Monitoring of the colonization process at Tagoro submarine volcano, El Hierro Island (Spain), held during the first three years since its generation.

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Internship period (start and end date): 26/04/2016 – 24/06/2016

Introduction

The Spanish Institute of Oceanography was created by Royal Decree of April 17, 1914, it is a public research organization (OPI) exclusively devoted to research in marine science, especially in relation to the scientific knowledge of the oceans, the sustainability of marine living resources, including fisheries, the protection of the marine environment and the experimentation in aquaculture. The IEO depends on the Spanish Ministry of Economy and Competitiveness, through the State Secretary of Research, Development and Innovation.

There are ten different Centers (Oceanographic Centers, CO) that belong to the IEO framework, distributed around the Spanish geography. I am currently working at the Canary Islands Oceanographic Center (COC), on the marine environment Department under the supervision of Dr. Eugenio Fraile Nuez, oceanographer and IP of Bimbache, Vulcano-I-II and Vulcana, for the study of the physical-chemical and biological and geological variations of the submarine volcano of El Hierro Island.

In October 2011, patches of pale-coloured water began appearing off the island's southern coast, dead fish floated on the ocean surface, and locals noted a strong smell of sulphur in the air. These, it turned out, were the first signs of the first submarine volcanic eruption in the last 500 years of volcanology history of the Canary Islands at 1.8 km south of La Restinga village, some 400 metres below the surface of the Atlantic Ocean. In that moment, the Spanish Institute of Oceanography (IEO) together with both Canary Universities and other research institutions began to monitor the event. The eruption continued until March the following year, leaving the cone of the volcano just 88 metres below the water's surface. Nowadays, the submarine volcano is still active in a degasification phase with a release of heat, gases and metals that produce significant physical-chemical anomalies in the surrounding waters.

The volcano-affected area has exhibited responses that are occurring globally, making El Hierro a unique natural laboratory where the main climate change stressors are acting simultaneously. The results emerging from this volcanic eruption will help to improve the scientific understanding of how future climate change may impact marine biota.

On the other hand, we now have the perfect opportunity to find out how the colonization process evolves in a new submarine volcanic habitat, i.e. without any previous inhabiting form of life and in such a young substrate. After the eruption event, new basaltic lava material covered the major part of the sea bottom of "El Mar de Las Calmas", a Marine Reserve, damaging all previous habitats and living organisms. During my internship I will study and establish the colonization process that took place from 03/2012 to 03/2014 at the submarine volcano, bearing in mind the species diversification among time and place and the physical-chemical and biological conditions that made that possible. In order to do this, underwater visual techniques and dredges were used during three cruises.

Objectives

The objectives of the internship are the followings:

- Species identification from the video images from Remote Observing Vehicle (VOR)
- Species identification from the video images from Remote Operate Vehicle-Liropus 2000 (ROV).
- Species identification from the rocks, samples taken with a dredge.
- Environmental characterization (proximity to the main and secondary summits, chemical depositions on the substrate, slope, complexity of the bathymetry, depth, orientation, etc.)
- Establish a succession of species diversity based on the identified species for the different sampled surveys (time) and sampled stations (position) and on the characterization of the new habitats.

Overview of activities

1- Knowledge acquirement by reading the following (see Literature): (two weeks)

- Survey blogs written during their accomplishment.
- Survey reports. A summary of every activity and problem was written down.
- Literature that has been published from previous research projects carried out on the volcano behalf.
- Other published articles related in some way (submarine volcano, lava substrate colonization, physical-chemical and biological alterations, etc.) with the concerning project.

2- Species identification by video analysis of the images recorded with the Remote Observational Vehicle (VOR) during Vulcano1013. In order to do this, I have been working with Marcos Gonzalez, a benthos expert at the Canary Center of the IEO. The workload consists of 7 videos of 35 min each (fig. 1,2); they were taken at the stations located at vicinities of the volcano (fig. 1), ranging from 88 m to 340 m depth. The analyzing procedure is as follows: (two weeks)

- Screenshot of the possible marine organism during the video screening (fig. 3). Each photo was labeled with number of belonging video and time of the shooting. One file was done for each of the videos with all the taken photos.
- Species identification to the lowest taxonomic level.
- Summarize of the found species in the whole group of video samples from VOR (table 1).

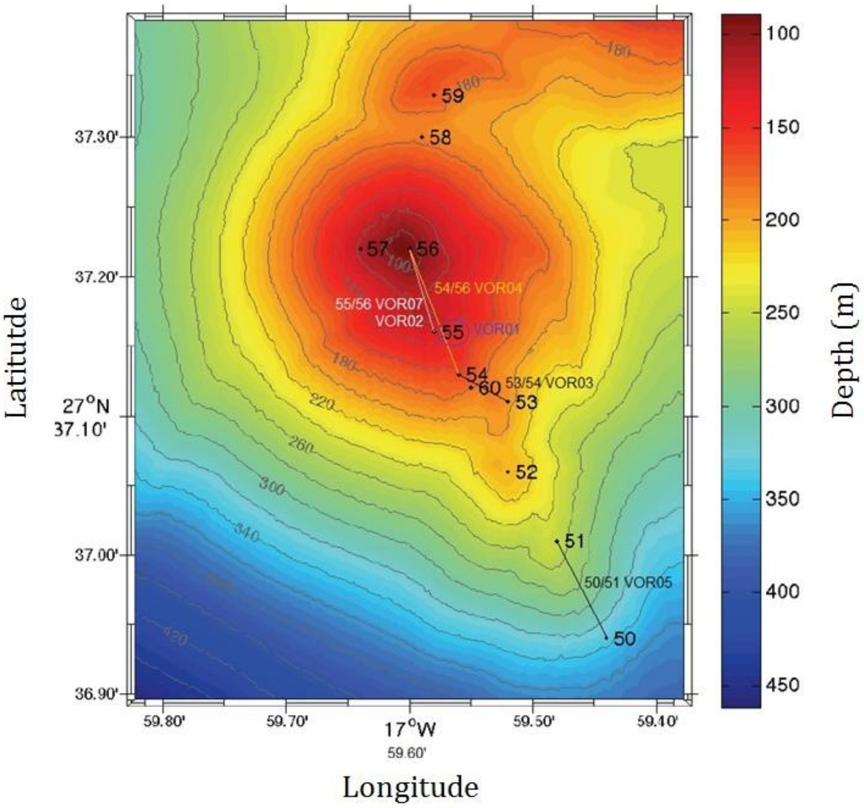

Figure 1
Map of the volcano. Isobaths and station numbers are shown. The colored lines are the filmed transects with the VOR, (VOR 02, 03, 04, 05 and 07). The black circle means a static recording position, and corresponds to VOR01. VOR06 is missing as it was recorded in another area out of this map.

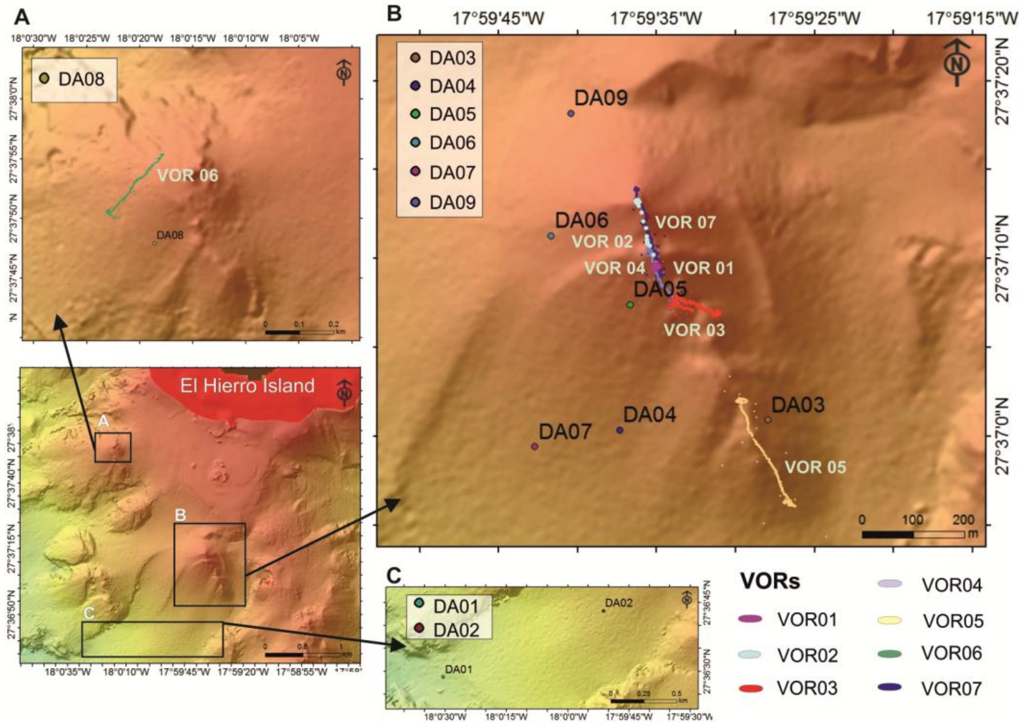

Figure 2
In the left-bottom side the Volcano area. A: transect of the VOR06 in green and Dredge sampling point DA08. B: VOR 01, 02, 03, 04, 05 and 07 are shown as well as DA 03, 04, 05, 06, 07 and 09. C: Dredges 01 and 02.

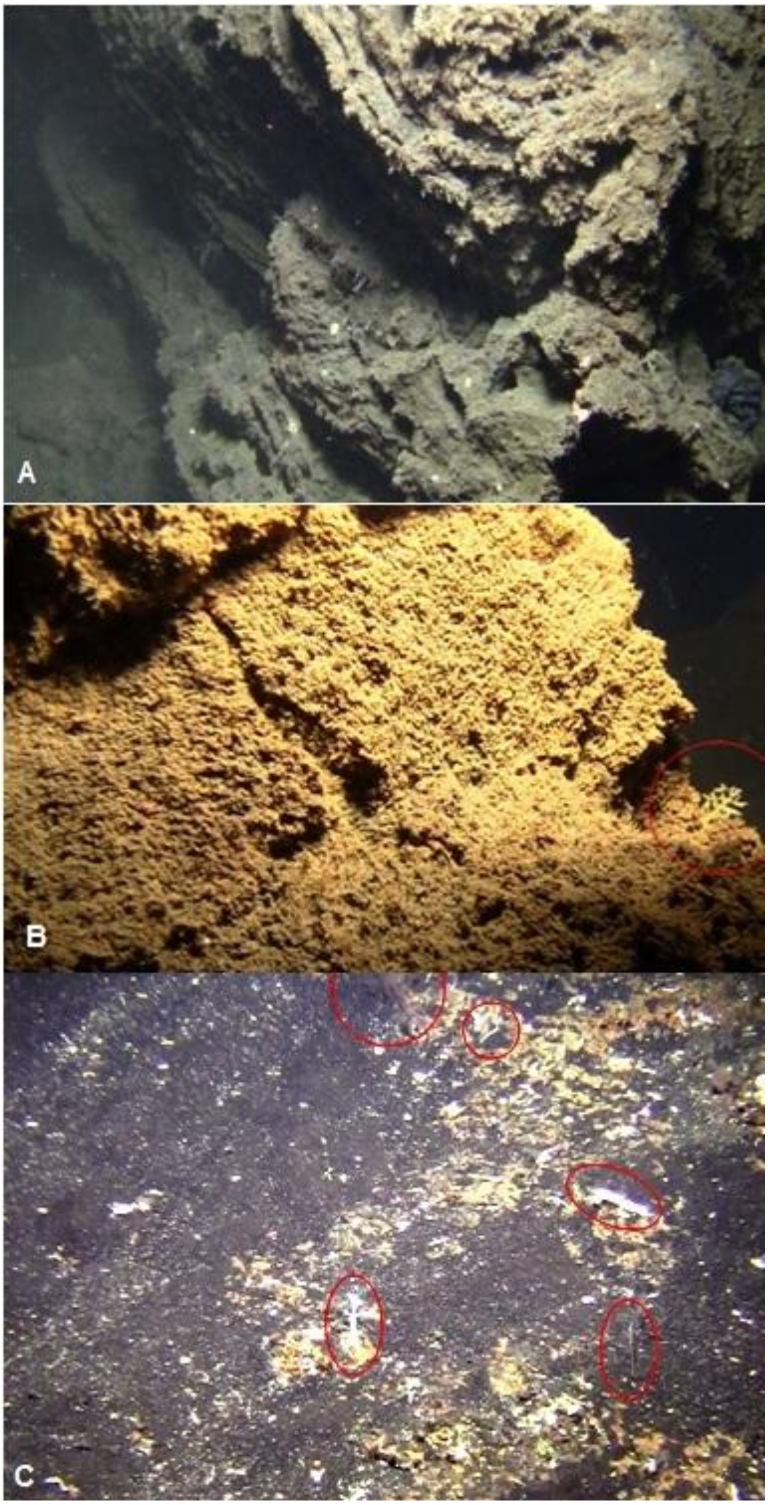

Figure 3
Shoots of marine organisms found when screening the underwater videos. These images belong to Remote Observational Vehicle (VOR) taken during Volcano1013. A: VOR03; B: VOR04 and C: VOR06. A and B are close locations to the volcano main summit, and C the most remote sampled site.

3- Species identification by video analysis of the images recorded with the Remote Operational Vehicle-Liropus 2000 (ROV) (fig. 5a) during Vulcano0314 (table 1). In order to do this, I have also been working with Marcos Gonzalez and the procedure is the same as is explained before. Here the workload consists of 36 h of video that was recorded during 4 days. (half a week)

4- Species identification by direct observation of the rocky samples taken during the two first surveys of the Vulcano project (Vulcano 0313 and Vulcano 1013). Those samples are permanently located at the Malaga center of the IEO; consequently I moved there for one week in order to analyze them and work hand in hand with Dr. José Rueda, a benthos expert. All dredges were analyzed and the identified species were properly labeled and stored in Ethanol 75%. The output of this part is shown in table 1, together with the data collected from the VOR and ROV analysis. (two weeks) The travel expenses were supported by the EMBC+ program.

5- At the same time, I had the possibility to visit the storehouse of the Institute where they keep the oceanographic instrumentation together with one of the instruments used in this project, the dredge, the rock samples collector (fig. 4a). Figure 4b-c show how the dredge was used during the volcano cruises.
Figure 5b shows the underwater camera, called "trineo", used during Volcano1013 cruise. This consists of a metallic structure sleigh shape, with a protected camera in the middle, which hangs from the boat and by gliding over the bottom and following the vessel shifts, films all what is on the seabed. The images are not transmitted in real-time onboard while they are being recorded.

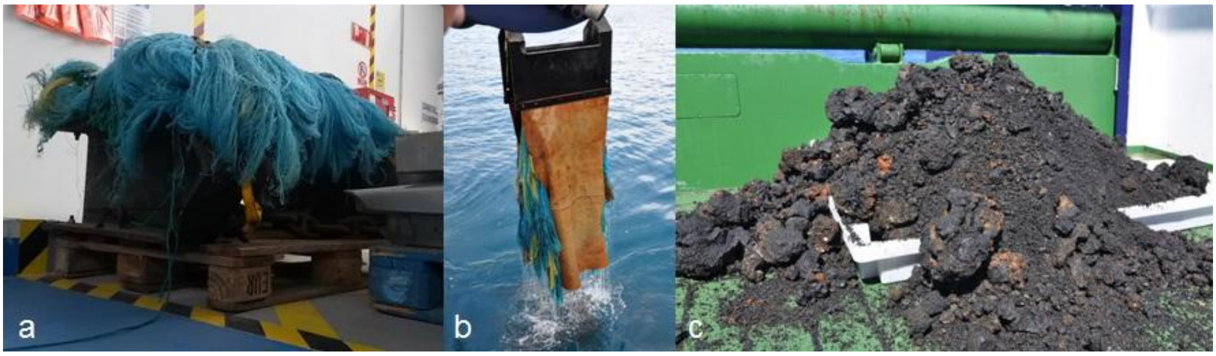

Figure 4
Rock sampling procedure. a: Dredge Instrument at the IEO storehouse. b: Dredge coming out from the water. d: Rock sample from the volcano area during Vulcano1013.

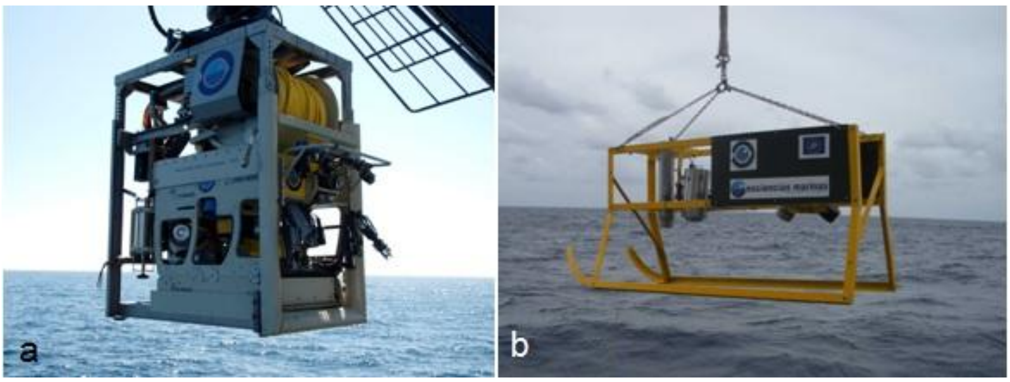

Figure 5
Underwater Visual Instruments. a: Remote Operational Vehicle-Liropus 2000 (ROV). b: "Trineo", Remote Observational Vehicle (VOR).

Preliminary Results and Conclusions

Dredge samples collected at the closest points to the main and secondary craters (e.g. dredge03-Vulcano0313, fig. 6), showed dark black lava with no colonization at all.This substrate can be considered as the predominant one after the eruption, being the starting point from which the colonization process began.

Figure 6
Piece of Lava sampled at 200m depth.
Dredge 03 during Vulcano0313 survey.

In table 1 is shown all taxa identified from VOR and ROV video analysis and from the Dredge samples. At first glance, we can see that from 200 m to 300 m depth is where the biggest species richness is found. Now, if we take into account the phyla identified from the dredge samples and we compare the species diversity found in the volcano area with these from the control area, we can clearly observe big differences among the phyla richness (fig. 7).

Table 1
Species diversity inhabiting the submarine volcano identified from diferent data sources.

Phylum	Reference	Species	VOR1013	ROV0314	DREDGES 2013
Porifera	Grant, 1836	Porifera unid.	6		
	Sollas, 1885	Demospongiae unid.1			8
	Sollas, 1885	Demospongiae unid.2			8
	Sollas, 1885	Demospongiae unid.3			8
	Sollas, 1885	Demospongiae unid.4			8
	Sollas, 1885	Demospongiae unid.5			8
	Sollas, 1885	Demospongiae unid.6			8
	Sollas, 1885	Demospongiae unid.7			8
	Sollas, 1885	Demospongiae unid.8			8
	Sollas, 1885	Demospongiae unid.9	5		
	Sollas, 1885	Demospongiae unid.10	6		
	Sollas, 1885	Demospongiae unid.11	6		
	Sollas, 1885	Demospongiae unid.12	6		
	Nardo, 1833	*Ircinia* sp			8
	Schmidt, 1862	*Axinella* sp	5,6		8
	Lamarck, 1815	*Geodia* sp	6		8
	Schmidt, 1868	*Pachastrella* sp			8
	Nardo, 1834	*Aplysina* sp			8
	Cárdenas, Perez & Boury-Esnault, 2012	Heteroscleromorpha unid.			14
	Gray, 1867	Euplectellidae unid.			14
Brachiopoda	Logan, 1988	*Pajaudina atlantica*			8
	Linnaeus, 1767	*Megerlia truncata*			8
Cnidaria	Owen, 1843	Hydrozoa unid.			3
	Lamouroux, 1812	*Aglaophenia* sp 1			10,8
	Lamouroux, 1812	*Aglaophenia* sp 2			8
	Lamouroux, 1821	*Sertularella* cf. gayi			8,11
	Alder, 1857	*Sertularella* cf. tenella			3,4,5,6,7,8,11,12,14
	Linnaeus, 1758	*Sertularella* cf. polyzonias			3,4
	Gray, 1848	*Sertularella* sp 1	all		8
	Lamarck, 1816	Plumulariidae unid.	3,6		3,5
	Hincks, 1868	Lafoeidae unid.1			3,4,5,8
	Hincks, 1868	Lafoeidae unid.2			8
	Péron & Lesueur, 1810	*Obelia* sp			8

		Corallimorpharia unid.	5	
	Gray, 1860	*Stichopathes setacea*	6	3,8
	Gray, 1857	*Antipathes furcata*	6	8
	Opresko, 2001	*Tanacetipathes cavernicola*	6	8
	Lamarck, 1801	*Caryophyllia* sp		8
	Stokes & Broderip, 1828	*Caryophyllia smithii*		8
	Pourtalès, 1871	*Anomocora fecunda*	6	8
	Milne Edwards & Haime, 1849	*Cladocora debilis*		8
	Milne Edwards & Haime, 1849	*Madracis* sp		8
	Lamouroux, 1812	Alcyonacea unid.1	3	8
	Koch, 1887	*Villogorgia bebrycoides*		8
	Philippi, 1842	*Bebryce mollis*		8
	Pallas, 1766	*Callogorgia verticillata*	6	
	Delle Chiaje, 1822	*Paralcyonium spinulosum*	6	
	Johnson, 1863	*Viminella flagellum*	3,6	
	de Blainville, 1830	Zoantharia unid.		8
	Perrier, 1893	Ceriantharia unid.	5	
Bryozoa		Bryozoa unid.	6	
	Busk, 1875	Frondiporidae unid.		8
	Lamouroux, 1821	*Hornera* sp		8
	Busk, 1884	*Reteporella* sp		8
Annelida	Quatrefages, 1866	*Chloeia* cf. venusta		3,4,5,7,9,10,11
	Audouin & Milne Edwards, 1833	*Onuphis* sp		3,4,5,6,8,10,9
	Malmgren, 1867	*Hyaloniecia* sp		7
	Cuvier, 1817	*Eunice* sp		8
	Blainville, 1828	*Lumbrineris* sp		8
	Kinberg, 1856	Polynoidae unid.		
	Lamarck, 1818	*Glycera* sp		1,3,7,11,13
	Roule, 1896	*Leocrates atlantica*		1
	Linnaeus, 1758	*Nereis* sp		3,8
	Grube, 1850	Syllidae unid.		3,4,8
	M Sars, 1856	*Spiochaetopterus* sp		10,5,6,7
	Johnston, 1846	Terebellidae unid.		3,4,8,11
	Rafinesque, 1815	Serpulidae unid.1		6,8
	Marenzeller, 1878	*Hyalopomatus* sp		1,2,3,6,7,9
	Delle Chiaje, 1822	*Semivermillia* cf torulosa		4,6,7,8
	Saint-Joseph, 1894	*Vermiliopsis* sp		9
	Philippi, 1844	*Placostegus* sp		9
	Risso, 1826	*Protula* sp		6,8,9
	Linnaeus, 1767	*Serpula vermicularis*		8
	Latreille, 1825	Sabellidae unid.		8
	Fabricius, 1785	*Spio* sp		3
Arthropoda	Ellis, 1758	*Megabalanus tulipiformis*		5
	Darwin, 1851	*Heteralepas cornuta*	7	8
	Latreille, 1802	Decapoda unid.	3,5	
	Couch, 1851	*Monodaeus couchii*		10,3,4,5,6
	Fabricius, 1798	*Alpheus* sp		10,5,6,9
	Hailstone, 1835	*Alpheus macrocheles*		10,6
	Leach, 1820	*Munida* sp	3,5	11,4
	Spence Bate, 1888	*Plesionika* sp		5
	A. Milne-Edwards, 1883	*Plesionika martia*		2
	Fabricius, 1787	*Plesionika narval*	3,5	3
	Brandt, 1851	*Plesionika edwardsii*	5	
	Whiteaves, 1874	*Munidopsis* sp		14
	Smith, 1884	*Acanthephyra eximia*		3
	Miers, 1881	*Heterocrypta maltzami*		5
	Fabricius, 1793	*Homola barbata*		6
	Leach, 1814	*Macropodia* sp		8
Mollusca	Rafinesque, 1815	Amoniidae unid.	all	
	Poli, 1795	*Neopycnodonte cochlear*		3,5,6,8,9,10,
	Lamarck, 1809	Arcidae unid.		14
	O. F. Müller, 1776	*Asperarca nodulosa*		8
	Linnaeus, 1758	*Pteria hirundo*		8
	H. Adams & A. Adams, 1852	*Onoba* sp		14
	Risso, 1826	*Mitrella* sp		3
	A. Adams, 1852	*Nassarius denticulata*		5,8
	Cuvier, 1817	Nudibranchia unid.	3,5	
Echinodermata	Philippi, 1845	*Stylocidaris affinis*	3	3
	A. Agassiz, 1872	*Coelopleurus floridianus*		6
	Gray, 1855	Diadematoidae unid.		6
	Philippi, 1845	*Centrostephanus longispinus*		8
	Gray, 1840	Ophiuroidea unid.		8

Chordata	Linnaeus, 1758	*Anthias anthias*	T	10,6
	Günther, 1874	*Serranus atricauda*	4	
	Linnaeus, 1758	Scorpaena unid.1	5	
	Cuvier, 1816	Seriola unid.	2	
	Linnaeus, 1767	Ascidia unid.	6	
	Forbes & Hanley, 1848	Clavelinidae sp.	6	

Figures 7 summarize table 1 and clearly show how Cnidaria and Porifera, are the most abundant groups at the control station with 20 and 13 different species respectively. Conversely, inside of the volcano affected area, the same groups represent a 40% and 15%, respectively from the total number of species at the control area. Due to their slow growth rates, Porifera and Cnidaria with bigger sizes cannot be considered as new colonizers of the volcano area but survivors.

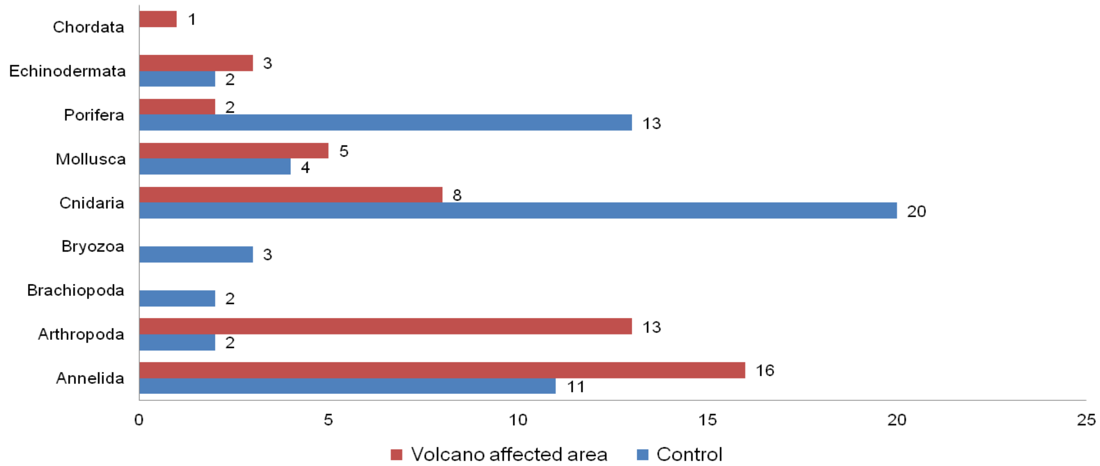

Figure 7
Comparision of phyla abundances for the Volcano affected area (red) and the Control area (blue)

In the same way, at the volcano affected area, four groups have been identified as the first and more diverse colonizers (Echinodermata, Mollusca, Arthropoda and Annelida), with higher number of species respect to the control of 1, 1, 11, 5, respectively, which suppose an increase of species respect to the total of 50%, 25%, 550% and 45%, respectively.

Lastly, as it has been proved, Tagoro is a submarine volcano with an active desgasification phase comprising a release of heat and gases (mainly CO_2), by the main and secondary craters (Santana-Casiano et al, 2016). consequetly, differenciated habitats have been found in the proximities of the 8 observed craters. Those habitats are covered by mats of sulphurous dipossits, suitable only for some bacteria species (fig. 8).

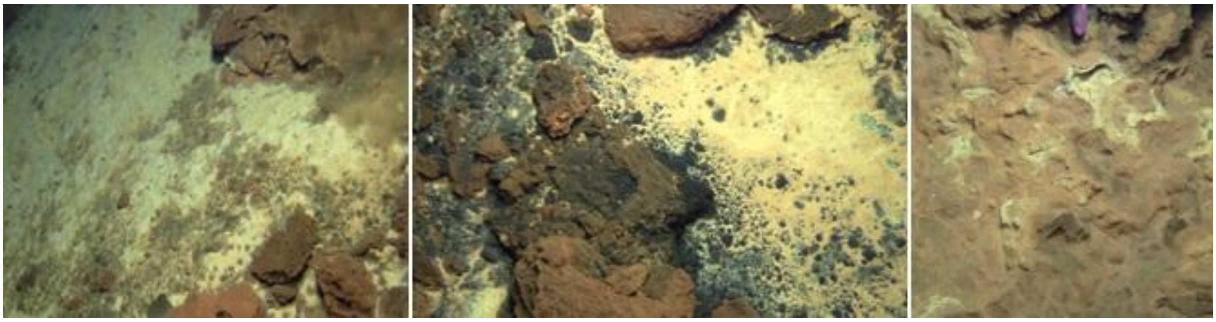

Figure 8
Sulphur mats filmed at the proximities of the main and secondary craters

Give an overview of any positive / negative experiences related to the internship

Everything has gone perfectly. Since the second day from my arrival to Tenerife I have being working in a very fascinating project, where oceanography, marine biology and geology met.

I had a worm welcoming and I have been treated with a very high level of professionalism, for what I have to thank Eugenio Fraile, my supervisor.

I had the opportunity of learning the way of working and how is the environment in a research public Institution. The multidisciplinary and the shearing of knowledge are here two main topics that are highly considered, which are the basics for science and development.

Literature

Acosta, J., Uchupi, E., Muñoz, A., Herranz, P., Palomo, C., Ballesteros, M., & ZEE Working Group. (2005). Geologic evolution of the Canarian Islands of Lanzarote, Fuerteventura, Gran Canaria and La Gomera and comparison of landslides at these islands with those at Tenerife, La Palma and El Hierro. In*Geophysics of the Canary Islands* (pp. 1-40). Springer Netherlands.

Ariza, A., Kaartvedt, S., Røstad, A., Garijo, J. C., Arístegui, J., Fraile-Nuez, E., & Hernández-León, S. (2014). The submarine volcano eruption off El Hierro Island: effects on the scattering migrant biota and the evolution of the pelagic communities. *PloS one*, *9*(7), e102354.

Baumberger, T., Lilley, M. D., Resing, J. A., Lupton, J. E., Baker, E. T., Butterfield, D. A., ... & Früh-Green, G. L. (2014). Understanding a submarine eruption through time series hydrothermal plume sampling of dissolved and particulate constituents: West Mata, 2008–2012. *Geochemistry, Geophysics, Geosystems*, *15*(12), 4631-4650.

Blanchi, C. N. (1981). *Policheti serpuloidei. Guide per il riconoscimento delle specie animali delle acque lagunari e costiere italiane. CNR*. AQ/1/96, 5: 1-187.

Blanco, M. J., Fraile-Nuez, E., Felpeto, A., Santana-Casiano, J. M., Abella, R., Fernández-Salas, L. M., ... & López, C. (2015). Comment on "Evidence from acoustic imaging for submarine volcanic activity in 2012 off the west coast of El Hierro (Canary Islands, Spain)" by Pérez NM, Somoza L, Hernández PA, González de Vallejo L, León R, Sagiya T, Biain A, González FJ, Medialdea T, Barrancos J, Ibáñez J, Sumino H, Nogami K and Romero C [Bull Volcanol (2014) 76: 882-896]. *Bulletin of Volcanology*, *77*(7), 1-8.

Brito, A.; Pascual, P.J; Falcón, J.M.; Sancho, A. & González, G. (2002), Peces de las Islas Canarias, Catálogo comentado e ilustrado. Ed. *Francisco Lemus Editors*, Arafo, Tenerife, Spain. 419p.

Brito, A. & Ocaña, O. (2004). Corales de las Islas Canarias. Ed. *Francisco Lemus Editor*. Arafo, Tenerife, Spain. 477p.

Carey, S., & Sigurdsson, H. (2007). Exploring submarine arc volcanoes. *Oceanography-washington dc-oceanography society-*, *20*(4), 80.

Carracedo, J. C. (1994). The Canary Islands: an example of structural control on the growth of large oceanic-island volcanoes. *Journal of Volcanology and Geothermal Research*, *60*(3-4), 225-241.

Coca, J., Ohde, T., Redondo, A., García-Weil, L., Santana-Casiano, M., González-Dávila, M., ... & Ramos, A. G. (2014). Remote sensing of the El Hierro submarine volcanic eruption plume. *International Journal of Remote Sensing*, *35*(17), 6573-6598.

Espino, F.; Boyra, A.; Tuya, F. & Haroun, R. (2006). Guía visual de Especies Marinas de Canarias. Ed. *Oceanográfica, Divulgación, Educación y Ciencia.* Las Palmas de Gran Canaria, Spain. 482p.

Eugenio, F., Martin, J., Marcello, J., & Fraile-Nuez, E. (2014). Environmental monitoring of El Hierro Island submarine volcano, by combining low and high resolution satellite imagery. *International Journal of Applied Earth Observation and Geoinformation*, *29*, 53-66.

Ferrera, I., Arístegui, J., González, J. M., Montero, M. F., Fraile-Nuez, E., & Gasol, J. M. (2015). Transient changes in bacterioplankton communities induced by the submarine volcanic eruption of El Hierro (Canary Islands). *PloS one*, *10*(2), e0118136.

Fraile-Nuez, E., González-Dávila, M., Santana-Casiano, J. M., Arístegui, J., Alonso-González, I. J., Hernández-León, S., Blanco, M.L, Rodríguez-Santana, A., Hernandez-Guerra, A., Gelado-Caballero, M.D., & Eugenio, F. (2012). The submarine volcano eruption at the island of El Hierro: physical-chemical perturbation and biological response. *Scientific reports*, *2.*

González, J.A. (1995). Catálogo de los Crustáceos Decápodos de las Islas Canarias. Ed. *Publicaiones Turquesa.* Santa Cruz de Tenerife, Spain.282p.

Hayward, Peter J., and John Stanley Ryland. *Handbook of the marine fauna of North-West Europe*. Oxford University Press, 1995.

Head, J. W., & Wilson, L. (2003). Deep submarine pyroclastic eruptions: theory and predicted landforms and deposits. *Journal of volcanology and geothermal research*, *121*(3), 155-193.

Husemann, M., Deppermann, J., & Hochkirch, A. (2014). Multiple independent colonization of the Canary Islands by the winged grasshopper genus Sphingonotus Fieber, 1852. *Molecular phylogenetics and evolution*, *81*, 174-181.

Manuel, R. L. "British Anthozoa, rev. edn." *EJ Brill, Leiden* (1988).

Meletlidis, S., Di Roberto, A., Pompilio, M., Bertagnini, A., Iribarren, I., Felpeto, A., Torres, P.A., & D'Oriano, C. (2012). Xenopumices from the 2011–2012 submarine eruption of El Hierro (Canary Islands, Spain): Constraints on the plumbing system and magma ascent. *Geophysical Research Letters*, *39*(17).

Pelegrí, J. L., Arístegui, J., Cana, L., González-Dávila, M., Hernández-Guerra, A., Hernández-León, S., Marrero-Días, A., Montero, M.F., Sangrà, P., & Santana-Casiano, M. (2005). Coupling between the open ocean and the coastal upwelling region off northwest Africa: water recirculation and offshore pumping of organic matter. *Journal of Marine Systems*, *54*(1), 3-37.

Pérez, J.M.S., & Batet, E.M. (1990). Invertebrados Marinos de Canarias. Ed. *Abildo Insular de Gran Canaria*, Las Palmas de Gran Canaria, Spain. 334p.

Resing, J. A., Lebon, G., Baker, E. T., Lupton, J. E., Embley, R. W., Massoth, G. J., Chadwick, W.W., & De Ronde, C. E. J. (2007). Venting of acid-sulfate fluids in a high-sulfidation setting at NW Rota-1 submarine volcano on the Mariana Arc.*Economic Geology*, *102*(6), 1047-1061.

Resing, J. A., Rubin, K. H., Embley, R. W., Lupton, J. E., Baker, E. T., Dziak, R. P., Baymberger, T., Lilley, M.D., Huber, J.A., Shank, T.M., & Butterfield, D. A. (2011). Active submarine eruption of boninite in the northeastern Lau Basin. *Nature Geoscience*, *4*(11), 799-806.

Rivera, J., Lastras, G., Canals, M., Acosta, J., Arrese, B., Hermida, N., ... & Amblas, D. (2013). Construction of an oceanic island: Insights from the El Hierro (Canary Islands) 2011–2012 submarine volcanic eruption. *Geology*, *41*(3), 355-358.

Rodriguez-Losada, J. A., Eff-Darwich, A., Hernandez, L. E., Viñas, R., Pérez, N., Hernandez, P., Melián, G., Martines-Frías, J., Romero-Ruiz, C.M., & Coello-Bravo, J. J. (2015). Petrological and geochemical Highlights in the floating fragments of the October 2011 submarine eruption offshore El Hierro (Canary Islands): Relevance of submarine hydrothermal processes. *Journal of African Earth Sciences*, *102*, 41-49.

Rubin, K. H., Soule, S. A., Chadwick, W. W., Fornari, D. J., Clague, D. A., Embley, R. W., Beker, E.T., Perfit, M.R., Caress, D.W., & Dziak, R. P. (2012). Volcanic eruptions in the deep sea.

Santana-Casiano, J. M., González-Dávila, M., Fraile-Nuez, E., De Armas, D., González, A. G., Domínguez-Yanes, J. F., & Escánez, J. (2013). The natural ocean acidification and fertilization event caused by the submarine eruption of El Hierro. *Scientific reports*, *3*.

Santana-Casiano, J. M., Fraile-Nuez, E., González-Dávila, M., Baker, E. T., Resing, J. A., & Walker, S. L. (2016). Significant discharge of CO2 from hydrothermalism associated with the submarine volcano of El Hierro Island.*Scientific reports*, *6*.

Simó TC, (2002) Esponjas marinas de Canarias. Ed. *Consejería de Política Territorial y Medio Ambiente del Gobierno de Canarias.* S/C Tenerife, Spain. 260p.

Southward, Eve C., and Andrew C. Campbell. *Echinoderms: keys and notes for the identification of British species*. FSC Publications, 2006.