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Citizen science recording the shifting distribution of subtropical species in the Southwestern Atlantic: the southernmost records of *Orthopristis ruber* (Haemulidae, Lutjaniformes)

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Abstract. In recent times, citizen science has proved to be a major contribution in the study of rare fish species and marine diversity. Since 1997, there has been an increase in the amount of sea surface temperature anomalies (SSTA) in the Uruguayan coast, and in the last 10 years these have been more intense, with longer duration and higher values. Here we report the first records of the Corocoro grunt *Orthopristis ruber* in the Uruguayan coast (34˚54´S), extending its range *circa* 700 km south of the previously reported southern limit in Brazil (18˚S to 31˚S). Eight records, coming from recreational and artisanal catches obtained in 2018-2020, were compiled using social networks. Two fishes were collected and preserved as voucher specimens. Several features of the records suggest that these are not occasional and that the distributional range of this species is truly expanding to higher latitudes, namely: 1) the occurrence of juveniles and adults in Uruguayan waters; 2) the number of records compiled; 3) the consecutive years of the records; 4) the testimony of several Uruguayan anglers indicating that they had already fished this species in previous years; and 5) a global scenario of ocean warming with positive sea surface temperature anomalies.

Key words: monitoring; recreational fishing; ocean warming; Corocoro grunt; Uruguay.

Resumen: Registro de cambios en la distribución de especies subtropicales en el Atlántico Sudoccidental mediante ciencia ciudadana: el registro más austral de *Orthopristis ruber* (Haemulidae, Lutjaniformes). Recientemente la ciencia ciudadana ha demostrado una contribución muy importante al estudio de las especies raras de peces y de la diversidad marina. Desde 1997, ha habido un aumento en la cantidad de anomalías positivas de la temperatura superficial del mar (TSM) en la costa uruguaya, y en los últimos 10 años éstas han sido más intensas, con mayor duración y valores más altos. Aquí reportamos los primeros registros del Corocoro *Orthopristis ruber* en Uruguay (34˚54'S), extendiendo su distribución 700 km al sur del rango previamente reportado en Brasil (18˚S a 31˚S). Se recopilaron ocho registros, procedentes de capturas recreativas y artesanales entre 2018-2020, utilizando las redes sociales. Se recolectaron dos ejemplares que se conservaron como especímenes vouchers. Varias

características de los registros sugieren que éstos no son ocasionales y que el rango de distribución de esta especie se está expandiendo a latitudes más altas: 1) la ocurrencia de juveniles y adultos en aguas uruguayas; 2) el número de registros recopilados; 3) los años consecutivos de los registros; 4) el testimonio de varios pescadores uruguayos indicando que ya habían pescado esta especie en años anteriores; y 5) un escenario global de calentamiento del océano con anomalías positivas de la TSM.

Palabras clave: monitoreo; pesca recreativa; calentamiento del océano, Corocoro; Uruguay.

Introduction

The marine bony fish diversity of Uruguay lacks recent in-depth revisions, and the greatest research efforts date back to the past century (see e. g. Devincenzi 1926, Menni *et al.* 1984). A recent effort (Nion *et al.* 2016) to compile the recorded species for Uruguayan waters fails to relate the species to past literature or unpublished records, indicating a great challenge to be developed in this regard. Furthermore, the history and development of ichthyological collections has been difficult in the country, hindering ichthyological research (Loureiro *et al.* 2016). Therefore, new efforts are being carried out through interinstitutional and transdisciplinary approaches, especially considering the biogeographical context of the Uruguayan waters (Laporta *et al.* 2018). In this context, citizen science constitutes a powerful and cost-effective method for the detection and monitoring of rare native and non-native fish species (Tiralongo *et al.* 2020). In fact, data collected from these activities by the participants were often easily verifiable and can be considered as equally reliable to those collected by scientists, as already highlighted in appropriate literature (Lewandowski & Specht 2015).

Climate change may affect the life cycle seasonality, and distribution of marine species (Poloczanska *et al.* 2013, 2016). Isotherms at the ocean surface have migrated at comparable or faster rates than isotherms over land during the past 50 years (1960-2009) (Burrows *et al.* 2011). Thus, a higher rate of ocean warming could affect the distribution, abundance, and life history traits of fishes (Pauly & Cheung 2018).

During the past three decades, there has been a systematic increase in sea surface temperature (SST) over the Southwestern Atlantic Ocean (Ortega *et al.* 2012). At the same time, since 1997 there has been an increase in the amount of positive sea surface temperature anomalies (SSTA) in the Uruguayan coast, and in the last 10 years these have been more intense, with longer duration and higher values (Ortega *et al.*, 2016; Martínez *et al.*, 2017, Manta *et al.* 2018, Gianelli *et al.* 2019, Franco *et al.* 2020). These facts have implied the occurrence of marine species of different taxa with tropical and subtropical distribution, associated to an extended presence of warm subtropical water derived from the Brazilian Current along the Uruguayan continental shelf (Leoni *et al.* 2016, Martínez *et al.* 2017, De Wysiecki *et al.* 2018, Pereyra *et al.* 2019).

The Corocoro grunt *Orthopristis ruber* (Cuvier, 1830) (Haemulidae, Lutjaniformes) is one of the seven valid species of the genus as reviewed and redefined based on the analysis of color patterns and meristic data, as well as DNA barcoding by Marceniuk *et al*. (2019). These authors restricted its distribution to Brazil, from Espírito Santo (18˚S) state to Rio Grande do Sul (31˚S) and indicated that this species is abundant in estuarine and coastal waters over several bottom types, up to 70 m depth.

The present study reports the first records of *Orthopristis ruber* in Uruguayan waters by using citizen science and it extends its previously known distribution range.

Materials and methods

Study area: This study is focused on the Uruguayan Atlantic coast in the Southwestern Atlantic Ocean (SWAO) shelf (Fig. 1). The SWAO shelf extends from Cabo Frio (~22° S, Brazil) to the tip of Tierra del Fuego (55° S, Argentina) (Franco *et al.* 2020). The continental shelf in the study region is oceanographically complex, characterized by seasonal variations modulated by the confluence of two water masses with different thermohaline characteristics (Piola *et al.* 2018). This confluence is marked by a complex array of strongly contrasting water types (Gordon 1989). Subtropical warm waters are carried southward by the Brazil Current along the shelf, while Subantarctic cold waters are transported northwards by the Malvinas Current (Scarabino *et al.* 2016, Franco *et al.* 2018).

Records of the Corocoro grunt along the Uruguayan coast were obtained from the marine recreational fisheries pilot monitoring program carried out by the National Directory of Aquatic Resources (ICES 2020). This started in 2015 with

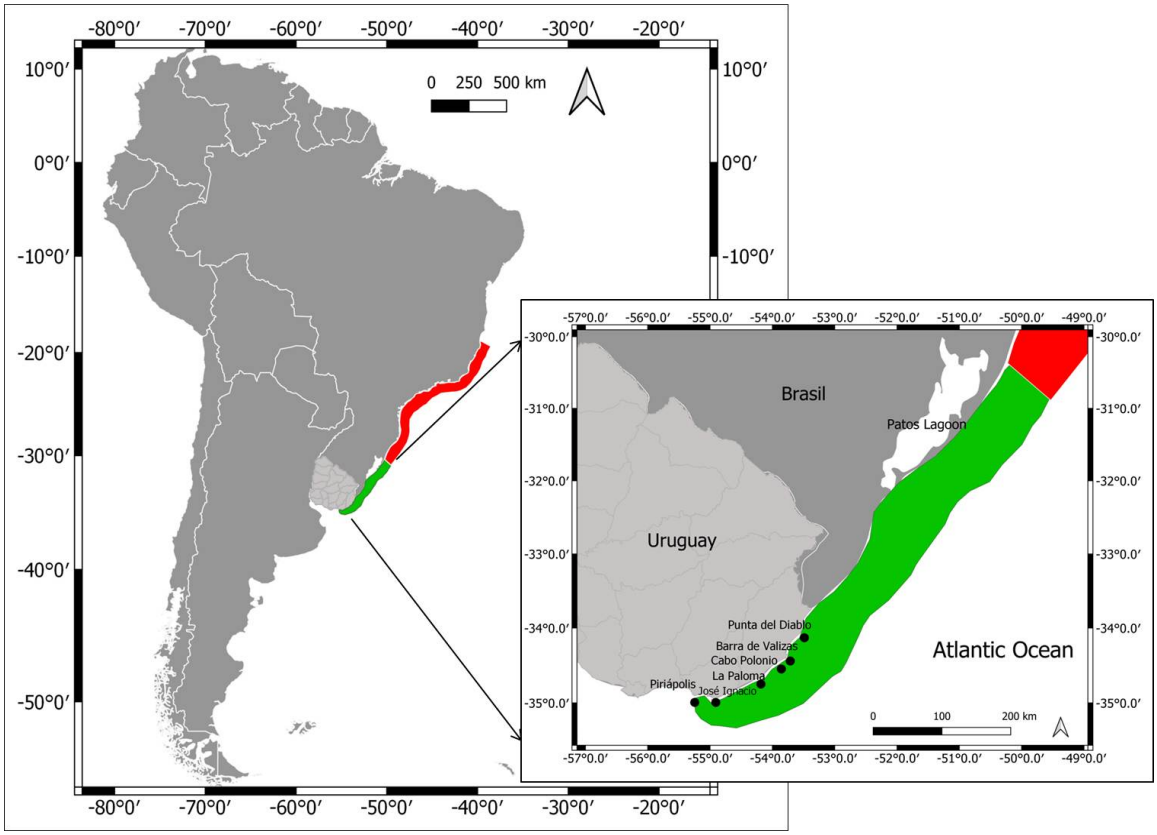

Figure 1. Previously known geographic marine range of *Orthopristis ruber* (red area: 18˚S - 31˚S) in Marceniuk *et al.* (2019) and the extended range (green area) with the locations on the Uruguayan coast where the records were reported in the Southwestern Atlantic Ocean.

the main goal of collecting data on the catches and providing a baseline for the management and regulation of these fisheries. It is a participatory program, where fishers and spearfishers contribute information about their catches voluntarily. Data sources came from catches, biological samplings, personal contacts between scientists and fishers, and from publications in social media made by the fishers. Data collected were date, fishing zone and modality, fisher´s name, specimen photographs, total length, and weight (when it was possible). The specimens were identified using the key proposed by Marceniuk *et al.* (2019). Whenever possible, the captured fishes were secured and used to confirm the identity, and later preserved and deposited as voucher specimens in the Ichthyological collection of the Museo Nacional de Historia Natural, Montevideo (MNHN).

Results and discussion

Eight records of *O. ruber* were obtained from March 2018 to October 2020 along the Uruguayan coast. All of them come from six coastal localities with rocky outcrops and sandy beaches (Table I; Fig. 1). Six of these records were caught by recreational anglers, other by a recreational spearfisher, mentioning that at the time of their capture there were two fishes inside a cave, and he could only shoot one of them, and that they emitted a sound similar to the snoring of the white-mouth croaker *Micropogonias furnieri*. The remaining record was obtained from an artisanal fishery boat (Table I).

In two of these records, it was possible to collect and preserve the specimens in the MNHN ichthyological collection (MHNM 4199; MHNM 4200). For these two specimens, most meristic characters and other diagnostic features agreed with those indicated by Marceniuk *et al*. (2019) (Table II).

The two specimens collected, as well as other five for which only photographs are available, also matched the coloration pattern described by Marceniuk *et al.* (2019) for living specimens, i.e., body with very conspicuous vertical bars, large and conspicuous black humeral spot above pectoral fin base, and small black spot on rear border of operculum (Fig. 2). Additionally, once fixed the collected specimens coincided with the preserved coloration pattern described by these authors, i.e., light brown, lighter ventrally, with dark spot on rear

Table I. Records of Corocoro *Orthopristis ruber* obtained along the Uruguayan coast: TL= total length; [†]= estimated by size reference in picture; Fig.2= letter of photo in Figure 2. Localities: BV: Barra de Valizas; LP: La Paloma; PD: Punta del Diablo; CP: Cabo Polonio; Ps: Piriápolis; JI: José Ignacio.

Date	Locality	Coordinates	Media	Gear	Other data	Fig. 2
27-03-2018	BV	34˚20´S - 53˚46´W	WhatsApp Inc®	Boat angling	TL 21 cm[†]	A
30-04-2018	LP	34˚40´S - 54˚09´W	WhatsApp Inc®	Coastal angling	TL 29 cm[†]	B
24-02-2019	PD	34˚02´S - 53˚32´W	WhatsApp Inc®	Coastal angling	TL 13 cm[†]	C
12-05-2019	CP	34˚24´S - 53˚47´W	WhatsApp Inc®	Coastal angling	TL 18 cm[†]	
19-052019	CP	34˚24´S - 53˚47´W	Sampling	Coastal angling	**MHNM-4199** (TL: 18 cm; W: 95 g)	D - F
18-01-2020	Ps	34˚54´S - 55˚15´W	Facebook™	Artisanal gillnet	TL 28 cm[†] (Southermost record)	**G**
25-04-2020	BV	34˚20´S - 53˚46´W	Sampling	Coastal angling	**MHNM-4200** (TL: 13 cm; W: 32 g)	E
10-10-2020	JI	34˚50´S - 54˚37´W	WhatsApp Inc®	Spearfishing	TL 28 cm[†]	H

Table II. Meristic characteristics of the collected *Orthopristis ruber* specimens compared with those indicated by Marceniuk *et al.* (2019) for the diagnosis of the species.

Diagnostic character	Specimen		Diagnosis by Marceniuk *et al.* (2019)
	MHNM-4199	MHNM-4200	
Dorsal-fin rays	XII / 15	XII / 15	XII / 14–15
Anal-fin rays	III / 10	III / 10	III /10
Pectoral-fin rays	17	17	17 - 18
Pelvic-fin rays	I / 5	I / 5	I / 5
Principal caudal-fin rays	9 + 8 = 16	9 + 8 = 17	9 + 8 = 17
Lateral-line scales	57	55	52 - 57
Scales above lateral line to base of first dorsal-fin spine	10	10	10 - 13
Scales below lateral line to first anal-fin spine	15	16	15 - 17
Opercle lacking exposed spine, covered with 6–7 vertical rows of ctenoid scales	6	6	6 - 7

border of scales, forming irregularly oblique dark brown lines on the flanks; dark brown spots on operculum and below eyes; small, marked black spot on rear border of operculum and a conspicuous black humeral spot above pectoral-fin base; trunk with six dark faded irregular vertical bars, their width nearly equal to eye length; dorsal and anal fins hyaline, with dark brown line along the base of the hyaline pectoral and pelvic fins, and caudal fin dusky, darker in middle rays (Fig. 2. F).

A specimen recorded on May 12, 2019 had its guts and head removed by the fisher who caught it before the photograph was taken. However, the specimen was identified as *O. ruber* through the analysis of the photo, since the color patterns described previously were the same in this specimen. In addition, the same fisher reported a subsequent record a week later (MHNM 4199); his testimony explaining that it was the same fish helped to validate the identification of the previous individual.

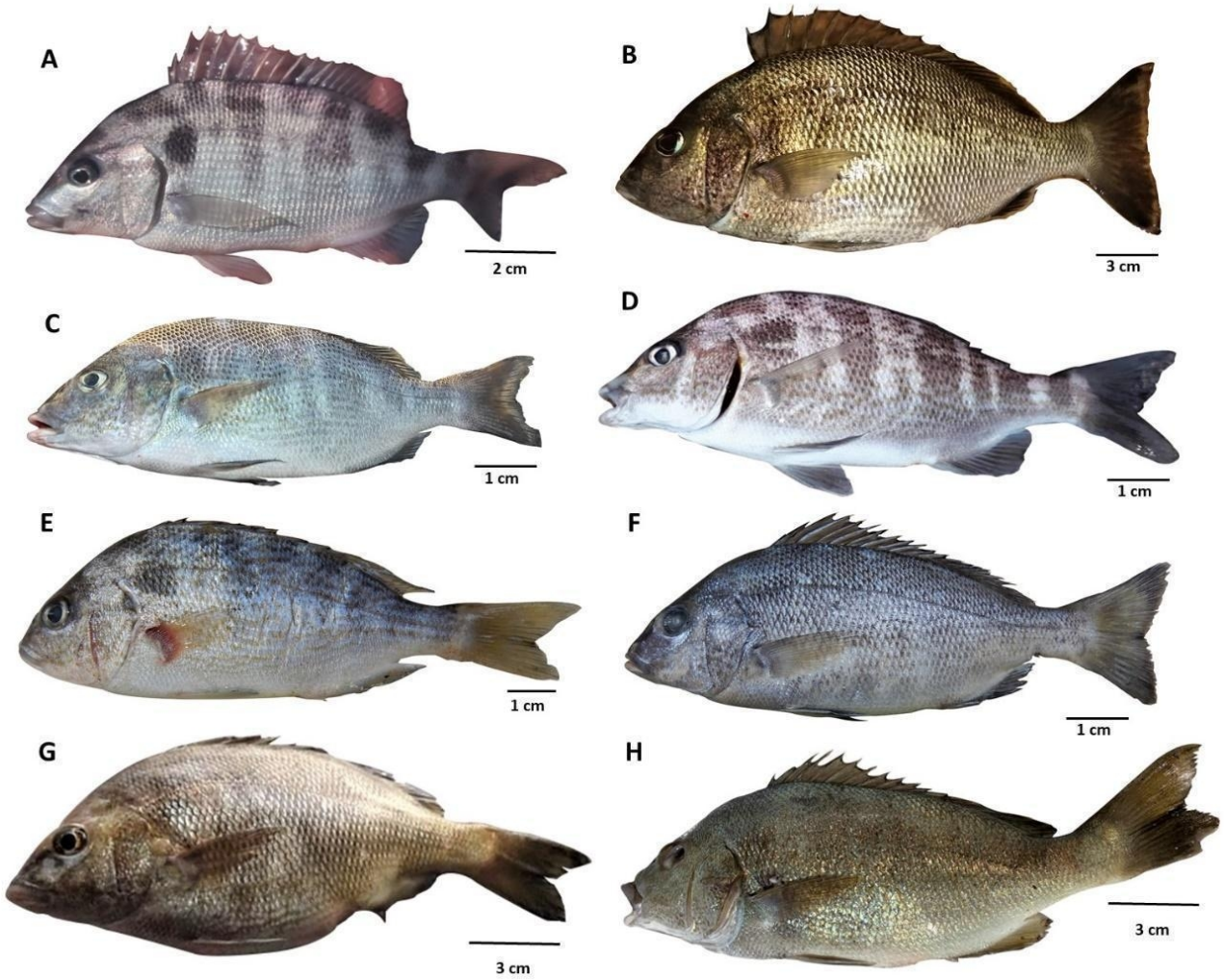

Figure 2. Photographies of recently obtained specimens of *Orthopristis ruber* registered along six coastal localities in Uruguay. **A-B-C.** Registered by anglers. **D-E.** Registered by anglers, sampled, collected and preserved (**D**= MHNM-4199 – **E**= MHNM-4200). **F.** Fixed specimen D= MHNM-4199, after being preserved in formalin 10%. **G.** Registered by artisanal fisher, southernmost record. **H.** Registered by spearfisher.

The three largest *Orthopristis ruber* specimens, with about 28 and 29 cm total length (Figure 2. B-G-H), are considered adults according to the size at first maturity (Lm50) estimated by Vianna and Veranni (2002). In the photographs of these specimens, it is not possible to observe the very conspicuous vertical bars neither the large and the conspicuous black humeral spot above pectoral fin base; Marceniuk et al. (2019) indicated that "Dark bars fade soon after death", however two other specific diagnostic features can be observed: the diffuse small black spot on the rear border of the operculum and the punctuations or small rounded brown-orange spots in the upper half of the body.

All the records of *O. ruber* in Uruguayan coastal waters here reported were obtained in months and years with positive sea surface temperature anomalies (SSTA) registered for the Southwestern Atlantic region (NOAA 2020a,b,c,d,e,f). This implies an extended presence of the warm subtropical waters in the Uruguayan Atlantic coast and could explain the occurrence of this tropical and subtropical species in these temperate latitudes.

The previously southernmost published record for *O. ruber* has been recently indicated by Marceniuk *et al.* (2019) based on specimens collected in the Brazilian coast of Rio Grande do Sul

(MZUSP 68079, 4: 133–174 mm SL, 30°63'S, 49°81'W). However, this species was also cited for the Patos Lagoon, RS, Brazil by Vieira *et al.* (2018) and Possamai *et al.* (2018) in their species list, but without further data. Possamai (pers. comm.[1]) indicated that their record is based on fishes caught by beach seine in May 2000 (n=4) and in July 2006 (n=1), both at the same site (Praia dos Franceses: 32°03'38.9 "S and 52°05'16.3 "W), during a long-term monitoring programme (https://peld.furg.br/).

Our results expand southward the marine range distribution of *Orthopristis ruber* reported in Marceniuk *et al.* (2019) from 30°63'S to 34˚54´S (~700 km). Several features of the records and their context suggest that the Uruguayan records are not occasional and that the marine distributional range of this species is truly expanding to higher latitudes, namely: 1) the simultaneous occurrence of juveniles (two specimens) and adults (six specimens) in Uruguayan waters; 2) the amount of records compiled in this study (eight specimens); 3) the consecutive years of these records (2018 to 2020); 4) the testimony of several Uruguayan anglers indicating that they had already fished the species in previous years; 5) the extension of its distribution along the Uruguayan coast (150 km); 6) the proximity to Patos Lagoon records published by Vieira *et al.* (2018) and Possamai *et al.* (2018) to the northeastern-most site where it was recorded in Uruguay (~250 km); 7) the time elapsed between the recording of Patos Lagoon in 2006 and the recent recording in Uruguay in 2020 (fourteen years); 8) a global scenario of ocean warming with high intensity of positive sea surface temperature anomalies in the last 10 years (Ortega *et al.* 2016; Martínez *et al.* 2017).

The joint work carried out between fishers and researchers reveals the importance of the contribution of citizen science in providing knowledge about the distribution of rare fish species and marine diversity in general (Irigoyen *et al.* 2005, Lehtiniemi *et al.* 2020, Pita *et al.* 2018, 2020, Tiralongo *et al.* 2020). Together, social networks and mobile applications are proving to be fundamental tools for reporting and estimating catches from recreational fisheries, which would otherwise be almost inaccessible (Venturelli *et al.* 2016). In countries such as Uruguay, where governmental resources are often scarce for developing marine research applied to strengthening fisheries management, this type of approach, together with participatory monitoring programs, become even more relevant and help building baseline knowledge towards improving its regulations.

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Conclusions

The records here reported are the first for Uruguayan waters and expand the marine range distribution of *Orthopristis ruber* from that previously reported in Brazil to nearby 700 km to the South in Uruguay.

Some particularities of our results suggest that the Uruguayan records are not occasional and that the marine distributional range of this species is truly expanding to higher latitudes, mainly due a global scenario of ocean warming with high intensity of positive sea surface temperature anomalies in the last 10 years in the SWAO shelf. The involvement of citizen science was essential in compiling all records of *Orthopristis ruber* presented in this study.

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References

Burrows, M. T., Schoeman, D. S., Buckley, L. B., Moore, P., Poloczanska, E. S., Brander, K. M., Brown, C., Bruno, J. F., Duarte, C. M., Halpern, B. S., Holding, J., Kappel, C. V., Kiessling, W., O'Connor, M. I., Pandolfi, J. M., Parmesan, C., Schwing, F. B., Sydeman, W. J., Richardson, A. J. 2011. The pace of shifting climate in marine and terrestrial ecosystems. **Science**, 334: 652-655. https://doi: 10.1126/science.1210288.

Devincenzi, G.J. 1926. Peces del Uruguay. **Anales del Museo de Historia Natural de Montevideo**, Serie 2, T. I., pp 97-293 & T. II, pp. 201-211.

https://www.mnhn.gub.uy/innovaportal/file/81454/1/anales-1926-1928-serie-2-numero-2---devincenzi---peces-del-uruguay-notas-complementarias.pdf

De Wysiecki, A. M., Bruno, I., Carvalho-Filho, A. & Milessi, A. C. 2018. First documented records of tropical morays (Muraenidae) in Argentina and Uruguay. **Pan-American Journal of Aquatic Sciences**, 13(3): 254-259. https://panamjas.org/pdf_artigos/PANAMJAS_13(3)_254-259.pdf

Franco, B. C., Palma, E. D., Combes, V., Acha, E. M., Saraceno, M. 2018. Modeling the offshore export of Subantarctic Shelf Waters from the Patagonian shelf. **Journal of Geophysical Research**: Oceans, 123: 4491–4502. https://doi.org/10.1029/2018JC013824

Franco, B. C., Defeo, O., Piola, A. R., Barreiro, M., Yang, H., Ortega, L., Gianelli, I., Castello, J. P., Vera, C., Buratti, C., Pájaro, M., Pezzi, L. P. & Möller, O. 2020. Climate change impacts on the atmospheric circulation, ocean, and fisheries in the southwest South Atlantic Ocean: a review. **Climatic Change**, 1-19. https:/doi: 10.1007/s10584-020-02783-6

Gianelli, I., Ortega, L., Marín, Y., Piola, A. R. & Defeo, O. 2019. Evidence of ocean warming in Uruguay's fisheries landings: the mean temperature of the catch approach. **Marine Ecology Progress Series**, 625: 115–125. https://doi.org/10.3354/meps13035

Gordon, A. L. 1989. Brazil-Malvinas Confluence-1984. **Deep-Sea Research**, 36: 359-384. https://doi.org/10.1016/0198-0149(89)90042-3

ICES. 2020. Working Group on Recreational Fisheries Surveys (WGRFS; outputs from 2019 meeting). **ICES Scientific Reports**. 2:1. 78 pp. https://doi.org/10.17895/ices.pub.5744

Irigoyen, A. J., Galván, D. E., & Venerus, L. A. 2005. Occurrence of dusky grouper *Epinephelus marginatus* (Lowe, 1834) in gulfs of northern Patagonia, Argentina. **Journal of Fish Biology**, 67: 1741-1745. https://doi.org/10.1111/j.1095-8649.2005.00866.x

Laporta, M., Fabiano, G., Silveira, S., Pereyra, M. I, Scarabino, F. & Santana, O. 2018. Peces e invertebrados capturados en las pesquerías artesanales oceánicas de enmalle y palangre de fondo de Uruguay. **Revista del Frente Marítimo**, Vol. 25: 325-348. http://ctmfm.org/upload/archivoRevista/ctmfm_vol25-153668188585.pdf

Lehtiniemi, M., Outinen, O. & Puntila-Dodd, R. 2020. Citizen science provides added value in the monitoring for coastal non-indigenous species. **Journal of Environmental Management**, Vol. 267: 110608. https://doi.org/10.1016/j.jenvman.2020.110608

Leoni, V., González, S., Ortega, L., Scarabino, F., Failla-Siquier, G., Dutra, A., Rubio, L., Abreu, M., Serra, W., Alonzo Campi, A. G., Stampar, S. N. & Morandini, A. C. 2016. *Tamoya haplonema* (Cnidaria: Cubozoa) from Uruguayan and adjacent waters: oceanographic context of new and historical findings. **Marine Biodiversity Records**, 9: 92. https://doi.org/10.1186/s41200-016-0093-7

Lewandowski, E., & Specht, H. 2015. Influence of volunteer and project characteristics on data quality of biological surveys: data quality of volunteer surveys. **Conservation Biology**, 29: 713–723. https://doi.org/10.1111/cobi.12481

Loureiro, M., Serra, W. S. & Scarabino, F. 2016. Colecciones Ictiológicas del Uruguay: Pasado y Presente. In: Del Moral, L. F., Ramírez, A. J., Martínez, J. A., González A. P. & Franco, J. (Eds.) **Colecciones ictiológicas de Latinoamérica**. Tlalnepantla, Edo. de México: Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, 586 pp. https://www.researchgate.net/profile/Luis_Fernando_Flores/publication/328518387_Colecciones_ictiologicas_de_Latinoamerica/links/5bd25d5e92851c6b278f2d9e/Colecciones-ictiologicas-de-Latinoamerica.pdf

Manta, G., de Mello, S., Trinchin, R., Badagian, J., & Barreiro, M. 2018. The 2017 record marine heatwave in the Southwestern Atlantic shelf. **Geophysical Research Letters,** 45: 12.449–12.456. https://doi.org/10.1029/2018GL081070

Marceniuk, A. P., Caires, R. A., Machado, L., Dantas Cerqueira, N. N. C., M. de S. Serra, R. R. & Oliveira, R. 2019. Redescription of *Orthopristis ruber* and *Orthopristis scapularis* (Haemulidae: Perciformes), with a hybridization zone off the Atlantic coast of South America. **Zootaxa**, 4576 (1): 109–126. https://doi.org/10.11646/zootaxa.4576.1.5

Martínez, A., Méndez, S., Fabre, A. & Ortega, L. 2017. Intensificación de floraciones de dinoflagelados marinos en Uruguay. **INNOTEC**, 13: 19 – 25. https://doi.org/10.26461/13.02

Menni, R. C., Ringuelet, R. A. & Aramburu, R. H. 1984. **Peces marinos de la Argentina y Uruguay. Reseña histórica, Clave de familias, géneros y especies. Catálogo crítico**. Ed. Hemisferio Sur, Buenos Aires, 359 pp. https://core.ac.uk/download/pdf/301080665.pdf

Nion, H., Ríos, C. & Meneses, P. 2016. **Peces del Uruguay. Segunda Edición corregida y ampliada**. DINARA, Uruguay. 174 pp. https://asociacionoceanograficauruguaya.files.wordpress.com/2018/08/peces-de-uruguay-21.pdf

NOAA. 2020a. **National Centers for Environmental Information**, State of the Climate: Global Climate Report for March 2018 (06/21/2020). Retrieved from https://www.ncdc.noaa.gov/sotc/global/201803.

NOAA. 2020b. **National Centers for Environmental Information**, State of the Climate: Global Climate Report for April 2018 (06/21/2020). Retrieved from https://www.ncdc.noaa.gov/sotc/global/201804.

NOAA. 2020c. **National Centers for Environmental Information**, State of the Climate: Global Climate Report for February 2019 (06/21/2020). Retrieved from https://www.ncdc.noaa.gov/sotc/global/201902.

NOAA. 2020d. **National Centers for Environmental Information**, State of the Climate: Global Climate Report for May (06/21/2020). Retrieved from https://www.ncdc.noaa.gov/sotc/global/201905.

NOAA. 2020e. **National Centers for Environmental Information**, State of the Climate: Global Climate Report for January 2020 (06/21/2020). Retrieved from https://www.ncdc.noaa.gov/sotc/global/202001.

NOAA. 2020f. **National Centers for Environmental Information**, State of the Climate: Global Climate Report for April 2020 (06/21/2020). Retrieved from https://www.ncdc.noaa.gov/sotc/global/202004.

Ortega, L., Castilla, J. C., Espino, M., Yamashiro, C. & Defeo, O. 2012. Effects of fishing, market price, and climate on two South American clam species. **Marine Ecology Progress Series**, 469: 71−85. https://doi.org/10.3354/meps10016

Ortega, L., Celentano, E., Delgado, E. & Defeo, O. 2016. Climate change influences on abundance, individual size and body abnormalities in a sandy beach clam. **Marine Ecology Progress Series**, 545: 203-213. https://doi.org/10.3354/meps11643

Pauly, D. & Cheung, W. W. L. 2018. Sound physiological knowledge and principles in modeling shrinking of fishes under climate change. **Global Change Biology**, 24:e15–e26. https://doi.org/10.1111/gcb.13831

Pereyra I., Mas, F., Scarabino, F. Laporta, M. Silveira, S., Martínez & Fabiano, G. 2019. Excepcionales y olvidados: los registros más australes del género *Rhizoprionodon* (Chondrichthyes: Carcharhinidae) en el Atlántico sudoccidental. **Libro de Resúmenes del Primer Congreso Latinoamericano de Tiburones, Rayas y Quimeras y VIII Simposium Nacional de Tiburones y Rayas**. p.146. https://www.researchgate.net/profile/Edgar_Becerril-Garcia/publication/332232911_Libro_de_Resumenes_del_Primer_Congreso_Latinoamericano_de_Tiburones_Rayas_y_Quimeras_y_VIII_Simposium_Nacional_de_Tiburones_y_Rayas/links/5ca7a067a6fdcca26d012943/Libro-de-Resumenes-del-Primer-Congreso-Latinoamericano-de-Tiburones-Rayas-y-Quimeras-y-VIII-Simposium-Nacional-de-Tiburones-y-Rayas.pdf

Piola, A. R., Palma, E. D., Bianchi, A. A., Castro, B. M., Dottori, M., Guerrero, R. A., Marrari, M., Matano, R. P., Möller, O. O., Saraceno, Jr. M. 2018. Physical Oceanography of the SW Atlantic Shelf: A Review. Pp 37-56. In: Hoffmeyer, M., Sabatini, M., Brandini, F., Calliari, D., Santinelli, N. (Eds) **Plankton Ecology of the Southwestern Atlantic. From the Subtropical to the Subantarctic Realm**. Springer, Cham, Switzerland, 592 p. https://doi.org/10.1007/978-3-319-77869-3.

Pita, P., García-Allut, A., Villasante, S. 2018. The role of marine stakeholders in the co-

production of scientific knowledge: lessons from Galicia (NW Spain). Pp 55-65. In: Briand, F. (Ed.) **CIESM 2018. Engaging marine scientists and fishers to share knowledge and perceptions – Early lessons. CIESM Workshop Monograph** n° 50. CIESM Publisher, Paris, Monaco, 218 p. http://www.ciesm.org/online/monographs/Paris18.html

Pita, P., Antelo, M., Hyder, K., Vingada, J. & Villasante, S. 2020. The use of recreational fishers' ecological knowledge to assess the conservation status of marine ecosystems. **Frontiers in Marine Science**, 7. https://doi.org/10.3389/fmars.2020.00242

Poloczanska, E. S., Brown, C. J., Sydeman, W. J., Kiessling, W., Schoeman, D. S., Moore, P. J., Bruno, J. F, Buckley, L. B., Burrows, M. T., Duarte, C. M., Halpern, B. S., Holding, J., Kappel, C. V., O'Connor, M. I, Pandolfi, J. M., Parmesan, C., Schwing, F., Thompson, S. A. & Richardson, A. J. 2013. Global imprint of climate change on marine life. **Nature Climate Change**, 3: 919-925. https://doi:10.1038/nclimate1958

Poloczanska, E. S., Burrows, M. T., Brown, C. J., García-Molinos, J., Halpern, B. S., Hoegh-Guldberg,O., Kappel, C. V., Moore P. J., Richardson, A. J., Schoeman, D. S. & Sydeman, W. J. 2016. Responses of marine organisms to climate change across oceans. **Frontiers in Marine Science**, 3:62. https://doi: 10.3389/fmars.2016.00062

Possamai, B., Vieira, J. P., Grimm, A. M., & Garcia, A. M. 2018. Temporal variability (1997-2015) of trophic fish guilds and its relationships with El Niño events in a subtropical estuary. **Estuarine, Coastal and Shelf Science**, 202, 145-154. https://doi.org/10.1016/j.ecss.2017.12.019

Scarabino, F., Zelaya, D. Orensanz, J. M. (Lobo), Ortega, L., Defeo, O., Schwindt, E., Carranza, A., Zaffaroni, J. C., Martínez, G., Scarabino, V. & García-Rodríguez, F. 2016. Cold, warm, temperate and brackish: Bivalve biodiversity in a complex oceanographic scenario (Uruguay, southwestern Atlantic). **American Malacological Bulletin**, 31 (2): 284-30. https://doi.org/10.4003/006.033.0219

Tiralongo, F., Crocetta, F., Riginella, E., Lillobd, A. O., Tondob, E., Macalibe, A., Mancinibf, E., Russob, F., Cocobg, S., Paolilloh, G. & Azzurroci, E. 2020. Snapshot of rare, exotic and overlooked fish species in the Italian seas: A citizen science survey, **Journal of Sea Research**, 164: 101930. https://doi.org/10.1016/j.seares.2020.101930.

Venturelli, P. A., Hyder, K. & Skov, C. 2016. Angler apps as a source of recreational fisheries data: opportunities, challenges and proposed standards. **Fish and Fisheries**, 18 (3): 578-595. https://doi.org/10.1111/faf.12189

Vianna, M. & Verani, J. R. 2002. Biologia populacional de *Orthopristis ruber* (Teleostei, Haemulidae) espécie acompanhante da pesca de arrasto do camarão-rosa, no sudeste brasiliero. **Atlântica**, 23(1): 27-36. https://doi.org/10.5088/ATL.2002.4

Vieira, J. P., Garcia, A. M. & Lemos, V. M. 2018. Species composition and abundance patterns of fish assemblages at shallow waters of Patos Lagoon estuary. v1.8. **Sistema de Informação sobre a Biodiversidade Brasileira - SiBBr.** Dataset/Samplingevent.https://ipt.sibbr.gov.br/peld/resource?r=species_composition_and_abundance_patterns_of_fish_assemblages_at_shallow_waters_of_patos_lagoon_estuary&v=1.8 https://doi.org/10.15468/kci8zb

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