Latin American Journal of Aquatic Research, 50(4): 622-627, 2022
DOI: 10.3856/vol50-issue4-fulltext-2879

Short Communication

On the presence of *Branchiostoma elongatum* juveniles (Cephalochordata: Branchiostomatidae) on the north-central coast of Chile

Armando Mujica[1], María Luisa Nava[1] & Francisco Leiva-Dietz[2]
[1]Departamento de Acuicultura, Facultad de Ciencias del Mar, Universidad Católica del Norte
Coquimbo, Chile
[2]Instituto de Fomento Pesquero (IFOP), Valparaíso, Chile
Corresponding author: Armando Mujica (amujica@ucn.cl)

ABSTRACT. The presence of juvenile *Branchiostoma elongatum* captured in plankton samples from the north-central coast of Chile during February-March of consecutive years (2013-2020) is described. Its low abundance showed interannual variation as well as its frequency of occurrence. Its geographical distribution was preferably coastal. It covered the entire sampling area (1-20 nm from the coast) longitudinally, and specimens were captured between the extreme north of the sampling area and 30°20'S. The lowest abundances were found in years of negative thermal anomalies (2017-2018) and the highest mainly in neutral conditions (2013-2015).

Keywords: *Branchiostoma elongatum*; juvenile; distribution; north-central Chile

Amphioxus belongs to the subphylum Cephalochordata, and according to Del Moral-Flores et al. (2016), there are 35 valid species. The Branchiostomatidae family has three genera (*Asymmetron*, *Branchiostoma*, and *Epigonichthys*), with *Branchiostoma* being the genus with the highest species richness (23 valid species) (Galván-Villa et al. 2017). They are exclusively marine, with wide distribution in temperate and tropical waters (Del Moral-Flores et al. 2016). They are generally buried in shallow bottoms near the coast and thick sediments (sand, gravel, shell remains), spending most of their lives filtering small organic particles (Rodríguez-Uribe et al. 2019). These authors also indicate that some species are occasional swimmers, spending part of their life in plankton, and can inhabit depths greater than 200 m.

On the coasts of Chile and Peru, which are affected by the Humboldt Current System, only *Branchiostoma elongatum* (Sundevall, 1852) has been described in shallow sandy bottoms (Laudien et al. 2007).

The study area is located in one of the most productive pelagic ecosystems globally (Laudien et al. 2007), characterized by complex oceanography with periodic upwelling events that brings cold, nutrient-rich deep waters to surface layers and affected by aperiodic El Niño events, which generate considerable oceanographic variations (Thiel et al. 2007).

Del Moral-Flores et al. (2016) point out that the distribution of *B. elongatum* is restricted to the coasts of Peru, Chile, and the Galapagos Islands. They doubt the identification of the specimens captured in Baja California carried out by Poss & Boschung (1996). In the literature, only Laudien et al. (2007), Moreno et al. (2008), Pacheco et al. (2010) and Vergara et al. (2012) cite this species for the northern coasts of Chile (Iquique-Antofagasta, 20°11'-23°45'S), although originally Porter (1909) reported its presence in the Valparaíso Bay (32°02'S).

The present work provides information on the distribution and abundance of *B. elongatum* juveniles in plankton, contributing to their knowledge of their abundance, population dynamics, dispersion, and interannual variation. The zooplanktonic data of the present work was obtained from the scientific research cruises between February and the first days of March (February-March) of the years 2013-2020, in the central-northern zone of Chile (Paposo, 25°00'S and Puerto Oscuro, 31°40'S), by multidisciplinary surveys

Corresponding editor: Jaime Farber

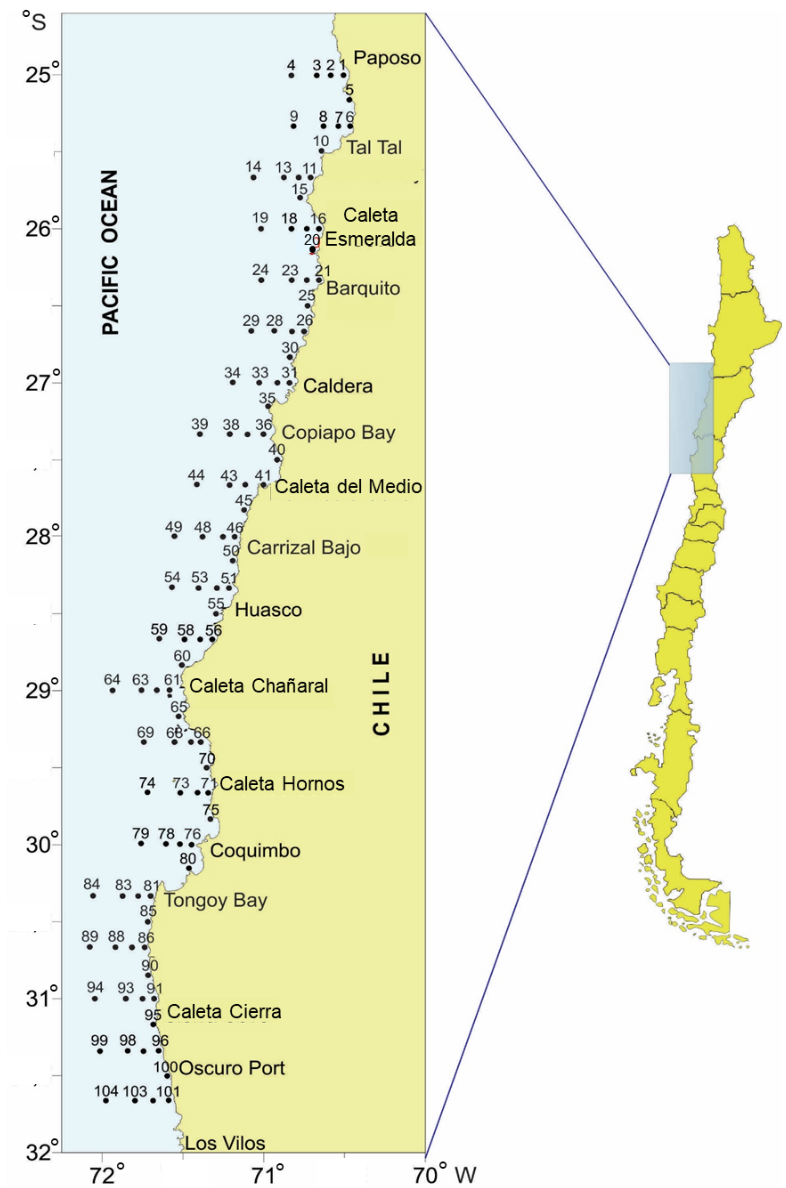

Figure 1. Oceanographic sampling stations in February-March 2013-2020.

carried out by the Instituto de Fomento Pesquero oceanographic platform, R/V Abate Molina. The information analyzed (February-March 2013-2020) considers warm, normal, and cold periods of a wide coastal zone in north-central Chile (Castillo et al. 2013, Leiva et al. 2014, 2015, 2016, 2017, 2018, 2019, 2020). These authors point out that, in February 2014, 2015, and 2020, neutral thermal conditions were recorded in the study area, warm in February 2016 and 2019 (strong and moderate El Niño) and moderately cold in February 2017 and 2018 (weak La Niña). However, the temperature ranges in the sampled area in all periods were relatively similar (12 to 23°C).

Zooplankton samples were taken in 104 oceanographic stations, distributed in 21 transects perpendicular to the coast, at 1, 5, 10, and 20 nm, in addition to one at 1 nm between each transect (Fig. 1). Bongo nets of 59 cm in diameter and 300 µm mesh opening, equipped with flow meters, were used. They were hoisted vertically from 70 m to the surface or 10 m above the bottom when the site depth was less.

Species specimens were separated and counted; their abundance is expressed as the number of specimens in 100 m^3 of filtered water. The numerical dominance was determined from the percentage relation of the number of specimens captured at each coast distance concerning each year sampled. The frequency of occurrence was determined as the percentage of stations with their presence relative to the total stations sampled each year. To compare the abundance, frequency of occurrence, and numerical dominance of each year sampled at different distances from the coast (1, 5, 10, and 20 nm), the stations located 1 nm from the coast sampled between each transect were discarded.

The larvae and juvenile settlement would occur between November and March. The size of the *B. elongatum* juveniles captured on this occasion (8.0-11.8 mm total length, TL) is within the size range (6-20 mm) indicated by Vergara et al. (2012). In addition, the analyzed samplings time coincides with the hypothetical model of the species reproductive cycle proposed by these authors.

Among the main diagnostic characteristics used in cephalochordate identification, the myotomes number and formula, pharyngeal clefts, and oral cirrus are some of them (Del Moral-Flores et al. 2016). However, Poss & Boschung (1996) point out that there is ontogenetic variation in these structures' number and anatomical arrangement in addition to the wide intraspecific variability. The total number of myotomes (average) was 79. Its formula is 44 preatrioporal myotomes (42-47), 24 between the atriopore and anus (22-26), and 11 postanal (10-12), which partially differs from that reported by Rodríguez-Uribe et al. (2019) for the species adults, who indicate that they have 49 preatrioporal, 18 preanal, and 12 postanal myotomes. The number of postanal and total myotomes coincides with those meant for adults. Hubbs (1922) and Nishikawa (1981, 2004) also refer to the myotome number variation in some species, affecting the relative position of the atriopore and the anus. This variability is possibly influenced by temperature in their development.

Concerning the abundance of the different zooplankton groups captured, the abundance of amphioxus juveniles was low. Its distribution was preferably coastal and mainly in the northern part of the study area, although longitudinally up to 20 nm from the coast were captured. South of 30°20'S, no specimens of the species was found (Fig. 2). The abundance and frequency of total occurrence had important interannual variations, registering values between 998 and 223 specimens in 100 m^3 of filtered water and frequency of occurrence of 27.9 to 9.6% (Table 1). The maximum total abundance was registered in February-March 2013, when the frequency of occurrence also had its highest value (Table 1). The minimum abundance was recorded in 2017 and 2018, and the lowest frequency of occurrence was in February-March 2015 (Table 1).

Table 1. Abundance (ind 100 m^{-3}) and frequency of occurrence (%) total annual of *Branchiostoma elongatum* juveniles in February-March of each sampling year (warm and moderately warm years in red, normal in black, and moderately cold in light blue).

Feb-Mar	Abundance	Frequency
2013	998	27.9
2014	748	22.1
2015	423	9.6
2016	660	22.1
2017	223	14.4
2018	223	13.5
2019	404	21.2
2020	388	16.3

The maximum abundances per station (>100 juveniles 100 m^{-3}) were found in two coastal stations (1 nm) in the northern part of the study area (February-March 2013 and 2015) and a station located 10 nm from the coast (February-March 2014) (Fig. 2).

When comparing the abundance of juveniles concerning the distance from the coast (discarding the stations at 1 nm between transects), it was possible to determine their predominance on the coast in February-March 2013, 2015, and 2019, which corresponds to the maximum numerical dominances in stations located at 1 nm (41.0 to 52.9%), while the frequency of occurrence was greater than 5 nm from the coast in February-March 2015 (Table 2).

In the remaining sampling years (February-March 2014, 2016-2018, and 2020), the highest abundances were found in stations 10 nm from the coast, with numerical dominances between 34.5 and 37.0% (Table 2). Among these sampled periods, the frequency of occurrence was higher in stations located 10 nm from the coast, except for 2014, when the highest values were detected in stations located 1 and 20 nm from the coast, and in February 2018 to 20 nm (Table 2). In February-March 2017 and 2018, when the lowest total abundances were detected (Table 1), the distribution and abundance of the juveniles were relatively homogeneous at different distances from the coast (Table 2, Fig. 2).

The period considered in this analysis includes years with positive, neutral, and negative thermal anomalies (NOAA 2021). In February-March of the years sampled, the sea surface thermal conditions in the

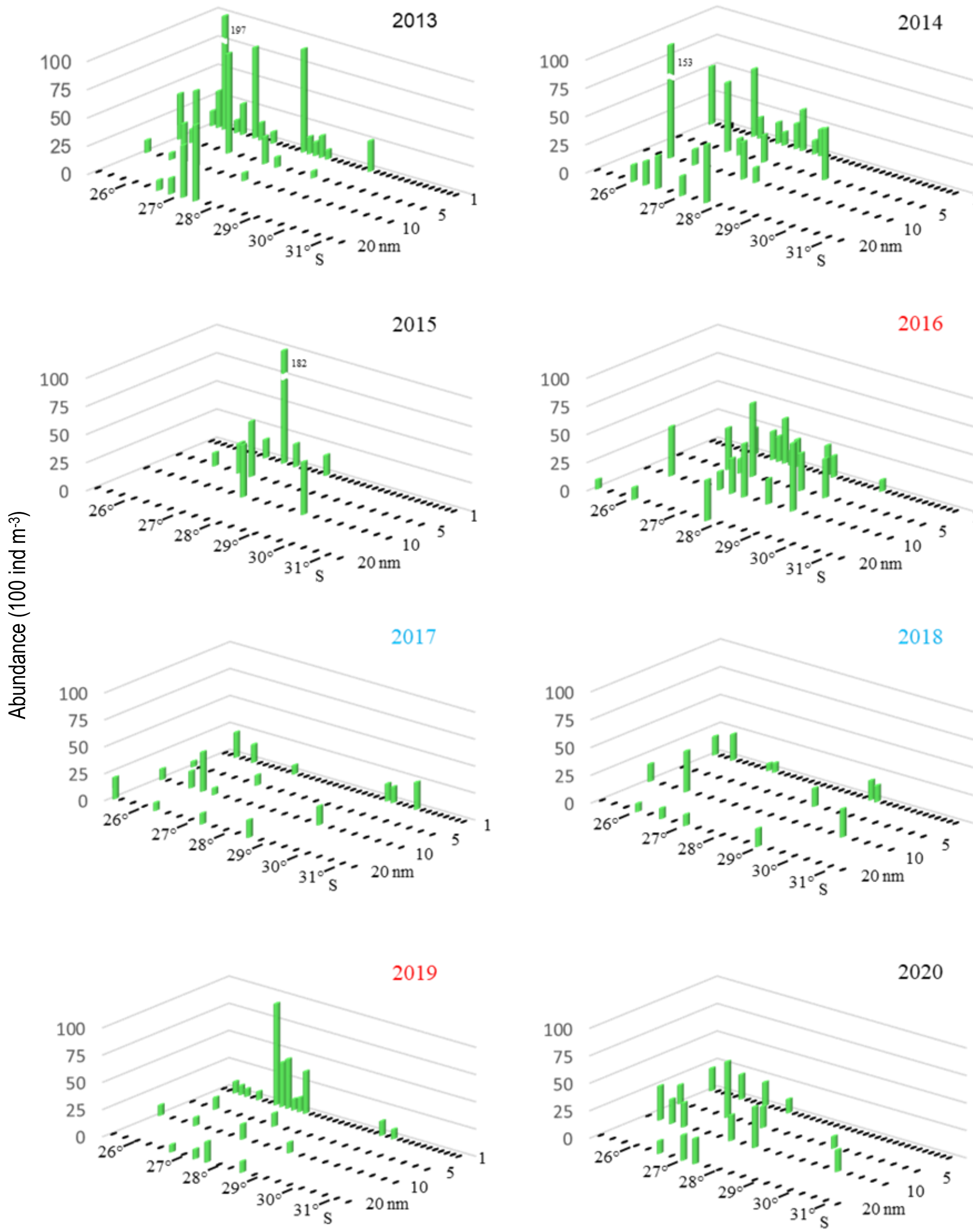

Figure 2. Distribution and abundance of *Branchiostoma elongatum* juveniles in February-March 2013-2020 (warm and moderately warm years in red, normal in black, and moderately cold in light blue).

area and time of the study, 2013-2015, and 2020, were neutral; warm in 2016 and 2019 and slightly cold in 2017 and 2018. In this regard, it can be noted that the highest concentrations of juveniles of the species were found in times when the surface thermal conditions of the sampling area were normal (February-March 2013-2015), while the lowest abundances were recorded in slightly cold and cold periods (February-March 2017 and 2018). It was also possible to establish that the highest frequencies of occurrence of juveniles (>20%) occurred in neutral and warm thermal periods (Table 1).

Table 2. Abundance (ind 100 m^{-3}), frequency of occurrence (%), and numerical dominance (%) of *Branchiostoma elongatum* juveniles at different distances from the coast in nautical miles (nm) in February-March of each sampling year (warm and moderately warm years in red, normal in black and moderately cold in light blue).

Feb-Mar		Distance from the coast in nautical miles (nm)			
		1	5	10	20
2013	Abundance	307	179	126	136
	Frequency	38.1	28.6	23.8	19
	Dominance	41	23.9	16.8	18.2
2014	Abundance	126	145	213	134
	Frequency	23.8	19	19	23.8
	Dominance	20.4	23.4	34.5	21.7
2015	Abundance	202	87	93	0
	Frequency	9.5	14.3	9.5	0
	Dominance	52.9	22.8	24.4	0
2016	Abundance	117	182	221	55
	Frequency	23.8	23.8	28.6	14.3
	Dominance	20.4	31.6	38.4	9.6
2017	Abundance	56	9	76	34
	Frequency	14.3	4.8	19	14.3
	Dominance	32.1	5.4	43.3	19.3
2018	Abundancia	42	16	77	43
	Frequency	14.3	4.8	14.3	19
	Dominance	23.6	9.1	43.2	24
2019	Abundance	114	23	41	45
	Frequency	28.6	9.5	19	19
	Dominance	51.2	10.4	18.4	20
2020	Abundance	20	98	156	58
	Frequency	4.8	19	28.6	14.3
	Dominance	6.1	29.5	47	17.4

ACKNOWLEDGMENTS

This study was funded by the project "Hydroacoustic evaluation of anchovy recruitment between the III and IV Regions," awarded by the Fondo de Investigación Pesquera y de Acuicultura (FIPA). The authors also thank the support the Instituto de Fomento Pesquero (IFOP) provided that, in partnership with Universidad Católica del Norte, obtained the information used as a starting point for the present study. Special thanks go to the IFOP research vessel R/V Abate Molina crew and the personnel who aided in sample collection. Finally, thanks go to José Iván Sepúlveda for the translation and critical review of the manuscript.

REFERENCES

Castillo, J., Saavedra, A., Leiva, F., Reyes, H., Pizarro, M., Cascales, E., et al. 2013. Evaluación hidroacústica del reclutamiento de anchoveta entre la III y IV Regiones, año 2013. Informe final. Instituto de Fomento Pesquero, Valparaíso.

Del Moral-Flores, L., Guadarrama-Martínez, M. & Flores-Coto, C. 2016. Composición taxonómica y distribución de los cefalocordados (Cephalochordata: Amphioxiformes) en México. Latin American Journal of Aquatic Reserch, 44: 497-503.

Galván-Villa, C., Ríos-Jara, E. & Ayón-Parente, M. 2017. New records of the Californian lancelet *Branchiostoma californiense* (Cephalochordata: Branchiostomidae) from the Pacific coast of Mexico. Revista Mexicana de Biodiversidad, 88: 995-998.

Hubbs, C.L. 1922. A list of the lancelets of the world with diagnoses of five new species of *Branchiostoma*. Occasional Papers of the Museum of Zoology, 105: 1-16.

Laudien, J., Rojo, M.E., Oliva, M.E., Arntz, W.E. & Thatje, S. 2007. Sublittoral soft-bottom communities and diversity of Mejillones Bay in northern Chile (Humboldt Current upwelling system). Helgoland Marine Research, 61: 103-116.

Leiva, F., Legua, J., Cifuentes, U., Giglio, S., Reyes, H., Pizarro, M., et al. 2014. Evaluación hidroacústica del reclutamiento anchoveta en la III y IV Regiones, año 2014. Informe final. Instituto de Fomento Pesquero, Valparaíso.

Leiva, F., Legua, J., Cifuentes, U., Grendi, C., Pizarro, M., Vargas, R., et al. 2015. Evaluación hidroacústica del reclutamiento de anchoveta en la III y IV Regiones, año 2015. Informe final. Instituto de Fomento Pesquero, Valparaíso.

Leiva, F., Legua, J., Pizarro, M., Bustamante, A., Cifuentes, U., Grendi, C., et al. 2016. Evaluación hidroacústica del reclutamiento de anchoveta entre la III y IV Regiones, año 2016. Informe final. Instituto de Fomento Pesquero, Valparaíso.

Leiva, F., Legua, J., Pizarro, M., Bustamante, A., Cifuentes, U., Gutiérrez, J., et al. 2019. Evaluación hidroacústica del stock de anchoveta entre la III y IV Regiones, año 2019. Informe final. Instituto de Fomento Pesquero, Valparaíso.

Leiva, F., Legua, J., Velasco, E., Varas, A., Grendi, C., Cifuentes, U., et al. 2017. Evaluación hidroacústica del reclutamiento de anchoveta entre la III y IV Regiones, año 2017. Informe final. Instituto de Fomento Pesquero, Valparaíso.

Leiva, F., Pizarro, M., Bustamante, A., Cifuentes, U., Gutiérrez, J., Sánchez, F., et al. 2020. Evaluación hidroacústica del stock de anchoveta entre las Regiones de Atacama y Coquimbo, año 2020. Informe final. Instituto de Fomento Pesquero, Valparaíso.

Leiva, F., Villegas, V., Alarcón, D., Bustamante, A., Cifuentes, U., Grendi, C., et al. 2018. Evaluación hidroacústica del reclutamiento de anchoveta entre la III y IV Regiones, año 2018. Informe final. Instituto de Fomento Pesquero, Valparaíso.

Moreno, R.A., Sepúlveda, R.D., Badano, E.I., Thatje, S., Rozbaczylo, N. & Carrasco, F.D. 2008. Subtidal macrozoobenthos communities from northern Chile during and post El Niño 1997-1998. Helgoland Marine Research, 62: 45-55.

Received: December 15, 2021; Accepted: June 30, 2022

Nishikawa, T. 1981. Considerations on the taxonomic status of the lancelets of the genus *Branchiostoma* from the Japanese waters. Publications of the Seto Marine Biological Laboratory, 26: 135-156.

Nishikawa, T. 2004. A new deep-water lancelet (Cephalochordata) from off Cape Nomamisaki, SW Japan, with a proposal of the revised system recovering the genus *Asymmetron*. Zoological Science, 21: 1131-1136.

National Oceanic and Atmospheric Administration (NOAA). 2021. Multivariate ENSO Index Version 2 (MEI.v2). [https://www.psl.noaa.gov/enso/mei/]. Reviewed: November 30, 2021.

Pacheco, A., Laudien, J., Thiel, M., Oliva, M. & Arntz, W. 2010. Succession and seasonal variation in the development of subtidal macrobenthic soft-bottom communities off northern Chile. Journal of Sea Research, 64: 180-189.

Porter, C. 1909. Protovertebrado nuevo para la fauna chilena. Revista Chilena de Historia Natural, 13: 123.

Poss, S.G. & Boschung, H.T. 1996. Lancelets (Cephalochordata: Branchiostomatidae): how many species are valid? Israel Journal of Zoology, 42: 13-66.

Rodríguez-Uribe, M., Chávez-Dagostino, R., Del Moral-Flores, L. & Bravo-Olivas, M. 2019. First record of amphioxus *Branchiostoma californiense* (Amphioxiformes: Branchiostomatidae) adjacent to a shallow submarine hydrothermal system at Banderas Bay (Mexico). Diversity, 11: 227.

Thiel, M., Macaya, E.C., Acuña, E., Arntz, W.E., Bastías, H., Brokordt, K., et al. 2007. The Humboldt Current System of northern and central Chile: oceanographic processes, ecological interactions, and socioeconomic feedback. Oceanography and Marine Biology: An Annual Review, 45: 195-344.

Vergara, M., Oliva, M. & Riascos, J. 2012 Population dynamics of the amphioxus *Branchiostoma elongatum* from northern Chile. Journal of the Marine Biological Association of the United Kingdom, 92: 591-599.