricidae	1	2	5
Pyralidae	1	1	2
Crambidae	3	4	3
Geometridae	2	3	3
Erebidae	1		
Noctuidae	2	8	7
Total	**15**	**26**	**28**

THE VEGETATION OF THE AZORES

Due to the rich vegetation of the Azores the Islands have been geographically classified to Macaronesia like the Islands of Madeira, the Salvage Islands and Canary Islands (STIEGLITZ 2009:8f.). However, new explorations shows, that the conformity of the vegetation is less distinctive than it has been assumed earlier. According to Schäfer (2002) the Azores are rather geographically classified to the Holarctic. Madeira and the Canary Islands are classified to the Mediterranean region and the Salvage Islands to the Palaeotropical.

Vegetation Impact Factors

The age of the Azorean archipelago and the distance to the next, with vegetation covered, area had influence on the vegetation of the islands. Therefore, the Azores have an isolated ecosystem, which has developed over the years. This kind of evolution caused high biodiversity of endemic species (PFADENHAUER & KLÖTZLI 2014:29ff.). Especially European Islands are described as “Hot-Spots” of biodiversity due to their isolation (SILVA ET. AL. 2008:28). Furthermore, the climate of the Azores has also an impact on the development of the rich vegetation. (STIEGLITZ 2009:9). The summer-dry climate and the seasonal precipitation (WAKONIGG

2009:62) represent ideal conditions for the growth of plants (STIEGLITZ 2009:11). However, the different altitudes above the sea level result in a climate change which has an influence on the predominate vegetation as well (see table 6).

Table 6: Plant community in different altitudes at the Azorean archipelago (STIEGLITZ 2009: 10ff.).

Vegetation zone	originally vegetation	today's vegetation
Coastal zone -up to 300 m over the main sea level.	Woods up to the coast, Myrica *(Myrica faya), E*ndemic *Picconia azorica.*	Sweet pittosporum (*Pittosporum undulatum*).
Damp troposphere - 300 - 1500 m over the main sea level.	Azores heather (*Erica azorica*), Azores juniper (*Juniperus brevifolia*), Azores laurel (*Laurus azorica*).	Bigger remainders, also on Pico.
Above the troposphere - over 1500 m over the main sea level.	Calluna (*Calluna vulgaris*), *Thymus caespititius*, Daboecia (*Daboecia azorica*), Sea campion (*Silene uniflora*).	Nearly unchanged.

Furthermore, the table above shows the anthropogenically caused changes. With an increasing height the temperature is falling, but humidity and precipitation are increasing. Above 1500 m over the main sea level the precipitation is decreasing again. This context is named as vegetation zone influenced by the climatic conditioned altitude (STIEGLITZ 2009:10f.).

The Different Types of Vegetation on the Azores

The occurrence of various types of vegetation depends on the different vegetation zones on the respective islands. Each zone implies specific conditions which influence the growth and the appearance of the vegetation. They include ecological aspects as humidity, temperature or nutrition. Examples for the different types of vegetation on the Azores as well as examples for the endemic species and neophytes are specified in table 20 in the appendix (see table 20).

The Coastal Zone

The vegetation of the coastal zone reaches up to 300 m above sea level and originally consisted of coastal forests. The predominant species on the Azores includes the Macaronesian Gagelbaum (*Myrica faya*) and the endemic Picconie (*Piccoria azorica*). The original vegetation of the zone has been almost completely replaced by settlements and agriculture due to its accessibility and climatic conduciveness for humans (see Figures 12 &13). For example, the plant *Pittosporum undulatum* was introduced to protect the orange plantations from the

wind, which has now almost completely displaced the native forest trees to about 600 m above sea level (STIEGLITZ 2009: 10ff.)

The Troposphere

Figure 12: The vegetation of the coastal zone (Picture: OTHMER 2016).

Figure 13: The vegetation in the humid troposphere (Picture: OTHMER 2016).

The vegetation of the humid cloud zone is located between 300-1500 m above sea level. The natural vegetation is called laurisilva or laurel forest and consists largely of the endemic tree species heath (*Erica azorica*) and juniper (*Juniperus brevifolia*) and the laurel berry (*Laurus azorica*). The natural vegetation is today decimated by logging and the establishment of pastureland. Larger remainders of the laurisilva are only to be found on São Miguel, Terceira and Pico (STIEGLITZ 2009: 10ff.)

The Height Level above the Troposphere

The summit region of the Pico is the only zone on the Azores which altitude is located above the troposphere. In addition to various Lichens, the Broom heath (*Calluna vulgaris*), the Iridescent Thyme (*Thymus caespititius*), the Azorean bog heather (*Daboecia azorica*) and the Cliff greaser (*Silene uniflora*) are also found at this height (STIEGLITZ 2009: 10ff. & 16).

Figure 14: The vegetation above the troposphere (Picture OTHMER 2016).

Endemic Species

The vegetation of the Azores is characterized by a high diversity of endemic species. They occur in all vegetation zones but have become very rare due to human intervention and grow almost exclusively on steep slopes and ravines, cliffs and volcanic craters. Due to their endangerment, all endemic species are strictly protected on the Azores. Examples for these species are the Azorean bellflower (*Azorina vidalii*) and the mallow-leaved cineraria (*Pericallis malvifolia*) (SCHÄFER 2005:9f.).

Neophytes

The greatest threat to native flora and endemic species are the plants introduced by humans, the neophytes, especially the invasive species (STIEGLITZ 2009: 12). Island ecosystems are particularly sensitive to the introduction of invasive species, as they can spread rapidly due to the limited area and are hardly affected by external events due to their isolation (SILVA et al., 2008: 28). In total, only 149 species are indigenous. This means that they arrived in the Azores before the first human settlers through wind, water or birds. In contrast, 645 plants are neophytes, of which 56 are classified as invasive species (SCHÄFER et al. 2011: 392). Neophytes have been brought to the Azores for a variety of reasons since the 19th century.

The Hydrangea (*Hydrangea macrophylla*) thrives in the humid climate of the Azores very well and is used to limit pastures (see Figure 15) even if they often suppress the growth of native species. Another example is the Kahili ginger (*Hedychium gardnerianum*) which was introduced as an ornamental plant and whose strongly growing roots hardly allow the growth of other plants in its environment. The Japanese cedar (*Cryptomeria japonica*), which was introduced for forestry purposes, has meanwhile become the most commercially important tree on the Azores even if its thick needle carpet prevents the growth of other species. Today only about 5% of the islands are covered with native flora due to the introduction of exotic species and the colonization and agriculture since the 16th century. Since the beginning of the 1990s, nature conservation and landscape conservation measures have been implemented on the Azores. Natura 2000 protected

Figure 15: The Hydrangea (Hydrangea macrophylla) (Picture: OTHMER 2016).

areas have been designated on all islands and all endemic species have been classified as strictly protected (STIEGLITZ 2009: 10ff; see Figure. 16).

Figure 16: Typical agricultural land on Pico (Picture: OTHMER 2016).

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APPENDIX

List of Species seen during the excursions in May (20th-24th) & August (5th-9th)

Table 7: Sightings on the 20th of May2018 in the morning (self-description).

Species		Individuals	Behaviour
Fin Whale	*Balaenoptera physalus*	12	Individuals were all in the same area close to the shore. The reason for the gathering was expected to be a food source.
Common Dolphin	*Delphinus delphis*	Big school	Big school was sighted multiple times over the day. Individuals were close to the boat and surfing in the wave caused by the bow of the boat.
Striped Dolphin	*Stenella coeruleoalba*	School	School was sighted multiple times over the day. Individuals were jumping around and swimming close to the boat. Sighted together with Common Dolphin.

Table 8: Sightings on the 21th of May2018 in the morning (self-description).

Species		Individuals	Behaviour
Blue Whale	*Balaenoptera musculus*	3	First sighting was a female blue whale with her calf. Both Individuals approached the boat twice before diving under it. The Calf was breaching before both dived away. Blue whale bull was sighted later that day. Not as interested in coming closer to the boat than the other two Individuals before.
Fin Whale	*Balaenoptera physalus*	2	Individuals were spotted together. Both approached the boat and left excrement in the water.
Striped Dolphin	*Stenella coeruleoalba*	School	School was only sighted once that day. Individuals were sighted in distance to the boat and swam away when the skipper tried to approach them.

Table 9: Sightings on the 22th of May2018 in the afternoon (self-description).

Species		Individuals	Behaviour
Blue Whale	*Balaenoptera musculus*	2	The sighting was the female blue whale with her calf again. They appeared close to the boat while preparing to dive away.
Common Dolphin	*Delphinus delphis*	Big school	The school were travelling while passing the boat. The School consisted of adult and young Individuals.
Bennett´s Flying Fish	*Cheilopogon pinnatibarbatus*	1	Appeared next to the boat before flying away.
Loggerhead Turtle	*Caretta caretta*	1	Approached the boat while breathing on the surface. Dived under the boat before it disappeared into the deep.

Table 10: Sightings on the 23th of May2018 in the morning (self-description).

Species		Individuals	Behaviour
Fin Whale	*Balaenoptera physalus*	1	Individual was spotted alone. Was breathing multiple times before it disappeared.
Risso's Dolphin	*Grampus griseus*	Approx. 5-10	The group approached the boat sometimes while swimming but never appeared right next to it → kept distance but were always visible.
Hammerhead Shark	*Sphyrna zygaena*	1	Circling the boat.
Portuguese Man o' War	*Physalia physalis*	1	Swimming in the water.

Table 11: Sightings on the 24th of May2018 in the morning (self-description).

Species		Individuals	Behaviour
Sperm Whale	*Physeter macrocephalus*	2	Individuals were asleep when first spotted. They were breathing while floating on the surface or diving down into shallow deeps to prepare for a deep dive.
Risso's Dolphin	*Grampus griseus*	Approx. 5-10	The group dived away when they noticed the approaching boat → bad visibility.
Common Dolphin	*Delphinus delphis*	Big school	The School consisted of adult and young Individuals which were jumping and swimming along with the waves caused by the boat.
Striped Dolphin	*Stenella coeruleoalba*	School	Individuals were swimming and jumping around when the boat approached. They dived away when they noticed the approaching boat.
Portuguese Man o' War	*Physalia physalis*	1	Swimming in the water.
Loggerhead Turtle	*Caretta caretta*	2	Swimming on the surface due to heating up the body and breathing.

Table 12: Sightings on the 5th of August 2018 in the morning (self-description).

Species		Individuals	Behaviour
Sperm Whale	*Physeter macrocephalus*	3	Three Individuals seen in different places before they dived away.
Sei Whale	*Balaenoptera borealis*	1	Relaxed swimming and breathing.
Risso's Dolphin	*Grampus griseus*	Approx.8-10	A group of older males with white heads, relaxing, sleeping and socialising.
Atlantic Spotted Dolphin	*Stenella frontalis*	2 Schools	The schools crossed the way of the boat, jumping and playing.

Table 13: Sightings on the 6th of August 2018 in the morning (self-description).

Species		Individuals	Behaviour
Sperm Whale	*Physeter macrocephalus*	2	Because of the size it must have been two females.
Sei Whale	*Balaenoptera borealis*	1	The Individuals were feeding in big circles. One turned on the backside showing off its fluke.
Short-Finned Pilot Whale	*Globicephala macrorhynchus*	Approx. 100	A group of Pilot whales was sighted once that day. But only approximately 100 Individuals were visible -> normally up to 500-1000 Individuals per group. The group was relaxing and socialising with each other. Young ones were also seen.
Risso's Dolphin	*Grampus griseus*	School	It was a group of females, males and young Individuals.
Bottlenose Dolphin	*Tursiops truncatus*	Big school Approx. 200-300	A big school, jumping and socialising all around Pico's south. Many young Individuals, with adults.

Table 14: Sightings on the 7th of August 2018 in the morning (self-description).

Species		Individuals	Behaviour
Sperm Whale	*Physeter macrocephalus*	8	One male and a group of seven females socialising and resting. Two of them dived to feed.
Sei Whale	*Balaenoptera borealis*	1	The female was interested in the boat. It was swimming around, diving under the boat, turning on the backside and showing the flipper and the fluke. Breathing and swimming near by the boat. not a normal behaviour, but the sei whale was relaxed and interested.
Short-Finned Pilot Whale	*Globicephala macrorhynchus*	School	A big group of Pilot whales was resting and socialising. There were young and older individuals in the group.
Sowerby's Beaked Whale	*Mesoplodon bidens*	3 Sightings	Maybe different groups or the same group swimming fast and far away from the boat.
Atlantic Spotted Dolphin	*Stenella frontalis*	3 Sightings	The dolphins were swimming around the boat, jumping and clapping with their fluke on the water. Was a part of the mating ritual → more interested in each other than in the boat.
Dead Brown Shyshark	*Haploblepharus fuscus*	1	The deep-sea shark was not long dead and floating on the surface. Because of a bite half of his head was missing.
Portuguese Man o' War	*Physalia physalis*	1	A small Portuguese man o' war was seen on the trip.

Table 15: Sightings on the 8th of August 2018 in the morning (self-description).

Species		Individuals	Behaviour
Sperm Whale	*Physeter macrocephalus*	Approx. 20 or more	Big group all around Pico's south, resting, socialising and mating with each other. Followed a big male on his way to a group of females, swimming fast and mating with one of the females. Another male was breaching twice. Always seen more than four Individuals close to each other.
Sowerby's Beaked Whale	*Mesoplodon bidens*	Approx. 4-6	Four of them were breaching twice at the same time and one of them breached after that three or four times again.
Pyrosome	*Pyrosoma atlanticum*	1	An approximately one meter long and red pyrosome was drifting on the water surface.
Bennett´s Flying Fish	*Cheilogopon pinnatibarbatus*	1	The flying fish was seen near by one side of the boat once.

Table 16: Sightings on the 9th of August 2018 in the morning (self-description).

Species		Individuals	Behaviour
Sperm Whale	*Physeter macrocephalus*	3	Maybe a young one and a female or two females were seen nearby each other. The adults were diving to feed. Furthermore, the Individual with the missing Finn was spotted again. The scared individual was diving down. The Finn was nearly gone and the back was heavily marked with scars.
Sei Whale	*Balaenoptera borealis*	1	A fast swimming individual which slowed down after a while to turn to the side.
Atlantic Spotted Dolphin	*Stenella frontalis*	3 Sightings	The dolphins were swimming around the boat, jumping very high. Playing, swimming and bow riding with the boat. Every time they were seen, it was a big group with young individuals.
Striped Dolphin	*Stenella coeruleoalba*	School	The group were swimming very fast. When the boat approached they tried to avoid contact.

Table 17: Sighted sea species around Pico in April, May and August 2018 (self-description).

Classification	Species		Sighting Period		
			April	May	August
Mammals	Blue Whale	*Balaenoptera musculus*	X	X	
	Fin Whale	*Balaenoptera physalus*	X	X	
	Sperm Whale	Physeter macrocephalus	X	X	X
	Sei Whale	*Balaenoptera borealis*	X		X
	Short-Finned Pilot Whale	*Globicephala macrorhynchus*	X		X
	Sowerby's Beaked Whale	*Mesoplodon bidens*			X
	Sowerby's Beaked Whale	*Mesoplodon spec.*	X		
	Short-Beaked Common Dolphin	*Delphinus delphis*	X	X	
	False Pilot Whale	*Pseudorca crassidens*	X		
	Striped Dolphin	*Stenella coeruleoalba*	X	X	X
	Atlantic Spotted Dolphin	*Stenella frontalis*			X
	Bottlenose Dolphin	*Tursiops truncatus*	X	X	X
	Risso's Dolphin	*Grampus griseus*	X	X	X
"Pisces"	Bennett´s Flying Fish	*Cheilogopon pinnatibarbatus*		X	X
	Long Snouted Lancetfish	*Alepisaurus ferox*	X		
	Box Ray or Chilean Devil Ray	*Mobula tarapacana*			X
	Brown Shyshark (Dead)	*Haploblepharus fuscus*			X
	Smooth Hammerhead	*Sphyrna zygaena*		X	
"Reptiles"	Loggerhead Sea Turtle	*Caretta caretta*	X	X	X
Crustacea	Smooth Gooseneck Barnacle	*Lepas anatifera*		X	
	Japanese Shore Crab	*Hemigrapsus sanguineus*	X	X	X
Cnidaria	Portuguese Man o' War	*Physalia physalis*	X	X	X
Tunicata	Pyrosome	*Pyrosoma atlanticum*			X

Figure 17: Common dolphin (Delphinus delphis) (Picture: FUNKEN 2018).

Figure 18: Striped dolphin (Stenella coeruleoalba) (Picture: MATTNER 2016).

Figure 19: Blue whales, Mother (left) and calf (right) (Balaeon-optera musculus) (Picture: FUNKEN 2018).

Figure 20: Risso's dolphin (Grampus griseus) (Picture: MATTNER 2016).

Figure 21: Sperm whale (Physeter macrocephalus) (Picture: WÄLTER 2018).

Figure 22: Atlantic Portuguese man o' war (Physalia physalis) (Picture: SCHMITT 2018).

Figure 23: Loggerhead se turtle (Caretta caretta) (Picture: KELLNER 2016).

Figure 24: Fin whale (Balaenoptera physalus) (Picture: SCHMITT 2018).

Table 18: Sighted bird species around Pico in April, May & August 2018 (self-description).		**Sighting Period**		
Species		**April**	**May**	**August**
Cory's Shearwater	*Calonectris diomedea*	X	X	X
Manx Shearwater	*Puffinus puffinus*	X		
Grey Heron	*Ardea cinera*			X
Little Egret	*Egretta garzetta*	X	X	
Tufted Duck	*Aythya fuligula*	X		
American Wigeon	*Anas americana*	X		
Common Buzzard	*Buteo buteo rothschildii*	X	X	X
Quail	*Coturnix coturnix conturbans*	X	X	X
Sanderling	*Calidris alba*	X		
Ruddy Turnstone	*Arenaria interpes*	X		
Whimbrel	*Numaenius phaeopus*	X		X
Great Skua	*Stercorarius skua*	X	X	
Parasitic Jaeger	*Stercorarius parasiticus*	X		
Yellow-Legged Gull	*Larus michahellis*	X	X	X
Common Tern	*Sterna hirundo*	X	X	X
Roseate Tern	*Sterna dougallii*			X
Wood Pigeon	*Columba palumbus azorica*	X		
Grey Wagtail	*Motacilla cinera patriciae*	X	X	
Blackbird	*Turdus merlua*	X	X	X
Starling	*Sturnus vulgaris*	X	X	X
European Robin	*Erithacus rubecula*		X	
Blackcap	*Sylvia atricapilla*		X	X
House Sparrow	*Passer domesticus*	X	X	X
Chaffinch	*Fringilla coelebs*	X	X	X
Goldfinch	*Carduelis carduelis*	X		
Wild Canary	*Serinus canaria*	X	X	X
Total amount of species		**22**	**15**	**14**

Table 19: Sighted moth species on Pico in April, May and August 2018 (P. Zahn)			Sighting Period		
Family	**Subfamily**	**Species**	**April**	**May**	**August**
Tineidae	Tineinae	*Monopis crocicapitella*		X	X
	Hieroxestinae	*Oinophila v-flava*		X	
		Opogona omoscopa	X	X	X
		Opogona sacchari	X		
Gracillariidae	Gracillariinae	*Caloptilia coruscans*	X	X	X
Bedelliidae	Bedellia	*Bedellia somnulentella*		X	
Blastobasidae		*Blastobasis desertarum*			X
		Blastobasis maroccanella	X		X
Gelechiidae	Gelechiinae	*Aproaerema anthyllidella*		X	X
		Phthorimaea operculella		X	X
Epermeniidae	Epermeniinae	*Epermenia aequidentellus*	X	X	
Choreutidae	Choreutinae	*Tebenna micalis*			X
Tortricidae	Tortricinae	*Aethes sanguinana*			X
		Epiphyas postvittana	X	X	X
	Olethreutinae	*Crocidosema plebejana*		X	X
		Endothenia oblongana			X
		Selania leplastriana			X
Pyralidae	Phycitinae	*Cryptoblabes gnidiella*			X
		Phycitodes albatella	X	X	X
Crambidae	Scopariinae	*Eudonia luteusalis*	X		
		Scoparia aequipennalis		X	
		Scoparia spec.		X	X
	Spilomelinae	*Diasemiopis ramburialis*		X	
		Herpetogramma licarsisalis			X
		Palpita vitrealis	X	X	X
		Udea ferrugalis	X	X	X
Geometridae	Ennominae	*Ascotis fortunata*			X
	Sterrhinae	*Cyclophora azorensis*	X	X	X
	Larentiinae	*Costaconvexa centrostrigaria*		X	X
		Gymnoscelis rufifasciata	X	X	
Erebidae	Hypeninae	*Hypena obsitalis*	X		
Noctuidae	Plusiinae	*Chrysodeixis chalcites*		X	X
		Ctenoplusia limbirena		X	
	Xyleninae	*Galgula partita*	X	X	
		Mesapamea storai		X	X
		Spodoptera littoralis			X
	Hadeninae	*Mythimna unipuncta*	X	X	X
	Noctuinae	*Agrotis segetum*		X	
		Noctua pronuba		X	X
		Peridroma saucia		X	X
		Xestia c-nigrum			X
Total amount of species			**15**	**26**	**28**

Figure 25: Gymnocelis rufifasciata (Picture: ZAHN 2018).

Figure 26: Eudonia luteusalis (Picture: ZAHN 2018).

Figure 27: Peridroma saucia (Picture: ZAHN 2018).

Figure 28: Noctua pronuba (Picture: ZAHN 2018).

Figure 29: Cyclophora azorensis (Picture: ZAHN 2018).

Table 20: Examples of the typical vegetation of the Azores (Stieglitz 2009: 10ff. & 16; Schäfer 2005:9f.).

Classification	Species	
Vegetation of the coastal zone	Macaronesian Gagelbaum	*Myrica faya*
	Picconie	*Piccoria azorica*
	Sweet Pittosporum	*Pittosporum undulatum*
Vegetation of the tropo-sphere	Tree Heath	*Erica azorica*
	Juniper	*Juniperus brevifolia*
	Laurel Berry	*Laurus azorica*
Vegetation above the height level of the tropo-sphere	Broom Heath	*Calluna vulgaris*
	Iridescent Thyme	*Thymus caespititius*
	Azorean Bog Heather	*Daboecia azorica*
	Cliff Greaser	*Silene uniflora*
Endemic species	Azorean Bellflower	*Azorina vidalii*
	Mallow-Leaved Cineraria	*Pericallis malvifolia*
Neophytes	Hydrangea	*Hydrangea macrophylla*
	Kahili Ginger	*Hedychium gardnerianum*
	Japanese Cedar	*Cryptomeria japonica*