PANAMJAS
Pan-American Journal of Aquatic Sciences

Analysis of artisanal fishing effort in San Nicolás, Paraná River delta, Argentina

JORGE LIOTTA

Dirección de Planificación y Gestión de Pesquerías, Subsecretaría de Pesca y Acuicultura, Ministerio de Agricultura, Ganadería y Pesca de Argentina, Ciudad Autónoma de Buenos Aires, Argentina

Museo de Ciencias Naturales "Antonio Scasso", San Nicolás, Buenos Aires, Argentina.

*Corresponding author: jorgerliotta@gmail.com

Abstract. River fisheries in La Plata river basin in Argentina are very important, both in social and economic terms. Published data about quantification of the effort carried out by fishermen is very scarce, although this information is key to evaluate the total effort of this activity. The objective of this work is to present data referred to fishing effort, obtained from the activity of a group of fishermen which land their catches in San Nicolás city, in the north of Buenos Aires province. Their dedication to work is diverse: some are completely dedicated to the activity; for others, fishing is complementary to other works, such as construction. Others in addition, care for or possess cattle in wetlands. The mean dedication to fishing was 158.9 ± 53.9 days worked per year, with a median value of 131. The median of the CPUE is 104.4 kg per fisherman and day, or 13.6 tn per fisherman and year. The dispersion of the values is high. Factors related with environmental and climatic phenomena, demand for fish and operational aspects, modulate the time invested in fishing.

Key words: small-scale inland fisheries, CPUE.

Resumen: **Análisis de la dedicación a la pesca artesanal en San Nicolás, delta del río Paraná.** Las pesquerías fluviales de pequeña escala de la cuenca del Río de la Plata en Argentina son significativamente importantes en términos sociales (como aportes a la seguridad alimentaria y a las economías familiares) y económicos. Son muy escasos los datos publicados sobre la cuantificación del esfuerzo efectuado por los pescadores, aunque esta información es clave para evaluar la magnitud de la actividad. El objetivo de este trabajo es presentar datos de dedicación a la pesca artesanal, y analizar la influencia de diversos factores sobre aquella, de un grupo de pescadores de cauce del Delta del Paraná, que desembarcan sus capturas en San Nicolás, en el extremo norte de la provincia de Buenos Aires. La dedicación a la pesca fue de 158.9 ± 53.9 días trabajados por año, con una mediana de 131 días. La mediana de la CPUE del período fue de 104.4 kg/pescador.día, o 13.6 tn/pescador-año, utilizando ambas medianas. Todos los valores mostraron una amplia dispersión. Algunos pescadores se dedican por completo a la actividad; otros, la complementan en proporciones variables con tareas como el cuidado de ganado vacuno en zona de islas, la construcción o diversas tareas temporarias. Factores relacionados con fenómenos ambientales (variaciones de nivel hidrométrico) y climáticos (fuertes vientos), disponibilidad y demanda de pescado y aspectos operativos modulan la dedicación a la pesca.

Palabras clave: pesquerías continentales de pequeña escala, CPUE.

Introduction

River fisheries in the Río de la Plata basin in Argentina are of a small-scale or an artisanal type: they use only manual work in capture, processing, distribution and marketing of resources, they are usually practiced by individuals, family or

community groups settled in coastal communities or riverside, from boats with little autonomy, and worth arts and techniques of minimum modernization (Parlatino 2017). Small-scale fisheries are significantly important in social (contributing to food security and family economies; Araya et al. 2009; FAO 2015) and economic terms (generating genuine revenue cushioning crises situations; Mahon 1997; FAO 2005; Daw *et al.* 2009). However, in most of temperate and tropical river systems, information on this activity is fragmentary and sparse, generating an underestimation of its magnitude, and therefore insufficient consideration by government administrations (Castello *et al.* 2007; Welcomme *et al.* 2010; FAO 2018).

The time invested by fishermen in obtaining their catch, known as fishing effort, is a key parameter to evaluate the magnitude of this activity. The designation of professional or full time, part-time and occasional fishermen is usual; FAO (2016) estimates that by 2014, 36% of fishermen engaged in the activity as full-time, 23% part-time and the rest were occasional or without specifying situation. Different criteria can be used to justify this classification (Welcomme 1992, OIT 2003): time spent in activity; occasion of fishing (for special celebrations, for example); percentage of revenue earned from fishing; destination of the fish (own or community consumption, sale); number and complexity of the fishing gear used.

For inland fisheries in Argentina, only few authors mention proportions of fishermen with different dedication. In Paraguay river, 44% of 3,300 fishermen were full-time (Espinach Ros & Delfino 1993). For lower Paraná alluvial plains fisheries, fishermen spent, on average, 50% of their time to fishing, ranging from less than 25% to 90% (Espinach Ros & Fuentes 2000). In the province of Corrientes, Iwaszkiw (2001) mentions that 62.5% of 640 fishermen were full time, and 37.5%, part time. These works, however, do not identify the criteria used for classification.

The objective of this work is to present data on CPUE and fishing effort, obtained from the record of the activity of a group of fishermen from San Nicolás, at the northern end of Buenos Aires province. Variables that limit fishing are described and analyzed.

Materials and methods

The arrival of fishermen to land their catches in a sector called "Paseo Costanero" in San Nicolás city (33°20'S, 060°15' W) was recorded daily for 588 days (from October 2016 to May 2018).

Biweekly, semi-structured interviews (Diaz Bravo *et al.* 2013) were conducted. For this purpose, an "interview guide" was prepared, with questions grouped by topic, aimed at gaining knowledge about aspects of the activity, on two-time scales: the last fishing trip (corresponding to the landing present at the time of the survey) and the previous two weeks. Questions concerning the last fishing trip refer to: (i) landing composition and volume, (ii) fishing gear, (iii) gear modality and intensity of use, (iv) aquatic body -river, lagoon, among others- in which each gear was used, and (v) duration of trip in days. The topics asked for the previous two weeks were: (i) dedication to other works and (ii) elements that hindered fishing.

For each fisherman, the number of landings carried out (L) and mean time (=fishing effort, FE, in days) of an individual trip were calculated. The annual fishing effort (AFE) was obtained. It is defined as AFE = L * FE. The values were obtained for the whole period of study and standardized to 365 days. The number of landings that occurred per day and per week, and the days with increased frequency of landings were also obtained.

Values of catch per unit effort (CPUE), in kg per fisherman and day (kg/fisherman.day) and % were calculated for the most representative species of this fishery: sábalo *Prochilodus lineatus*, boga *Megaleporinus obtusidens*, patí *Luciopimelodus pati*, armado común *Pterodoras granulosus*, dorado *Salminus brasiliensis*, surubí pintado *Pseudoplatystoma corruscans*, and for the total catches for each time a fisherman was interviewed.

Graphs of water level (WL) of San Nicolás port since October 2016 to May 2018 were made using data from the Prefectura Naval Argentina website (https://contenidosweb.prefecturanaval.gob.ar/alturas/index.php). For the same period, daily weather conditions (temperature, precipitation, and wind intensity) data was obtained from the Experimental Station of Instituto Nacional de Tecnología Agropecuaria San Pedro (https://inta.gob.ar/documentos/informacion-agro-meteorologica-eea-san-pedro), located about 64 km SE from San Nicolás.

Results

There are about 25 active fishermen in San Nicolás (recent official statistics on these values were unavailable). The activity develops throughout

the year. Fishermen work in the main channel of Paraná river and adjacent wetlands, in an approximately semicircular area with a radius of 15 km from the landing site. There, around 10 fishermen sell their catches in individual stands. At early morning, the fishermen land their catches, obtained from the previous hours, or on few occasions from two days prior; one of them (identified here as fisherman 7) landed just one day a week (on Sunday) but fishes 3 or 4 days per week. The values of AFE are shown in Table I. Three of the fishermen were not considered in this analysis since landed their catches less than 5 times in the period (and so they were considered here as occasional fishermen).

The resulting statistics for AFE are (in days of work per year): mean = 158.9; standard deviation = 53.9; first quartile = 128; median = 131 and third quartile = 204.1 (Fig. 1).

A maximum of 7 fishermen worked simultaneously on the site, being more frequent the presence of 2 during the period (Fig. 2). Almost 10% of the days there was no activity. The days with most landings were Saturday, Sunday and Friday in descending order. Those days, the average number of three fishermen with landings was exceeded (Fig. 3). The minimum frequency of landings was on Monday.

The median of the CPUE for all the fishermen and the whole period was 104.4 kg landed per fisherman and day (Q1=83.5; Q3=137.7). The main species was sábalo (54%), followed by patí (12%) and boga (7%). The former two species were captured all the year. CPUE of boga and armado común were greater in autumn and spring (with differences between years). Dorado and surubí pintado were caught mainly in summer, although in small numbers and percentages (Fig. 4).

The annual CPUE obtained was 13.6 tn/fisherman.year (using the median values for daily CPUE and AFE). A brief description of each fisherman is presented (and summarized in Table II) from data obtained during 87 interviews (in 36 dates from the period).

Fisherman 1 and 2 had a similar fishing mode. Both were highly dedicated fishermen, although they also owned livestock in wetlands, where they permanently reside. Most of them used nets, such as passive fishing gear in lagoons, and dragging in the main channels. They sold fish mainly to the public, although in times of plenty, they delivered part of their catch to "acopiadores" (collectors that sell in local markets or for export). Fisherman 3 was exclusively dedicated to fishing, being specialist in the use of hook gears (although sometimes used also different nets); in general, he fished less days than the previous two; their catches had a great diversity, with prices on average higher than that of the most common species (sábalo). He sold exclusively to the public. Fishermen 4 and 5 showed a variable dedication to fishing, with periods of intense activity interspersed with times almost without presence in their stands. They fished in environments of the alluvial valley near the landing site and their equipment was more limited than that from the previous ones: for them, fishing is an activity that takes place in times when more money is needed, or when catches are especially abundant or profitable. They sold to the public, although they sometimes delivered fish to collectors. Fisher 6 specialized in the capture of large, valuable specimens, such as surubí pintado and dorado: he worked exclusively in the main course, with passive nets located deep in backwaters, or long lines with large hooks; as fishermen 1 and 2, he owned cattle; in winter (when their preferred species are less abundant) very little time was devoted to fishing. He sold to the public, or (on request) to fish restaurants. Fisher 7 landed his catch only on Sunday, but fished at least three days a week and sometimes even with more than one canoe; he worked with helpers; as a result, his landings were much larger than those of all previous;

Table I. Parameters used to calculate the time invested in fishing.

Parameter	Unit	1	2	3	4	5	6	7	Mean
N	Total landings number	318	323	189	203	210	141	85	-
L	Landings / year	197	201	117	126	130	88	53	130.3
L%	Landings / year (%)	54%	55%	32%	35%	36%	24%	14%	35.7%
FE	Worked days / landing	1.13	1.14	1.12	1	1	1	3.5	-
AFE	Worked days / year	223	229	131	126	130	88	186	158.9
AFE%	Worked days / year (%)	61%	63%	36%	35%	36%	24%	51%	43.5%

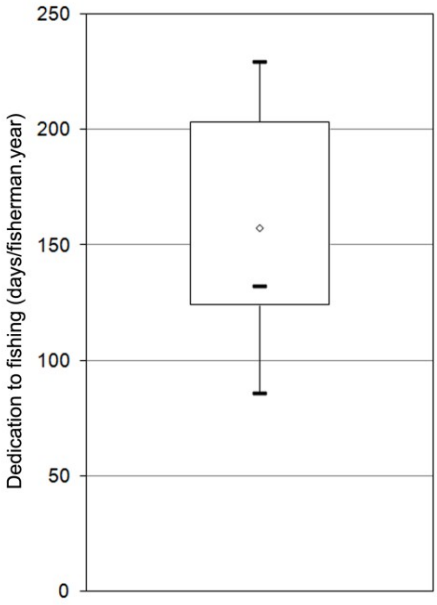

Figure 1. Boxplot of annual fishing effort (in days per year). Diamond: mean value.

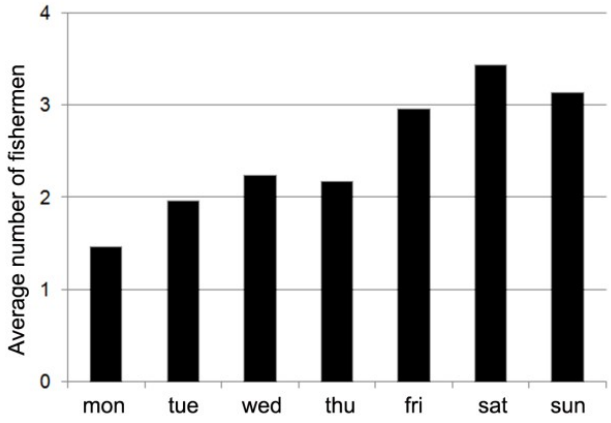

Figure 2. Number of landings per day of the week.

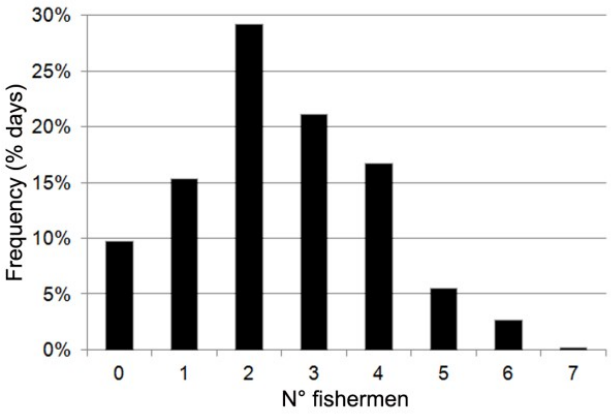

Figure 3. Percentage frequency of the number of fishermen landing per day.

he sold to the public, although he sometimes delivered part of the catches to collectors. Fishermen 8 and 9, who landed less than 5 times in the period, were not included in the study, nor fisherman 10, who generally got their fish from fishermen from other places.

The sequence of certain meteorological and hydrological parameters and the weekly frequency of landings is observed in Figure 5.

Specific events of heavy rainfall (end of December 2016, February 2018), strong winds (end of August 2017) (see Fig. 5 A and B) or persistent fog hindered fishing, are related with low frequency of landings.

Discussion

The effort and the catch values obtained allow characterizing the magnitude of the fishery. The AFE obtained is variable, with 158.9 ± 53.9 days worked per year, and a median value of 131 day/year. These are the first concrete values of fishing effort for this small-scale fishery.

The CPUE values obtained (104.4 kg/fisherman/day) agree with the values of “more than 110 kg” mentioned by Quirós *et al.* (2007) for the lower middle Paraná.

Most of the fishermen showed important fluctuations in their landing frequency over the whole period. This was caused by various factors: some fishermen are completely engaged to the activity; others complement it in varying proportions with tasks like cattle care in wetlands, construction or diverse temporary works.

Among the causes that modulate frequency of landings, the environment imposes some of them. At the beginning of the period, with the WL fluctuating around 2.5 m, the level which surpasses the bankfull level (therefore connecting the main channel to the floodplain), landings were more numerous. From mid April 2017 onwards there was a period of high WL and low air temperatures, which coincided with fewer landings. The WL remained high since the beginning of 2018 until the end of the analysis period, coinciding again with lower frequency of landings. For fishermen, the greater difficulty of catching fish in situations of large flooded areas is clear and predictable, as well as the ease of catching them in lagoons and canals in low waters. The inverse relationship between fishing intensity (expressed here as landing frequency) and the NH in floodplain rivers, mentioned by Neiff (1999) and Arthington *et al.* (2004), is confirmed here. Strong

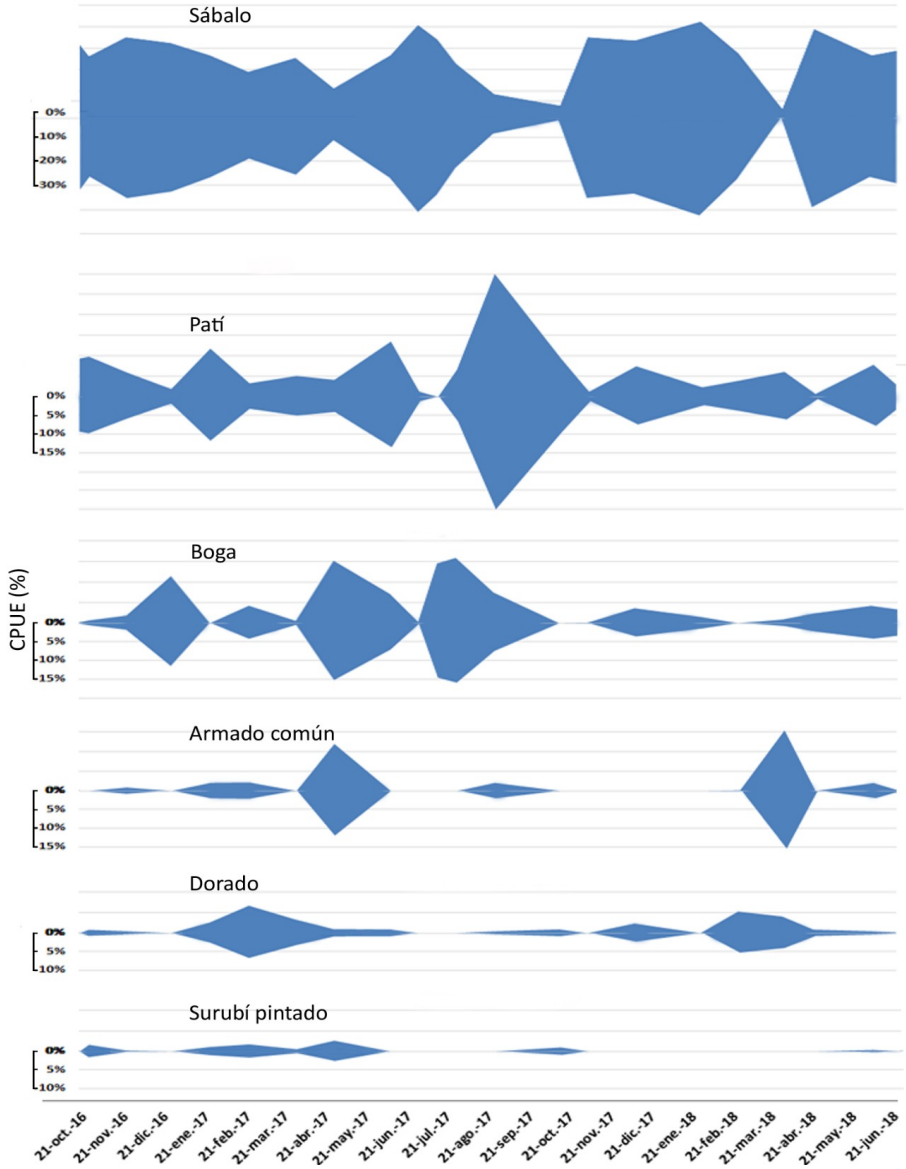

Figure 4. CPUE (in percentage) for the main species landed in San Nicolás from oct-16 to jun-18.

Table II. Characterization of the fishermen. The notation +, ++, +++, ++++ refers to a scale of increasing relative value.

N	Use of habitats	Seasonality	Annual fishing effort (% of a year)	Other activities	Fishing gears diversity	Landing volume	Catches' destination		
							Public	Restaurant	Collectors
1	Both	All year	61%	Cattle	++	+++	+++		+
2	Both	All year	63%	Cattle	++	+++	+++		+
3	Channel	All year	36%	No	+++	++	++++		
4	Floodplain	When jobless or high catches	35%	Construction, others	+	++	++		++
5	Floodplain	When jobless or high catches	36%	Construction, others	+	++	++		++
6	Channel	All year	24%	Cattle	+	+	++	++	
7	Both	All year	51%	No	+++	+++	+++		+

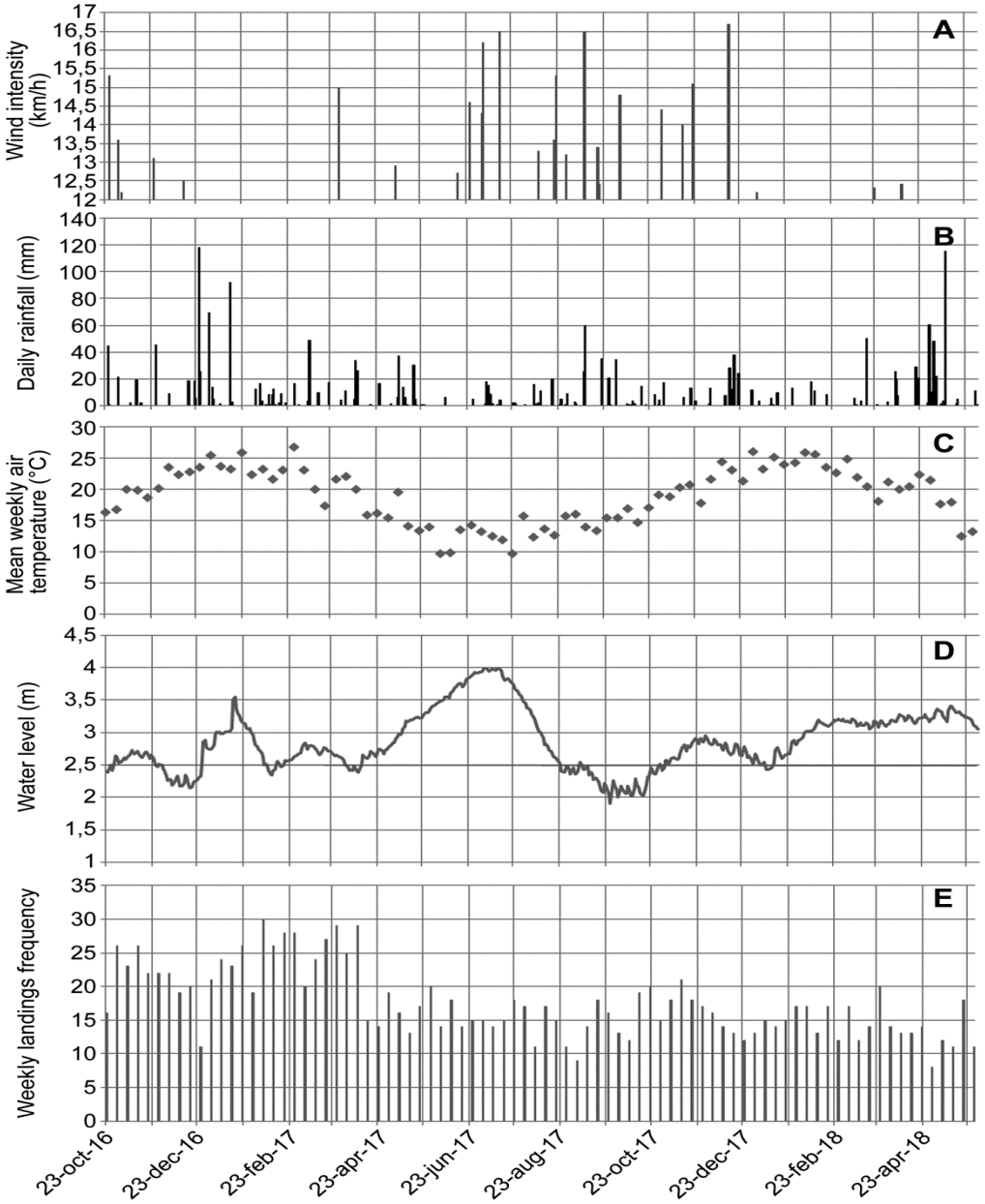

Figure 5. **A)** Daily mean wind intensity; **B)** daily rainfall; **C)** Mean weekly air temperature; **D)** water level (at 2,5 m, the WL surpasses the bankfull level, connecting the main channel to the floodplain); **E)** weekly landings frequency.

winds, persistent fog and heavy rainfall can also reduce the frequency of landings.

Other environmental causes that reduced landings were the abundance of piranhas (carnivorous fish of the family Serrasalmidae, which can break nets especially in summer times) and the drift of branches, water hyacinths, and debris (mainly during high WL).

In this region, channel fisheries are particularly active during upstream and downstream migration of fishes (Segura & Delfino 1991; Espinach Ros & Delfino 1993). This results in increases in the demand for certain species during their migration stages: boga in autumn, silverside *Odontesthes bonariensis* during winter and armado común in autumn and spring; the most valuable species, dorado and surubí pintado, are mainly caught in summer. There is also a significant increase in the demand for fish at Easter (coincident with the upward migration of several species). It is common for fishermen to work more intensively several weeks before, storing their catches, because collectors and the public buy more these days. Finally, a monthly fluctuation was mentioned, associated by fishermen to a lower availability of money from consumers at the end of each month.

Inconveniences of the fishermen themselves, such as health problems or difficulties with their equipment (mainly broken engines) also reduced the frequency of their landings. Strictly speaking, however, the time spent in repair and maintenance of boats, engines and fishing gear (not quantified in this study) should be considered as dedicated to the activity.

There were also situations of temporary dedication to other activities (times of vaccination or transfer of cattle, increase in the demand for labor in other fields, such as construction or industry). The fact that fishermen work simultaneously or alternately in different productive activities has been recognized as part of the island's way of life in the Paraná Delta (Boivin *et al.* 2000); The same strategy occurs in a large number of inland fisheries in the world (Welcomme *et al.* 2010).

The observed complexity, typical of small-scale fisheries, makes it difficult to consider a fisherman as full- or part-time. The calculation of statistical parameters of fishing effort for a complete set of fishermen allows obtaining effort scenarios, useful in small-scale fisheries such as these, often with limited data (Welcomme 2011).

Acknowledgements

To Mr. Ramón Carabajal (†) for kindly helping in the record of data used in this work. To Beatriz Giacosa, for her involvement in the execution of tasks on the site, in conducting surveys and suggestions for an earlier version. To Ariana Liotta for her help in the English translation. To all the fishermen and helpers for sharing their experiences and contributing data to this analysis. To an anonymous reviewer for valuable suggestions. Part of this work was carried out under the Artisanal Fishing Landings Monitoring Program of the Dirección de Planificación y Gestión de Pesquerías, Subsecretaría de Pesca y Acuicultura, Ministerio de Agricultura, Ganadería y Pesca de Argentina.

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Received: October 2019
Accepted: June 2020
Published: September 2020