Note

Skates in the demersal trawl fishery of San Matías Gulf, Patagonia: species composition, relative abundance and maturity stages

Marilú Estalles1,2,a, Nidia M. Coller2,3, Maria Raquel Perier2,3 and Edgardo E. Di Giácomo2,3

1 Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina
2 Instituto de Biología Marina y Pesquera “Alte. Storni” (IBMP), Güemes 1030, 8520 San Antonio Oeste, Río Negro, Argentina
3 Universidad Nacional del Comahue (UNCo), Lab Recursos Ict, Grp CONDROS, Guemes 1030, RA-8520 San Antonio Oeste, Río Negro, Argentina

Received 30 December 2010; Accepted 23 May 2011

Abstract – Argentina is one of the countries with the largest overall landings of skates and rays (24 000 t/year). As a consequence of high levels of exploitation and deficient management tools, many of these species are threatened with extinction. In the bottom trawl fishery of San Matías Gulf, northern Patagonia, skates and rays are caught as bycatch and all have historically been recorded in the fishery logbook under the category “rays”. Therefore, species composition and their characteristics were unknown. The aim of this study was to characterize the commercial exploitation of batoid species in this fishery. Our results indicate that commercial landings include nine species of skate, six of which are common. Among these, Atlantoraja platana, Sympterygia bonapartii and Dipturus chilensis were considered the main species of this fishery. Their combined relative abundance and weight made up about 90% of the batoid catch throughout the year. Sexual segregation was detected in four species in which individuals of one sex dominated commercial landings. The commercial fraction was composed of individuals with a wide range of sizes. Immature individuals could represent 90% of the individuals landed for some species. At present, lack of data prevents us from quantifying the impact that this fishery is having on these species, but our findings highlight the importance of conducting research surveys to assess the abundance and geographic extent of these populations. The information presented here provided the basis for the proposal of a new logbook format incorporating species-level identification. The new logbook was implemented on 1 January 2010.

Key words: Chondrichthyes / Elasmobranch / Rajidae / Commercial landings / Argentina / Southwest Atlantic

1 Introduction

Annual batoid (skates and rays) landings worldwide have been around 250 000 t over the last few years (FAO 2010). These species are caught mainly as bycatch in fisheries targeting more valuable species, although in some countries they are also fished as target species themselves (Bonfil 1994; Stevens et al. 2000; Field et al. 2009). As chondrichthynes, they have a life history strategy characterized by slow growth, late maturing age, low fecundity, low productivity, low natural mortality and a long lifespan. These features make them vulnerable to high levels of exploitation (Hoenig and Gruber 1990; Stevens et al. 2000; Field et al. 2009). Declines in their abundances and changes in their community structures have been reported by several authors (Brander 1981; Casey and Myers 1998; Walker and Hislop 1998; Agnew et al. 2000; Dulvy et al. 2000; Figueiredo et al. 2007).

Argentina is one of the countries with the largest overall landings of these species worldwide (FAO 2010). As a consequence of high levels of exploitation and deficient management tools, the coastal waters of Argentina, Uruguay and southern Brazil are among the regions with the largest amount of threatened chondrichthyan species (Field et al. 2009), many of them batoids (Batoidea: sawfishes, guitarfishes, electric rays, skates, and sting rays). About 45 species of skates and rays, 16 of which are of commercial interest, have been recorded on the Argentinean continental shelf (Cousseau et al. 2007). Landings increased steadily from 900 t in 1993 to 28 000 t in 2007, reaching an average of 24 000 t in the last two years (Ministerio de Agricultura Ganadería y Pesca 2010). Skates and rays are caught mainly as bycatch by industrial bottom trawlers, although since 1999 they have also been targeted by a long-liner with a maximum allowable catch of 1800 t per year.

San Matías Gulf (SMG) is situated in northern Patagonian waters (41–42°S; 64–65°W), where a bottom trawl fishery has been established since 1971 (Di Giácomo and Perier 1992).
Its annual landings are around 13,000 t, constituting an economically important activity for the region. In this fishery, the common hake, *Merluccius hubbsi*, is the target species, and chondrichthyans are captured bycatch (Di Giácomo and Perier 1991). During 2009, the chondrichthyan with the highest total landings was the holocephalan *Callorhynchus callorhynchus* (1457 t), followed by batoids (448 t) and sharks (240 t). About 19 batoid species have been recorded in these waters (Perier et al. 2007). Commercial batoids have historically been recorded in the logbook under the category "rays", without details on species composition or other characteristics. The aim of this study was to identify batoid species, and to analyze their relative abundance, length frequency structure and the proportion of immature individuals and sexes that composed commercial landings in the demersal trawl fishery of San Matías Gulf.

2 Materials and methods

Commercial landings of batoids were sampled once or twice a month at local fish-processing plants from April 2007 to February 2009 (except in the months of December 2007 and November 2008) and during June, August, November and December 2009. Every month, a minimum of 10 boxes from a single trawler were randomly selected and sampled. During the 2007–2009 period, the demersal trawl fishery of San Matías Gulf was composed of 14–16 vessels. In this study, 11 of these vessels operating from San Antonio Oeste port were sampled. Bottom trawlers were from 16 to 29 m long. They fished in the gulf (Fig. 1) between the isobaths of 90 and 130 m, following the main concentrations of the common hake, the target species of the fishery (Di Giácomo and Perier 1991). In San Matías Gulf, the temperature of the surface water is from 11 to 18 °C, while the temperature of the bottom from 10.4 to 11.3 °C (Perier and Di Giácomo 2002).

Batoid species were classified following Cousseau et al. (2007) and families were assigned according to McEachran and Aschliman (2004). Species were classified as *common* when they were recorded in more than 50% of the samples, *frequent* when they were recorded in 20 to 49%, *occasional* when they were found in 5 to 19% and *rare* when they were recorded in less than 5% of the samples.

The number and sex of individuals of each species were recorded. Whenever possible, total length (TL) to the nearest cm, total weight (W) in grams and maturity stages were determined for each individual. Males were classified as immature when claspers either did not attain the margin of the pectoral fins or when they exceeded the pectoral fins but were flexible, and as mature when claspers exceeded the pectoral fins and were completely calcified. Females were classified as immature when oviducts, oviducal gland and ovaries were undeveloped or developing with no yolked oocytes in the ovaries, and as mature when oviducal glands and oviducts were completely developed and ovaries presented yolked oocytes (modified from Stehmann 2002).

The smallest mature individual was recorded and when possible, size at 50% of maturity (TL50) was estimated using the FISHPARM 3.05 program (Prager et al. 1987). Length and weight relationships were estimated for each sex and compared using a t-test (Zar 1984). Curves were considered significantly different when \( p < 0.05 \). Additional information obtained from research cruises between 2004 and 2007 and the observer program were used to estimate these curves. When available, length and weight relationships and TL50 were used to infer the weight and maturity stage of individuals. The relative abundance of each species was analyzed, as well as their seasonal variations and relative contribution in terms of weight. The proportion of immature individuals and sexes and their seasonal variations were assessed using a \( \chi^2 \) test (Zar 1984). Differences were considered significant when \( p < 0.05 \).

3 Results

3.1 Species contribution

A total of 31 visits to the local fish-processing plants were made from April 2007 to December 2009, over which a total of 7057 batoids were sampled. Nine species of skates (Rajidae) were recorded in commercial landings. *Dipturus (=Zearaja) chinensis* was recorded in all samples. This species together with *Atlantoraja platana, Sympterygia bonapartii, Dipturus trachyderma, Atlantoraja castelnauii, and Atlantoraja cyclophtora* were considered *common* species; *Rioraja agassizii* was frequent; while *Bathyraja brachyrups* and *Bathyraja macloviana* were rare (Table 1).

The most abundant species were *S. bonapartii, A. platana* and *D. chinensis*. These were the dominant species throughout the year, collectively contributing more than 90% of the individuals sampled. *A. platana* was the most abundant species in autumn and summer, while *S. bonapartii* was the most abundant in spring and winter (Fig. 2). The relative abundance of the other six species was considerably lower (Table 1; Fig. 2).

The relative weights of the species were estimated using the length and weight relationships (Table 2). *A. platana* was...
Table 1. Species composition and contributions to commercial landings. Latin and common names; status in the IUCN Red List of Threatened Species; percentage of occurrence, relative abundance and weight. Bold type indicates the contributions of the dominant species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name (English/Spanish)</th>
<th>IUCN status*</th>
<th>Occurrence (%)</th>
<th>Relative abundance (%)</th>
<th>Relative weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantoraja castelnaui</td>
<td>(Miranda Ribeiro Spotback skate/Raya a lunares 1907)</td>
<td>EN</td>
<td>71</td>
<td>3.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Atlantoraja cyclophora</td>
<td>(Regan 1903) Eyespot skate/Raya de ocelos</td>
<td>VU</td>
<td>68</td>
<td>3.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Atlantoraja platana</td>
<td>(Günther 1880) La Plata skate/Raya platana</td>
<td>VU</td>
<td>97</td>
<td>34.5</td>
<td>41.8</td>
</tr>
<tr>
<td>Rioraja agassizii</td>
<td>(Müller and Henle Rio skate/Raya lisa 1841)</td>
<td>VU</td>
<td>22</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Sympterygia bonapartii</td>
<td>Müller and Henle Smallnose fanskate/Raya marmorada 1841</td>
<td>DD</td>
<td>97</td>
<td>35.1</td>
<td>26.5</td>
</tr>
<tr>
<td>Dipturus chilensis</td>
<td>(Guichenot Yellownose skate/Raya picuda 1848)</td>
<td>VU</td>
<td>100</td>
<td>21.5</td>
<td>21.3</td>
</tr>
<tr>
<td>Dipturus trachyderma</td>
<td>(Krefft and Stehmann 1975) Roughskin skate/Raya de vientre áspero</td>
<td>VU</td>
<td>74</td>
<td>1.5</td>
<td>4</td>
</tr>
<tr>
<td>Bathyrja brachyurops</td>
<td>(Flower 1910) Broadnose skate/Raya de cola corta</td>
<td>LC</td>
<td>3</td>
<td>0.7</td>
<td>0.01</td>
</tr>
<tr>
<td>Bathyrja macloviana</td>
<td>(Norman 1937) Patagonian skate/Raya espinosa</td>
<td>NT</td>
<td>3</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

*a IUCN: International Union for Conservation of Nature, Red List of Threatened Species – see definitions on their website; Least concern (LC), near threatened (NT), vulnerable (VU), endangered (EN), critically endangered (CR). IUCN URL: http://www.iucnredlist.org/

3.2 Length frequency structures, proportion of immature individuals and sexes

3.2.1 Atlantoraja platana

Sexes were equally represented in the samples as a whole, but females were more abundant during winter (Table 2; Fig. 2). More than 80% of the individuals caught were smaller than 70 cm (Fig. 3). Immature individuals accounted for 63% of the males and 77% of the females sampled and dominated in all seasons. The lowest percentage of immature individuals was recorded in winter, while the highest was recorded in autumn (Fig. 4). Females bearing egg capsules accounted for 62% of the mature females assessed (n = 81). They ranged from 68 to 88 cm and were found throughout the year, except in April and September.

3.2.2 Sympterygia bonapartii

Females dominated in the samples from all seasons (Table 2; Fig. 2). More than 80% of the individuals caught were smaller than 60 cm (Fig. 3). Immature individuals accounted for 61% of the males and 48% of the females sampled. The proportion of immature individuals was only higher than that of mature ones in spring. In winter and summer, mature individuals were more abundant and no significant differences were recorded in autumn (Fig. 4). Females bearing egg capsules accounted for 62% of the mature females assessed (n = 81). They ranged from 68 to 88 cm and were found throughout the year, except in April and September.

the main contributing species, representing almost 42% of the total weight of the sample (Table 1). This species together with S. bonapartii and D. chilensis represented almost 90% of the total weight. The other species each accounted for less than 5% of the estimated catch weight. Bathyrja macloviana and B. brachyurops were excluded from this analysis because their weights could not be recorded and no length and weight relationships had been previously reported.
Table 2. Commercial batoid species. Number of individuals sampled (N); male: female ratio, with significant differences in $\chi^2$-test indicated by *; length at fifty percent of maturity (TL50); total length (TL) and weight (W) relationships, given with the number of individuals used to for this estimate (n) and the correlation coefficient ($R^2$). Other data references: (a) Colonello (2009), (b) Coller unpublished data; (c) Estalles et al. (2009); (d) Cedola et al. (2005); ** denotes estimated weight range of the individuals sampled.

<table>
<thead>
<tr>
<th>Species</th>
<th>Sex</th>
<th>N</th>
<th>ratio</th>
<th>Smallest mature size range (cm)</th>
<th>TL50 (cm)</th>
<th>$n$</th>
<th>$R^2$ relationships</th>
<th>W(g)-TL(cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantoraja castelnaui</td>
<td>F</td>
<td>112</td>
<td>1:1</td>
<td>48–125</td>
<td>107</td>
<td>109</td>
<td>0.0037 $\times TL^{3.1136}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>113</td>
<td></td>
<td>46–112</td>
<td>93</td>
<td>98</td>
<td>0.008 $\times TL^{2.983}$</td>
<td></td>
</tr>
<tr>
<td>Atlantoraja cyclophora</td>
<td>F</td>
<td>151</td>
<td>1:2*</td>
<td>34–69</td>
<td>54</td>
<td>59</td>
<td>0.97 0.008 $\times TL^{2.853}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>78</td>
<td></td>
<td>36–62</td>
<td>49</td>
<td>53</td>
<td>0.98 0.012 $\times TL^{2.853}$</td>
<td></td>
</tr>
<tr>
<td>Atlantoraja platana</td>
<td>F</td>
<td>1243</td>
<td>1:1</td>
<td>33–88</td>
<td>66</td>
<td>72</td>
<td>0.017 $\times TL^{2.849}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>1196</td>
<td></td>
<td>29–83</td>
<td>54</td>
<td>64</td>
<td>0.008 $\times TL^{2.983}$</td>
<td></td>
</tr>
<tr>
<td>Rioraja agassizii</td>
<td>F</td>
<td>8</td>
<td></td>
<td>46–59</td>
<td>59</td>
<td>57</td>
<td>460–590**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>4</td>
<td></td>
<td>41–52</td>
<td>55</td>
<td>50.4</td>
<td>410–520**</td>
<td></td>
</tr>
<tr>
<td>Sympterygia bonapartii</td>
<td>F</td>
<td>1769</td>
<td>1:2.5*</td>
<td>34–75</td>
<td>52</td>
<td>59</td>
<td>0.0039 $\times TL^{3.155}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>711</td>
<td></td>
<td>32–69</td>
<td>46</td>
<td>56</td>
<td>0.99 0.007 $\times TL^{3.995}$</td>
<td></td>
</tr>
<tr>
<td>Dipturus chilensis</td>
<td>F</td>
<td>650</td>
<td>1:0.8*</td>
<td>37–119</td>
<td>75</td>
<td>93.5</td>
<td>0.0051 $\times TL^{3.0435}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>867</td>
<td></td>
<td>39–100</td>
<td>74</td>
<td>83</td>
<td>0.0034 $\times TL^{3.1561}$</td>
<td></td>
</tr>
<tr>
<td>Dipturus trachyderma</td>
<td>F</td>
<td>93</td>
<td>1:7*</td>
<td>48–125</td>
<td>90</td>
<td></td>
<td>0.0024 $\times TL^{3.7175}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>14</td>
<td></td>
<td>46–90</td>
<td>83</td>
<td></td>
<td>0.0024 $\times TL^{3.7175}$</td>
<td></td>
</tr>
<tr>
<td>Bathyraja brachyurops</td>
<td>F</td>
<td>66</td>
<td>1:2*</td>
<td>51–77</td>
<td>66</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>16</td>
<td></td>
<td>55–72</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bathyraja macloviana</td>
<td>F</td>
<td>1</td>
<td></td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3. Size frequency distribution of the common species. Males (black bars) and females (white bars). For Dipturus trachyderma, sexes were combined.

3.2.3 Dipturus chilensis

Males dominated in the samples as a whole, except in autumn, when sexes were equally represented (Table 2; Fig. 2). More than 80% of the individuals caught were smaller than 60 cm (Fig. 3). Immature individuals accounted for 88% of the males and 96% of the females sampled and dominated in all seasons, ranging from 83% in summer to 96% in autumn (Fig. 4). Females bearing egg capsules accounted for 43% of the mature females sampled ($n = 28$). They ranged from 95 to 110 cm in total length and were found from January to March and from June to September.

3.2.4 Atlantoraja castelnaui

Both sexes were equally represented in the samples as a whole and seasonally (Table 2; Fig. 2). Summer was excluded from the analysis because only seven individuals were recorded in that season. More than 80% of the individuals caught were smaller than 80 cm (Fig. 3). Immature individuals accounted for 88% of the males and 90% of the females sampled and they dominated in all the seasons evaluated, ranging from 76% in autumn to 92% in winter. Summer was excluded from the analysis since not enough individuals were recorded in this season (Fig. 4). Four females bearing egg capsules and measuring between 107 and 125 cm were found in July, August and October.

3.2.5 Atlantoraja cyclophora

Females dominated in the samples as a whole, except in summer, when sexes were equally represented (Table 2;
Sexual segregation is a common characteristic of elasmobranch fishes (Wearmouth and Sims 2008). In the present study it was detected in *D. chilensis*, *D. trachyderma*, *B. brachyurops*, *S. bonapartii* and *A. cyclophora*, with

4 Discussion and conclusion

Only nine out of the 19 batoid species recorded for the San Matías Gulf (SMG) were found in commercial landings, all of which are frequently found in SMG (Perier et al. 2007). The exceptions are *B. brachyurops* and *B. macloviana*, whose presence seems to be sporadic, as this was the second and first record for these species in SMG, respectively. The nine landed species are endemic to South America and are exploited throughout their geographic range (Agniew et al. 2000; Cedrola et al. 2005; Massa et al. 2004; Tamini et al. 2006; Licandeo et al. 2006; Quiróz et al. 2007; Domingo et al. 2008). As a consequence of high levels of exploitation and deficient management tools, six of these species are on the IUCN red list of endangered species, categorized as vulnerable or endangered with extinction (IUCN 2010).

*Atlantoraja platana* *S. bonapartii* and *D. chilensis* are considered the main species of this fishery. Their combined relative abundance and weight were about 90% of the batoid catch, dominating commercial landings throughout the year. For *A. platana* this is the only population known in the Argentine Sea (Coller pers. obs.) and the fishery in SMG constitutes a major threat for it. For the other species, their interrelationship with individuals of the adjacent platform is not clearly established. As a consequence, these populations could also be impacted by other fisheries or restored by migrating individuals.

One particular finding of the present study was that *D. trachyderma* showed a skewed length frequency distribution towards mature individuals, and maximum lengths (about a metre) and sizes at maturity (about 40 cm) that were noticeably smaller than in other localities (Cedrola et al. 2005; Licandeo et al. 2007), which could represent a source of error. *Dipturus* spp. are commonly subject to misidentification because they often present similar external morphologies (Cedrola et al. 2005; Iglesias et al. 2010). In addition, another species of *Dipturus* (*D. argentinensis*) from the Patagonian shelf was described during the course of this study (Díaz de Astarloa et al. 2008). We are not convinced that the differences between the present and previous studies can necessarily be attributed to population-level variation. Although identifications in the present work were carefully carried out, most samples were taken in fish factories, with limited time. Therefore, we cannot eliminate the possibility that some individuals, especially the smallest ones (<60 cm) could have been misidentified. A misidentification of individuals of *D. trachyderma* as *D. chilensis* could explain the skewed length frequency distribution towards mature individuals and the sex ratio shown in *D. trachyderma*. *D. argentinensis* has not been recorded in SMG since its description. For the moment, we have rejected the idea that individuals of this species may have been mixed with individuals of the other *Dipturus* species in the present study. A revision of the genus in the Southwest Atlantic could both clarify the differences between the present and previous studies and propose key characteristics to accurately discriminate between species.
individuals of one sex dominating commercial landings. Some
of the underlying hypotheses proposed to explain this be-
behavior are sex-based differences in activity, nutritional re-
quirements and habitat selection (Wearmouth and Sims 2008),
although information is still insufficient in these species to
distinguish the possible causes. The segregation patterns of
these species mean the sexes differed in their exploitation
rates. While in D. trachyderma, B. brachyurops, S. bonaparti
and A. cyclophora females were fished in larger numbers than
males, in D. chilensis males were more frequent. Differences
in the exploitation of the sexes have been suggested as a po-
tential factor exacerbating the declines of elasmobranch pop-
ulations (Steven1933; Wearmouth and Sims 2008; Mucientes
et al. 2009). For the present, however, lack of data prevents us
from quantifying and exploring the possible effects that this
sex-biased exploitation is having on these populations.

The survival of juveniles is suggested as the key factor
for the maintenance of populations of elasmobranch fishes
(Stevens et al. 2000). In the present study commercial land-
ings were dominated by immature individuals, which in some
cases exceeded 80% of the individuals landed (D. chilensis and
A. castelnaui). The case of D. chilensis deserves particular at-
tention because this skate is extremely vulnerable to fishing
exploitation (Quiroz et al. 2011). A recent study has shown that
the population growth rate is slow even in absence of fish-
ing mortality and that the main contributing factors are the sur-
ival of juveniles and early life stages (Quiroz et al. 2011). Ac-
cording to their models, abundance is only maintained when
the fished population is composed of mature individuals of
older ages. Therefore, it is suggested that conservation actions
should be focused on the regulation of the fishing mortality of
juveniles (Quiroz et al. 2011). One way to mitigate the impact of
removing immature individuals would be to establish a size
limit for landed skates. Studies carried out in bottom trawl fish-
eries have shown that the survival of discarded skates reaches
50 to 60%, and can be higher depending on the species, sex,
duration of the tow and codend weight (Laptikhovsky 2004;
Enever et al. 2009). A size limit of 60 cm for commercial skates
would considerably reduce the proportion of immature
individuals in commercial landings. However, mortality rates
among discards and the key factors affecting discard mortality
must be examined before the value of this strategy can be as-
sed. In addition, other measures such us a reduction in the
duration of the tow could be adopted. It is also indispensable to
conduct research surveys that will allow us to assess the sea-
sonal abundances and geographic ranges of these populations
in order to quantify the impact that this fishery is having on
them.

Finally, this study provided the basis for a proposal to the
local government for a new logbook format to record com-
mercial catches incorporating species-level identification. The
species were selected taking into account their occurrence in
commercial landings and the ease of a rapid and accurate clas-
sification by the crew on board. Five species were incorporated
and, because D. chilensis and D. trachyderma are difficult to
differentiate, we proposed to put both species under a com-
mon category. The new logbook format was implemented on
1 January 2010.

Acknowledgements. We thank Téc. Miguel Camarero; Téc. Gimena
Mora, Téc. Matías Suarez and Téc. Bettiana Rivero for helping us
with the samplings. We also acknowledge the local fish-processing
plants “Marítima San José”, “Camaroneria Patagónica”, “Al Pesca”
and “Calme Pesquera” for providing us with the biological material
and allowing us to sample at their facilities. We thank Romina Es-
talles, teacher in English, for helping us with the proof reading. This
research was supported by Universidad Nacional del Comahue grant:
Pez gallo, rayas y tiburones del Golfo San Matías: Hacia una ex-
plotación pesquera sustentable 004/M020. This was a contribution of
the Group of Study of Chondrichthyan Fishes “CONDROS”. We also
thank an anonymous referee for their comments, which greatly im-
proved the manuscript.

References
Approaches to the assessment and management of multispecies
skate and ray fisheries using the Falkland Islands fishery as an
Bonfil R., 1994, Overview of world elasmobranch fisheries. FAO
BRANDER K., 1981, Disappearance of common skate Raia batis
Caskey J.M., Myers R.A., 1998. Near extinction of a large, widely dis-
of skates (Elasmobranchii: Arhynchobatidae, Rajidae) in the
Patagonian red shrimp fishery. Fish. Res. 71, 141–150.
Colonnello J.H., 2009, Ecología reproductiva de tres batoideos
(Chondrichthyes): Atlantoraja castelnaui (Rajidae), Rioraja
agassizi (Rajidae) y Zapaterix breviostris (Rhinobatidae).
Implicancias de distintas estrategias adaptativas en un escenario
de La Plata.
Cousseau M.B., Figueroa D.E., Díaz de Astarola J.M., Madragaña
E., Lucifora L.O., 2007, Rayas, chuchos y otros batoideos del
Atlántico Sudoccidental. Instituto Nacional de Investigación y
Desarrollo Pesquero INIDEP, Mar del Plata.
Díaz de Astarola J.M., Madragaña E., Hanner R., Figueroa
D.E., 2008, Morphological and molecular evidence for a new
species of longnose skate (Rajiformes: Rajidae: Dipturus)
from Argentinean waters based on DNA barcoding. Zootaxa
1921, 35–46.
Di Giacomo E.E., Perier M.R., 1991. Evaluación de la biomasa y ex-
plotación comercial del pez gallo (Callorhynchus callorhynus)
en el Golfo San Matías, Argentina. Frente Maritimo 9, Sect. A,
7–13.
y zona de desove de la merluza (Merluccius hubbsi) en el
Domingo A., Forseleddo R., Miller P., Passadore C., 2008, Plan de
Acción Nacional para la conservación de condrictios en las pes-
Dulvy N.K., Metcalfe J.D., Glaville J., Pawson M.G., Reynolds J.D.,
2000, Fishery stability, local extinctions, and shifts in community
Enever R., Catchpole T.L., Ellis J.R., Grant A., 2009. The survival of
skates (Rajidae) caught by demersal trawlers fishing in UK
waters. Fish. Res. 97, 72–76.