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*Research Article*

# Records of bycatch of *Hippocampus patagonicus* (Pisces: Syngnathidae) in commercial fishing in southern Brazil

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**ABSTRACT.** *Hippocampus patagonicus* is classified as endangered in the vulnerable category by Brazilian law (MMA, 2014), and by IUCN (International Union for Conservation of Nature) criteria. Thirteen boats from the commercial fishing fleet of southern Brazil were monitored for 17 months to supplement data for the evaluation of this species. Three seahorse collection points were established, where the fish are landed: port of Imbé/Tramandaí and port of Passo de Torres (northern coast (NC) of Rio Grande do Sul) and the port of Rio Grande (southern coast (SC) of Rio Grande do Sul). The presence of *H. patagonicus* was recurrent, and the collected animals were between 22 and 130 mm in height. The species was captured from 11 to 57 m deep as bycatch of significant transboundary marine resources (Brazil, Uruguay, and Argentine). In bycatch of gillnet fishing (NC), estimated capture was 0.68 ± 0.97 seahorses/month/vessel, annually, an average of 89.76 seahorses would be removed from the sea by the 11 vessels involved. In trawling (SC), it was 49.66 ± 64.86 seahorses/month/double-rig trawl. It is estimated that 8,342 seahorses are removed annually as bycatch, only in this mode of fishing. The information obtained reinforces the need to apply ecosystem management to fisheries for the recovery of stocks that are over-exploited and accompanying fauna as well, especially small species with poorly known life histories such as *H. patagonicus*.

**Keywords:** *Hippocampus patagonicus*, seahorse, endangered, gillnet fishing, trawling, transboundary marine resources.

## INTRODUCTION

The impacts of commercial fishing have been revealed not only in the over-exploitation of the various target resources, but also in the incidental capture of many species that make up the bycatch, including endangered species (Baum *et al.*, 2003; FAO, 2014; Vasconcellos *et al.*, 2014; Cardoso & Haimovici, 2015). The negative impacts of trawling are today globally recognized, with the indiscriminate harvest of the fauna and flora of the ocean floor that damage all kinds of life and produce tons of bycatch. The discarding of juveniles in large numbers affects the composition of natural stocks, consequently reducing the volume of fish caught in the next harvest, which makes fishing less productive and increasingly more costly (Revill *et al.*, 1999; Polet *et al.*, 2010).

According to the latest survey conducted by the government, in 2010, Brazil was ranked 25th among the thirty largest fish-producing countries exclusively from extractive fisheries, representing 0.88% of this total. In 2011, the marine extractive fishery was the primary source of fish production in Brazil (fishing plus aquaculture), accounting for 38.7% with 553,670 ton (MPA, 2011).

The commercial fishing fleet is represented by five types of modalities: trawl fleet, purse-seine fleet or trawler fleet, a fleet of cages or traps, handline or longline fleet and gillnet fleet (MPA, 2011). The trawl fleet used for the exploitation of the continental shelf is represented by stern trawling (simple trawling), double-rig trawling (drag tangones), and pair trawling. These are responsible for catching the most significant share of demersal fishery resources. Gillnet fishing involves

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catching fish with the net by the anterior portion of these animals, and maybe a surface or bottom activity. The nets have a mesh aperture significantly larger than that of the trawl net and are considered selective and less damaging (REVIZEE, 2005).

One of the biggest threats to fish stocks in the world is commercial fishing, especially the one with the indiscriminate capture of non-target organisms, typically referred to as bycatch. While bycatch can be sold, it is mostly unused, and this portion is then called discard. In this definition, global marine fisheries data indicate that bycatch accounts for 40.4% of marine catches, and in Brazil, this rate is 57.9% (Davies *et al.*, 2009), where 442,150 ton derive from trawling of shrimp, fish, and other sea animals.

Seahorses are part of the bycatch of gillnet and trawl fisheries, both for shrimp and other organisms (Choo & Liew, 2005; Salin *et al.*, 2005; Vianna & Almeida, 2005; Foster & Vincent, 2004, 2010; Silveira, 2011; Filiz & Taşkavak, 2012; Jardim *et al.*, 2012; Buchheister, 2013; Foster & Arreguin-Sánchez, 2014). According to Vincent *et al.* (2011), there is a need for global, systematic, and long-term monitoring of the Syngnathidae in relation to fishing to obtain data that allow us to assess the conservation status of their populations and to obtain the commercial records. Most commercial seahorses (up to 95%) come from the bycatch in shrimp nets, because they share the demersal environment, are slow swimming and have a similar size as shrimp. The main countries with an incidental catch of seahorses in trawls include Philippines, Thailand, India, Malaysia, Indonesia, Mexico and the United States. Baum *et al.* (2003) estimated that 72,000 seahorses are extracted annually as a companion fauna in shrimp trawling in Florida. CITES data indicate that, although Thailand has been considered the major exporter of seahorses, since 1996, mainland China has also become a major exporter of such dried animals (Vincent, 1996). Live animals originating in Asia (mainly Vietnam, Sri Lanka and Indonesia) are exported to North America or the European Union (Vincent, 1996).

Of 598 interviews with fishermen from around the world, 403 (67%) revealed that the capture of seahorses as companion fauna had declined between 30-93% in Central Philippines, Vietnam, Malaysia, Thailand and on the coast of the Atlantic Ocean (Vincent *et al.*, 2011). A recent review of data on fisheries in 22 countries indicated an incidental catch of 0.96 seahorses/vessel/day, and it is possible to estimate an annual haul of 37 million seahorses in the countries sampled. Of 594 fishermen interviewed in 18 countries, fishermen in 15 countries reported a decline in the bycatch of seahorses rather than increase or no change in catches (Lawson *et al.*, 2017).

In Brazil, dry trade is not regulated, but undeclared exports from bycatch of trawl nets are known. Rosa *et al.* (2011) reported that the main sources of seahorses for the dry trade were derived from the bycatch in shrimp trawls and in fishing for *Micropogonias furnieri*, *Lophius gastrophysus* and *Mullus argentinae* in South (S) and Southeast (SE) Brazil and lobster in Northeast (NE) Brazil. According to Vaz-dos-Santos & Rossi-Wongtschowski (2005), several species of Brazilian target animals such as mollusks, crustaceans, and fish are shared with Uruguay and Argentina, forming the category of cross-border resources present in the Exclusive Economic Zones (EEZs) of two or more countries. According to this concept, *Hippocampus patagonicus* Piacentino & Luzzatto, 2004 represents a cross-border resource, since its confirmed geographical distribution stretches from Patagonia, Argentina, to Rio de Janeiro, Brazil (Piacentino & Luzzatto, 2004; Silveira *et al.*, 2014).

A pilot project was carried out to determine which species of seahorses would be bycatch and if *H. patagonicus*, which occurs in estuaries and bays in Argentina (Piacentino & Luzzatto, 2004), but not in estuaries in Brazil (R. Silveira, *pers. observ.*), would occur in industrial, marine fishing along the Brazilian South coast. There are still uncertainties about the extent of the occurrence area of *H. patagonicus* in Brazil. It was observed in the sea only up to the s Rio de Janeiro State (Silveira *et al.*, 2014), but it was found in the public market in Recife, PE, sold as a zootherapist, and raising the question of its origin in that region. We present the first bycatch data of the seahorse *H. patagonicus* from the commercial fishing fleet in Southern Brazil, showing their interaction with the target fisheries and the environment where they occur.

## MATERIALS AND METHODS

### Study area

Rio Grande do Sul, Brazil, Uruguay, and Argentina form the continental shelf of the western South Atlantic. The region is between parallels 29°S and 55°S, where the width of the platform varies between 120 and 380 km and where the depth of the shelf break zone varies between 60 and 180 m. Several sedimentary deposits from the last Pleistocene regression are recognized, in addition to the modern deposits from coastal drainage. The facies that make up the continental shelf are the platform (silt and clay) and continental muds, sands (quartzose and bioclastic), terrigenous gravel and shells. The continental shelf sludge extends from Rio Grande do Sul to Argentina, through the external and internal platform, respectively, and the former are separated from the coastline by sand and gravel (Martins *et al.*, 2005). These muddy environments are often the site of several commercial fisheries (Capítoli & Bemvenuti, 2004).

Southern Brazil is influenced by the Subtropical Convergence in the South Atlantic Ocean (CSAO), which is characterized by the interaction between the Brazil Current and the Malvinas Current, with great freshwater input from the basins of Rio da Prata and Patos-Mirim. Due to these characteristics, it is an important breeding and feeding area for many marine organisms (Seeliger *et al.*, 1997), thus being recognized as an area with great fishing potential (Haimovici *et al.*, 1996). This geographical region extends from Uruguay (34°40'S) to the region of Laguna (28°40'S), southern Brazil. In the northern portion of the CSAO, four fishing ports are well established: Laguna, SC (28º29'S, 48º46'W), Passo de Torres/Torres, RS (29º19'S, 49º43'W), Imbé/Tramandaí, RS (29º58'S, 50º07'W) and Rio Grande, RS (32º07'S, 52º06'W).

### Fishing ports for seahorses sampling

Between July 2011 and November 2012, 13 boats from the commercial fishing fleet of southern Brazil, 11 on the northern coast and two on the southern coast of Rio Grande do Sul were monitored. Three seahorse collection points were established (Fig. 1), where the fish are landed: port of Imbé/Tramandaí and port of Passo de Torres (gillnet fishing, northern coast of Rio Grande do Sul) and port of Rio Grande (pair trawling, southern coast of Rio Grande do Sul).

### The northern coast of Rio Grande do Sul

Eleven vessels of the gillnet fleet that operated at the ports of Imbé/Tramandaí and Passo de Torres between the coordinates 29º58'S, 50º07'W and 29º19'S, 49º43'W, respectively, were monitored (Fig. 1). During 2011 and 2012, 73 landings were scheduled for the collection of data on the incidental capture of seahorses, which involved six of the eleven vessels monitored (four in Passo de Torres and two in Imbé/Tramandaí). After completion of the scheduled landings, another 26 seahorses were received from a boat in the port of Imbé/Tramandaí. During landings, the following fishing parameters were recorded: type, length, and mesh size of nets, many times nets were cast, length of time at sea and depth of nets, vessel distance from shore and geographic coordinates, and target species in the fishery. Collected seahorses were stored in 90% alcohol.

### The southern coast of Rio Grande do Sul

Of the 28 vessels operating at the port of Rio Grande, only two were prepared to assist in the collection and storage of seahorses coming from bycatch. The boats were visited, and a container with 90% alcohol was delivered to each collaborator. Monthly, the material was collected and a new container delivered for the collection of the fish on the following trip, whose usual time at sea was between 15 and 20 days. The trawls were made from 32°S to 33°S, between Verga Beach, in Santa Vitória do Palmar-RS and Barra do Chuí, bordering Uruguay (Fig. 1). During sampling, the fishers also provided the following data: fishing type, net length, net mesh size, fishing duration, depth and distance from the coast of the trawl, geographical coordinates and species targeted in the fishery.

### Data collection and analysis

The seahorses were identified according to Lourie *et al.* (2004), Piacentino & Luzzatto (2004) and Silveira *et al.* (2014). The absolute frequency of each species, height (Ht, linear measure from the top of the head to the tip of the stretched tail) and the fishing effort, measured in individuals per cast (ind $cast^{-1}$) and per hour (ind $h^{-1}$), were recorded. All materials were processed in the laboratory, where males and females were counted according to height class. The criterion for distinguishing males and females was through the macroscopic evaluation of the gonads.

For each fishery information resulting from the ports of Passo de Torres, Imbé/Tramandaí and Rio Grande, the mean and standard deviation were calculated. The comparison between means was made using the Wilcoxon test with a significance level of 5%. The difference between the catch percentages resulting from the ports of Passo de Torres and Imbé/Tramandaí was compared using the binomial test.

## RESULTS

### Seahorses landed at the port of Passo de Torres

Of the nine vessels monitored through scheduled landings, four caught seahorses incidentally (Annex 1). The fishing area extended from Arroio do Silva in Santa Catarina (29º01'83.45'S, 49º30'30.65'W) to Itapeva in Rio Grande do Sul (29º23'17.29"S, 49º71'0.68"W). We monitored 145 net casts were monitored, of which seven (4.8%) caught 20 seahorses incidentally, resulting in 0.138 ind $cast^{-1}$ or 0.017 ind $h^{-1}$ (Tabla 1).

In the gillnet fishery directed at kingcroaker (*Menticirrhus* spp.), flounder (*Paralichthys patagonicus*) and anchovy (*Pomatomus saltatrix*), 16, 3 and 1 seahorses were captured, respectively. Of these, 19 indi-

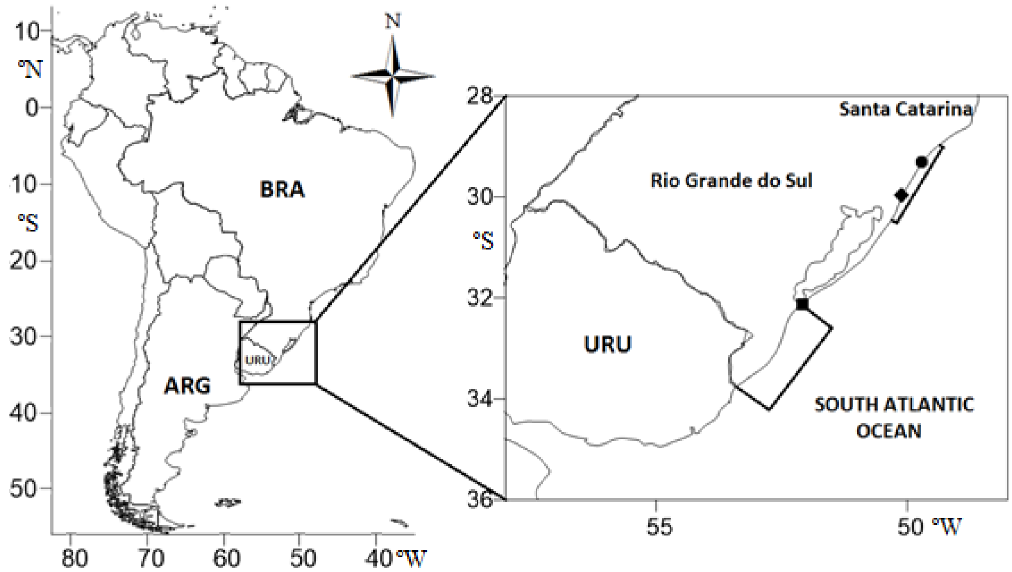


**Figure 1.** Selected ports for captured seahorse survey: ■ port of Rio Grande, ♦ port of Imbé/Tramandaí, ● port of Passo de Torres. ▬ Area of the Brazilian coast covered by the gillnet and trawl fleet where seahorses were captured (proximity to the coast, where the drawn line indicates the distance from the coast where fishing occurred).

**Table 1.** Fishing effort on resources landed at the port of Passo de Torres and the port of Imbé/Tramandaí.

| Scheduled landings | Passo de Torres | Imbé/Tramandaí | *P*-value |
|---|---|---|---|
| Total hours | 1140.8 | 708.5 | |
| Mean hours/cast | 7.867 | 14.459 | 0.0000 |
| Standard deviation | 10.01 | 6.34 | |
| Number of casts | 145 | 49 | |
| Number of casts that captured seahorses | 7 (4.8%) | 5 (10.2%) | 0.1768 |
| Number of captured seahorses | 20 | 5 | |
| Seahorses/cast | 0.138 | 0.102 | |
| Seahorses/hour | 0.017 | 0.007 | 0.1875 |

viduals were of the species *H. patagonicus* and one *H. erectus*. Individuals between 32 and 105 mm in height represented *H. patagonicus*, whereas the only *H. erectus* was 64 mm in height.

The meshes of the nets involved in the fisheries ranged from 70 to 220 mm between opposite knots, with the 70 mm mesh size being responsible for catching a higher number of seahorses (16 of the 20 specimens collected). The length and height of the net in which the individuals were collected ranged from 700 to 11,000 m and 1.8 to 2.5 m, respectively, and the fishing type was bottom-set gillnets.

The presence of a seahorse was recorded in a surface net in anchovy fishing, 3,700 m long and 16 m high, which remained only two hours in the water. The other nets were anchored for 25.67 ± 16.21 h, at a depth of 5.75 ± 4.03 m (Annex 1). The casts that caught seahorses (4.8%) did so at a distance of 1.35 ± 0.48 nm from the coast (Annex 1).

**Seahorses landed at the port of Imbé/Tramandaí**

At the port of Imbé/Tramandaí, seahorses were captured in five of the 49 net casts in the scheduled landings (10.2%), resulting in a catch of 0.102 ind cast$^{-1}$ or 0.007 ind h$^{-1}$ (Annex 1). After the completion of the collections made in scheduled landings, 20 seahorses were obtained from a boat that was willing to continue collaborating, but in this case, little information was obtained on seahorse bycatch (Annex 1). All seahorses caught incidentally were identified as *H. patagonicus*, except for one specimen of *H. reidi*. The species *H. patagonicus* was represented by individuals between 33 and 100 mm, whereas the only *H. reidi* measured 90 mm in height.

Catches occurred at approximately 1.73 nm from the coast, where the depth was 20.2 ± 4.9 m. Most of the specimens captured in the scheduled landings. Twenty-one out of 25 individuals were in the kingcroaker (*Menticirrhus* spp.) net, three in the hake

(*Urophycis brasiliensis*) net and one in the flounder (*Paralichthys patagonicus*) net.

There was no significant difference between the fishing parameters and quantity of seahorses caught incidentally and landed at the ports of Passo de Torres and Imbé/Tramandaí (Table 2).

The females landed in northern Rio Grande do Sul had a mean height of 4.93 ± 1.83 cm, while males were 4.47 ± 1.52 cm. The relative frequency by height classes shows that in this fishery (gillnet), juveniles as small as 3.1 cm were caught (Fig. 2). In total, for northern coast (port of Passo de Torres + port of Imbé/Tramandaí), the estimated capture was 0.68 ± 0.97 seahorses/month/vessel. Annually, considering the regular fishing of the 11 boats involved in the study, an average of 89.76 seahorses would be removed from the sea.

### Seahorses landed at the port of Rio Grande

The vessels that carried out trawl fishing had as target catch the croaker (*Umbrina canosai*), whitemouth croaker (*Micropogonias furnieri*), weakfish and seatrout (*Cynoscion* spp.). For six months, 298 seahorses were collected, but the number of casts involved in this catch was unknown, so we only recorded a mean catch of 49.66 ± 64.85 ind month$^{-1}$ (Annex 2). In total, for SC (port of Rio Grande) the estimated capture was 595.9 seahorse/year/vessel; considering the 28 vessels that make up the pair fleet (a net for two vessels), it is estimated that 8,342 seahorses are removed annually as bycatch, only in this mode of fishing (other fishing modes also include other types of trawling). All seahorses were identified as *H. patagonicus* with height ranging from 22 to 130 mm. The nets involved in the fisheries were 9 to 14 mm between opposite knots and were between 27 and 46 m in length. The duration of the trawls was 2.58 ± 0.20 h and the depth was 36.50 ± 14.32 m, while the distance from the coast was 36.17 ± 26.15 nm. The females landed in southern Rio Grande do Sul showed a mean height of 5.87 ± 2.95 cm, while males 5.70 ± 2.62 cm. The relative frequency by height class showed that in this fishery (trawling), juveniles as small as 2.5 cm were caught (Fig. 2). There was a significant difference in the distance from the coast ($P$ = 0.0014) and the depth ($P$ = 0.0209) for the fish landed at the ports of Passo de Torres and Imbé/Tramandaí (NC) and Rio Grande (SC).

## DISCUSSION

In the scheduled landings of the gillnet fishing on the northern coast, where the catch was landed at the port of Passo de Torres, seahorses caught amounted to 0.138 ind cast$^{-1}$, similar to that landing port of Imbé/ Tramandaí (0.102 ind cast$^{-1}$). However, in Passo de Torres, there were 145 casts of which 4.8% were positive for the presence of seahorses, while at Imbé/ Tramanda with only 49 casts, 10.2% turned out to be positive for the presence of seahorses, this could suggest a higher catch of these fish in the Imbé region. Nevertheless, when we measured catch effort in hours,

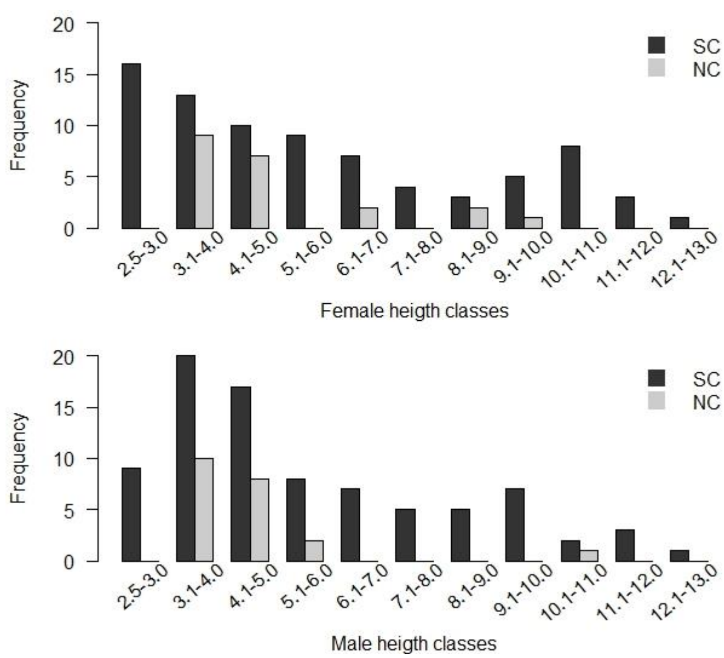


**Figure 2.** Relative frequency by height class of males and females in the southern coast (SC) and northern coast (NC) of Rio Grande do Sul.

**Table 2.** Comparison of fishing parameters related to the casts that captured seahorses on the northern coast of Rio Grande do Sul. †Does do not include seahorses caught after completion of scheduled landings. SD: standard deviation.

| Variable | Imbé/Tramandaí | Passo de Torres | *P*-value |
|---|---|---|---|
| | Mean ± SD | Mean ± SD | |
| Dist. coast (nm) | 1.73 ± 0.99 | 1.35 ± 0.48 | 0.8340 |
| Net length (m) | 3460.00 ± 1680.18 | 6900.00 ± 4460.94 | 0.3142 |
| Net mesh (cm) | 8.60 ± 1.52 | 12.00 ± 7.75 | 0.9203 |
| Net height (m) | 2.22 ± 0.38 | 2.03 ± 0.36 | 0.4606 |
| Net in water (h) | 18.40 ± 1.67 | 25.67 ± 16.21 | 0.2110 |
| Depth (m) | 20.20 ± 4.87 | 15.75 ± 4.03 | 0.2643 |
| Seahorse/Cast† | 1.00 ± 0.00 | 3.17 ± 3.06 | 0.1041 |
| Seahorse/Hour | 0.05 ± 0.01 | 0.18 ± 0.16 | 0.9264 |

we found 0.007 ind $h^{-1}$ at Imbé/Tramandaí and 0.017 ind $h^{-1}$ at Passo de Torres, where the results were similar in terms of bycatch percentage ($P = 0.1795$) and rate ($P = 0.1875$). When we considered all the catches landed at the port of Imbé/Tramandaí (adding the seahorses received after the completion of the scheduled landings), we had a mean of 0.112 ± 0.106 ind $h^{-1}$ or 2.27 ± 2.57 ind $cast^{-1}$. On the coast of Belgium, Pinnegar *et al.* (2008) reported the capture of 120 *H. hippocampus* seahorses in gillnet fishing with five casts over six months, resulting in 24 ind $cast^{-1}$.

There was no significant difference between the sites on the northern coast. Although the nets that caught seahorses stayed in the water for a shorter mean time at Imbé/Tramandaí (19.27 ± 4.17 h), at similar depths and distances from the coast (Passo de Torres with a depth of 5 to 14 m, and distance of 1.35 nm; Imbé with a depth of 11 to 25 m and distance of 1.73 nm), compared to Passo de Torres (25.67 ± 16.21 h, Table 2). In Belgium, casts that "entangled" 120 seahorses were approximately 6 nm off the coast, while other casts at 3 and 5.6 nm captured 1 and 12 seahorses, respectively. In Brazil, seahorse catch recorded the farthest from the coast was in Pará, 570 km or 307 nm, and the specimen (*H. reidi*) was deposited at the Harvard Museum of Comparative Zoology, under N°MCZ168387 (Silveira, 2011). At the port of Rio Grande, the trawlers that landed had operated at a mean distance from the coast of 36.167 ± 26.147 nm The depth of capture was 36.5 ± 14.32 m and this practice removed 298 specimens of *H. patagonicus* from the ocean in approximately 120 days. Baum *et al.* (2003) estimated the removal of 72,000 *H. erectus* seahorses by bycatch in trawling at Hernando Beach, Florida. The catches were between 6 and 13 nm from the coast in shallow waters, with depths ranging from 1 to 6.4 m (3.76 ± 0.87 m); for 50 nights, the nets were cast and dragged for 5.8 ± 0.23 h (8-9 nets per night), resulting in 916 *H. erectus* caught by 95 night vessels. Half of the nets caught *H. erectus*, which had a standard length (SL) ranging from 41.4 to 202 mm, and there were only two *H. zosterae* caught and no catch of *H. reidi* (the three species occurring in the United States). In this work, in pair trawl fishing, 100% of the seahorses landed at The port of Rio Grande were *H. patagonicus*, while in gillnet fishing (ports of Passo de Torres and Imbé/Tramandaí), one *H. reidi* and one *H. erectus* were caught, while the rest were *H. patagonicus*, where the height varied between 22 and 130 mm. The analysis of seahorses by height classes showed that the smallest fish caught (2.5-3.0 cm) occurred only in trawling, suggesting that, at this stage of life, *H. patagonicus* shows a benthic behavior, with no further vertical exploration of the environment. The next height class (3.1-4.0 cm) was recorded in both fisheries, and up to 13.0 cm, all height classes were represented in the trawl, with few classes represented in the gillnet (Fig. 2).

According to Filiz & Taskavak (2012), fishers claimed that they encountered seahorses at depths of 1 to 100 m, but usually catching them between 15 and 25 m, and the seahorses were caught as bycatch in gillnets and trawl nets, from 1 to 100 seahorses per season per fisher. They are used in traditional medicine, sold as dry souvenirs and are also commercially exploited in observation diving. In Brazil, seahorses are found at the water surface down to depths of 50 m, and fishers state that incidental capture frequently occurs from Piauí to Paraná (Rosa *et al.*, 2005; Silveira, 2011). At Sakthikulangara, Gulf of Mannar, India, 561,418 seahorses of *H. borbonienses* and *H. trimaculatus* were caught as bycatch in 2001, while resource-directed fisheries extracted 1,368,569 animals (Salin *et al.*, 2005). At Canal de Santa Cruz, Pernambuco, Brazil, 452 *H. reidi* specimens were captured as bycatch in only 52 days, an observation made only with mangote fishing (small trawl net with 8 to 10 mm mesh, handled manually) and in the daytime, without considering nighttime fishing (Silveira, 2011). Recent data from this fishery estimate the capture of more than 49,000 seahorses per year (Silveira, *unpubl. data*).

Foster & Vincent (2010) and Foster & Arreguín-Sánchez (2014) showed the great difficulty of minimizing the impacts of shrimp trawling because the bycatch is extremely diversified in species and length classes, requiring specific spatial and temporal management measures. They emphasized that such measures should contemplate the divergent patterns of distribution and the importance of variables such as areas of concentration and seasons of the year.

The trawl fishing on the southern coast of Rio Grande do Sul that captured the most seahorses was that targeting croaker (*Umbrina* spp.), whitecroaker (*Micropogonias furnieri*), sea trout (*Cynoscion* spp.) and hake (*Merluccius* spp.). On the northern coast of Rio Grande do Sul, and on the southern coast of Santa Catarina, in gillnets, kingcroaker (*Menticirrhus* spp.), sole (*Paralichthys patagonicus*) and anchovy (*Pomatomus saltatrix*) were the target species, whose fishing incidentally removed seahorses from the sea. Several of these fish are also described as bycatch in shrimp trawling, Rosa *et al.* (2011) described the dried seahorse trade of animals originating from trawl fishing of shrimp and of the fishes *Micropogonias furnieri*, *Lophius gastrophysus* and *Mullus argentinae* in the south and southeast regions of Brazil and lobster nets in northeast Brazil. Paiva-Filho & Schmiegelow (1986) reported that around Baia de Santos, São Paulo, the ten most abundant fish species in the trawl fishing of seabob shrimp *Xiphopenaeus kroyeri* include whitemouth croaker and king weakfish (*Macrodon ancylodon*), and the biomass ratio of shrimp to fish ranged from 1:1.08 to 1:47.5. These and other species constitute the portion of the bycatch that is sold, just like seahorses. According to Foster & Vincent (2004), more than 95% of seahorses present in international trade come from bycatch. Jardim *et al.* (2012) reported the capture of *H. hippocampus*, *H. fuscus* and *H. guttulatus* in pair trawling. Filiz & Taskavak (2012) observed *H. hippocampus* and *H. ramulosus* (synonym of *H. guttulatus*) in the bycatch of trawl fishing in Turkey, where many fishers have reported throwing the caught seahorses back into the sea because they found them beautiful and of no commercial value. In Turkey, the government prohibits fishing for *H. hippocampus*, but since fishers do not know how to differentiate species, the law is ineffective.

In Brazil, it is estimated that for every kilogram of shrimp caught by trawlers, 8.9 kg of bycatch are produced, and only 10% of this is used. The total catch of trawlers, shrimp, and others, is estimated to be 842,150 ton annually (with 57.9% bycatch, or 487,450 ton (Davies *et al.*, 2009)). Vianna & Almeida (2005) estimated that for each kilogram of shrimp caught, there is 10.5 kg of bycatch of bony fish, with *H. erectus* and *Syngnathus folletti* being caught in trawling for the sea shrimp *Farfantepnaeus brasiliensis* and *F. paulensis*.

The capture of *H. patagonicus* in the extreme south of Brazil (Barra do Chuí), and its distribution in Argentina (Piacentino & Luzzatto, 2004; Luzzatto *et al.*, 2012), suggests that the species may inhabit in Uruguay since there are no barriers to prevent its dispersion between Argentina and Brazil. A fact observed by Luzzatto *et al.* (2014) that cites the capture of a specimen of *H. patagonicus* in Uruguayan waters. The cold current of the Malvinas is responsible for the dispersal of several marine organisms from the region of Patagonia, although the northern limit of its influence is unknown. Five hundred and forty species of fish are recorded in the temperate portion of the Atlantic coast *versus* 1300 species in the tropical region (Miloslavich *et al.*, 2011). The reef species, especially, have their southern limit in the western south Atlantic at 28°S, corresponding to Santa Catarina (Floeter *et al.*, 2001; Kulbicki *et al.*, 2013). Anderson *et al.* (2015) observed species with a distribution limit down to Santa Catarina, and others, whose distribution extended to Uruguay and Argentina. Ferreira *et al.* (2004) reported that carnivorous fish (such as seahorses) extend their occurrence to higher latitudes and are not limited by the thermal gradient as in the case of herbivorous fish, which have lower densities in temperate waters throughout the world (Floeter *et al.*, 2004). As streams disperse larvae and juveniles, the duration of the planktonic stage of the species will determine its greater or lesser dispersal period and consequent extension to new and more distant colonization areas (Floeter & Gasparini, 2000). Seahorses have limited swimming capacity and presumably low dispersal capacity, but their distribution is broad, which refers to a greater dispersion capacity mediated by rafting on macroalgae and other objects (Woodall *et al.*, 2009; Boehm *et al.*, 2013; Luzzatto *et al.*, 2013).

Although the circulation pattern is the primary factor in the distribution of fish larvae and juveniles, this distribution is indirectly affected by climate (Hidalgo *et al.*, 2012). Palácio (1982) observed that differences of 2°C could influence the geographic distribution of the thermophilic fish species towards the southern South Atlantic. In addition, the decrease in the number of species in that direction would be associated with the entrance of Sub-Antarctic water and physical disturbances occurring on the continental shelf due to the actions of these currents, whose flows greater than 1 m $s^{-1}$ produce disturbances that inhibit feeding functions and settlements of larvae and juveniles (Wood, 2001; Capítoli & Bemvenuti, 2004). Perhaps,


**Figure 3.** a) *Hippocampus patagonicus* alive, pulled by a gillnet in fishing along the northern coast of Rio Grande do Sul, b) *Hippocampus patagonicus* with the digestive tract everted by the pressure endured in the trawl net in fishing along the southern coast of Rio Grande do Sul.

the temperature factor is essential for the limited occurrence of *H. reidi* or *H. erectus* in the southern South Atlantic, as seen in this work. However, these species occur in the North Atlantic, on the east coast of the United States, at similar temperatures (Lourie *et al.*, 2004; Silveira *et al.*, 2014), suggesting that further studies on the occurrence, distribution, and ecology of seahorses are needed.

A large part of Uruguayan and Argentinean resources is shared with Brazil, and the commercial and artisanal fisheries carried out in the EEZs of these countries are directed at the target resources mentioned in this study. Over-exploitation of these resources is recognized in the three countries (FAO, 2014; Lorenzo, 2016), It is the only region where *H. patagonicus* occurs, and we highlighted the main fisheries responsible for seahorse removal from the environment (Luzzatto *et al.*, 2012; Silveira *et al.*, 2014).

Our limited knowledge of *H. patagonicus* biology and distribution, together with a poor understanding of the causes explaining its presence in large numbers in the bycatch of trawling and gillnet fishing, hamper the species' conservation. Nevertheless, we observed that trawling swiftly increases the number of captured seahorses and causes considerable damage to the animals and the environment. It was common to find seahorses with part of the digestive tract everted by the pressure endured during the trawl (Fig. 3), or killed by asphyxiation. There are also exceptions where it is possible to rescue live animals. In gillnet fishing, for example, a seahorse may "naively" anchor its tail onto a mesh net several times larger than itself; when the net is drawn, the animal feels the movement and holds on strongly with its tail in the net, thereby getting caught (Fig. 3).

Rosa *et al.* (2011) also noted that in the interviews with fishermen they said that most of the specimens in the trawl nets looked dead, but some appeared to move when thrown on the deck. There is a great concern that goes beyond the decline in populations generated by bycatch, since the lifestyle of these animals (social structure, monogamy, a small area of occupation, low fecundity and habitat loss) before anthropic influences, makes them especially vulnerable (Vincent *et al.*, 2011). Since the resources present in the bycatch still do not have an alternative that can minimize these catches, we must take advantage of the material in the bycatch to obtain data about the life history of the species. With a better understanding of its bio-ecology, distribution, and association with the main target resources, we will have a broad vision for possible joint management of marine species. The ecosystem approach to fisheries, although not new in theory, is far from being at the desired level in practice, since stocks of many of our most commonly used marine resources are on the verge of collapse (Defeo *et al.*, 2009; FAO, 2013). Unsurprisingly, part of the fauna that emerges as bycatch, some with poorly described life histories, such as seahorses, are becoming increasingly threatened with extinction.

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**Annex 1.** Gillnet data on the northern coast of Rio Grande do Sul. †Seahorses received after the end of the scheduled landings and not considered with the average bottom gillnet. Location: RS, Rio Grande do Sul; SC, Santa Catarina.

| Date | Port | Vessel | Fishing gear | Distance of coast (nm) | Net | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Length (m) | Net (cm) | Height (m) | Anchored (h) |
| 15/07/2011 | Imbé/Tramandaí | A | Bottom gillnet | 0.95 | 4500 | 7 | 1.8 | 20 |
| 14/08/2011 | Imbé/Tramandaí | A | Bottom gillnet | 1.3 | 2500 | 10 | 2.5 | 18 |
| 29/09/2011 | Imbé/Tramandaí | B | Bottom gillnet | 1.6 | 1200 | 9 | 2.5 | 18 |
| 02/03/2012 | Imbé/Tramandaí | A | Bottom gillnet | 1.35 | 3600 | 7 | 1.8 | 16 |
| 09/03/2012 | Imbé/Tramandaí | A | Bottom gillnet | 3.46 | 5500 | 10 | 2.5 | 20 |
| 14/03/2012 | Imbé/Tramandaí † | A | Bottom gillnet | | | | | 27 |
| 26/04/2012 | Imbé/Tramandaí † | A | Bottom gillnet | | | | | 24 |
| 26/04/2012 | Imbé/Tramandaí † | A | Bottom gillnet | | | | | 24 |
| 11/05/2012 | Imbé/Tramandaí † | A | Bottom gillnet | | | | | 15 |
| 26/05/2012 | Imbé/Tramandaí † | A | Bottom gillnet | | | | | 15 |
| 27/05/2012 | Imbé/Tramandaí † | A | Bottom gillnet | | | | | 15 |
| Average | | | | 1.732 | 3460.00 | 8.600 | 2.220 | 18.400 |
| Standard deviation | | | | 0.993 | 1680.18 | 1.517 | 0.383 | 1.673 |
| 13/07/2011 | Passo de Torres | C | Bottom gillnet | 0.77 | 700 | 7 | 1,8 | 20 |
| 28/07/2011 | Passo de Torres | C | Bottom gillnet | 1 | 1800 | 7 | 1.8 | 20 |
| 17/10/2011 | Passo de Torres | D | Bottom gillnet | 2 | 8500 | 7 | 1.8 | 20 |
| 06/03/2012 | Passo de Torres | E | Bottom gillnet | 1.5 | 11000 | 7 | 1.8 | 4 |
| 11/03/2012 | Passo de Torres | E | Bottom gillnet | 1.5 | 9700 | 22 | 2.5 | 45 |
| 13/03/2012 | Passo de Torres | E | Bottom gillnet | | 9700 | 22 | 2.5 | 45 |
| 10/11/2011 | Passo de Torres † | F | Bottom gillnet | 7.12 | 3700 | 9 | 16 | 2 |
| Average | | | | 1.354 | 6900.00 | 12.000 | 2.033 | 25.667 |
| Standard deviation | | | | 0.481 | 4460.94 | 7.746 | 0.363 | 16.207 |

| Location | Initial | | Final | | Depth (m) | Target species | Seahorse /Cast | Seahorse (h) |
|---|---|---|---|---|---|---|---|---|
| | Longitude | Latitude | Longitude | Latitude | | | | |
| Tramandaí-RS | -29.9892 | -50.1070 | | | 14 | *Menticirrhus* spp. | 1 | 0.050 |
| Tramandaí- RS | -30.0040 | -50.0999 | -30.0245 | -50.1130 | 20 | *Cynoscion* spp. | 1 | 0.056 |
| Mostarda- RS | -30.1360 | -50.6742 | -30.5080 | -50.2010 | 25 | *Urophycis brasiliensis* | 1 | 0.056 |
| Tramandaí- RS | -29.9945 | -50.1006 | -30.0247 | -50.1145 | 17 | *Menticirrhus* spp. | 1 | 0.063 |
| Tramandaí- RS | -30.0365 | -50.0745 | | | 25 | *Urophycis brasiliensis* | 1 | 0.050 |
| | | | | | | *Paralichthys patagonicus* | 1 | 0.037 |
| | | | | | | *Menticirrhus* spp. | 9 | 0.375 |
| | | | | | | *Menticirrhus* spp. | 5 | 0.208 |
| | | | | | | *Menticirrhus* spp. | 1 | 0.067 |
| | | | | | | *Menticirrhus* spp. | 1 | 0.067 |
| | | | | | | *Urophycis* /*Menticirrhus* spp | 3 | 0.200 |
| Average | | | | | 20.200 | | 1.000 | 0.055 |
| Standard deviation | | | | | 4.868 | | 0.000 | 0.005 |

Continuation

| Location | Initial | | Final | | Depth (m) | Target species | Seahorse /Cast | Seahorse (h) |
|---|---|---|---|---|---|---|---|---|
| | Longitude | Latitude | Longitude | Latitude | | | | |
| Bella Torres - SC | -29.2931 | -49.6765 | -29.2854 | -49.6704 | 11 | *Menticirrhus* spp. | 6 | 0.300 |
| Rosa do Mar - SC | -29.2412 | -49.6214 | -29.2508 | -49.6351 | | *Menticirrhus* spp. | 8 | 0.400 |
| In front rio Mampituba | -29.3233 | -49.6734 | | | | *Menticirrhus* spp. | 1 | 0.050 |
| Bella Torres - SC | -29.2582 | -49.6329 | | | 18 | *Menticirrhus* spp. | 1 | 0.250 |
| SC to Itapeva - RS | -29.3128 | -49.6491 | -29.3882 | -49.7107 | 20 | *Paralichthys patagonicus* | 1 | 0.022 |
| Itapeva - RS | | | | | 14 | *Paralichthys patagonicus* | 2 | 0.044 |
| Arroio do Silva - SC | -29.0183 | -49.3031 | | | 25 | *Pomatomus saltatrix* | 1 | 0.500 |
| Average | | | | | 15.750 | | 3.167 | 0.178 |
| Standard deviation | | | | | 4.031 | | 3.061 | 0.160 |

**Annex 2**. Trawling data on the southern coast of Rio Grande do Sul.

| Date | Port | Vessel | Fishing gear | Dist. coast (nm) | Net | | | Size trawl (h) | Trawl $d^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Height (m) | Length (m) | Mesh (cm) | | |
| Oct/2011 | Rio Grande | A e B | Pair trawling | 15 | 3 | 27 | 14 | 2.5 | ? |
| Feb/2012 | Rio Grande | A e B | Pair trawling | 29.4 | 5 | 40 | 9 | 2.5 | ? |
| Mar/2012 | Rio Grande | A e B | Pair trawling | 78 | 5 | 40 | 10 | 2.5 | ? |
| Apr/2012 | Rio Grande | A e B | Pair trawling | 39.6 | 5 | 46 | 9 | 2.5 | ? |
| Aug/2012 | Rio Grande | A e B | Pair trawling | 5 | 3 | 27 | 14 | 3 | ? |
| Nov/2012 | Rio Grande | A e B | Pair trawling | 50 | 5 | 46 | 10 | 2.5 | ? |
| Average | | | | 36.167 | 4.333 | 38 | 11 | 2.583 | |
| Standard deviation | | | | 26.147 | 1.033 | 8.687 | 2.366 | 0.204 | |

| Location | Initial | | Final | | Depth (m) | Target species | Seahorses/ month |
|---|---|---|---|---|---|---|---|
| | Latitude | Longitude | Latitude | Longitude | | | |
| Rio Grande | | | -32.1009 | -51.466 | 35 | *Micropogonias furnieri*, *Umbrina* spp., *Cynoscion* spp. | 13 |
| Barra do Chuí | | | -33.4545 | -52.4749 | 30 | *Micropogonias furnieri*, *Umbrina* spp., *Cynoscion* spp. | 126 |
| Rio Grande to Barra do Chuí | -33.0002 | -51.5144 | -33.524 | -51.5451 | 57 | *Micropogonias furnieri*, *Umbrina* spp., *Cynoscion* spp. | 140 |
| Barra do Chuí | -32.582 | -51.5202 | -33.524 | -51.5451 | 43 | *Micropogonias furnieri*, *Umbrina* spp., *Cynoscion* spp. | 4 |
| Farol da Conceição to Barra de Rio Grande | -31.4525 | -51.2248 | -32.1421 | -52.0255 | 14 | *Micropogonias furnieri*, *Umbrina* spp., *Cynoscion* spp. | 13 |
| Barra do Chuí | | | -33.4423 | -52.2159 | 40 | *Micropogonias furnieri*, *Umbrina* spp., *Cynoscion* spp. | 2 |
| Average | | | | | 36.5 | | 49.667 |
| +Standard deviation | | | | | 14.321 | | 64.859 |