MASS MORTALITY IN THE BENTHIC INFAUNA OF PORT FOSTER RESULTING FROM THE ERUPTIONS IN DECEPTION ISLAND (South Shetland Is.).

MORTANDAD MASIVA DE LA INFAUNA BENTONICA DE LA BAHIA FOSTER RESULTANTE DE LAS ERUPCIONES EN ISLA DECEPCION (ISLAS SHETLAND DEL SUR)

VICTOR ARIEL GALLARDO

JORGE GONZALO CASTILLO

Departamento de Zoología

Instituto Central de Biología

UNIVERSIDAD DE CONCEPCION

Concepción, Chile

1968

MASS MORTALITY IN THE BENTHIC INFAUNA OF PORT FOSTER RESULTING FROM THE ERUPTIONS IN DECEPTION ISLAND (SOUTH SHETLAND IS.) *

by

Víctor Ariel Gallardo and Jorge Gonzalo Castillo

ABSTRACT

On December 21 and 31, 1967 a limited survey of the bottom was carried out by the authors to observe the effects of the volcanic events of Dec. 4 on the benthic infauna of Port Foster. Fifteen 0.1 m^2 and one 0.2 m^2 Petersen grab samples, and five dredge hauls gave evidence that most of the bottom had been covered by a layer of ash of a minimum thickness of 30 cm. Bottom samplers caught little if no infauna in the greater part of Port Foster and dredgings from the same area showed no residues of the previously existing infauna. Comparison with yields from samples taken on a previous year at Port Foster and outside the bay gave an idea of the extent of the mortality. Near the mouth of Port Foster, where the bottom does not show considerable ash covering, infaunal animals were more numerous. A dredge haul here caught many specimens of living *Ophionotus victoriae,* together with some dead ones. Also all Echinoidea (*Sterechinus neumayeri*) were dead and in advanced state of decomposition. Mortality in this case was presumably due to other chemical or physico-chemical factors. Other causes of mortality in the bottom fauna of Port Foster were: the uplift of the bottom and the formation of a new islet at Telefon Bay, the high concentration of toxic compounds and the high temperature reached by the water nearby. Further alterations of the ecosystem at Port Foster were evidenced by the absence of fish and other sea life at the time of the observations. Turbidity of the water and the presence of toxic compounds might have also altered the productivity of the surface layers. Port Foster is now an excelent spot to study the reestablishment of an ecosystem in relation to the evolution of all parameters to normality.

RESUMEN

Los días 21 y 31 de diciembre de 1967, los autores llevaron a cabo un estudio limitado del fondo marino con el objeto de observar los efectos de los sucesos volcánicos del 4 de diciembre de 1967, en la infauna bentónica de Bahía Foster. Quince muestras cuantitativas tomadas con una drada Petersen 0.1 m^2 y una con la 0.2 m^2, y 5 rastreos ponen en evidencia que el fondo había sido cubierto con una capa de ceniza de un

---

* Presentado al Segundo Simposio sobre Biología Antártica, Cambridge, Inglaterra 1968.

grosor mínimo de 30 cm. Los muestreadores de fondo cogieron poca o ninguna infauna en la mayor parte de Bahía Foster y los rastreos de la misma área no mostraron residuos de la infauna existente previamente a las erupciones. Comparaciones con las capturas logradas en muestras tomadas anteriormente y con las obtenidas en esta oportunidad fuera de Bahía Foster, dan una idea de la extensión de la mortandad. Cerca de la boca de Bahía Foster, donde el fondo no mostraba un recubrimiento con cenizas de consideración, los animales infaunísticos eran más numerosos. Una rastra tomada aquí cogió muchos especímenes vivos de *Ophionotus victoriae,* junto con algunos muertos. También todos los Echinoidea (*Sterechinus neumayeri*) estaban muertos y en avanzado estado de descomposición. La mortandad en este caso se debió presumiblemente a otros factores químicos o físico-químicos. Otras causas de mortandad en la fauna del fondo de la Bahía Foster fueron el solevantamiento del fondo y la formación de un nuevo islote en Bahía Telefon, la alta concentración de compuestos tóxicos y la alta temperatura alcanzada por el agua en los alrededores. Que el ecosistema de Bahía Foster sufrió además otras alteraciones queda evidenciado por la ausencia de peces y otras formas de vida marina durante el período de las observaciones. La turbidez del agua y la presencia de compuestos tóxicos puede también haber alterado la productividad de las capas superficiales. Bahía Foster es ahora un excelente lugar para estudiar el restablecimiento de un ecosistema en relación con la evolución de todos los parámetros a normalidad.

INTRODUCTION

Vulcanism has been in many occasions the cause of mass mortality in different parts of the world. A valuable compilation of recent cases of mass mortality in the sea is that of Brongersma-Sanders (1957). Vulcanism may affect marine organisms through several agencies, and these may be here separated into physical and chemical. Among the first the following can be cited: 1) increase of water temperature; 2) rain of ash and actual covering by it; 3) uplift of the bottom leaving it exposed to the air, or to different hydrographical conditions; 4) land slides; 5) flood waves, and 6) shock. Poisonous gases and liquids can be mentioned among the chemical agencies (Brongersma-Sanders op. cit.).

Most of the known cases of mass mortality in the sea by vulcanism and tectonic disturbances, have been reported from the Mediterranean and the East and West Pacific, although the general occurrence of sediments evidencing vulcanisms in the sea is widespread (Murray and Renard, 1891). Fewer cases have been reported from the Atlantic and Indian Oceans, and none from Antarctica.

The eruption in Deception Island (lat. 62º 57' S, long. 60º 38' W) started on December 4, 1967. According to the description of the phenomenon (Valenzuela et al. 1968), Deception Island had undergone intense seismic activity for several months before. Seismographic data obtained at the Chilean Air Force Base "Pedro Aguirre Cerda" in the months previous to November show somewhere between 4 and 30 earthquakes of force 2, in the international scale, monthly. Seismicity increased markedly in November with about 300 earthquakes of the same intensity as above. On December 4 the regularity of earthquake intensity was broken by two force 4 earthquakes (06.20 and 09.30 hrs) and one of force 5 (14.40 hrs) From then on force 5 earthquakes occurred at a rate of four to five per minute. The eruption itself started at 18.40 hrs and was evidenced by a column of black smoke and ash which formed a courtain-like cloud directed east-west, of more than 2.500 m altitude. Winds at the time were of about 20 knots from the

NNW. At Pendulum Cove water begun to boil and a strong sulphur smell was felt. The sea-level changed at a rate of once every two or three minutes. According to the above authors during the eruption only gases and pyroclastics were ejected. Of the first SH2 and ClH were recognized by their characteristic smells. Pyroclastics were mostly in the form of ash and lapilli, their amount deposited on the island and Port Foster being estimated on the order of 52 x 10^6 m^3.

The authors are deeply endebted to the Chilean Navy for allowing time and facilities to carry out the observations here reported on board the AGS "Yelcho". We also thank the Hydrographic Institute of the Chilean Navy for their valuable colaboration and to the Chilean Antarctic Institute and the University of Concepción for jointly financing this research. Gratitude is expressed to Prof. E. Valenzuela for the study of sediment samples taken in Port Foster.

MATERIALS AND METHODS

Both quantitative and qualitative gear were employed in the benthic sampling (see List of Stations), both in Port Foster and outside (Fig. 1). Subsamples were saved for sedimentological analysis and the rest was washed through a sieve of 1 mm^2 mesh-size. Animals were preserved in formaline 10% and after returning home, shifted into 70% ethanol, counted and weighed. Bathythermograph casts were performed in stations 7-10 only. Except for one attempt of fishing within Port Foster and one outside, both with negative results, further observations were not performed because of lack of elements.

RESULTS

The following figures show the results of the quantitative sampling in Port Foster. Figure 2 clearly demostrates that a strong decrease in the number of bottom invertebrates occurs as one approaches the northern end of the bay. On the other hand Station 17 and 18 have higher numbers per sample. Biomass follows the same pattern (Fig. 3).

If the number of individuals obtained through dredging are now compared, the same trend is appreciated (Table 1).

Table 1.—Number of individuals per 10-minute triangular dredging.

Sta. Nº	Nº of Individuals	Location
11	3	Port Foster
12	1	Port Foster
16	753	Port Foster
13	2177	Outside Port Foster
14	4690	Outside Port Foster

DISCUSSION

The data above indicates that the highest levels of numbers of benthic invertebrates and biomass, are met outside Port Foster (Station 1 with grab samples 1-4, and dredge stations 13 and 14). Dredge station 16,

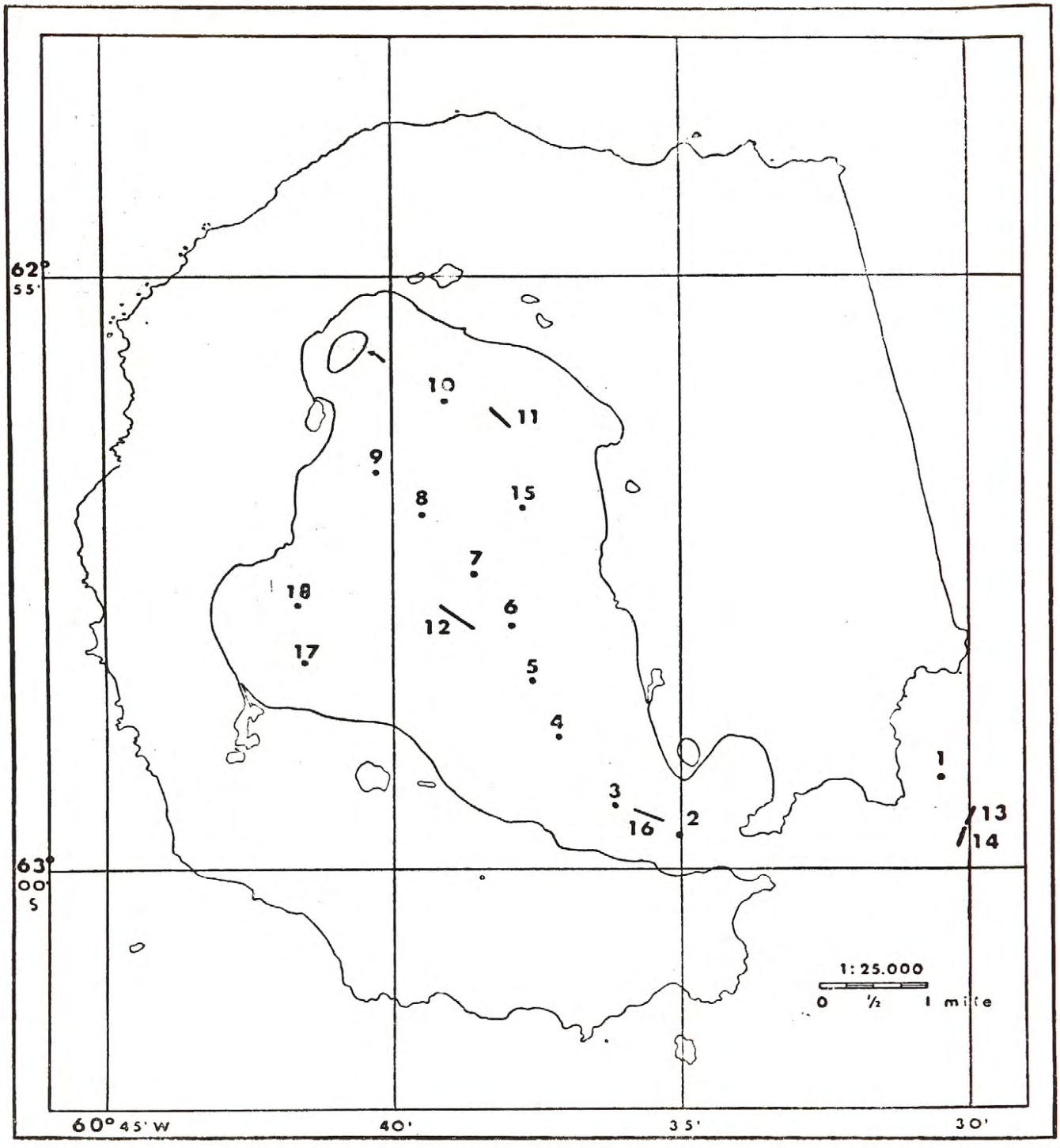

Figure 1.—Benthic sampling stations covered at Port Foster (Deception I.) during the Twenty-second Chilean Antarctic Expedition. Grab samples = ·; dredge samples—.

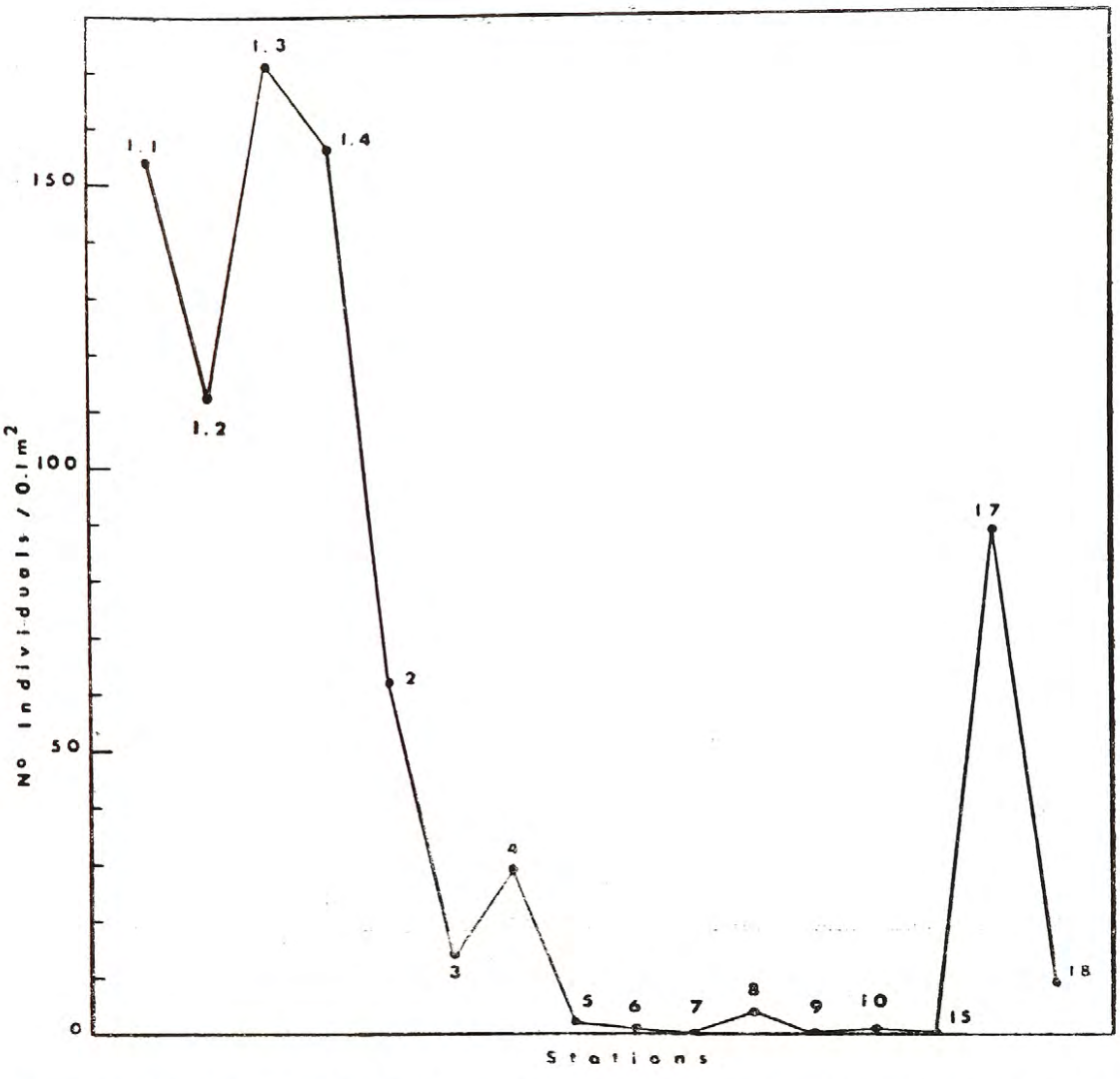

Figure 2.—Number of individuals per 0.1 m² samble in quantitative stations of the benthic survey at Port Foster (Deception I.).

located at the mouth of Port Foster shows a contrastingly higher number of individuals than those from the other two interior dredge stations (Sta. 11 and 12). Grab station 17, and to a lesser degree also station 18, have comparatively larger numbers of individuals than other grab samples taken within Port Foster. This may be explained by the fact trat this portion of Port Foster was slightly away from the main direction of the ash fallout. However, it should be noted that some of the ophiurans (*Ophionotus victoriae*) and all echinoids (*Sterechinus neumayeri*) taken at station 16, the richest of all samples obtained within Port Foster, were dead and in various stages of decomposition. This was not the case with dredgings performed outside Port Foster. The latter were especially rich and varied with large quantities of Isopoda, Amphipoda, Ascidiacea, Polychaeta, Echinoidea, Asteroidea, etc. The larger yields obtained in stations from the entrance channel of Deception Island could be accounted by the weaker settlement of ash due to stronger tidal currents which can be expected in this narrow area. As to the observed fact that all echinoids were found dead, it should be mentioned that

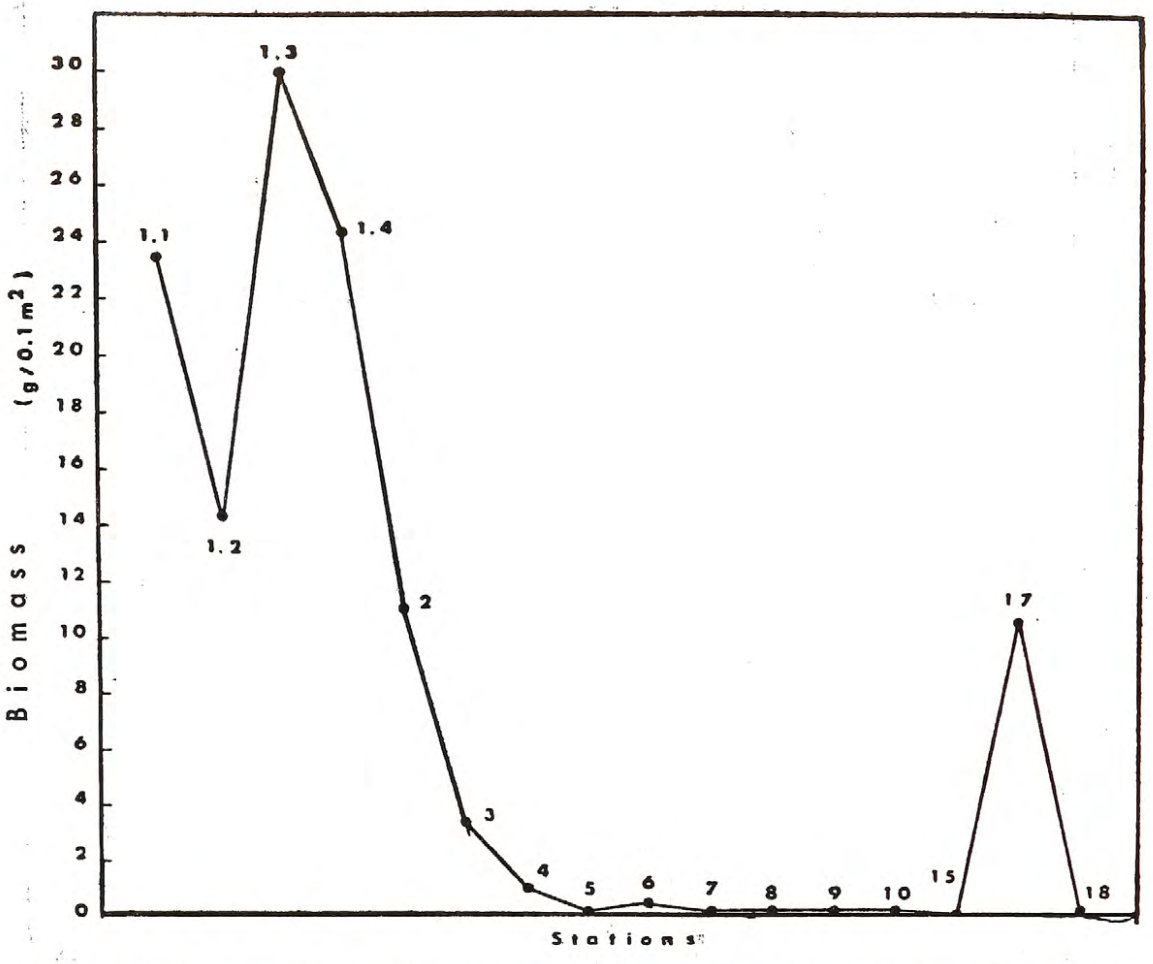

Figure 3.—Biomass (g|0.1 m^2) in quantitative stations of the benthic survey at Port Foster (Deception I.).

Bianco (1906) reports similar findings after the eruption of the Vesuvius in 1906.

In short, mortality must have occurred (and was probably still occurring at the time of the observations) through several agencies. Near the location where an islet was formed (indicated by an arrow in Fig. 1), temperature, poisonous gases and liquids must have been the primary factors. In most of the rest of the bottom of Port Foster, mortality must be presumed to have ocurred by the actual burial of the bottom fauna by the large amounts of ash deposited there. The layer of ash is considered to be in this area of a minimum of 30 cm. thickeness (i, e., the height of the quantitative grab). Actually, the grabs only caught the very surface of this layer, composed of the finest materials (mean grain size = 0.010 — 0.017 mm and sorting coefficient = 1.92 — 2.00 for Stas. 5 and 7 respectively). The actual thickness of the ash must be greater than 30 cm but the exact measurement was not possible to perform.

The high number of individuals outside the bay (and also those found in Chile Bay) give an idea of what the situation might have been within Port Foster before the eruptions. It is unfortunate that quantitative benthic data from Port Foster, obtained previous to these events, are absent from the literature, although dredgings have been performed by expeditions in the past. Partial examination of some of this informa-

tion indicates that species of various benthic taxa have been collected in Port Foster by the *Deuxiéme Expedition Antarctique Francaise* in 1908 and 1909 (Fauré-Fremiet 1914, Topsent 1917, Richardson 1913, Chevreux 1913, Lamy 1911, Koehler 1912, Sluiter 1914), and by the "Discovery" in 1927 (Monro 1930, Barnard 1932, Wheeler 1934, Mortensen 1936, Fisher 1940). Although it is not clearly stated, it appears that the most abundant species found in these samplings are *Ophionotus victoriae, Sterechinus neumayeri,* and *Odontaster validus*. The French Expedition also collected specimens of littoral amphipods, and in this connection, it shoud be noted chat Chevreux (*op. cit.*) reports that numbers of the amphipod *Cheirimedon dentimanus* have been seen dead at the beaches of Port Foster, where the water temperature may be as high as 70º C. Mass killing of euphausiids has also been reported to the authors by Moyano (personal communication 1968). Although high temperatures were present in Telefon Bay and Pendulum Cove at the time of the observations, the highest temperature recorded in the rest of the bay were of the order of 2.7ºC, at about 10 m repth, and a thermocline was present between 20 and 30 m depth (Stas. 7-10). Bottom temperature ranged from 1.1 to 1.5ºC.

More recent data on the previously existing benthic fauna of Port Foster come from one dredging performed by Moyano (personal communication 1968) during the Nineteenth Chilean Antartic Expedition (1964-65) (Moyano 1965). This dredging was made in the center of the bay in 160 m depth and contained large numbers of the ophiuran *Ophionotus victoriae,* (Castillo 1967) and lesser numbers of *Sterechinus neumayeri,* polychaetes, nemerteans, poriferans, and small fish.

According to Hawkes (1961) there is the possibility that the last of the four volcanic episodes of the island may have taken place in 1842. Its intensity and effect on the benthic fauna of Port Foster are not known. By 1908 the benthic fauna is, however, recognizably similar to that found by Moyano and by us (as far as the contents of Stas. 2 and 16 goes). What the structure of the benthic association in Port Foster was before the eruptions we will never exactly know because this information is a result of quantitative surveys, and these, as far as we are aware, have never been performed in this bay. The fact that in at least four occasion the most abundant form in the bottoms of Port Foster appears to be *O. victoriae,* could be an indication of environmental peculiarity. It is also striking that *O. victoriae* appeared only twice in the 39 bottom samples taken in the Chile Bay survey. Some information regarding the past history of the bay might be obtained from bottom coring, which might also give more precise data as to the absolute age of the past volcanic events of the island. Most rewarding would be to keep a continuous check on this area in the future years in order observe the reestablishment of the benthic fauna where it was affected. The recruitments of the benthos in an area where larval forms of bottom-living invertebrates are almost completely absent in the zooplankton, except for Crustacea (Dell 1965), will probably show interesting features, especially in the enclosed bottoms of Port Foster.

REFERENCES

BARNARD K. H. 1932. Amphipoda. Discovery Rep. (5): 1-326.

BIANCO SALVATORE LO. 1906. Azione della pioggia di cenere, caduta durante l'eruzione del Vesuvio dell' Aprile 1906, sugli animali marini. Mitt. zool. Sta. Neapel 18 (1): 73-104.

BRONGERSMA - SANDERS M. 1957. Mass mortality in the sea. Geol. Soc. America, Mem. 67 (1): 941-1010. Treatise on Marine Ecology and Paleoecology, vol. I. Ed. J. Hedgpeth.

CASTILLO J. 1967. Ophiuroídeos colectados por la XIX Expedición Antártica Chilena. Publ. Inst. Ant. Chileno (13): 35 pp.

CHEVREUX E. 1913. Amphipodes. Deux. Exp. ant. Franç. (1908-1910): 79-186.

DELL R. K. 1965. Marine Biology. In Hatherton T.: Antarctica. Methuen & Co. Ltd. London: 129-152.

FAURE - FREMIET E. 1914. Foraminiferes. Deuxi Exp. ant. Franc. (1908-1910): 1-14.

FISHER W. K. 1940. Asteroidea. Discovery Rep. (20): 69-306.

HAWKES D. D. 1961. The geology of the South Shetland Islands. II. The geology and petrology of Deception Island. Sci. Rep. Falkland Is. Surv. (27): 43 pp.

KOEHLER R. 1912 Echinodermes (Astéries, Ophiures et Echinides). Deux. Exp. ant. Franç. (1908-1910): 1-270.

LAMY E. 1911. Gastropodes, Prosobranches. Scaphopode et Pelécypodes. Deux Exp. ant. Franç. (1908-1910): 1-31.

MONRO C. C. A. 1930. Polychaete worms. Discovery Rep. (2): 1-222.

MORTENSEN T. 1936. Echinoidea and Ophiuroidea. Discovery Rep (12): 199-348.

MOYANO H. I. 1965. Bryozoa colectados durante la Expedición Antártica Chilena 1964-65. Publ. Ant. Chileno (5): 29 pp.

MURRAY J. and A. F. RENARD 1891. Deep-sea deposits. Rep. Voy. "Challenger" 1873-1876, XXIX + 525 pp.

RICHARDSON H. 1913. Crustacés Isopodes. Deux. Exp. ant. Franç. (1908-1910): 1-24.

SLUITER C. P. 1914. Les tuniciers. Deux. Exp. ant. Franç (1908-1910: 1-39.

TOPSENT E. 1917. Spongiaires. Deuxi. Exp. ant. Franç (1908-1910): 1-88.

VALENZUELA E.; L. CHAVEZ y F. MUNIZAGA. 1968. Informe preliminar sobre la erupción de Isla Decepción ocurrida en Diciembre de 1967. Bol. Inst. Ant. Chileno. (3): 5-16.

WHEELER J. F. G. 1934. Nemerteans from the South Atlantic and Southern Oceans. Discovery Rep. (9): 215-294.

LIST OF STATIONS

Sta. N°	Date (M-D-Y)	Time (local)	Lat. S	Long. W	Depth (m)	Bottom type
Petersen 0.1 m² Grab						
1	12-21-67	7.1	62° 59.6	59° 26.2	37	Sand (4 samples)
2	12-21-67	7.7	62° 59.4	60° 33.5	99	Mud
3	12-21-67	8.0	62° 59.2	60° 34.6	108	Mud
4	12-21-67	8.2	62° 58.6	60° 35.5	112	Mud
5	12-21-67	8.3	62° 58.2	60° 36.1	135	Mud
6	12-21-67	8.6	62° 57.8	60° 36.4	158	Mud
7	12-21-67	8.9	62° 57.3	60° 37.1	147	Mud
8	12-21-67	9.2	62° 56.8	60° 37.9	153	Mud
9	12-21-67	9.6	62° 56.4	60° 38.8	156	Mud
10	12-21-67	9.9	62° 55.8	60° 37.6	144	Muddy sand
Triangular dredge						
11	12-21-67	10.7	62° 55.9	60° 36.8	144	Muddy sand
12	12-21-67	11.5	62° 57.8	60° 37.2	155	Mud
13	12-21-67	16.0	62° 59.4	60° 28.5	41	Sand
14	12-21-67	16.5	62° 59.3	60° 28.6	32	Sand
Petersen 0.2 m² Grab						
15	12-26-67	15.3	62° 56.1	60° 35.7	90	Muddy sand
Triangular dredge						
16	12-31-67	10.5	62° 59.4	60° 34.0	97	Mud
Petersen 0.1 m² Grab						
17	12-31-67	11.8	62° 58.1	60° 40.1	93	Muddy sand
18	12-31-67	12.1	62° 57.6	60° 40.2	112	Mud

INSTITUTO ANTARTICO CHILENO
TRIANA 849 - SANTIAGO, CHILE

Se ofrece y se acepta canje.

Exchange with similar publications is desired.

On désire l'echange avec les publications congénéres.

Wir bitten um Austausch mit aehnlichen Fachzeitschriften.

PUBLICACIONES DEL INSTITUTO ANTARTICO CHILENO

Nº 1.— ALDUNATE A. Boletín meteorológico y sismológico. Base Presidente Gabriel González Videla. Año 1963. (1964)

Nº 2.— GUTMANN W. y E. CAVIEDES. Relaciones alométricas de algunas aves antárticas. (1964)

Nº 3.— OFICINA METEOROLOGICA DE CHILE. Anuarios Meteorológicos Antárticos de Chile, 1947-64. (1965).

Nº 4.— FOLLMAN G. Una asociación nitrófila de líquenes epipétricos de la Antártica Occidental con *Ramalina terebrata* Tayl et Hook, como especie caracterizante. 18 págs. (1965)

Nº 5.— MOYANO H. I. Bryozoa colectados durante la Expedición Antártica Chilena 1964-65. (1965)

Nº 6.— DODGE C. W. Líquenes de las Islas Shetland del Sur y de la Tierra de O'Higgins (Península Antártica). (1965)

Nº 7.— ARAYA B. y W. ARAVENA. Las aves de Punta Armonía, Isla Nelson, Antártica Chilena. Censo y Distribución. (1965)

Nº 8.— HERVE F. y R. ARAYA. Estudio Geomorfológico y Geología de las Islas Shetland del Sur, Antártica. (1966).

Nº 9.— COVARRUBIAS R. Observaciones cuantitativas sobre los invertebrados terrestres antárticos y preantárticos. XIX Expedición Antártica Chilena, 1964-1965 (1966).

Nº 10.— VELASQUEZ H. Boletín Meteorológico Base Presidente González Videla. Año 1962. (1966).

Nº 11.— MOYANO H. I. Bryozoa colectados por la Expedición Antártica Chilena 1964 - 1965 II. (1966).

Nº 12.— VILLARROEL H. S., Estudio Cristalográfico de Minerales de la Antártida (1966).

Nº 13.— CASTILLO J. Ophiuroideos colectados por la XIX Expedición Antártica Chilena. (1967)

Nº 14.— SAIZ F. y E. HAJEK R. Estudios ecológicos en Isla Robert (Shetland del Sur) 1.— Observaciones de temperatura en nidos de Petrel gigante. (1967).

Nº 15.— SCHLATTER R., W. HERMOSILLA y F. DI CASTRI. Estudios ecológicos en Isla Robert (Shetland del Sur) 2.— Distribución altitudinal de los Artrópodos terrestres. (1968).

O|T. 524 - 500 Ejs. - Instituto Geográfico Militar - 1969