SPRFMO
South Pacific Regional Fisheries Management Organisation

11th MEETING OF THE SCIENTIFIC COMMITTEE

11 to 16 September 2023, Panama City, Panama

SC11 – JM09

Reproductive aspects of JM in Peru

Republic of Peru

SPRFMO
South Pacific Regional Fisheries Management Organisation

11th MEETING OF THE SCIENTIFIC COMMITTEE

Panamá, 11-16 September 2023

REPRODUCTIVE ASPECTS OF JACK MACKEREL IN PERU (*Trachurus murphyi*)

by

Grecia Chávez, Ángel Perea, Betsy Buitrón, Antonio Cuba, Javier Sánchez

Instituto del Mar del Perú (IMARPE)

This report contains information on the jack mackerel stock and fishery in Peruvian jurisdictional waters that, we reiterate, the delegation of Peru, in use of its discretionary powers, voluntarily provides for the purpose of information and support to the scientific research work within the Scientific Committee of the SPRFMO. In doing so, while referring to Article 5 of the Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean and reiterating that Peru has not given the express consent contemplated in Article 20 (4) (a) (iii) of the Convention, Peru reaffirms that the decisions and conservation and management measures adopted by the SPRFMO Commission are not applicable within Peruvian jurisdictional waters.

2023

ABSTRACT

Trachurus murphyi (Nichols 1920) is a widely distributed pelagic species that covers a large territory of the South Pacific, distributed off the coasts of Ecuador, Peru and Chile (Dioses, 1995). There is diverse literature on its reproductive cycle; however, there is still a lack of information on the distribution of reproductively active schools of Jack mackerel. This work identifies the areas of reproductively active schools of Jack mackerel *Trachurus murphyi* along the Peruvian coast from 2019 to 2022; in addition, the estimated fecundity values are presented for the Casma and Atico areas, between October and November 2022. The identification of areas of reproductively active schools was estimated by calculating the GSI during the months of greatest reproductive importance, analyzing the data with the statistical package *fenix* of the R program. The results were categorized as: areas of schools with lower reproductive activity (GSI<1.5%) and areas of schools with higher reproductive activity (GSI>1.5%), identifying the main areas of greater reproductive importance off the central-southern coasts of the country. The fecundity count was carried out with specimens of sizes between 41 and 56 cm LT off the Casma and Atico areas, calculating batch fecundity as 158 538 ± 84 006 hydrated oocytes per spawning batch and relative fecundity as 134 ± 54 hydrated oocytes/gram of fish. The results obtained in this study show that Jack mackerel develop their entire reproductive cycle in waters under Peruvian jurisdiction, mainly off the central-southern zone of the coast.

INTRODUCTION

Marine fishes are often structured in metapopulations connected by the exchange of individuals in early life stages or in the juvenile and/or adult phases. These subpopulations are likely to have different vital, ecological and demographic characteristics due to genetic diversity and phenotypic plasticity, thus, showing different responses to environmental variability and fishing pressure (Devesa, 2020). For this reason, describing a population is complex because it is necessary to combine the analysis of different biological disciplines, such as genetics, life cycle (Abaunza *et al.,* 2008), feeding, morphology, among others.

Trachurus murphyi (Nichols 1920) is a widely distributed pelagic species that covers a large area of the South Pacific, distributed off the coasts of Ecuador, Peru and Chile (Dioses, 1995). As a widely migratory resource, it is characterized by its location in different oceanographic conditions, in addition to making large movements in the event of climatic changes (Tsukayama 198, Zuta 1983, Bertrand *et al*. 2004). In Peru, Jack mackerel is one of the most important pelagic fisheries, being one of the resources targeted exclusively for direct human consumption (CDH) (Ñiquen *et al.* 2013). There is diverse literature on its reproductive cycle, which mentions that its maturation and spawning period is registered between the months of September and December, reaching peak values in the month of November (Santander & De Castillo 1971, Dioses 1988, Dioses 1995). Sánchez *et al.* (2013) described their oocyte development, validating the maturity scale and typifying that this is a species with partial reproduction, which is characterized by spawning in "baches" or spawning batches. However, there is still a lack of information regarding the distribution of reproductively active schools of Jack mackerel, which is why this work was carried out in order to know the important areas of maturity and spawning of the resource. With respect to other studies on reproductive aspects, carried out in Peru, the gonadal maturity scale has been validated (Sánchez, 2013), the distribution of eggs and larvae has been described in order to know the spawning areas at different times of the year (Santander & De Castillo 1971, Ayón 2013); data on Jack mackerel fecundity have been reported in the 1980s, described by Dioses *et al.* (1988), who estimated partial fecundity and relative fecundity.

This work identifies the areas of reproductively active schools of Jack mackerel *Trachurus murphyi* along the Peruvian coast from 2019 to 2022. The determination of spawning areas based on reproductive adults off the Peruvian coast is very important since it is part of a comprehensive study that includes studies in other lines of research (genetics, feeding, parasites, etc.), contributes to the process of discrimination of Jack mackerel population groups. In addition, the estimated fecundity values for the Casma and Atico area, between the months of October and November 2022, are presented.

METHODOLOGY

A) Identification of areas of reproductively active schools of fish.

The information used came from the pelagic fishery monitoring program carried out by the Instituto del Mar del Perú (IMARPE) on a constant basis along the Peruvian coast, using information from 2019 to 2022. Mature and spawning specimens were found in 64

samplings, from which biometric and biological data were obtained. The formula proposed by Vazzoler (1982) was used to calculate the GSI.

$$GSI = \frac{Wgonad}{Wgutted} * 100$$

Where:

Wgonada: Weight of gonad (g)

Weviscerated: Gutted weight (g)

In order to determine the months of greatest reproductive activity in the adult population, a similarity analysis was carried out between the monthly average values of the GSI. The GSI reference value was estimated at 1.5%, from which higher values determine periods of greater reproductive importance. Subsequently, this value was used to categorize isoparalittoral areas into: Areas of important reproductively active shoals (GSI>1.5%) and areas of shoals with lower reproductive activity (GSI<1.5%). Using the fenix package of the R statistical program, the categorized isoparalittoral areas were plotted.

B) Estimation of fecundity of Jack mackerel *Trachurus murphyi*

The fecundity study was carried out with adult specimens of sizes from 41 to 56 cm total length (TL), caught by the artisanal and small-scale fleet off Casma (09°S) and Atico (16°S) in the months of October and November 2022. For the study, 41 hydrated ovaries were used, which were discarded histologically (only one lobe) in order to consider only females with hydrated oocytes (OH) and discard ovaries with post-ovulatory follicles (POF). Of the ovaries not discarded, 5 subsamples were taken from the apical, central apical, central, distal central, and distal regions.

The calculation of batch and relative fecundity was made according to Santander *et al.* (1984), according to detail

$$Bf = \frac{N°Oocytes * Wgonad}{Wsubsampe}$$

Where:

Bf: Batch fecundity per individual.

N°oocytes: Average number of oocytes in the subsample per individual.

Wgonad: Gonad weight (g) per individual.

Wsubsample: Average subsample weight per individual (g).

$$Rf = \frac{Bf}{Wgutted}$$

Where:

Rf: Relative fecundity.

Bf: Batch fecundity.

Wgutted: Gutted weight (g).

RESULTS

A) Identification of areas of reproductively active shoals

According to the similarity analysis, it was observed that the period of greatest reproductive activity of Jack mackerel occurs between the months of September and December, with the greatest intensity in the month of November. This result coincides with that found by Perea *et al*. (2013), who state that the relatively long period of maturation and spawning extends between September and December, with maximum GSI values in November.

The results showed that, from 2019 to 2022, in the important reproductive period of the resource, with samples coming mainly from the south-central zone of the Peruvian coast (Callao to Ilo), in the years 2019 and 2020 the areas with important reproductively active schools (GSI > 1.5%) were distributed from Pisco to Ilo, mainly from 30 nm to 50 nm from the coast. In the years 2021 and 2022 from Ilo to Atico, they were located within 40 nm offshore. In the year 2021 from San Juan de Marcona to Huarmey they were present outside the 50nm. While, in 2022, they were observed in two zones within 10 nm (Atico and Chimbote) and between 20 nm and 40 nm from San Juan de Marcona to Callao. Shoal zones with lower reproductive activity (GSI<1.5%) were also observed; in 2019, these shoals were located within 30nm offshore from Ilo to Atico and at 90 nm and 100 nm offshore off Pisco; in 2020, they were off Pisco at 20 nm offshore; in 2021, from 0 to 20 nm offshore; while, in 2022 they were located at 30 nm and 40 nm offshore off Pisco (Fig. 1). These results, with active and non-reproductively active schools, would demonstrate that the entire reproductive cycle of Jack mackerel also takes place in waters under Peruvian jurisdiction, mainly off the central-southern zone of the country. Similar results are mentioned by Flores & Santander (1983) who identified the main spawning area in Peru between 16° and 18°S. Later, Ayón & Correa (2013), mention that there is a permanent area of reproductive activity with the presence of a stable spawning stock, describing spawning areas between 14°S and 18°S between 1966 and 1978, varying towards the north of the country between 4°S and 14°S in the years from 1979 to 1994 and finally from 1995 to 2010, located in an intermediate position between the two periods mentioned above.

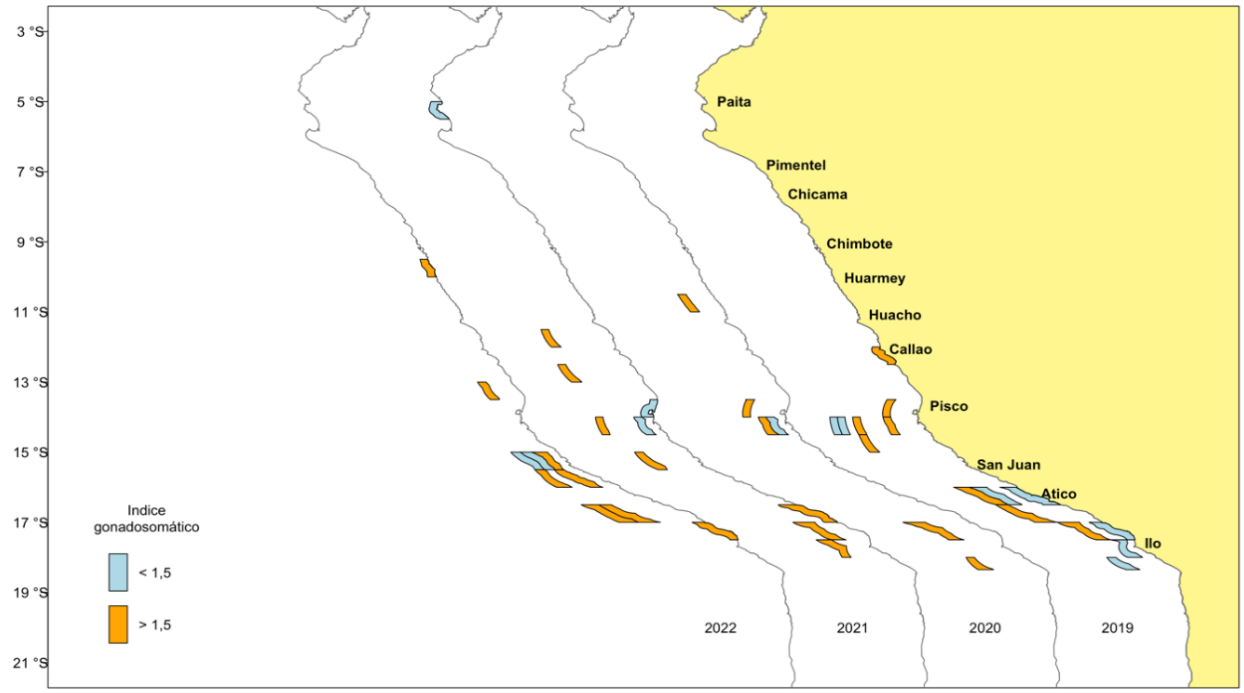

Figure 1.- Isoparalittoral areas of reproductively active schools of Jack mackerel *Trachurus murphyi* off the Peruvian coast from 2019 to 2022, determining areas of important reproductively active schools (GSI>1.5%) and areas of schools with lower reproductive activity (GSI<1.5%).

B) Estimation of fecundity of Jack mackerel *Trachurus murphyi*

Average batch fecundity (BF) values were calculated at 158 538 ± 84 006 hydrated oocytes per spawning batch, with a minimum value of 13 439 oocytes, corresponding to a total length (TL) of 43 cm and a total weight (TW) of 757 g and gonadal weight (GW) of 12.9 g. The highest fecundity, 315 274 oocytes, was found in a specimen of 52 cm (TL), 1391 g TW and 215.6 g GW; reinforcing the theory described by Hunter *et al.,* (1985), who mention that fecundity depends directly on the size, weight of the fish and the type of reproduction.

When analyzing the relationship between batch fecundity (BF) and gonad-free weight (GW), it was observed that the number of oocytes increases as the gonad-free weight increases (Fig. 4). This relationship was similar to that obtained when analyzed with total length (Fig. 5). The partial fecundity values found in this study were higher than those recorded in Peru by Dioses et al. (1988), who reported 78 789 oocytes/spawning run and those reported by Gonzales et al. (2020) who determined a partial fecundity of 35 293 oocytes/spawning run for the same species in Chile.

Relative fecundity (RF) was calculated at 134 ± 54 hydrated oocytes/gram of fish, ranging from 18 to 227 hydrated oocytes/gram of fish, in females with lengths between 43 and 52 cm LT, respectively, whose total and gonadal weights were the same as those described for BF. The relationship between relative fecundity (RF) and weight without

gonad showed that RF increases as GW increases (Fig. 6); this directly proportional relationship was also found when the same analysis was performed with fish size (Fig. 7). The calculated RF values are lower than those described by Dioses et al. (1988) who estimated a RF of 225, attributing this difference to the different environmental conditions. In other species of the genus *Trachurus*, values of 112 oocytes/gram fish weight have been reported for *T. symmetricus* in California (Macewicz and Hunter, 1993), in Greece and Portugal values of 205 and 200 oocytes/gram fish weight were obtained for T. *trachurus*, respectively (Karlou and Economidis, 1997, Goncalves et al., 2009).

Table 1.- Estimated values of batch and relative fecundity of Jack mackerel *Trachurus murphyi* with respect to length and weight during 2022.

Region	Total Lenght (cm)	Total weight	Gutted weight	Batch Fertility	Relative Fertility
Atico (16° S)	41	636	597	55,446	87
	42	637	622	18,330	29
	43	760	727	58,352	77
	43	757	744	13,439	18
	43	654	623	40,752	62
	44	806	769	61,573	76
	45	813	789	35,668	44
	45	845	775	113,876	135
	45	795	764	59,203	74
	46	929	876	114,846	124
	46	859	824	45,554	53
	46	813	778	62,875	77
	47	851	817	72,429	85
	48	941	905	69,993	74
	49	1034	997	68,089	66
	50	1217	1111	184,850	152
	51	1391	1275	226,944	163
	52	1340	1166	274,410	205
	52	1391	1175	315,274	227
	54	1418	1301	203,748	144
Casma (09° S)	49	1174	1038	186,674	159
	49	1118	1009	200,111	179
	50	1081	962	183,183	169
	50	1117	1002	185,278	166
	50	1106	999	187,204	169
	50	1227	1121	202,833	165
	51	1223	1104	186,396	152
	51	1230	1117	214,543	174
	51	1197	1061	185,048	155
	52	1213	1094	228,443	188
	52	1233	1138	166,811	135
	52	1254	1164	200,024	160
	52	1257	1116	250,565	199
	52	1223	1108	158,370	129
	52	1250	1141	186,284	149
	52	1234	1097	221,713	180
	52	1312	1172	255,873	195
	53	1270	1128	229,769	181
	53	1315	1174	246,600	188
	54	1414	1264	231,509	164
	56	1679	1500	297,173	177

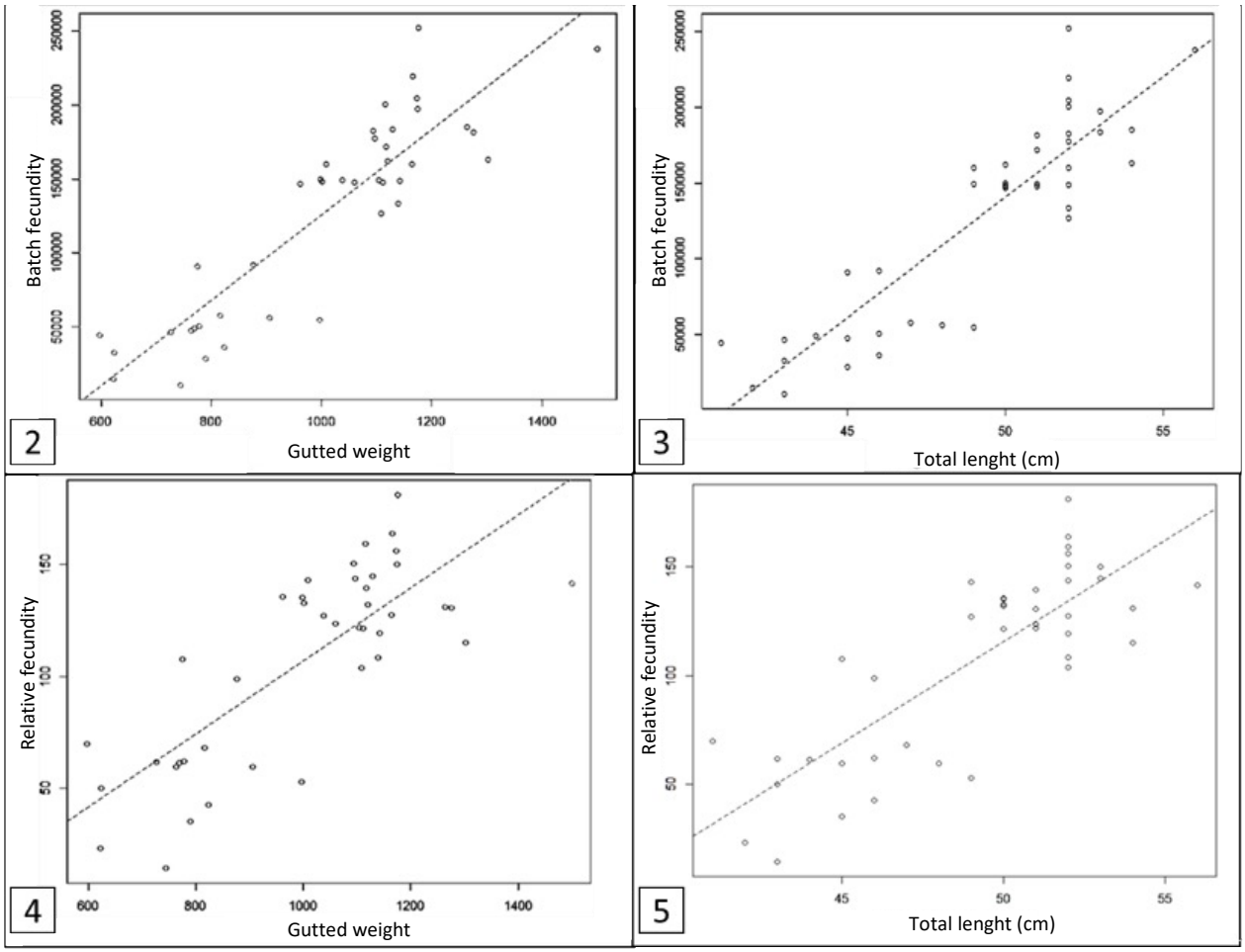

Figure 2. Relationship between partial fecundity and weight without gonad in *T. murphyi* females. **Figure 3.** Relationship between partial fecundity and total length in *T. murphyi* females. **Figure 4.** Relationship between relative fecundity and weight without gonad in *T. murphyi* females. **Figure 5.** Relationship between relative fecundity and total length in *T. murphyi* females.

CONCLUSIONS

The results of this study show that there are reproductively active schools in Peru, with important gonadal maturation and spawning areas, mainly off the central-southern area of the Peruvian coast; in addition, the hydrated individuals worked, indicates that the complete reproductive cycle of Jack mackerel would also take place in the waters under Peruvian jurisdiction.

REFERENCES

Abaunza P, LS Gordo, MS García Santamaría, SA Iversen, AG Murta, E Gallo. 2008. Life history parameters as basis for the initial recognition of stock management units in horse mackerel (*Trachurus trachurus*). Fisheries Re-search 89: 167-180.

Ayón P., Correa J., . 2013. Spatial and temporal variability of horse mackerel *Trachurus murphyi* larvae in Peru between 1966-2010. In: Csirke J., R. Guevara-Carrasco & M. Espino (Eds.). Ecology, fishery and conservation of Jack mackerel (*Trachurus murphyi*) in Peru. Rev. Peru. biol. special issue 20(1): 083- 086 (September 2013).

Bertrand A., A. Chaigneau, S. Peraltilla, J. Ledesma, M. Graco. 2011. Oxygen: A Fundamental Property Regulating Pelagic Ecosystem Structure in the Coastal Southeastern Tropical Pacific. PLoS ONE 6(12): e29558. DOI:10.1371/journal.pone.0029558.

Buitrón, B., A. Perea, J. Mori, J., Sánchez & C. Roque. 2011. Protocol for studies on the reproductive process of pelagic and demersal fishes. Boletin Instituto del Mar Perú, 38: 373-384.

Cubillos, LA., Alarcón C., Castillo-Jordán C., Claramunt G., Oyarzún C., Gacitúa S. 2011. Spatial and temporal changes in the partial fecundity of common sardine and anchoveta off central and southern Chile (2002 - 2007). Ciencias Marinas, 37: 547 - 564.

Devesa C. 2020. Population structure, movement patterns and habitat connectivity of blue Jack mackerel, *Trachurus picturatus*, in the northeast Atlantic: otolith morphochemistry, body shape and genetic markers as combined tools for rational fisheries resource management. PhD thesis. Institute of Biomedical Sciences Abel Salazar, University of Porto. Portugal.236 pp.

Dioses, T. 1995. Analysis of the distribution and abundance of Jack mackerel and mackerel resources off the Peruvian coast. Inf. Prog. Prog. Inst. Mar Peru n°3, 1995.

Dioses, T., V. Alarcon, M. Nakama & A. Echevarria. 1988. Oocyte development, partial fecundity and vertical distribution of spawning schools of Jack mackerel, *Trachurus murphyi* (N). In: Memorias del Simposio Internacional de los Recursos Vivos y las Pesquerías en el Pacífico Sudeste. Viña del Mar, 9 - 13 May 1988. Rev. Pacífico Sur (Special Issue), pp. 287 - 294.

Goncalves, P., A. Costa & A. Murta. 2009. Estimates of batch fecundity and spawning fraction for the southern stock of horse mackerel (*Trachurus trachurus*) in ICES Division IXa. ICES Journal of Marine Science, 66: 617-622

González, P., M. González & M. Oliva. 2020. Una primera evaluación de la atresia en el jurel chileno *Trachurus murphyi* (Teleostei, Carangidae) del Pacífico suroriental. Rev. Biol. Mar. Oceanogr. 55, 100-109.

Gordo L., A. Costa, P. Abaunza, P. Lucio, A. Eltink & I. Figueiredo. 2008. Determinate versus indeterminate fecundity of horse caballa. Fisheries Research 89: 181 – 185

Hunter, J. R. & Goldberg, S. 1980. Spawning incidence and batch fecundity in northern anchovy, *Engraulis mordax*. Fishery bulletin, 77: 641-652.

Karlou, C. & P. Economidis. 1997. Spawning frequency and batch fecundity of horse mackerel, *Trachurus trachurus* (L.), in the Saronikos Gulf (Greece). J. Appl. Ichth. 13, 97-104.

Leal, Elson; Díaz, Eduardo; Saavedra-Nievas, J.C; Claramunt, Gabriel (2013). Ciclo reproductivo, longitud y edad de madurez de jurel *Trachurus murphyi*, en la costa de Chile. Revista de biología marina y oceanografía, 48(3), 601-611. doi:10.4067/S0718-19572013000300016

Macewicz, B. & J. Hunter. 1993. Spawning frequency and batch fecundity of Jack mackerel, *Trachurus symmetricus,*off California during 1991. Calif. Coop. Oceanic Fish. Invest. Rep. 34, 112-121.

Ndjaula, H.; Krakstad, J. & Kjesbu, O. 2013. Reproductive biology of horse mackerel *Trachurus capensis* and *Trachurus trecae* in Namibia and Angola. African Journal of Marine Science, 1-10.

Ñiquen M., M. Bouchon, D. Ulloa & A. Medina. 2013. Analysis of the Jack mackerel *Trachurus murphyi* fishery in Peru. In: Csirke J., R. Guevara-Carrasco & M. Es¬pino (Eds.). Ecology, fishery and conservation of Jack mackerel (Trachurus murphyi) in Peru. Rev. peru. biol. special issue 20(1): 097 - 106 (September 2013).

Perea, A. & B. Buitrón. 2004. Application of the ovary freezing method to estimate the spatial distribution of anchoveta spawning schools. Boletin Instituto del Mar Peru, 32: 123-126.

Santander, H & Flores, R. 1983. Spawning and larval distribution of four pelagic species and their relationships with marine environmental variables off Peru. FAO Fish. Rept. No. 291(3):835 - 867.

Santander, H.; Alheit, J. & Smith, P. 1984. Estimation of the spawning biomass of Peruvian anchoveta *Engraulis ringens* in 1981 by application of the Egg Production Method. Boletín - Instituto del Mar del Peru (Lima), 8: 213-250.

Tsukayama I. 1983. Pelagic resources and their fisheries in Peru. Rev. Com. Perm. South Pacific 13: 25-63.

Vazzoler A. 1982. Manual de métodos para estudios biológicos de populações de peixes. Reprodução e crescimento. CNPq, Programa Nacional de Zoologia, Brasília, 2: 108p.