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The nuisance of medusae (Cnidaria, Medusozoa) to shrimp trawls in central part of southern Brazilian Bight, from the perspective of artisanal fishermen

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Abstract. Large aggregations of medusae hinder trawl fishing in coastal waters of several locations worldwide by clogging nets. In Paraná, scyphozoan medusae reach biomass peaks during springtime, when they saturate shrimp trawl nets. In order to assess possible disturbances to trawling caused by species of medusa, 48 fishermen who regularly use fishing trawls from 10 communities in the states of Paraná and Santa Catarina, southern Brazil, were interviewed. The general attitude of the respondents toward jellyfishes was found to be negative. Fishermen associated medusae, particularly the scyphomedusa *Lychnorhiza lucerna*, with net clogging. Two cubomedusa species, *Chiropsalmus quadrumamus* and *Tamoya haplonema*, and the hydromedusa *Olindias sambaquiensis* were singled out for the painful stings they cause. Large aggregations of medusae in fisheries shorten the duration of trawl hauls, displace hauls to areas further away from the landing ports and prompt fishermen to shift to other fishing gears such as anchored gillnet and drift net, amongst others. The fishermen hold a body of ethnobiological knowledge about jellyfish, such as the identification of toxic species and their seasonal occurrence, and have designed gimmicks to prevent medusae from entering the nets.

Key words: Bloom, shrimp, *Lychnorhiza lucerna; Olindias sambaquiensis;* jellyfish

Resumo. O entrave de medusas (Cnidaria, Medusozoa) aos arrastos de camarões na parte central do embaiamento sul do Brasil, pela perspectiva de pescadores artesanais. Ao entupirem redes de arrasto, grandes populações de macromedusas atrapalham a pesca de arrasto em águas costeiras de vários locais do mundo. No Paraná, as macromedusas Scyphozoa, quando atingem os picos de tamanho e biomassa durante a primavera, podem encher completamente redes de arrastos camaroeiros. Para verificar possíveis distúrbios gerados pelas espécies de medusas locais aos arrastos, 48 pescadores atuantes nessa arte de pesca foram entrevistados em 10 comunidades do litoral do Paraná e Santa Catarina. A visão geral dos entrevistados em relação às medusas é negativa. Os pescadores associaram principalmente a cifomedusa *Lychnorhiza lucerna* ao entupimento de redes. Duas espécies de cubomedusas (*Chiropsalmus quadrumamus* e *Tamoya haplonema*) e a hidromedusa *Olindias sambaquiensis* foram responsabilizadas por dolorosas queimaduras. Grandes agregações de medusas nos locais de pesca diminuem o tempo dos lances de arrastos, deslocam essas operações e causam a evasão para outras artes de pesca como o fundeio e o caceio. Os pescadores detêm um vasto conhecimento etnobiológico sobre as medusas, como o reconhecimento de espécies tóxicas, conhecimento sobre a sazonalidade das ocorrências e artifícios para evitar a entrada de medusas nas redes.

Palavras-chave: Floração, camarão sete-barbas, *Lychnorhiza lucerna; Olindias sambaquiensis;* zooplâncton gelatinoso

Introduction

The occurrence of medusa or jellyfish (Cnidaria, Medusozoa) in high densities is a common phenomenon in coastal waters around the world and, occasionally, these animals completely dominate the planktonic biomass (e.g. Pagès *et al.* 1996, Benovic & Lucic 2001, Mills 2001). Due to their large size and the accidents with toxic species, the presence of jellyfish on beaches and shallow coastal waters is readily noticed by the public perception (review in Purcell *et al.* 2001, Haddad Jr. 2002, Purcell *et al.* 2007, Neves *et al.* 2007).

Large medusa aggregations can interfere with fishing activities in two ways: 1) via food chain, either competing for food with commercial species (Ishi & Tanaka 2001, Purcell & Sturdvant 2001, Uye & Ueta 2004; Barz & Hirche 2005) or directly preying upon eggs and larvae of commercial fishing resources (review in Purcell & Arai 2001); 2) via clogging of nets, when large numbers of medusae are caught in a short period, causing stinging accidents (Guest 1959), damaging fishing gear (Brierley *et al.* 2001) and obstructing or displacing local fishing activities (Russell 1970, Brodeur *et al.* 2002, Uye & Ueta 2004; Kawahara *et al.* 2006a).

Over the last decades, disturbances of fishing operations caused by large medusae appear to be correlated with recent population increases (Brierley *et al.* 2001, Brodeur *et al.* 2002, Uye & Ueta 2004; Kawahara *et al.* 2006a) and/or with the introduction of exotic species (Mills, 2001; Galil and Zenetus 2002; Graham *et al.* 2003). Such disturbances may be much more frequent than reported in the literature, as remarked by Purcell *et al.* (2007).

In Brazil, Mianzan and Guerrero (2000) reported high biomass of the large hidrozoans *Olindias sambaquiensis* F. Müller, 1861 and *Rhacostoma atlantica* L. Agassiz, 1850, in Cabo de Santa Marta upwelling (28ºS), but quantitative data on scyphomedusae is yet to be published. It is known, however, that macromedusae such the Hydrozoa *O. sambaquiensis*, the Cubozoa *Chiropsalmus quadrumamus* (F. Müller, 1859) and the three Scyphozoa *Lychnorhiza lucerna* Haeckel, 1880, *Phyllorhiza punctata* von Lendenfeld, 1884 and *Chrysaora lactea* Eschscholtz, 1829 occur in large numbers in trawl nets, stranded on the beach or floating on the water surface (Vannucci, 1951; Silveira and Cornelius 2000, Morandini *et al.* 2005; Haddad and Nogueira, 2006; Nogueira and Haddad 2006).

On shallow waters (<20 m) of the South Brazilian Bight (SBB), small-scale shrimp trawls can be filled up with medusae and their biomass exceed that of all other animal groups (Graça-Lopes *et al.* 2002, Branco and Verani 2006). Recent investigations on the biology of medusae on the coast of Paraná, comprising more than eight years of monthly sampling, revealed that short ten-minute trawls could catch dozens of kilograms (Fig.1) of the scyphomedusa *L. lucerna*, mainly in springtime (Nogueira, Haddad and Nagata unpublished data). In the present study, face-to-face interviews with artisanal fishermen from 10 communities of Paraná and north of Santa Catarina were conducted in order to ascertain whether such high scyphomedusae biomass represents a nuisance to shrimp trawls. Only Uye & Ueta (2004) used the same method to report fishery losses caused by gelatinous plankton. Based on a fishermen poll, these authors analyzed the increase of *Aurelia aurita* populations in the Island Sea of Japan during the last 20 years.

Figure 1. Catch of a small-scale shrimp trawl haul of 15 minutes, with abundance of *Lychnorhiza lucerna* in Paraná coast, Brazil. Courtesy of Cláudio D. Natividade.

Despite increased attention given to medusa disturbances to fishing worldwide (e.g. Mills 2001, Kawahara *et al.* 2006a, Purcell *et al.* 2007) and the great abundance of jellyfish on the Brazilian coast, which can potentially interfere with fishing operations, no study has investigated the social and commercial impacts in Brazil. This paper also documents, for the first time, information on fishermen's ethnobiological knowledge concerning these gelatinous animals.

Material and Methods

Study Site. The continental shelf is well developed along the Southern Brazilian Bight (SBB), reaching 175 to 190 km width. Along the coastline of the States of Paraná and Santa Catarina, between the beaches of Pontal do Sul and Itapema do Norte – SC (Fig. 2), local fishermen target more than 70 species of fish and shellfish. The main fishing resource in the area, however, is the sea-bob shrimp *Xiphopenaeus kroyeri* Heller, 1862, caught primarily by bottom trawling carried out by small trawling vessels (Natividade *et al.* 2004). This practice is limited to ca. 20 km off shore, where depths are 6 meters in average. (Andriguetto-Filho *et al.* 2006).

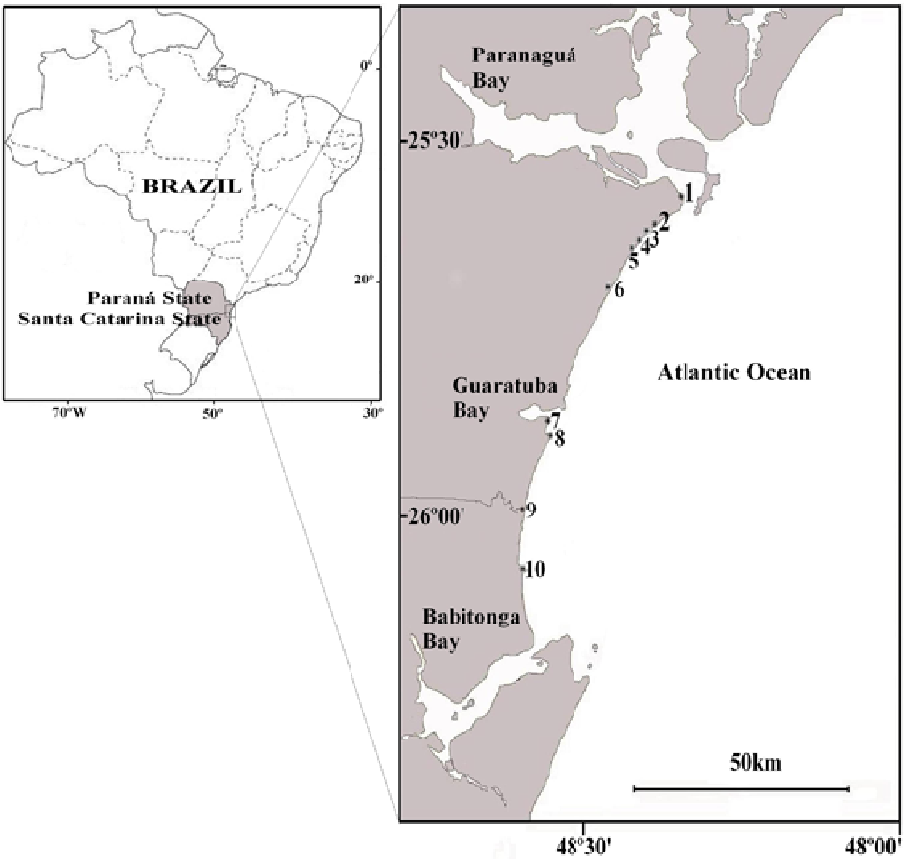

Figure 2. Site of interviewed fishing communities on Paraná and Santa Catarina states. 1- Pontal do Sul; 2 – Atami; 3– Barranco;4- Shangrilá; 5– Ipanema; 6– Praia de Leste; 7- Caieiras; 8- Brejatuba; 9- Barra do Saí; 10- Itapema do Norte.

Data Collection. Standardized questionnaires and open interviews (Table I) were given to 48 trawl fishermen active in 10 communities of Paraná and northern Santa Catarina (Fig. 2), over given periods from 2003 to 2004 and from 2006 to 2007. The following information was asked in the questionnaire: I) age of the fisherman; II) time of experience on fishing activities; III) whether trawling gear is used exclusively or not; IV) whether they report economic losses caused by jellyfish; V) whether large numbers of jellyfish cause an impediment to trawling; and VI) amount of time wasted when trawling results in massive jellyfish captures. When answers to the questionnaire suggested the presence of large medusae concentrations in the trawls, the following information was also gathered: A) references to jellyfish as a nuisance to trawls; B) reports of accidents caused by toxic species; and C) whether time of hauls was shortened in periods of large jellyfish abundance.

For the category of open interviews, 20 local expert fishermen, very experienced in the practice of trawl fishing, were recommended by researchers and members of the communities (Table I).

Formalin-fixed individuals of seven species of medusa frequently caught in trawl nets in the area (*Lychnorhiza lucerna, Phyllorhiza punctata, Chrysaora lactea, Chiropsalmus quadrumamus, Tamoya haplonema* F. Muller, 1859, *Olindias sambaquiensis* and *Rhacostoma atlantica,*) were displayed to the fishermen. After observing the material, the fishermen were asked the following questions about the various species: I) popular names and diagnostic characteristics; II) toxicity and treatments; III) seasonality, occurrence patterns and atypical occurrences; IV) biological aspects of medusae; and V) methods employed to prevent nuisance to trawl caused by large populations of medusae.

The data was analyzed according to the model of union of all individual competences. Every piece of information concerning the subject was taken into account, and a quali-quantitative treatment of the data was conducted (Marques 1991).

Table I. Number of fishermen interviewed on each fishing community from Paraná (PR) and north Santa Catarina (SC) coast.

Community sampled	***Standardized interviews***	***Opened interviews***
Pontal do Sul (PR)	8	4
Atami (PR)	2	1
Barranco (PR)	1	-
Shangrilá (PR)	7	6
Ipanema (PR)	1	-
Praia de Leste (PR)	7	1
Caieiras (PR)	5	2
Brejatuba (PR)	9	3
Barra do Saí (SC)	7	2
Itapema do Norte (SC)	1	1
Total	**48**	**20**

Results

Standardized interviews with trawl fishermen. Among the 48 interviewed fishermen, ages varied from 26 to 70 years (mean of 44, standard deviation of ± 12.98). Half of them had been in the fishing trade for more than 30 years and 22.9% made exclusive use of trawling gear.

Most fishermen (70.8%) claimed financial losses caused by high densities of medusae. A smaller percentage (29.17%) failed to correlate medusae with economic loss, but acknowledged time wasted and regarded the medusae as natural nuisances to the fishing activity (Table II).

Table II. Answers about the jellyfish effect on fishing, following interviews (n = 48) to fishermen.

Questions	**Yes**	**No**
Do jellyfish cause economic losses to trawlers?	70,83%	29,17%
Have you ever avoided fishing because of the large amount of jellyfish?	58,33%	41,67%
Have you ever hurried your return from a fishery because of the large number of jellyfish?	68,75%	31,25%

Among 34 respondents who claimed some economic loss, 73.5% reported a concomitant scarcity of shrimp in the same period (n=25) and 58.8% referred to extra fuel expenses to avoid medusae aggregations (n=20). Whenever a dramatic amount of large medusae was caught, 29.4% of the respondents (n=10) conveyed that they opened the cod-end, releasing all catches, including the shrimps. When the same 34 respondents were asked about what measures they took to mitigate the losses, 25% (n=8) answered none. Those who replied affirmatively (75%, n=26) said that they had changed their regular trawl activities to: I - fishing with gill nets (n=17); II - fishing at night, when the jellyfish move up to the surface (n=10); III - make use of gimmicks to reduce the amount of jellyfish during shrimp trawls (n=9); IV - explore other, more distant places such as Superagüi Island (n= 2).

There was marked similarity in the following reports from the respondents (n=48):

<u>I – Influence on trawling</u> – A view of medusae as pests, a cause of clogging of trawl nets, reduction in trawling time and time wasted.

<u>II - Accidents with toxic species</u> – All

fishermen reported frequent accidents that cause pain in the arms and trunk, making work extremely arduous.

III - By-catch – Medusae are more abundant in trawl nets than in other gears and can take up almost all the net space.

IV – Seasonal Occurrence – All respondents observed the seasonality of medusae and reported inter-annual fluctuations. They did not report any recent frequency increase in massive occurrences of medusae.

V – The duration of hauls - was significantly affected in periods of large amounts of medusae (Mann-Whitney, Z corrected = -8.47; $p < 0.001$; n=48), when shorter hauls were performed (Fig. 3).

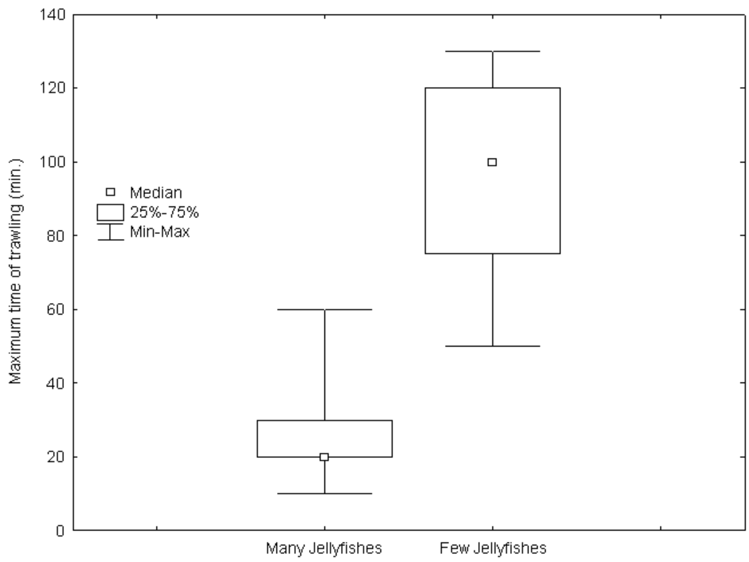

Figure 3. Maximum time of hauls performed by fishermen in periods of few medusae and in periods of many medusae (n=48).

Open interviews with local experts. Even though distinct names were not assigned to all species displayed, the fishermen showed familiarity with the jellyfish. The characteristics used to define the species and their respective popular names are summarized in Table III.

Table III. Popular names assigned by fishermen to the local large medusae and characteristics used for identification.

Species	*Common name*	*Characteristic according to interviews and frequency allocation of this feature. (n =20)*
Olindias sambaquiensis	água-viva relojinho	Yellow radial canals (20)
Chrysaora lactea	água-viva	-
Chiropsalmus quadrumanus	água-viva copo	Cuboid bell, palmate pedalium very toxic (5)
Lychnorhiza lucerna	água-viva, bolota, cabeça d'água	Hemispherical bell and cross-shaped stomach (11)
Tamoya haplonema	água-viva	Pedalium with a single long tentacle very toxic, called cords (11)
Rhacostoma atlantica	água-viva	Flat bell and consistent mesoglea (1)
Phyllorhiza punctata	água-viva	Brown hemispherical bell with white spots (8)

All species were referred to as “água-viva” (jellyfish). Other popular names such as medusa or “mãe d`água” were not mentioned. Only *O. sambaquiensis* was recognized by all respondents as “água-viva relojinho” (little watch jellyfish) or “relojinho”; however, five respondents also gave these same popular names to another species, *R. atlantica.* Some less careful fishermen confused Scyphozoa and Cubozoa species, simply assigning the name “água-viva” to them all, but such generalization was quite infrequent. *Phyllorhiza punctata* was pointed out as an unknown jellyfish until the years 2000-2001 by fishermen of Pontal do Sul, Caieiras and Brejatuba (n=11; 55%). The pedalia and tentacles of *C. quadrumanus* and *T. haplonema*, known as strings, were singled out as structures that cause painful stings by 5 and 11 respondents, respectively.

Knowledge concerning the toxicity of medusae to human skin was consistent with literature. Only three out of 20 respondents stated that all species cause stings, while the remaining associated toxicity with selected species only (Table IV).

Table IV. Trawl fishermen's knowledge on the toxicity of the species occurring in local trawls and a comparison with records in the literature (Haddad Jr. *et al*., 2002; Morandini *et al.* 2005).* Accidents according to the literature.

Species	*Number of fishermen who attributed stings to the species (N=20)*	*Toxicity for humans following literature*
*Olindias sambaquiensis**	20	High
Chrysaora lactea	3	Moderate
*Chiropsalmus quadrumanus**	9	High
Lychnorhiza lucerna	3	Low (only at oral arms filaments)
*Tamoya haplonema**	16	High
Rhacostoma atlantica	4	Low
Phyllorhiza punctata	3	Low

According to 90% of the respondents (n=18), the peak of large jellyfish abundance occurs in late winter to early summer (September to January). Due to the open character of the interviews, some informants reported four months of abundance, while others reported only one. In order to equalize the weight of the answers in the analysis, to each answers was attributed a weight of 1 (one), and this value was then divided by the total number of months mentioned in each interview. Thus, when only one month of high jellyfish concentrations was reported, a weight of 1 was attributed to this month; when two months were reported, the weight was 0.5; three months, mentioned, each one received 0.33; and four months, 0.25. Figure 4 shows the frequency of reports for each month of large abundance of medusae, as informed by the interviewers.

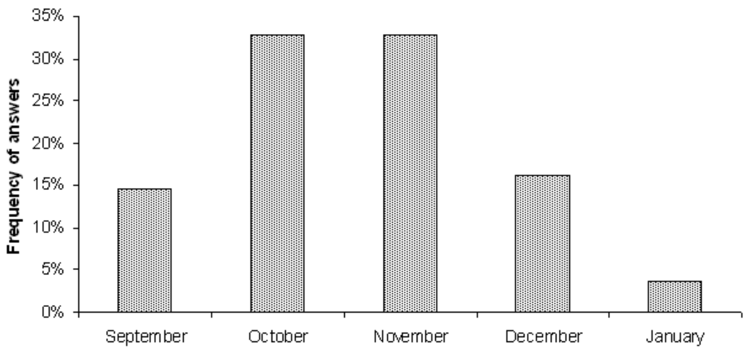

Figure 4. Periods of greater abundance of jellyfish, as the open interviews (N=18).

Throughout the open interviews, consensual biological knowledge emerged spontaneously from the accounts of various informants, highlighting their knowledge about interactions between medusae and fishing:

(1) Medusae concentrate on the surface during the night and in the bottom during the day (N=14; 70%). According to the respondents, even though large numbers of medusae can be seen on the water surface at night, they are either rare or absent in night trawls.

(2) Use of the crab *Ocypode quadrata* Fabricius 1787 (the Atlantic ghost crab, popularly known as "guaruçá" or "maria farinha", flour mary) in the treatment of stings (N=14; 70%). The respondents reported the application of a macerate of this crab over the sting to relieve pain, especially in accidents involving children and sea bathers. Some of them stated that it is an effective medicine and they have made use of it in many occasions. This information was given by fishermen of all communities and also by local residents not involved in fishing activities.

(3) Use of gimmicks in the trawl nets to reduce the catch of medusae was reported by 55% of the respondents (N=11). In order to avoid hauling

medusae, three types of modifications in the trawl nets were suggested, all of them reducing the vertical opening of the trawl to force the catch to concentrate in the bottom. They are: I – remove floats from the upper panel of the trawl (reported in Atami and Shangrilá); II - remove floats from the upper panel and set weights (reported in Pontal do Sul and Itapema do Norte); III – tie a rope between the upper and lower panels, restricting the opening of the mouth (reported in Shangrilá, Brejatuba and Barra do Saí).

Discussion

Standardized interviews with trawl fishermen. Some authors have briefly documented the presence of high concentrations of medusa in trawl catches in Brazil (Vannucci, 1954; Graça-Lopes *et al.* 2002), but knowledge about the dynamics of small-vessel trawls is still more restricted in the area studied. Consequently, several aspects addressed in this paper had not been mentioned in previous contributions (Andriguetto-Filho 2003; Chaves *et al.*, 2002; Chaves and Robert 2003; Robert and Chaves, 2006; Andriguetto-Filho *et al.* 2006).

Few respondents use trawling exclusively. Alternative fishing gear can be important in periods of large jellyfish aggregations, as for example set-nets, which are not compromised by asggregarions. However, in the Sea of Japan, set-nets failed to avoid medusa nuisance (Kawahara *et al.* 2006a). Medusae reduce the amount of time spent on trawl fishing, as they either make fishermen return sooner (68.75%), or discourage their activity (58.3%) altogether. A behavioral model for the fishing daily routine of factory trawlers in the west coast of North America was described by Dorn (2001), who pointed out some hierarchical levels of decisions-making such as: 1) go out fishing or not; 2) select a patch or fishing ground on which to operate. As detected during the interviews, these decisions are also relevant to the fishing dynamics of the communities studied in this research. When jellyfish are in high concentrations, trawlers either avoid fishing altogether (58.3%) or target other fishing resources by using gillnets (35.4%).

Scyphomedusa blooms also disrupt fisheries, such as those of *Nemopilonema nomurai* (Kishinouye 1922) in the Sea of Japan (Kawahara *et al.* 2006a) and *Rhopilema nomadica* Galil, Spanier, and Ferguson, 1990, in the Mediterranean Sea (Galil and Zenetus 2002). Some examples of the direct impact of medusae on trawling fisheries worldwide are summarized in Table V. Colonies of the bryozoan *Membraniporopsis tubigera* (Osburn, 1940) have been clogging trawl nets in southern Brazil (Gordon *et al.* 2006), apparently, in a similar manner to medusae.

Dorn (2001) remarks that a trawl fisherman controls fuel expenditure by minimizing his transits between fishing locations. This behavior is equivalent to that of a predator foraging in his territory. During the interviews, fishermen reported that they can avoid hauling over medusa aggregations by communicating with each other by radio or visually, tracing the outline of a medusa umbrella with hand gestures. In addition, they tend to trawl at different depths to escape the aggregations. This locomotion between fishing grounds may result in waste of time and fuel.

In the opinion of the respondents, the obliteration of trawl nets by medusae is noticeable in the power boost needed for pull of the boat. Also the net tends to float, failing to catch the shrimp as a demersal species, and the clogging causes a layer of water in the front of the mouth, which precludes the catching of other organisms. Consequently, hauls are compromised by the reduction in trawling time, similarly to what was observed by Kraeuter and Setzler (1975) in the estuaries of Georgia. Along the coast of Paraná, large catches of *L. lucerna* (>100kg) during 10 to 20 minute trawls either result in a major waste of time sorting out the catch, or end up with the entire volume of the trawl being discharged. *L. lucerna* causes fishing troubles also in the northern coast of Argentina, in summertime (Schiariti *et al.* 2008).

Open interviews with local experts. Fishermen's knowledge about the toxicity of different species of medusa was consistent with scientific literature. In the Brazilian coast, the medusae responsible for the most painful envenomations, two cubozoan and the hydrozoan *O. sambaquiensis*, are the only species recorded in accidents with bathers by Haddad Jr. *et al.* (2002). Guest (1959), for instance, mentions that *C. quadrumanus* was a painful obstacle to fishermen of Matagorda Bay in Texas in some years where blooms occur. *O. sambaquiensis* is regarded as a nuisance to tourism in some regions of Argentina (Mianzan and Zamponi, 1988).

Table V. Published reports of cnidarian jellyfish interfering with trawling operations around the world.

Species/Class	Local	Year (months)	Nuisance to trawling	Source
	North America			
Chrysaora melanaster (Brandt, 1835) **Scyphozoa**	Bering Sea	1990-1999 (Jun-Sep)	- Clog fishing nets. - Fishing vessels shunned areas with high jellyfish biomass	Brodeur *et al.* (2002)
Chiropsalmus quadrumanus **Cubozoa**	Matagorda Bay (Texas, USA)	1955 and 1956 (Aug - Sep)	- Stings to fishermen.	Guest (1959)
Stomolophus meleagris (L. Agassiz 1862) **Scyphozoa**	Estuaries of Georgia - USA	1972 (Abr-May)	- Clog fishing nets. - Reduction of trawling time.	Kraueter & Setzler (1975)
Phyllorhiza punctata **Scyphozoa**	Gulf of México	2000 (May – Sep)	- Clog fishing nets. - Losses to comercial shrimp as high as US$ 10 million in 2000.	Graham *et al.*(2003)
	South America			
Lychnorhiza lucerna **Scyphozoa**	Southern Brazil coast	Sep-Nov	- Clog fishing nets. - Shorten the duration of trawl hauls. - Displacing these hauls to areas further away from the landing ports. - Fishermen temporarily shift the fishing gears to anchored gillnet and drift net.	Present work
L. lucerna	Northern Argentina coast	Dec-May	- Clog/Damage fishing nets. - Reduce total fishing captures and catch quality. - Prevent fishermen to operate.	Schiariti *et al.* (2008)
Olindias sambaquiensis **Hydrozoa**	Southern Brazil – Northern Argentina coast	Jul-Oct	- Clog fishing nets. - The author cite that shrimp move off shore from the aggregation of jellies. - Stings to fishermen.	Vannucci (1951) Present work
	Africa			
Chrysaora hysoscella Linne, 1766 **Scyphozoa**	Namibian Benguela	Aug.-Sep.	- Clog/Burst fishing nets. - Collapse of pilchard fishery.	Brierley *et al.* (2001)

Table V. Published reports of cnidarian jellyfish interfering with trawling operations around the world (continued).

Species⁄Class	Local	Year (months)	Nuisiance to trawling	Source
	Europe			
Periphylla periphylla (Perón & Lesueur, 1810) **Scyphozoa**	Lurefjorden Fjord , Norway	Late 1940´s , since 1973 (Oct-Nov and Apr-May)	- Clog fishing nets. - Impeding trawl operations in the period of high biomass.	Fossa (1992)
Aurelia sp. **Scyphozoa**	North Atlantic of U.K.	Abr-Aug	- Clog⁄Burst fishing nets. - Displace hals to other areas. - Cod-end is open due to the weight. - Fishermen think that fish move away from the aggregation	Russell (1970)
Rhizostoma octopus Vanhöffen 1906 **Scyphozoa**	Black Sea	No available date	- Clog fishing nets.	Netchaerff & Neu 1940 *apud* Russel (1970)
Rhopilema nomadica autor? **Scyphozoa**	Mediterranean coast of Israel	Since mid 1980´s (Jun-Sep)	- Clog fishing nets. - Impeding trawl operations in periods of high biomass.	Lotan *et al*. (1992) Galil & Zenetos (2002)
	Asia			
Crambionella orsini (Vanhöffen 1888) **Scyphozoa**	Gulf of Oman and Persian Gulf		- Decreased catches in artisanal and industrial fisheries. - Damage to fishing gear.	Daryanabard & Dawson (2008)
Cyanea capillata (Linnaeus, 1758) **Scyphozoa**	Yangtze Estuary, China	Since 2004 (May)	- Clog fishing nets.	Xian *et al.* (2005)
Aurelia sp. **Scyphozoa**	Seto inland Sea, Japan	Summer	- Clog⁄Burst fishing nets. - Declining catches of zooplanctivorous fishes. - Reducing catches quality. - Stings to fishermen. - Increased labor to remove medusae from the nets.	Uye & Ueta (2004) Uye & Shimauchi (2005)
Nemopilonema nomurai **Scyphozoa**	Along coast of Japan	2002 – 2006 (Aug-Dec)	- Clog⁄Burst fishing nets. - Lower catches of finfish. - High mortality of finfish by nematocyst venom, and lower commercial value. - Increased labor to remove medusae from the nets. - Higher risk of capsizing trawl boats - Stings to fishermen.	Kawahara *et al.* (2006)

Accidents with fishermen happen during sorting of the catch, when urticating substances are released from the nematocysts or when they inadvertently touch certain parts of the animal's body, especially the tentacles. Structures such as tentacles and pedalia of cubomedusae, especially of *T. haplonema*, called "strings", are avoided for their high toxicity, which is justifiable by the greater concentration of nematocysts on those structures (Arai, 1997). Fishermen interviewed in this study did not associate the abundant *L. lucerna* with stings, eruptions or pain symptoms, although its oral arms filaments, when healthy, can cause little pain to hand human skin (Haddad personal observation). The absence of tentacles in Rhizostomeae scyphozoan medusae, like *L. lucerna*, generally results in reduced stings. However, three species of this same group, *Rhopilema hispidum*, *R. esculentum* and *Nemopilema nomurai*, highly exploited for human consumption as a delicacy in China, Japan and other Asian countries, have been attributed to accidents by fishermen in Japan (Kawahara *et al.* 2006b). Nematocyst toxins may diminish the market value or even preclude the commerce of exploitable species (Kawahara *et al.* 2006a; Purcell *et al.* 2007).

The seasonality in the life cycle of large medusae is a widely known phenomenon (Russell 1970; Arai 1997) and empiric observations along decades of trawl fishing provided the respondents with knowledge about the temporal fluctuation in medusa biomass. The months of large medusa biomass peaks indicated by the fishermen (Fig. 4) are the same cited in the literature of great abundance of the scyphomedusa *L. lucerna* (Silveira and Cornelius 2000; Morandini 2003; Nogueira and Haddad, unpublished data). This observation suggests that trawlers are aware not only of the periodicity of their target resources, but also of the other conspicuous elements of fishery. Although the bathymetric distribution of *L. lucerna* is not known, aggregations of this species possibly overlap with the occurrence zone of the shrimp *X. kroyeri*, which is limited to a maximum depth of 20 m (Andriguetto Filho *et al.* 2006).

As revealed by the fishery experts, the use of a macerate made with the crab *Ocypode quadrata* is a form of treatment against stings commonly practiced by the communities in the coast of Paraná. Fishermen from Cananéia and Guarujá, southern coast of São Paulo, make a similar use of it (Sérgio Stampar, personal communication). There is no mention of such treatment for cnidarian's stings in the literature. However, an adequate treatment can be conducted with a cold compress of saltwater or cold packs, and intramuscularly dipirona for pain control (Haddad Jr. *et al.* 2002).

Diel vertical migration (DVM) is documented for the great majority of zooplankton taxa, including medusae (Youngblouth and Blanstedt, 2001; Hays 2003; Sparks *et al.*, 2005). Common migration patterns usually involve individuals staying in deeper regions of the water column during the day and moving closer to the water surface at night. This behavior was reported for the medusae by 70% of the respondents and 30% of them pointed out that the ascent to the surface would be favorable for trawling during the night. The species that display such behavior were not distinguished in the interviews. In the area studied, large medusae aggregations have not been recorded on the water surface, at least during the day, with the exception of the zooxanthellate *P. punctata* (Haddad and Nogueira, 2006).

All modifications in the trawl nets, believed to reduce the intake of jellyfish, are based on the fishermen's perspective about the position of the animals in the water column. According to them, the shrimp *X. kroyeri* is a demersal species, while medusae would be found in mid-water. Thus, upon restricting the vertical opening of the trawl net – by removing the floats, placing weights or bringing the upper and lower panels close together with ropes – fewer medusas would be caught and the shrimp catch would not be affected. Contrary to the respondents' perception of medusae occurring in the mid-water position, acoustic surveys in Rio de la Plata estuary demonstrated aggregates of *L. lucerna* close to the bottom (Alvarez-Colombo *et al.* 2003). Along the coasts of Paraná and north of Santa Catarina, several trawl nets operating without floats have been observed, but other modifications have not. Jellyfish-exclusion devices of the "blubber-chute" type (Broadhurst and Kennelly 1996) or Jellyfish Excluder for Towed Fishing Gear "JET" (Matsushita and Honda 2006) have been developed in Australia and Japan. Such devices, set inside the trawl net, filter away larger organisms, excluding them through an exit window in the back of the net.

Many reports on trawl net clogging concern introduced medusae (Galil *et al.* 1990; Graham *et al.* 2003), a fact not observed in this study. The scyphomedusa *P. punctata* reappeared in the coast of Paraná in 2001, occurring in great abundance during summer and early autumn (Haddad and Nogueira 2006). The respondents noticed the appearance of this species, previously unknown to them (55%), but stated that it does not interfere with local trawls, because this scyphomedusa is more often encountered on the superficial layer of water (Haddad and Nogueira 2006).

Large Scyphozoa medusae (around 18 species, mainly in the Order Rhizostomeae) are a culinary delicacy in Southeast Asia, and over a thousand of years they have been locally exploited (Omori & Nakano, 2001, Schiariti 2008). The jellyfish market is steadily increased, particularly in Japan, Taiwan, South Korea, Indonesia, Malaysia and China. Commercial catches have increased since the 1970´s and regularly exceed 300 000 tons⁄year in wet weight (Omori and Nakano 2001). Medusae are fished in many places and countries of Southeast Asia, like Philippines, Vietnam, Malaysia, Thailand, Indonesia, Singapore and Myanmar and, more recently, small-scale exploitation has begun in Australia, India, Mexico, Turkey and the United States (Hsieh *et al.* 2001). By adding value to jelly discards, important benefits to fisheries and environment may be created. A trawl-clogger, *Stomolophus meleagris* (L. Agassiz 1862) in the coastal waters of U. S. A. is a successful commercial example (Kraueter and Setzler, 1975, Hsieh, 2001). Recent investigations on the development of jellyfish fisheries in the north of Argentina revealed that the costs involved in harvesting and processing *L. lucerna* are relatively low (Schiariti, 2008). The seasonal high biomass of this medusa in the south of Brazil and north of Argentina, the world requirements to attenuate pressure on individual fishing stocks and the increasing demand for this kind of food products points *L. lucerna* as a potential new resource to future sustainable exploration.

According to the results obtained by this study, the scyphomedusa *L. lucerna* is responsible for clogging trawl nets in the coast of Paraná due to its large spring biomass, causing a variety of disturbances to the routine of that fishing gear. The hydromedusa *O. sambaquiensis* and the cubomedusae *T. haplonema* and *C. quadrumamus* are the main species responsible for accidents with fishermen. The records of local knowledge on large medusae prompt other studies to evaluate the effectiveness of modifications in trawl nets suggested by fishermen to exclude medusae. One of the most valorous conclusions of this research, however, is that fishermen seem to possess ethnobiological knowledge that highlights the importance of welcoming their participation in integrated coastal management plans.

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