New records of parasitic copepods (Crustacea, Copepoda) from marine fishes in the Argentinean Sea

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Abstract
Increasing knowledge of the biodiversity of parasitic copepods in the Argentinean Sea will provide a baseline against which changes in the distribution of marine biota can be detected. We provide new information on the distribution of 13 known species of parasitic copepods gathered from 11 species of marine fishes from Argentinean Sea, including 7 new host records and 9 new locality records. These species are: Bomolochus globiceps (Vervoort et Ramírez, 1968) and Nothobomolochus cresseyi Timi et Sardella, 1997 (Bomolochidae Sumpf, 1871); Brasilochondria riograndensis Thatcher et Pereira, 2004 (Chondracanthidae Milne Edwards, 1840); Taeniacanthus lagocephali Pearse, 1952 (Taeniacanthidae Wilson, 1911); Caligus rogercresseyi Boxshall et Bravo, 2000 and Metacaligus uruguayensis (Thomsen, 1949) (Caligidae Burmeister, 1835); Hatschekia conifera Yamaguti, 1939 (Hatschekiidae Kabata, 1979); Clavellotis pagri (Krøyer, 1863), Clavella adunca (Strøm, 1762), Clavella bowmani Kabata, 1963 and Parabrachiella amphipacifica Ho, 1982 (Lernaeopodidae Milne Edwards, 1840), and Lernanthropus leidyi Wilson, 1922 and Lernanthropus caudatus Wilson, 1922 (Lernanthropidae Kabata, 1979). A list of host species lacking parasitic copepods, for which large samples were investigated by the authors, is also provided in order to compare in future surveys.

Keywords
Parasitic copepods, fishes, Argentinean Sea

Introduction
During the last few decades the exploration of the ocean have revealed an incredible diversity of life, including ecosystems and communities with a wealth of endemic species; however, much of the oceans biology and ecology remains poorly explored and understood. This is particularly the case of marine parasites that, despite being recognized as an important component of global biodiversity and research efforts directed at documenting parasite species have increased (Poulin and Morand 2000), they are probably the least known group of organisms (Rohde 1993).

The copepods are a common component of the ectoparasite assemblages of all kind of fishes, from all environments and ecosystems (Boxshall and Halsey 2004), however, only about 16% of extant fish species have been reported as hosts for these parasites (Ho 2001). This is probably because, among ichthyoparasitologists, the number of copepodologists is surprisingly small (Ho 2001), possible as a result of the complex anatomy of copepods and the scattered and largely archaic nature of systematic literature (Benz 2005).

Today, human impacts on the world’s oceans have been substantial, leading marine taxa to become extinct or disappear at top speed (Dulvy et al. 2003) as a result of habitat loss and destruction, the introduction of exotic species, human-generated pollution, over-fishing and global climate change. The latter is impacting the ecology and biogeography of marine fish populations and will continue to do so in the future (Arvedlund 2009); some species and populations could be lost if they are unable to adapt to the new climate conditions or relocate to adequate habitats, while others may flourish and expand their ranges.

It has been argued that the records of fish in unusual habitats may aid as an indicator of climate changes (Arvedlund 2009). Due to the dependence of parasites to their hosts and the strong effect of climatic conditions on parasite transmis-
Table I. Parasitic copepod species infecting marine fishes in the Argentinean Sea, with information about host identity, number of examined hosts (n), site of infection, locality and date of host capture, prevalence (P), mean intensity (MI) and material deposited (VS = voucher specimens, CN = collection number).

<table>
<thead>
<tr>
<th>Parasite species</th>
<th>Host (n)</th>
<th>Site</th>
<th>Date locality</th>
<th>P (%)</th>
<th>MI (range)</th>
<th>VS-CN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CYCLOPOIDA</strong></td>
<td></td>
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<tr>
<td><strong>Bomolochidae</strong></td>
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<tr>
<td>Boromolochus globiceps (Vervoort et Ramírez, 1968)</td>
<td>Odontesthes incisa (Jenyns) (Atherinopsidae) (60)</td>
<td>gills</td>
<td>October, 2000 Mar del Plata (38°08’S, 57°32’W)</td>
<td>8.3</td>
<td>1.2 (1–2)</td>
<td>6434</td>
</tr>
<tr>
<td>Nothoboromolochus cresseyi (Timi et Sardella, 1997)</td>
<td>Thysitops lepidopoides (Cuvier) (Gempylidae) (1)</td>
<td>gills</td>
<td>April, 2010 Mar del Plata (38°08’S, 57°32’W)</td>
<td>–</td>
<td>2</td>
<td>6435</td>
</tr>
<tr>
<td><strong>Chondracanthidae</strong></td>
<td></td>
<td></td>
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<tr>
<td>Brasilohondria riograndensis (Thatcher et Pereira, 2004)</td>
<td>Paralichthys patagonicus (Jordan) (Paralichthydae) (51)</td>
<td>inner side of operculum</td>
<td>September, 2010 Necochea (38°52’S, 58°10’W)</td>
<td>5.9</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Taeniacanthidae</strong></td>
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<tr>
<td>Taeniacanthus lagocephali (Pease, 1952)</td>
<td>Lagocephalus laevigatus (Linnaeus) (Tetraodontidae) (1)</td>
<td>pectoral fins, gills</td>
<td>December, 2008 Mar del Plata (38°08’S, 57°32’W)</td>
<td>–</td>
<td>6</td>
<td>6437</td>
</tr>
<tr>
<td><strong>SIPHONOSTOMATOIDEA</strong></td>
<td></td>
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<tr>
<td><strong>Caligidae</strong></td>
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<tr>
<td>Caligus rogercresseyi (Boxshall et Bravo, 2000)</td>
<td>Odontesthes argentinensis (Valenciennes) (Atherinopsidae) (27)</td>
<td>body surface</td>
<td>July, 2000 Mar del Plata (38°08’S, 57°32’W)</td>
<td>59.3</td>
<td>1.9 (1–5)</td>
<td>6438</td>
</tr>
<tr>
<td>Metacaligus uruguayensis (Thomsen, 1949)</td>
<td>Trichiurus lepturus (Linnaeus) (Trichiuridae) (4)</td>
<td>oral and gill cavities</td>
<td>June, 2010 Mar del Plata (38°08’S, 57°32’W)</td>
<td>100</td>
<td>47.5 (5–84)</td>
<td>6439</td>
</tr>
<tr>
<td><strong>Hatschekiidae</strong></td>
<td></td>
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</tr>
<tr>
<td>Hatschekia conifera (Yamaguti, 1939)</td>
<td>Brama brama (Bonnaterre) (Bramidae) (4)</td>
<td>gills</td>
<td>November, 2007; April, 2004 Mar del Plata (38°08’S, 57°32’W) San Matías gulf (41°10’–42°10’S, 63°50’–65°00’W)</td>
<td>50.0</td>
<td>1.5 (1–2)</td>
<td>6440</td>
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<tr>
<td><strong>Lernaeopodidae</strong></td>
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<tr>
<td>Clavellotis pagri (Kroyer, 1863)</td>
<td>Pagrus pagrus (Linnaeus) (Sparidae) (124)</td>
<td>gills</td>
<td>December, 2004 to October, 2005 Mar del Plata (38°08’S, 57°32’W)</td>
<td>35.5</td>
<td>2.5 (1–11)</td>
<td>6441</td>
</tr>
<tr>
<td>Clavella adunca (Strom, 1762)</td>
<td>Patagonotothen ramseyi (Regan) (Nototheniidae) (8)</td>
<td>gills</td>
<td>September, 2007 Patagonian waters (45°5’S, 61°W)</td>
<td>50.0</td>
<td>1.5 (1–3)</td>
<td>6442</td>
</tr>
<tr>
<td>Clavella bowmani (Kabata, 1963)</td>
<td>Patagonotothen ramseyi (Regan) (Nototheniidae) (8)</td>
<td>pectoral fins</td>
<td>September, 2007 Patagonian waters (45°5’S, 65°W)</td>
<td>12.5</td>
<td>2</td>
<td>6443</td>
</tr>
<tr>
<td>Parabrachiella amphipacifica (Ho, 1982)</td>
<td>Cottunculus granulosus Karrer (Psychrolutidae) (2)</td>
<td>gills</td>
<td>February, 2009 Patagonian waters (49°13’S, 63°14’W)</td>
<td>50.0</td>
<td>5</td>
<td>6444</td>
</tr>
<tr>
<td><strong>Lernanthropidae</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Lernanthropus leidyi (Wilson, 1922)</td>
<td>Umbrina canosa (Berg (Sciaenidae) (6)</td>
<td>gills</td>
<td>April, 2004 Mar del Plata (38°08’S, 57°32’W)</td>
<td>16.7</td>
<td>2</td>
<td>6445</td>
</tr>
<tr>
<td>Lernanthropus caudatus (Wilson, 1922)</td>
<td>Pagrus pagrus (Linnaeus) (Sparidae) (124)</td>
<td>gills</td>
<td>December 2004 to October 2005 Mar del Plata (38°08’S, 57°32’W)</td>
<td>34.7</td>
<td>1.8 (1–7)</td>
<td>6446</td>
</tr>
</tbody>
</table>
sion and distribution (Marcogliese 2001, Mouritsen and Poulin 2002), geographical shifts in copepod distribution can reinforce the utility of the detection of changes in ecosystem structure and function.

Recent discoveries of several fish species in southern regions of the Argentinean Sea, where they were never recorded previously (Góngora et al. 2009), are a clear indication of the effect of global warming in this region. It is necessary to increase our knowledge of the biodiversity of parasitic copepods to provide a baseline to detect future changes in the distribution of the marine biota.

Here we report the discovery of known species of parasitic copepods we gathered over recent years, which remained unpublished because only few fish hosts of each species were sampled plus other species found in ongoing studies that have not yet been published. A list of host species lacking parasitic copepods, for which large samples were investigated by the authors, is also provided in order to compare in future surveys in a scenario where the outbreak of parasitic diseases could occur (see Lafferty et al. 2004).

**Materials and methods**

Copepods were collected from fish examined during parasitological research carried out between 2000 and 2010. Fishes were caught in different regions of the Argentinean Sea. The parasites were removed from the fishes, fixed in formaldehyde solution 4%, and then transferred to 70% ethanol for storage until being studied; the copepods were cleared in lactic acid solution 4%, and then transferred to 70% ethanol for storage. Parasites were removed from the fishes examined by the authors, is also provided in order to compare in future surveys in a scenario where the outbreak of parasitic diseases could occur (see Lafferty et al. 2004).

Voucher specimens were deposited in the Carcinological Collection of the Museo de La Plata (CCMLP), La Plata, Argentina.

Higher-level classification of copepods follows Boxshall and Halsey (2004). The taxonomy and scientific names of fishes have been updated using FishBase (Froese and Pauly 2010).

A list of 4 fish species found free of parasitic copepods in the Argentinean Sea, is given, together with their taxonomic position, number of examined fish and date and locality of capture.

**Results**

A total of 13 host-parasite associations were found in 15 marine fish species from Argentinean Sea. Copepods belonged to 2 orders and 7 families while fishes were representatives of 5 orders and 10 families. Table I includes information on the distribution of the parasitic copepods species found and Table II provides information on fish species free of parasitic copepods in the Argentinean Sea.

**Discussion**

The present work provides new information on the distribution of 13 known species of parasitic copepods found in 11 species of marine fishes from Argentina, including 7 new host records and 9 new locality records and a list of host species lacking parasitic copepods, for which large samples were investigated, including first reports from the Southwestern Atlantic of *H. conifera*, *C. adunca* and *P. amphipacifica*, broadening considerably the geographical range of each. *Bomolochus globiceps* was originally described as *Parabomolochus globiceps* from specimens collected from the gills of *Odonthestes smitti* (Lahille) (as *Austroatherina smitti*) caught in Mar del Plata Port (Argentina) (Vervoort and Ramirez 1968). Later the genus *Parabomolochus* was discarded for being established based on false criteria (Vervoort 1969) and all species considered as *Parabomolochus* by Vervoort (1962) were transferred to the genus *Bomolochus* von Nordmann, 1832. This species was later redescribed by Timi and Etchegoin (1998) based on specimens collected from the type host, as well as from *Odontesthes argentinensis* (Valenciennes), both from the same locality. The presence of *B. globiceps* in the congeneric silverside, *O. incisa* (Jenyns), from Mar del Plata, constitutes a new host record.

*Nathobomolochus cressye* was described by Timi and Sardella (1997) from *Engraulis anchoita* Hubbs et Marini (Engraulidae) in coastal areas of Argentina and Uruguay. Over a

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Species</th>
<th>n</th>
<th>Date-locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anguilliformes</td>
<td>Congridae</td>
<td>Conger orbignianus Valenciennes</td>
<td>100</td>
<td>April-May, 2004, June, 2010, Mar del Plata (38°08′S, 57°32′W)</td>
</tr>
<tr>
<td>Clupeiformes</td>
<td>Engraulidae</td>
<td>Anchoa marinii Hildebrand</td>
<td>136</td>
<td>May, 1996, Mar del Plata (38°08′S, 57°32′W)</td>
</tr>
<tr>
<td>Pleuronectiformes</td>
<td>Paralichthydae</td>
<td>Paralichthys isosceles Jordan</td>
<td>51</td>
<td>May, 2009, Necochea (39°00′S, 58°55′W)</td>
</tr>
<tr>
<td>Scorpaeniformes</td>
<td>Congiopodidae</td>
<td>Congiopodus peruvianus (Cuvier)</td>
<td>265</td>
<td>May, 2007, January-March, 2009, Patagonic waters (41°10′-47°30′S, 58°26′-66°26′W)</td>
</tr>
</tbody>
</table>
total of 1,490 specimens of *E. anchoita* examined, only 8 specimens of *N. cresseyi* were found with prevalence 0.6% and mean intensity 1 (Timi and Sardella 1997). Later, Luque and Tavares (2007) found this species in *Anchoa marinae* Hildebrand (Engraulidae) from Rio de Janeiro, Brazil. The fact that in the present study 2 specimens were found in a single fish could indicate that *Thysitops lepidopoides* (Cuvier) represents the most common host in this area. The presence of *N. cresseyi* in *T. lepidopoides* represents a new host record.  

*Brasilochondria riograndonensis* was described as a parasite of *Paralichthys orbignyanus* (Valenciennes) from Rio Grande, Brazil (Thatcher and Pereira 2004). This species was later redescribed based on material collected from the branchial cavity of the same host from the coast off Buenos Aires Province, Argentina (Braicovich and Alarco 2007). The presence of this species in the Patagonian flounder, *P. patagonicus* Jordan from coastal waters off Mar del Plata, represents a new host record.  

*Taeniacanthus lagocephali* was described by Pearse (1952) from specimens obtained from the gills of *Lagocephalus laevigatus* (Linnaeus) collected off Padre Island, Texas, and then redescribed by Ho (1969). It was reported from the same host from Brazil and USA (Mississippi, Alabama and Texas) by Dojiri and Cressey (1987). Its presence has been also recorded in other species of *Lagocephalus*, namely *L. spadiceus* (Richardson) from Japan (as *T. sabafugu*) by Yamaguti and Yamasu (1959), and *L. lunaris* (Bloch et Schneider) and *L. inermis* (Temminck et Schlegel) from India (Pillai 1963, Uma Devi and Shyamasundari 1980). Pillai (1963) transferred *T. lagocephali* to *Iodes*, being transferred back to *Taeniacanthus* by Ho (1969). This is the first record of this species in Argentinean waters, and is the southernmost record for this species.  

*Caligus rogercresseyi* is the most important parasite impacting the salmon industry in Chile since it was recorded for the first time in 1997 (Bravo 2003, 2010; Johnson et al. 2004). It was described from the Atlantic salmon, *Salmo salar* Linnaeus, from Chile (Boxshall and Bravo 2000). It is a non-specific parasite of several wild marine fish, which are frequently found in the vicinity of salmon cages attracted by the waste feed (Carvajal et al. 1998, Bravo 2003). This species has also been reported as a parasite of the introduced anadromous brown trout, *Salmo trutta* Linnaeus, in the Rio Gallegos estuary, Patagonia, southern Argentina, since 1998 (Bravo et al. 2006). The record of *C. rogercresseyi* in *O. argentinensis* from waters off Mar del Plata constitutes therefore a new host and locality record, representing the northernmost locality reported for this species in the Atlantic.  

Thomsen (1949) proposed the subgenus *Metacaligus* to accommodate a new species of *Caligus* found parasitizing the cutlassfish, *Trichiurus lepturus* Linnaeus from the Uruguayan coast. Subsequently, Ho and Bashirullah (1977) elevated *Metacaligus* to generic status, including three species: *M. uruguayensis* (Thomsen, 1949), *M. rufus* (Wilson, 1908) and *M. hilae* (Shen, 1957). Later, Ho and Lin (2002) based on cladistic analysis of morphological characters of Caligidae confirmed *Metacaligus* as a valid genus. Another species, *Metacaligus latus* Ho et Lin, 2002 was found together with *M. uruguayensis* parasitic on *T. lepturus* from Taiwan (Ho and Lin 2002). The authors also reported chalimus larvae at various stages of development as being attached randomly to the cephalothorax, genital complex or abdomen of the adults of both sexes. According to Ho and Lin (2002) it is an unusual event, because chalimus stages are usually found attached directly to the fish host. However, Thomsen (1949) described three stages of development (chalimus I to chalimus III) found attached to three females. In the present study, of the 59 chalimus found, 42 were found attached to females (1 to 6 per female), 1 to a male and 16 to the hosts. Recently, *M. uruguayensis* was found in *T. lepturus* from Brazil (Luque and Tavares 2007). The present finding constitutes a new locality record.  

*Hatschekia conifera* originally described from *Stromateoides argeatus* (Euphrasen) (Stromateidae) from Japan (Yamaguti 1939), is a widely distributed species. Since its description it has been redescribed by Cressey (1968) from *Cubiceps caeruleus* Regan, a stromateid fish taken off the coast of Chile. It has been also reported from South Africa, Chile, Pacific coast of Canada, New Zealand and Japan (Yamaguti 1939; Barnard 1955; Cressey 1968; Kabata 1981; Oldewage 1993; Villalba 1986; Jones 1985; Ho and Kim 1996, 2001). Barnard (1948) described *H. acuta* Barnard, 1948 from False Bay, South Africa, parasitizing *B. brama* Bonnerterre (as *B. raii*). Kabata (1981), after finding *H. conifera* on *Brama japonicus* Schenider, in the eastern North Pacific Ocean, relegated *H. acuta* to a junior synonym of *H. conifera*. The presence of this copepod species in Argentinean waters represents a new locality record and the first one in the southwestern Atlantic.  

The genus *Clavellois* was established by Castro-Romero and Baeza-Kuroki (1984) to accommodate *C. dilatata* (Kroyer, 1863), which become its type species. Later, Kabata (1990) in a revision of the genus *Clavellois* Wilson transferred seven nominal species and one unnamed species to *Clavellois*; including *C. pagri*. *Clavellois pagri* has been recorded on the red porgy, *Pagrus pagrus* (Linnaeus), the salema, *Sarpa salpa* (Linnaeus) and the common pandora, *Pagellus erythrinus* (Linnaeus), all of them being sparids from the Mediterranean Sea. In Brazilian waters another species, *C. dilatata* has been reported as a parasite of *P. pagrus* (Luque and Tavares 2007). The present finding represents the southernmost locality record for this species and the first one in the western Atlantic.  

*Clavella adunca* (Strom, 1762) is a highly polymorphic species, with a great range of morphological variability and a wide range of fish hosts (Kabata 1979); this is reflected in its long list of synonyms and complex taxonomic history. This species has been recorded from as many as 30 fish species, mostly belonging to the family Gadidae, but also to other families (Kabata and Gusev 1966, Kabata 1979). Among the unusual host records for *C. adunca* is the scaly rockcod,
The second report of Clavella adunca parasitizing a nototheniid fish and is a new host record. Clavella adunca is considered a cosmopolitan species (Kabata and Gusev 1966), which inhabits predominantly the waters of the northern hemisphere; its records south of the Equator being comparatively few. The presence of this species in Patagonian waters, Argentina constitutes the first record of this ubiquitous species from the South Atlantic Ocean.

Kabata (1963) described Clavella bowmani from the fins of the nototheniid fish Notothenia sima (Richardson) (Nototheniidae) (valid name Patagonotothen sima), caught in the Strait of Magellan, Argentina. This species was also reported from the skin of P. sima from Malvinas Islands (Longshaw 1997). The present finding extends northwards its known geographical distributions in Patagonian waters, Argentina and represents a new host record. The male of C. bowmani is recorded for the first time; its description depends on increasing the number of specimens recovered.

Parabrachiella amphipacifica was originally described as Neobrachiella amphipacifica from two psychrolutid fish in the Pacific, Psychrolutes phricticus Stein et Bond from northern California and P. sio Nelson from northern Chile (Ho 1982). Recently, the species assigned to this genus by Kabata (1979) were transferred to Parabrachiella Wilson (Boxshall and Halsey 2004, Piasecki et al. 2010). Species of Parabrachiella seem to be highly host specific infecting a single fish species or a few closely related hosts (Piasecki et al. 2010). The finding of P. amphipacifica in the psychrolutid C. granulosus represents a new host record and the first record of this species in Atlantic waters. The male of P. amphipacifica is recorded for the first time; its description depends on increasing the number of specimens recovered.

Lernanthropus leidyi was firstly described from the gills of the white perch, Morone americana (Gmelin) (Moronidae) and from the gills of the yellowtail, Bairdiella chrysura (Lacepède) (Sciaenidae) from North Carolina, USA (Wilson 1922). This species was also reported parasitizing B. chrysura from Florida, USA (Pearse 1952, Causey 1955). Subsequently, Luque and Paraguassú (2003) redescribed it from specimens found in the Argentine croaker, Umbrina canosaí Berg (Sciaenidae) from Rio de Janeiro, Brazil. The present finding of L. leidyi is the first record of this species from Argentinean waters.

Lernanthropus caudatus was originally described by Wilson (1922) from the gills of the sheephead, Archosargus probatocephalus (Walbaum) (Sparidae) at North Carolina, USA. Other records of this species on A. probatocephalus were made from Florida and Texas, USA (Bere 1936, Pearse 1952). Subsequently the female was redescribed and the male was described for the first time by Luque and Paraguassú (2003) from Pagrus pagrus from the coastal zone of the State of Rio de Janeiro, Brazil. This is the first record of L. caudatus from Argentinean waters.

We acknowledge that identification of parasitic copepods based on morphology alone cannot prevent confusion between very similar or cryptic species. Future studies based on genetic analyses will be necessary to confirm the identity and accurately assess the distribution of these species. We are also aware that the effect of global climate change on distribution of marine biota is an ongoing process and therefore, the present findings of some parasitic copepods could be a consequence of recent shifts in relation to their original geographic ranges.

It is interesting to note that some fish species found to be devoid of parasitic copepods in the Argentinean Sea are commonly parasitized by copepods in Brazil, for example A. marinii harbour Caligus itacurussensis, C. haemulonis, and Nothobomolochus cresseyi, and P. isosceles is parasitized by Chondracanthus sp. The same occurs for P. pagrus; which was found harbouring two copepod species in Argentina and six species in Brazil (Luque and Tavares 2007). Therefore an increase in copepod diversity should be expected in these hosts in case global warming increases considerably the mean water temperatures at higher latitudes in the Southwestern Atlantic.

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References


Pagrus pagrus from the coastal zone of the State of Rio de Janeiro, Brazil. This is the first record of L. caudatus from Argentinean waters.


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