Chapter 10
Echinoderm Research in Uruguay

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10.1 Introduction

The eastern 220 km of the Uruguayan coastline are considered marine (salinities around 30–35 ‰), and the remaining ca. 350 km correspond to the Río de la Plata estuary. The Río de la Plata is the second largest river system in South America (drainage basin: 3.1 × 106 km^2, sediment load: 91 × 106 t y^{-1}, discharge of an average of 22,000 m^3s^{-1} water to the ocean) (Framiñan and Brown 1996; Guerrero et al. 1997; Syvitski et al. 2005). Along the coast there is a remarkable salinity gradient, with changing fronts, caused by the discharge of fresh water from the Paraná and Uruguay rivers into the Río de la Plata and from it into the Atlantic Ocean (Fig. 10.1a). Winds change the location of the salinity and turbidity fronts (Larrañaga 1894; Nagy et al. 1987). The Río de la Plata is extremely muddy because of mud derived mainly by the Paraná River.

The Atlantic area is influenced by the warm coastal N–S Brazilian Current and by the cold S–N Malvinas (Falkland) Current (Boltovskoy 1966; Podestá et al. 1991; Lentini et al. 2000; Piola et al. 2000). On the platform there are superficial warm waters and deeper cold ones (Fig. 10.1b). The sub-tropical warm waters converge and mix with the cold subantartic waters at about the isobaths of 100 and 200 m. Other factors such as topography, seasonality, and El Niño-Southern Oscillation (ENSO) phenomena also contribute to the littoral environmental conditions (Olson et al. 1988; Podestá et al. 1991; Lentini et al. 2000; Ortega and Martínez 2007; Raicich 2008). In brief, the estuary and the adjunct platform have complex horizontal and vertical structures complicated by a high degree of

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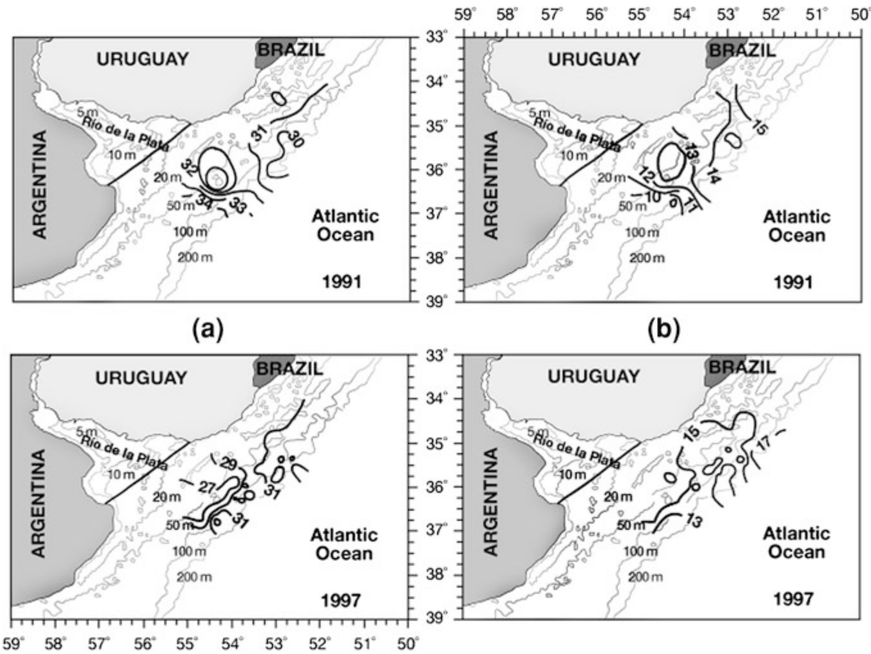

Fig. 10.1 **a** Examples of distribution of salinity (‰) in the Río de la Plata and adjacent platform (from Ortega and Martínez 2007). **b** Examples of distribution of temperature (°C) in the Río de la Plata and adjacent platform (from Ortega and Martínez 2007)

seasonal and inter annual variability. The substrate is dominated by soft sediments, with few areas consolidated or constituted by crystalline rocks (Correia et al. 1996).

The Uruguayan Atlantic coast shows arched (sometimes rather straight), wave dominated sandy beaches of variable size, delimitated by rocky points (Fig. 10.2). They have a wide range of morphodynamic grades, from dissipative to reflective. Coastal morphology is conditioned more by its geological background than by the present dynamics (Brazeiro et al. 2003; Gómez Pivel 2006). Astronomic tides are between 0.4 and 0.6 m, sea level changes induced by the wind being more important (Wells and Daborn 1997; SOHMA 2002).

Jurisdictional issues are regulated by the "Treaty between Uruguay and Argentina concerning the Río de la Plata and the Corresponding Maritime Boundary", signed November 19th 1973 (English version can be consulted in UN 2002, Spanish one in FREPLATA 2011). Apart from the Río de la Plata and Atlantic coastal boundaries, it establishes a "common fishing zone, beyond 12 nautical miles measured from the corresponding coastal baselines, for duly registered vessels flying their flag. Such zone shall be that determined by two arcs of circumferences of a radius of 200 nautical miles, the centers of which are located at Punta del Este (Eastern Republic of Uruguay) and Punta Rasa del Cabo San

Fig. 10.2 Examples of coastal morphology of Uruguay. **a** Lagoon, rocky point, and rather straight beaches at each side. **b** Rocky points and arched beaches in between

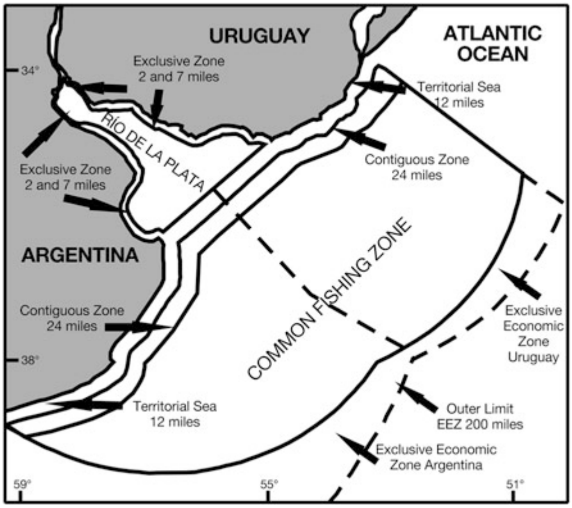

Fig. 10.3 Political limits of Uruguayan waters (modified from FREPLATA)

Antonio (Argentine Republic) respectively" (Fig. 10.3). It also provides a "Joint Technical Commission …which shall be responsible for conducting studies and adopting and co-coordinating plans and measures for the conservation, preservation and rational exploitation of living resources and the protection of the marine environment in the common zone binational organisms…"

Uruguay has a National System of Protected Areas (SNAP). In the Atlantic zone of influence, there are two coastal marine protected areas (from the terrestial coast seaward some miles: Laguna de Rocha and Cabo Polonio). Two additional areas will be formalized soon (Laguna Garzón and Cerro Verde). There are not exclusively marine Protected Areas (SNAP 2010).

In such a variable and unpredictable context as described above, it is not surprising that recent echinoderm faunas are rather poor. But, as mentioned below, the lack of research must be taken into account. Fossil echinoderms, although also not diverse, include key representatives of the extinct echinoid family Monophorasteridae, the sister group of the abundant and widespread Mellitidae. The aim of this chapter is give an overview of the knowledge about extinct and extant echinoderms of Uruguay.

10.2 Research

Echinoderm research is not yet systematically developed in Uruguay. There is little knowledge of the modern fauna. Evidence of this situation is the few papers that have been devoted to Uruguayan echinoderms.

Although Mortensen (1917) mentioned the presence of *Isometra vivipara* in Uruguay, the given coordinates (33°00′S; 51°10′W) correspond to Brazilian waters.

Barattini (1938) mentioned one ophiuroid species (*Ophioceramis januarii*, presently *Ophioplocus januarii*), two asteroid species (*Asterina marginata*, today classified as *Asterina stellifera*, and *Astropecten brasiliensis*) and two echinoid species (*Mellita quinquesperforata* and *Encope emarginata*; Fig. 10.4b). The same species are included in Barattini and Ureta (1961), a book for the general public. A similar book by Klappenbach and Scarabino (1969) mentions only the sand dollar species.

Bernasconi (1941a, b, 1947, 1953, 1955, 1966) and Bernasconi and D'Agostino (1977) made important contributions to the knowledge of the echinoderms of the Southwestern Atlantic, adding to the Uruguayan fauna one asteroid species (*Astropecten cingulatus*; Fig. 10.4a), three ophiuroid species and an echinoid species. This material was included in papers focused on museum collections or about the fauna collected in vessel campaigns at a regional scale (e.g. "Vema" from the Lamont Geological Observatory). Bernasconi (1964) include the species of asteroids and echinoids of Southern South America, including the Uruguayan species, to already known biogeographical entities (e.g. Argentine and Magellan provinces).

In the framework of a faunistic survey, Milstein et al. (1976) added five ophiuroid species to the Uruguayan fauna, and indicated some already known asteroid and echinoid species. Also in a report of a faunistic survey and ecologic study, Juanicó and Rodríguez-Moyano (1976) added three asteroid and two regular echinoid species to the Uruguayan fauna. Parts of these papers include environmental data.

Tommasi (1970a, b, 1974) and Tommasi et al. (1988a, b) published monographs or detailed surveys concerning Brazilian fauna, but included some Uruguayan species found near the borderline between the two countries. In fact, the only Uruguayan holothuroids identified at the species level can be found in these works.

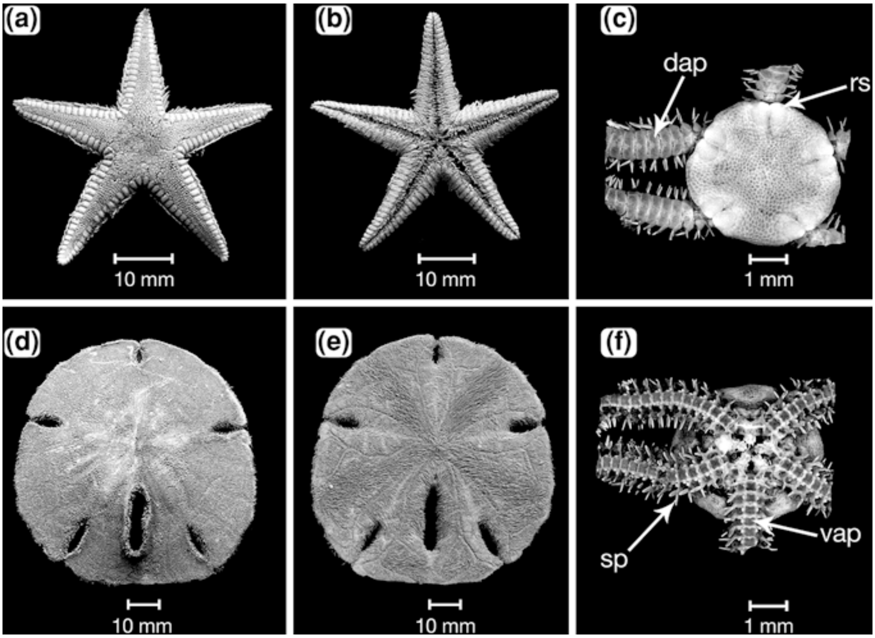

Fig. 10.4 **a** *Astropecten cingulatus*, dorsal view. **b** *A. cingulatus* ventral view. c *Amphiodia* sp., dorsal view (from Carranza et al. 2007). **d** *Encope emarginata*, adapical view. **e** *E. emarginata*, oral view. **f** *Amphiodia* sp., ventral view (from Carranza et al. 2007). Specimens of *A. cingulatus* and *E. emarginata* from S. Martínez's personal collection

Lucchi (1985) identified 17 species of ophiuroids in samples obtained between 10 and 800 m. (continental shelf and slope), being five of them reported for the first time for Uruguay. He and Martínez (2008, with an updated database and including asteroids) made some biogeographical considerations about ophiuroids (see below).

Martínez and Mooi (2005) published a bibliographical review about the fossil and recent sand dollars of Uruguay, recognizing three recent species, two Quaternary, and four Miocene ones. They stressed the importance of the extinct Miocene family Monophorasteridae in the phylogeny of Mellitidae and included some biogeographical observations (see Sect. 3.1).

Scarabino (2006) presents an updated list of the Uruguayan echinoderms reported to a depth of 50 m. He provided a brief account of the characteristics of their habitats. There is only one new record (Carranza et al. 2007) of *Amphiodia* sp. (Fig. 10.4c), an unnamed ophiuroid species different from the other Uruguayan representatives of the genus.

Amaro (1974), Riestra et al. (1992, 1998), Roux and Bremec (1996), Obenat et al. (2001), Giberto et al. (2004), Bremec and Giberto (2004), or Demichelli and Scarabino (2006) have considered Uruguayan echinoderms, adding new localities or habitat characteristics, but without adding new taxa.

Table 10.1 Numbers of echinoderms per taxonomic group in Uruguay

	Crinoidea	Asteroidea	Ophiuroidea	Echinoidea	Holothuroidea	Total
Order	0	3	2	3	3	11
Family	0	4	7	3	3	17
Genus	0	4	15	5	3	27
Species	0	5	24	5	3	37

Puig (1986) found three unidentified holothuroid species and three species of Ophiuroidea in the stomach content of the fish *Micropogonias opercularis*.

Fossil material has been more intensively studied (Martínez 1984, 1994; Martínez and Durham 1988; Mooi et al. 2000; Martínez and Mooi 2005). It is relatively well known but is restricted almost exclusively to Cenozoic echinoids because of their best preservation potential and of the characteristics of the sedimentary units of Uruguay.

10.3 Diversity and Distribution

10.3.1 Extant Echinoderm Fauna

The echinoderm fauna of Uruguay (Table 10.1) is composed of 37 species. Ophiuroidea is by far the richest class with 24 species. Asteroidea has five species; Echinoidea five species; and Holothuroidea three species. There are no species of Crinoidea recorded for Uruguayan waters. Is this species proportion among classes reliable? As commented below, there has been no systematic sampling of the Uruguayan waters, so this question remains open.

Twenty-four of these species have been collected from a depth of less than 50 m, four from between 50 and 100 m, two from between 100 and 200 m, four from 400 m, two from 700–800 m, and one at a wide range of depth (*Amphiura eugeniae*, 46–800 m).

Considering an average depth of 200 m for the shelf break, there are thus only seven species beyond the shelf. Again, it is not clear if this distributional pattern, with species concentrated in the littoral, is reliable, or if it is an artifact caused by the proximity of the coast (easier to collect), and/or by the fact that some collections are a side consequence of commercial fishing (more intense at these depths). Research-oriented faunistic surveys of the Uruguayan waters have been scarce, except for recent years and the collections have not been studied.

Biogeographic considerations have been few. Tommasi (1970a, b) indicated the marine area surrounding the mouth of the Río de la Plata (Rio Grande do Sul State, Brazil, to Buenos Aires Province, Argentina) is an area with reduced diversity. He related this to the latitudinal decrease of temperature, decrease in salinity caused by the discharge of the Río de la Plata, and the relatively cold water mass along the coasts of Rio Grande do Sul.

Lucchi (1985) identified two groups within the ophiuroids she studied, one related to the Malvinas (Falkland) Current and living at a depth greater than 60 m, and the other related to warm waters and living at less a depth than 60 m.

Martínez (2008) identified two distributional patterns of ophiouroid and asteroid species. The first one comprises species with the southern end of their distributional range near Uruguay. This was divided in two sub-groups, depending on whether their distribution extended across the Río de la Plata or not. Species whose distribution is limited by the Río de la Plata, are affected by two main factors in this area: temperature variation of the Subtropical Confluence Zone (ca. 30° to 45°S, see Boltovskoy 1966 for example), where the cold Malvinas (Falkland) and the warm Brazilian currents meet, and the strong variation in salinity and the increase of turbidity of waters caused by fresh water discharge from the Rio de la Plata (Piola et al. 2000, González-Silvera et al. 2004). The "salinity barrier" of the Río de La Plata has been considered an explanation for the truncation of the distribution of other organisms at the Rio de la Plata area, such as mollusks (Scarabino 1977) or sand dollars (Martínez and Mooi 2005). The second group is composed of species distributed within the area of the Argentinean or Patagonian Province (ca. 43°S and ca. 28°S; Scarabino 1977; Boschi 2000), a unit characterized by a complex faunal composition. Tommasi (1970b; ophiuroids), Scarabino (1977; mollusks) and Martínez and del Río (2002; mollusks) suggested this zone may be a true transition zone or "Provinciatone" between the adjacent Magellanic and Brazilian Provinces.

The distribution of sand dollars was studied by Martínez and Mooi (2005) with results and explanations comparable to the sub-groups of asterozoans that do not cross the Rio de la Plata barrier.

10.3.2 Extinct Echinoderm Fauna

There are only eight species of echinoderms in the Uruguayan fossil record, one crinoid species, one ophiuroid species, and six echinoid species. The crinoid and ophiuroid species are from the Devonian.The echinoid species are from the Cenozoic, being abundant in the Late Miocene. During those times (ca. 10 Ma. ago) the Monophorasteridae (sister group of the Mellitidae) were particularly abundant and diverse in what are today Uruguay and Argentina. Two species (*Mellita* sp. and *Encope* sp.) are recorded only for the Quaternary and are still extant in the area.

The following taxonomic arrangement of the fossil species. Suprageneric classification is based on: Crinoidea, Ausich (1998); Holothuroidea, Pawson et al. (2010); Ophiuroidea, Smith et al. (1995) and Shackleton (2005); Echinoidea: Kroh and Smith (2010).

Class Crinoidea J.S.Miller, 1821
Subclass Camerata Wachsmuth and Springer, 1885

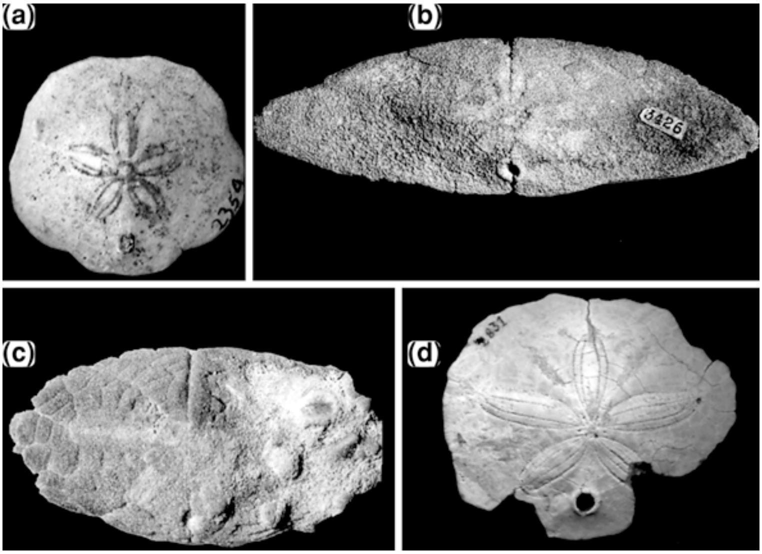

Fig. 10.5 Miocene sand dollars. **a** *Monophoraster duboisi* (x 1.3), FCDP 2359; **b** *Amplaster coloniensis* (x 0.9); holotype MNA-CPO 3426; **c** *Amplaster ellipticus* (x 0.9), paratype MNA-CPO 3425; **d** *Amplaster alatus* (x 1.3), FCDP 2831. From Martínez and Mooi (2005)

Order Monobathrida Moore and Laudon, 1943
Family Melocrinitidae d'Orbigny, 1852
Genus *Ctenocrinus* Bronn, 1840
Ctenocrinus sp.

References: Daners (1990).
Age and Stratigraphic Unit: Early Devonian, Cordobés Fm.
Comments: identified on the basis of columnar plates.

Class Ophiuroidea Gray, 1840
Family Encrinasteridae Schuchert, 1914
Genus *Encrinaster* Haeckel, 1866
Encrinaster pontis (Clarke, 1913)

References: Méndez-Alzola (1938).
Age and Stratigraphic Unit: Early Devonian, Cordobés Fm.
Comments: a single disk. The specimen is lost.

Class Echinoidea Leske, 1778
Order Clypeasteroida L. Agassiz, 1835
Crown group Clypeasteroida
Crown group Scutelliformes
Family Monophorasteridae Lahille, 1896
Genus *Monophoraster* Lambert and Thiéry, 1921
Monophoraster duboisi (Cotteau, 1884)
(Fig. 10.5a)

References: Martínez (1994), Mooi et al. (2000).

Age and Stratigrapic unit: Late Miocene, Camacho Fm.

Comments: Martínez and Mooi (2005) stated. "Prior to these records, all authors (e. g., Goso and Bossi 1966, Figueiras and Broggi 1971) mentioned the presence of *Monophoraster darwini* in Uruguay. In fact, this species is not present in the Miocene of Uruguay and all the known specimens are referable to *M. duboisi*. The species was originally described from the contemporaneous Paraná Formation of Argentina (Cotteau 1884, Mooi et al. 2000)."

Genus *Amplaste*r Martínez, 1984
Amplaster coloniensis Martínez, 1984
(Fig. 10.5b)

References: Martínez (1984, 1994) (partim), Martínez and Durham (1988), Mooi et al. (2000).

Age and Stratigrapic unit: Late Miocene, Camacho Fm.

Comments: This species is endemic to Uruguay.

Amplaster ellipticus Mooi, Martínez and Parma, 2000
(Fig. 10.5c)

References: Mooi et al. (2000).

Age and Stratigrapic unit: Late Miocene, Camacho Fm.

Comments: This species is endemic to Uruguay.

Amplaster alatus (Rossi de García and Levy, 1989)
(Fig. 10.5d)

References: Mooi et al. (2000).

Age and Stratigrapic unit: Late Miocene, Camacho Fm.

Comments: This species was described from the "Patagoniense" strata from Chubut Province (Rossi de García and Levy 1989), but with a controversial age assignment ranging from? Middle Eocene to the? Late Oligocene-Early Miocene (see Mooi et al. 2000).

Family Mellitidae Stefanini, 1912
Genus *Mellita* L. Agassiz, 1841
Mellita sp.

References: Figueiras (1962), Figueiras and Broggi (1967); Martínez and Mooi (2005).

Age and Stratigrapic unit: Holocene, Villa Soriano Formation.

Genus *Encope* L. Agassiz, 1841
Encope sp.

References: Martínez and Mooi (2005)

Age and Stratigrapic unit: Quaternary.

10.4 Aquaculture and Fisheries

There are no echinoderm fisheries or aquaculture currently in Uruguay (see in example Defeo et al. 2009). The effect of fishing of other species (fishes, shrimps) on echinoderm populations has not been evaluated.

10.5 Threats

For most of the Uruguayan coast, baseline studies include echinoderms only incidentally. Hence, it is unknown if species are being affected by anthropogenic activity (e.g., fishing, coastal urbanization), or if the echinoderms are affecting the environment to some extent.

There are not Uruguayan echinoderms considered to be charismatic or bioengineers.

10.6 Recommendations and Concluding Remarks

As shown in this chapter, knowledge of the Uruguayan echinoderm fauna is very poor. Therefore, the priority is to increase substantially all types of research on this group. A reliable inventory of the species must be developed, including basic data such as georeferences, depth, salinity, temperature, sedimentological characteristics, and other species associated with the echinoderms. The lack of national experts on the group undoubtedly has retarded the progress of the knowledge of echinoderms in Uruguay.

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