

# **Cruise Report**

## **ZDLV-10-2021**

### **Skate Survey and Mesh Trial**



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### **Acknowledgements**

We thank Captains Jose Antonio Vilar Marcote, Alfonso Garcia Juncal, the crew of the *F/V Petrel*, and Dr. Ander De Lecea of Fortuna Ltd. for their hospitality and assistance during this study. Thanks to Alex Blake for assistance with historical skate catch data.

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### **For citation purposes this publication should be referenced as follows:**

Parkyn, D. C., A. I. Arkhipkin, T. Trevizan, and T. Büring, 2021. Scientific Report, Skate Survey and Mesh Trial. Fisheries Cruise ZDLV-10-2021. Fisheries Department, Directorate of Natural Resources, Stanley, Falkland Islands Government. 35 p.

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## Introduction

Skate fisheries (Order Rajiformes) represent valuable food resources in temperate regions of the world. The Patagonian Large Marine Ecosystem and the Argentine Shelf, which includes the Falkland Islands, has a relatively rich assemblage of fish and skate species (Bisbal 1995, Agnew et al. 1999, Arkhipkin et al. 2008, 2012). This includes at least 10 species of genus *Bathyraja*, 4 species of *Amblyraja*, 3 species of *Psammobatis* and 3 species of *Dipturus* (Goyot et al 2020). Species are distributed from inshore coastal waters (e.g., *B. magellanica* and *Psammobatis*) to the shelf and shelf break (*B. brachyurops*, *B. griseocauda*, *B. albomaculata*) and deep continental slope (*B. meridionalis*, *B. papilionifera*). Commercial fisheries target five large abundant skates (*Dipturus lamillai*, *Dipturus trachydermis*, *B. brachyurops*, *B. griseocauda*, and *B. albomaculata*). The annual average catch of skate is relatively small (Figure 1, Goyot et al. 2020). Between 1100 and 8500 metric tons (MT) are reported caught within the Falkland Island waters annually (Figure 1, Winter 2018, Goyot et al. 2020), with the majority taken as bycatch in the licensed trawl fishery (Arkhipkin et al. 2008, 2012, Agnew et al. 2009). Discards vary between 26 MT and 183 MT. The group is assessed and managed as a multi-species complex. A closure has been maintained South of 51 °S since 1996. (Winter 2018).

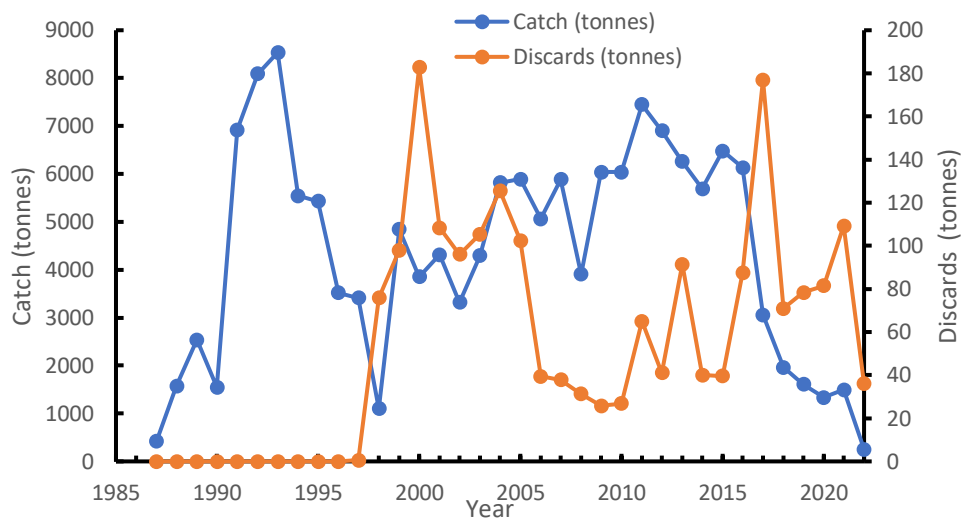


Figure 1. Annual catch and discards of skates in the Falkland Island Conservation Zone from 1987- 2022. Landings for 2022 represent only a portion of the total at the time of writing.

The present study assesses the regional abundance of skates and the current potential for a sustainable commercial fishery. Skates are fished under F licences, however the numbers of licences used annual has decline along with annual catch (Goyot et al. 2020, Figure 1). In a prior 2018 study, Falkland Island Government Fisheries Department compared catch gear for the specialized skate fishery in the Falkland Islands, employing 110 mm, 300 mm and 400 mm diamond mesh codend (DMC), which demonstrated a reduction in bycatch in larger meshes (Arkhipkin et al. 2018). In addition, a skate biomass study was conducted in 2020 to better understand population abundances (Goyot et al 2020). Typical mesh size within the Falkland Island EEZ for trawling vessels is a 110 mm DMC, which applies to all finfish trawlers regardless of their targeted species. In addition, skate-licensed trawlers are also permitted to use one or several tickler chains in front of their ground rope to increasing the efficiency of catch, while reducing trawl damage to the benthos. The employment of a relatively small mesh-size of the cod-end of the specialized skate fishery in the Falkland Islands raised concerns regarding the high proportion of bycatch, especially in regard to finfish species, as well as the unwanted bycatch of small and undersized skates. Elsewhere (for example, in the northern Atlantic), the minimum cod-end mesh size in skate fishery is 280 mm DMC mesh. Given the success of the 2018 study, and

given the current monetary value of skates (£12- 14 per kg retail as of 2021), a survey of skate abundance was discussed between the Falkland Island Government Department of Fisheries and Fortuna Ltd., to determine if catches of skates were sufficient to support a fishery. The resultant survey, outlined herein, employs a 400 mm DMC to minimize bycatch of undersize skates and other bycatch species. Four trawls were also conducted with a 110 mm codend liner to explore a large, dense school of unknown fish that were indicated by sonar in the southeast of FICZ.

### ***Cruise objectives***

- To study the species composition, distribution, and abundance of skate species along the continental slope in the area between 53 °S and approximately 50 °S including areas that are currently out of bounds to commercial skate fishery (Southwest Region).
- To study the distribution and species composition of the primary species of bycatch in that area.

### ***Vessel***

The cruise was conducted aboard the *F/V Petrel* (ZDLV), registered in the Falkland Islands.

### ***Personnel and responsibilities***

The following FIFD personnel participated in the cruise:

|                         |                                                                                     |
|-------------------------|-------------------------------------------------------------------------------------|
| Dr. Alexander Arkhipkin | Chief Scientist, trawl survey sampling, text for report                             |
| Toni Trevizan MSc       | Trawl survey sampling, data compilation                                             |
| Tobias Büring MSc       | Trawl survey sampling, data compilation, graphics                                   |
| Dr. Daryl Parkyn        | Trawl Survey sampling, lab biological sampling, analyses, graphics, text for report |

## ***Cruise overview***

The *F/V Petrel* departed from Stanley at 7 p.m. on October 18, 2021 and proceeded overnight to the first station (937) south of East Falkland (Figure 2, Table 1). Fishing was conducted from the 18<sup>th</sup> to the 28 November 2021. Trawling was performed in this Southeast region (defined as the Beauchêne region or south portion of the “Loligo box”, Roa-Ureta and Arkhipkin 2007) for trawls 937-940. We then proceeded to the adjacent Southwest region, below West Falkland Island - an area closed for commercial skate fishing (trawls 941-948) (Figure 2, Table 1). All sampling was north of 53° S and South of 49.7° S. Following completion of sampling in the Southwest region trawling was resumed in the Southeast region with a smaller, 110 mm diamond mesh codend (DMC) for trawls 949-952 (Figure 2). On October 23, the *F/V Petrel* moved further north to the Northeast sampling area, which is in the north-eastern part of the Argentine Patagonian Shelf edge (220-320 m depths) and situated within the commercial area for skate harvest, North of 51 °S. At this point, severe inclement weather precluded fishing until mid-day on 26 October, 2021 as we sought shelter. The same initial sampling protocol was employed using a 400 mm mesh codend. at depths of 265 - 323 m at trawl stations 953-959. The cruise ended October 29, 2021.

## **Methods**

### ***Trawling***

A commercial bottom (otter) trawl net (120 m horizontal opening) was used for the survey. It was equipped with two oval-foil doors, and three entwined tickler-chains that were attached to the ground rope. The trawl net was equipped with a 400 mm DMC for all but 4 trawl sets (Figure 2, Table 1), where a 110 mm DMC liner was deployed for exploratory trawls in the Southeast Region to examine a large school of what turned out to be Southern Blue Whiting (*Micromesistius australis*) (Figure 2, Table 1).

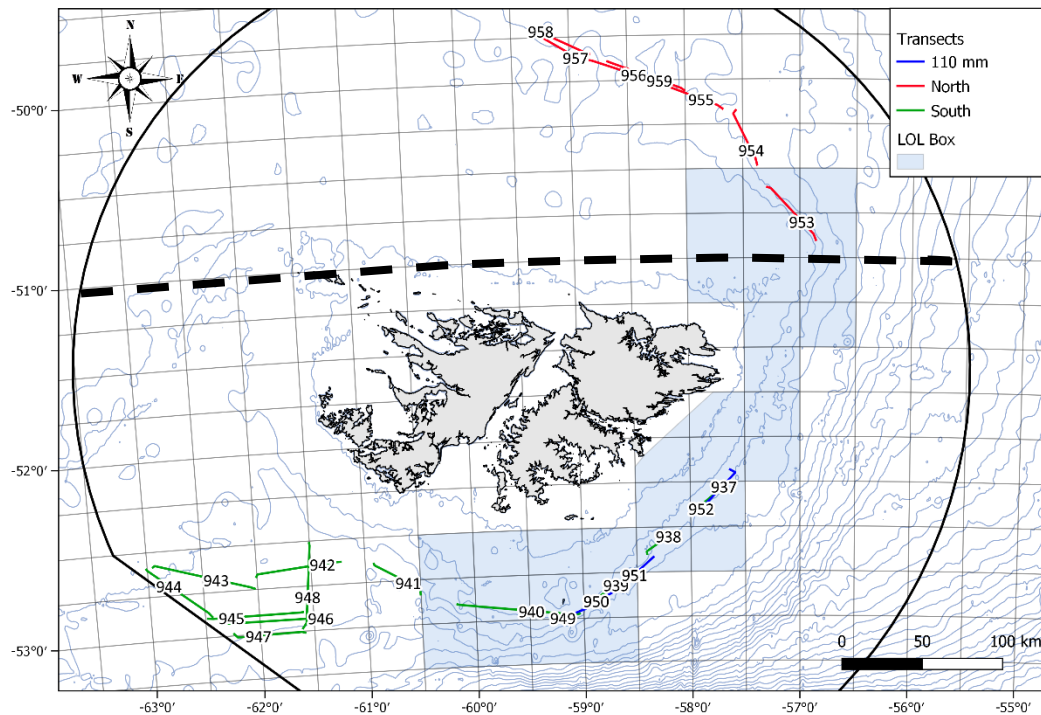


Figure 2. Trawl tracks (North — and South —) using a 400 mm diamond mesh cod end and 110 mm diamond mesh —. Skate fishing allowed North of dashed line.

### ***Trawl stations and biological sampling***

During the ZDLV-10-2021 research cruise, a total of 23 trawls were conducted with corresponding station numbers ranging from 937 to 959 (Figure 2, Table 1). Trawl stations 937 – 940 (Area 1 Southeast), 941 - 948 (Area 2 Southwest and 953 - 959 (Area 3 Northeast) were conducted with a 400 mm diamond mesh codend (DMC) for skate species. Trawl duration was  $369 \pm 125$  minutes. Trawls 949 - 952 were conducted with 110 mm mesh liner in the codend as a test series to investigate a dense false bottom on the sonar, and were not directly related to the assessment of the skate regional populations (duration  $169 \pm 59$  minutes).

Table 1. October 2021 Skate Survey trawls. Trawl latitude, longitude, and depth and duration. SE = Southeast, SW = Southwest, and NE = Northeast.

| Station | Date Time           | Start Latitude | Start Longitude | Final Latitude | Final Longitude | Start Depth (m) | Final Depth (m) | Codend (mm) | Area |
|---------|---------------------|----------------|-----------------|----------------|-----------------|-----------------|-----------------|-------------|------|
| 937     | 18/10/2021<br>06:15 | -52.274        | -57.69          | -52.387        | -57.915         | 293             | 293             | 400         | SE   |
| 938     | 18/10/2021<br>11:15 | -52.547        | -58.198         | -52.635        | -58.408         | 302             | 280             | 400         | SE   |
| 939     | 18/10/2021<br>15:50 | -52.805        | -58.668         | -52.917        | -58.945         | 271             | 307             | 400         | SE   |
| 940     | 18/10/2021<br>19:50 | -52.978        | -59.077         | -52.9          | -60.153         | 214             | 254             | 400         | SE   |
| 941     | 19/10/2021<br>07:55 | -52.798        | -60.508         | -52.657        | -60.915         | 326             | 366             | 400         | SW   |
| 942     | 19/10/2021<br>14:55 | -52.627        | -61.292         | -52.667        | -61.993         | 362             | 339             | 400         | SW   |
| 943     | 20/10/2021<br>22:05 | -52.735        | -62.068         | -52.577        | -62.93          | 339             | 344             | 400         | SW   |
| 944     | 21/10/2021<br>07:15 | -52.6          | -63.002         | -52.862        | -62.468         | 293             | 339             | 400         | SW   |
| 945     | 21/10/2021<br>14:10 | -52.897        | -62.43          | -52.895        | -61.623         | 343             | 366             | 400         | SW   |
| 946     | 20/10/2021<br>22:40 | -52.932        | -61.46          | -52.93         | -62.27          | 384             | 354             | 400         | SW   |
| 947     | 21/10/2021<br>07:25 | -53.01         | -62.215         | -53.003        | -61.618         | 388             | 435             | 400         | SW   |
| 948     | 22/10/2021<br>14:10 | -52.955        | -61.572         | -52.525        | -61.5           | 397             | 348             | 400         | SW   |
| 949     | 22/10/2021<br>06:30 | -52.988        | -59.165         | -52.947        | -58.98          | 260             | 340             | 110         | SE   |
| 950     | 22/10/2021<br>11:30 | -52.892        | -58.833         | -52.852        | -58.705         | 324             | 326             | 110         | SE   |
| 951     | 22/10/2021<br>17:20 | -52.765        | -58.53          | -52.677        | -58.367         | 331             | 340             | 110         | SE   |
| 952     | 23/10/2021<br>06:45 | -52.377        | -57.865         | -52.2          | -57.587         | 300             | 309             | 110         | SE   |
| 953     | 27/10/2021<br>12:05 | -50.868        | -56.878         | -50.612        | -57.255         | 263             | 311             | 400         | NE   |
| 954     | 26/10/2021<br>18:40 | -50.445        | -57.388         | -50.193        | -57.582         | 322             | 318             | 400         | NE   |
| 955     | 27/10/2021<br>00:30 | -50.145        | -57.718         | -50.012        | -58.25          | 306             | 296             | 400         | NE   |
| 956     | 27/10/2021<br>07:50 | -49.965        | -58.45          | -49.887        | -58.797         | 304             | 306             | 400         | NE   |
| 957     | 27/10/2021<br>12:30 | -49.843        | -58.99          | -49.727        | -59.285         | 305             | 305             | 400         | NE   |
| 958     | 28/10/2021<br>17:00 | -49.732        | -59.202         | -49.843        | -58.847         | 313             | 317             | 400         | NE   |
| 959     | 27/10/2021<br>22:35 | -49.9          | -58.637         | -50.047        | -58.035         | 313             | 293             | 400         | NE   |

The total catch of each station was not weighed. Instead, the sum of the round weights of each individual species were calculated using a DW to weight relationship. Similarly, the weights of discards were estimated on a per species basis. All discarded species (Rock Cod *Patagonotothen ramsayi*, Spiny Dogfish *Squalus acanthias*, greater hooked squid *Onykia ingens* etc.), as well as minor bycatch were estimated unless retained. All

skates were identified, gender was observed (female vs. male -with an external assignment of maturity stage). Skates were measured individually (disk width) and some were weighed for an additional study on diet that is still in the analysis phase. Species of bycatch were sampled (random samples of up to 100 individuals) and were measured, sexed and their maturity stages were identified as of standard biological analyses. During finfish otolith collection, individual weights were measured to the nearest gram. Additionally, some fish and squid specimens were frozen for analysis.

## RESULTS

### *Composition of Skate Catch*

Ten species and a total 11.173 metric tons (MT) of skates were caught (Table 2). Overall, Yellownose Skate (*Dipturus lamillai* or RFL) and Graytail Skate (*Bathyraja griseocauda* or RGR) dominated the species composition of the landings by weight, with 35% (3,962.55 kg) of the total catch by weight and 34% (3,835.03 kg), respectively. Broadnose Skate (*B. brachyurops* or RBR) also contributed a large proportion to the catch (8.6 % or 962.82 kg), (Table 2, Figure 3). On a numerical basis, Yellownose and Graytail skates dominated the skate catch by number (Table 2, Figure 3). The Cuphead Skate, RSC, and the White-spotted Skate, RAL, were also caught in sizeable quantities (613.3 kg and 593.9kg),

Table 2. Skate species captured in the Falkland Islands Conservation Zone by demersal otter trawl equipped with a 400 mm diamond mesh codend between October 19-29, 2021.

| Species                              | Weight (kg)      | Number      | Rank (W) |
|--------------------------------------|------------------|-------------|----------|
| <i>Amblyraja doellojuradoi</i> (RDO) | 45.35            | 61          | 10       |
| <i>Bathyraja albomaculata</i> (RAL)  | 593.907          | 385         | 5        |
| <i>B. brachyurops</i> (RBR)          | 962.82           | 294         | 3        |
| <i>B. cousseauae</i> (RBZ)           | 371.87           | 78          | 7        |
| <i>B. griseocauda</i> (RGR)          | 3,835.03         | 594         | 2        |
| <i>B. macloviana</i> (RMC)           | 60.98            | 70          | 9        |
| <i>B. multispinus</i> (RMU)          | 445.39           | 76          | 6        |
| <i>B. scaphiops</i> (RSC)            | 613.30           | 330         | 4        |
| <i>Zearaja argentinensis</i> (RDA)   | 281.08           | 30          | 8        |
| <i>Dipturus lamallai</i> (RFL)       | 3,962.55         | 1056        | 1        |
| Unassigned                           | 47.60            |             |          |
| <b>Total</b>                         | <b>11,173.94</b> | <b>2974</b> |          |

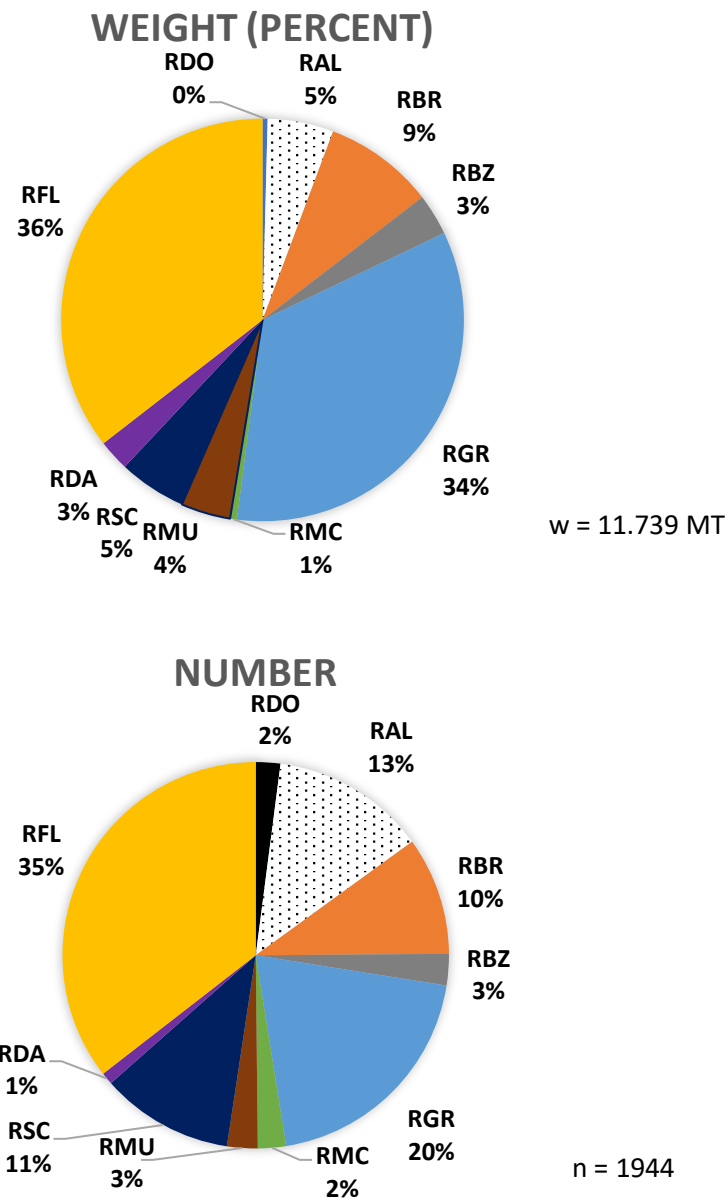


Figure 3. Percentage of catch of skates by weight and number from collections made in the FICZ by Otter Trawl with 400 mm DMC from October 19 -29, 2021.

### ***Regional Variation in Skate Distribution***

Catches also varied markedly, on a regional basis, with the most skates being captured in Southwest (SW) sampling region (Table 3, Figures 4-7). Despite a similar amount of effort in the Northeast (NE) and SW zones, catches of skates in the SW zone were 3 times higher than in the NE Zone (Table 3). In terms of numbers and weight, largest skate catch was observed in the Southwest Area, which was not surprising given

the location of this area was in a zone that has been closed to commercial harvest of skates (Table 3). However, even in this area, skate catches were not of considerable commercial size, averaging 1-2 t per trawl (110-283 kg·h<sup>-1</sup>) (Table 4). Skates were caught in only one of four trawl sets in the Southeast region, resulting in the capture of only 54 skates weighting 103 kg, although other fish species were captured. Instead, Ridgescale Rattail *Macrourus carinatus* predominated in the first 3 trawls and skates were not captured.

Catch in the NE region was more equally divided amongst three major species RBR, RFL, and RGR for both numbers and weight (Figure 5). Catches in the SW were completely dominated on a weight basis by RAL and RGR, despite the otherwise high species richness (Table 4, Figure 7). In contrast, RFL contributed the greatest to biomass of the catch in the adjacent SE region because of the small sizes of other numerically abundant species in the catch (Figure 6).

On a regional basis similar numbers of skate species were captured in the SW transects (1.13 skate spp. per trawl) compared to the NE transects (1.25 spp. per trawl), while 1.5 species per transect were observed in the SE area. The lower total number of species in the single trawl set containing skates in the Southeast region is a reflection of the lesser number of trawls conducted in the SE region. Likely the number of species would have been similar, if more trawls had been conducted. The highest diversity of skates was observed in the NE region, which was calculated at  $H^I = 2.80 \pm 0.11$  (95% C.I.) (Table 3). This is because the species composition was less dominated in terms of numbers of RGR and RAL.

Table 3. Relative abundance, numbers of skates and diversity of species in the sampling areas around the Falkland Islands using a demersal otter trawl with a 400 mm diamond mesh codend.

| Region | # Species | # Skates<br>(Weight in kg) | # of<br>Transects | Diversity<br>Index H' | Upper<br>CI 95% | Lower<br>CI 95% |
|--------|-----------|----------------------------|-------------------|-----------------------|-----------------|-----------------|
| SW     | 10        | 1944 (8358.06)             | 8                 | 2.39                  | 2.47            | 2.31            |
| SE     | 7         | 54 (103.20)                | 4                 | 2.28                  | 2.01            | 2.49            |
| NE     | 10        | 892 (2712.68)              | 7                 | 2.80                  | 2.68            | 2.91            |
| Total  | 10        | 2890 (11173.94)            | 19                |                       |                 |                 |

When considering skate catches only from the most productive area (Southwest), it is evident that the large catch totals obtained from the 400 mm mesh is due to a higher abundance of small skate inflating catch totals.

Overall, species composition of the catch was similar but there were differences in relative abundances amongst the regions (Figures 5-8). Yellow-nose Skate (RFL), Broadnose Skate (RBR), and Graytail Skate (RGR) were equally abundant in the Northeast region, while RFL and RMC dominated by number and RFL was a major component of the weight of the catch in the Southeast region (Figures 6). Interpretation of skate catch in the Southeast region was limited because skates were only captured in one of four trawls, which influenced sample size, total number of fish caught, as well as number of species present. RGR, RAL, and RSC were the most prominent species by number in the Southwest region and RAL, in particular, comprised half of the catch by weight (Figure 7). RGR was also abundant in the Southwest region and the Northeast region (Figures 5 and 7). Numbers of skate varied greatly among regions with over three times as many skate caught in the Southwest region compared to the Northeast region, despite a similar number of trawl sets. Catches in the Southeast region were miniscule, again because only one of four sets contained skates. Yellow-nose, Broadnose, and Graytail skates accounted for 73% of skates by number and 84 % of the catch by weight in the Northeast region (Figure 5). In contrast, Graytail (RGR), Cup-head (RSC), and White-spotted Skates (RAL) numerically dominated the catch in the Southwest region, while RAL and RGR together comprised the majority (83 %) of the skate catch by weight (Figure 7).

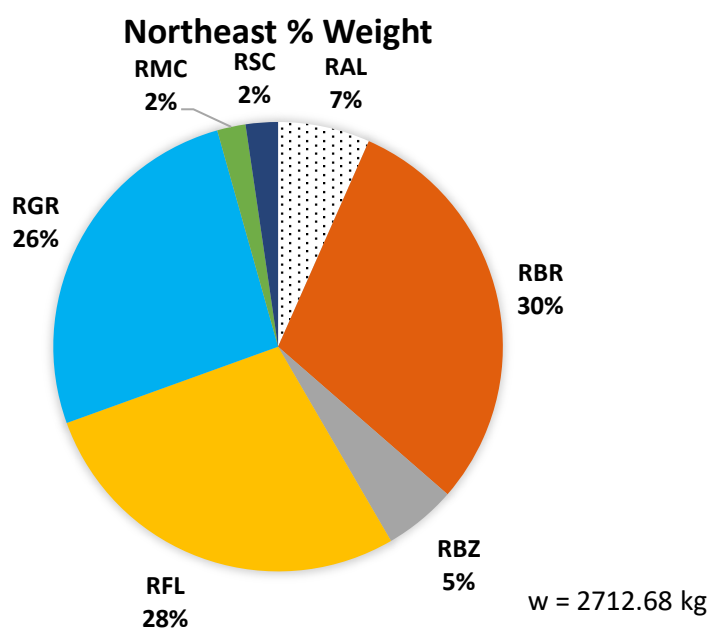
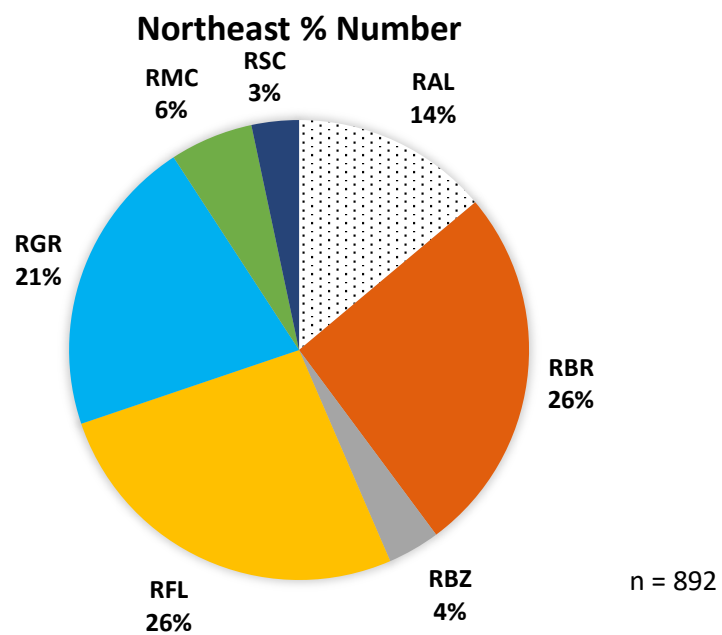


Figure 5. Percentage species composition by Number and Weight for skates caught in the Northeast region of Falkland Islands using a 400 mm diamond mesh demersal trawl.

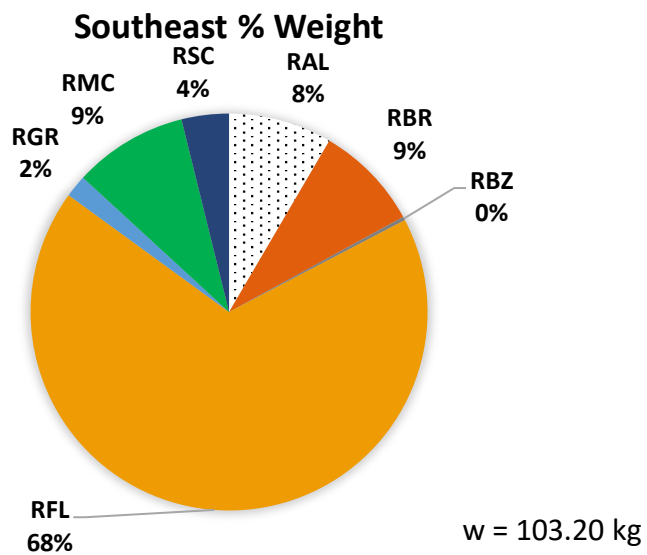
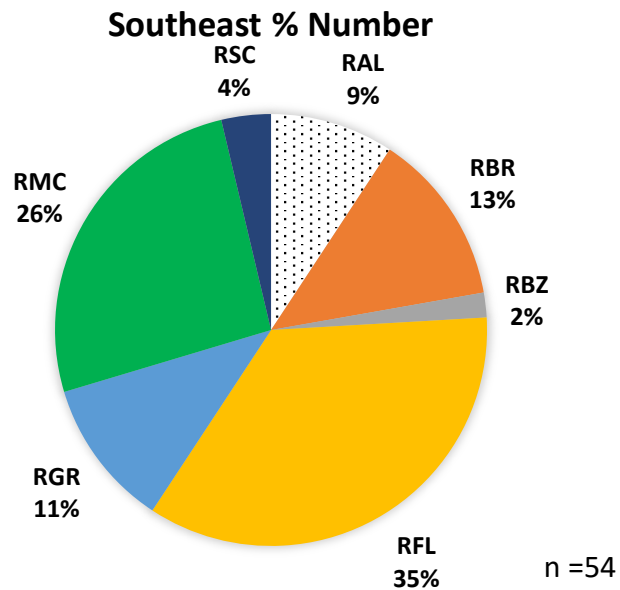


Figure 6. Percentage species composition by Number and Weight for skates caught in the Southeast region of Falkland Islands using a 400 mm diamond mesh demersal trawl. This data was not used in analyses because only one of four trawls captured skates.

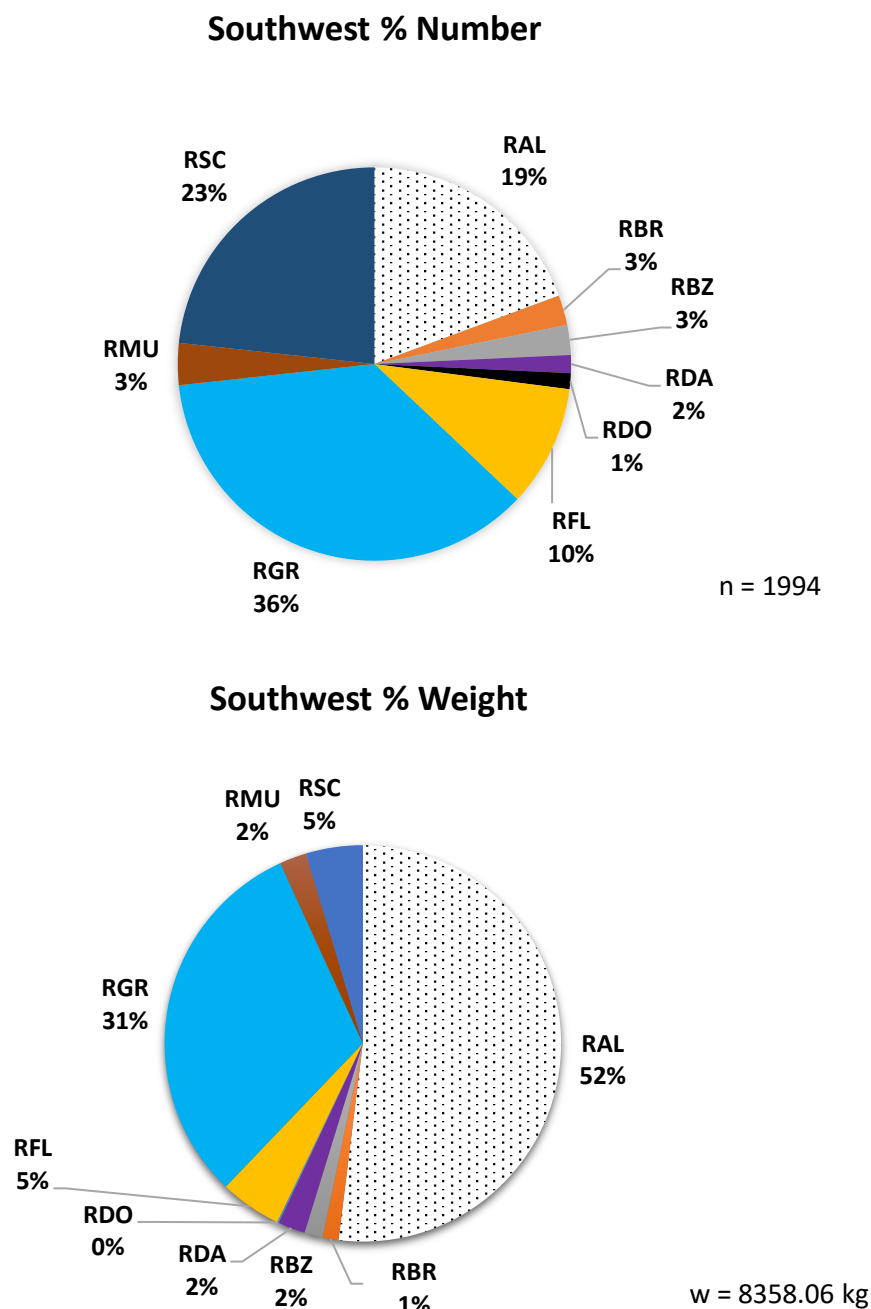


Figure 7. Percentage species composition by Number and Weight for skates caught in the Southwest region of Falkland Islands using a 400 mm diamond mesh demersal trawl.

### **CPUE**

Catch-per-unit Effort (CPUE) varied substantively among transects but was greatest in the southwest region transects 943 – 947 (Table 4, Figure 8). Overall, Southwest transects 941-948 yielded a mean CPUE ranging from more than 2 to almost 3 times the other two sampling areas: Northeast and Southeast (Table 3). It is evident

that the regional closure of the Southwest area to fishing, since 1996, has had some effect on catch rate, which was highest in this SW zone, although we cannot dismiss that it may also contain more suitable habitat for skates, since CPUE in the SE zone were not higher as well. CPUE was low compared to most years of past skate harvest at all but stations 943 to 947 in the SW zone (Winter 2018).

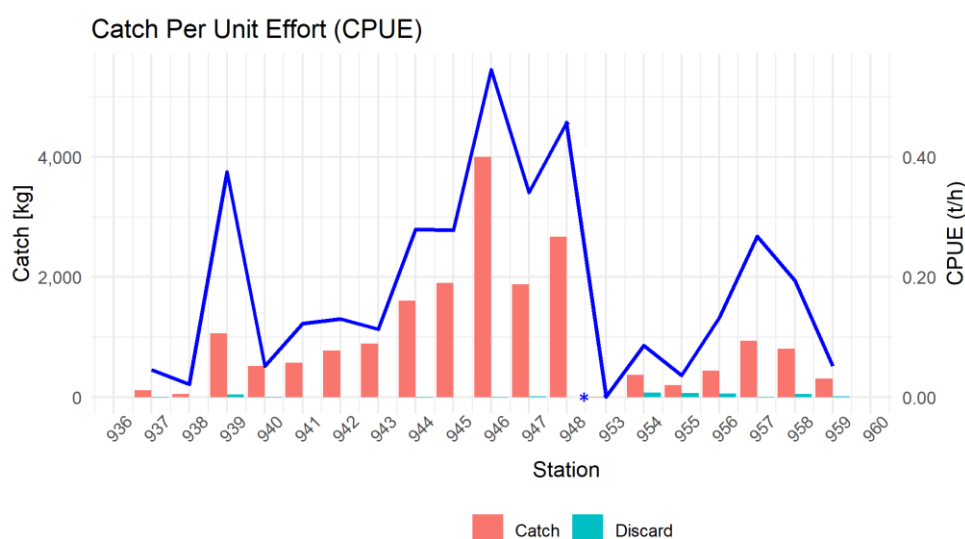


Figure 4. Catch per unit Effort CPUE — relative to catch and discards.

Table 4. Catch per unit effort of skates captured by demersal trawls with 400 mm diamond mesh codend by region within the Falkland Islands

| Region    | CPUE<br>kg·h <sup>-1</sup><br>(mean) | Standard<br>Deviation | # of<br>Trawls |
|-----------|--------------------------------------|-----------------------|----------------|
| Northeast | 110.21                               | 94.59                 | 7              |
| Southeast | 123.66                               | 167.99                | 4              |
| Southwest | 283.42                               | 160.44                | 8              |

### ***Length Frequencies and Sex Ratios OF Skate Species***

Overall, catches of Yellow-nosed Skate (*Dipturus lamillai*) were strongly skewed away from 1:1 towards females 13.3:1 (971F: 73M) ( $X^2_{2df}$ ,  $P < 0.0001$ ) (Figure 9). Given that skates are gonochoristic (they do not change sexes), this suggest the

possibilities of spatial partitioning in the sexes of this species, unequal sex determination during development, differential mortality of sexes, or differential catchability. Further study may eventually resolve this observation. This species was more abundant in southwest transects than on northern transects (Figures 4-7). Large mature males were observed in the catch but maturity was not examined in females of any of the skate species. However, almost all skates captured were greater than the 35 cm disk width minimum for retention.

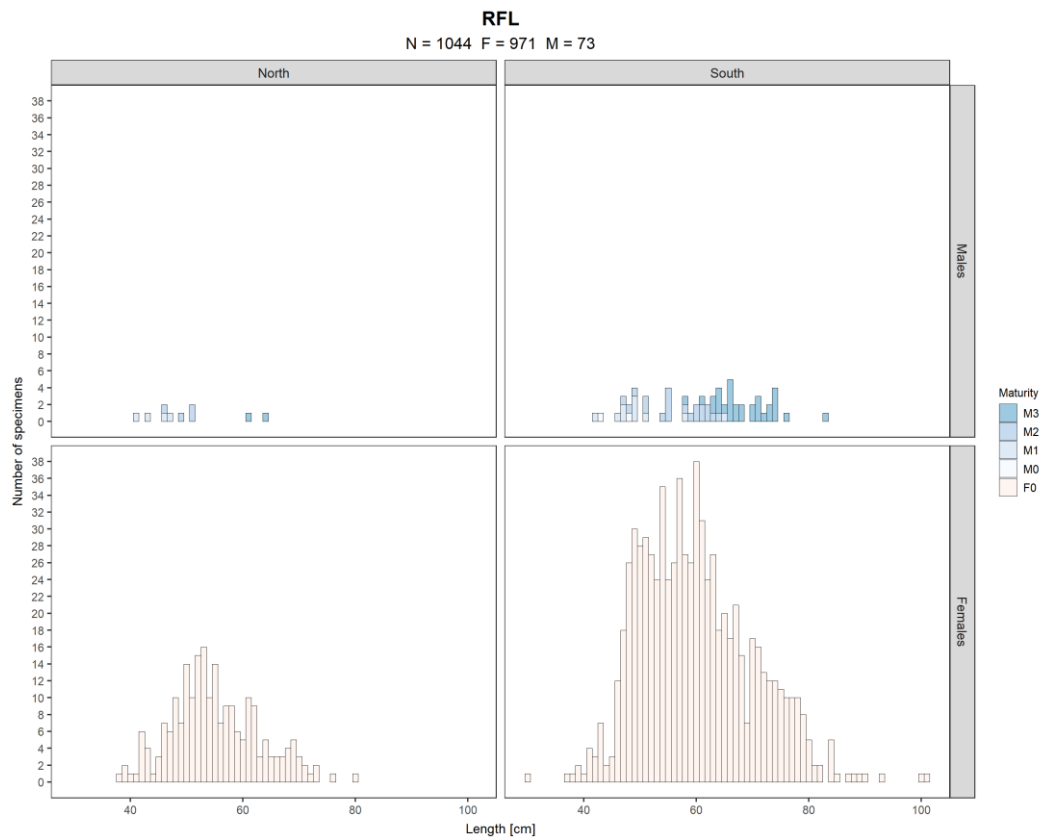


Figure 9. Disk width frequency distribution of female and male Yellow-nose Skates *Dipturus lamillai* captured in northern vs. Southern sampling areas.

Broadnose Skates *Bathyraja brachyurops* (RBR) also showed a skewed distribution ( $\chi^2_{2df}$ ,  $P < 0.0001$ ), with a ratio 2.24F:1M (Figure 10). However, considerably more males were captured alongside females, than was observed in Yellow-nose Skates, and approximately half of these males were considered mature. RBR were also more abundant in the Northern region than the Southern region (Figures

5-7). The majority of fish were greater than the 35 cm disk width minimum for retention. This species is considered Near Threatened by the IUCN (Ref. 125652).

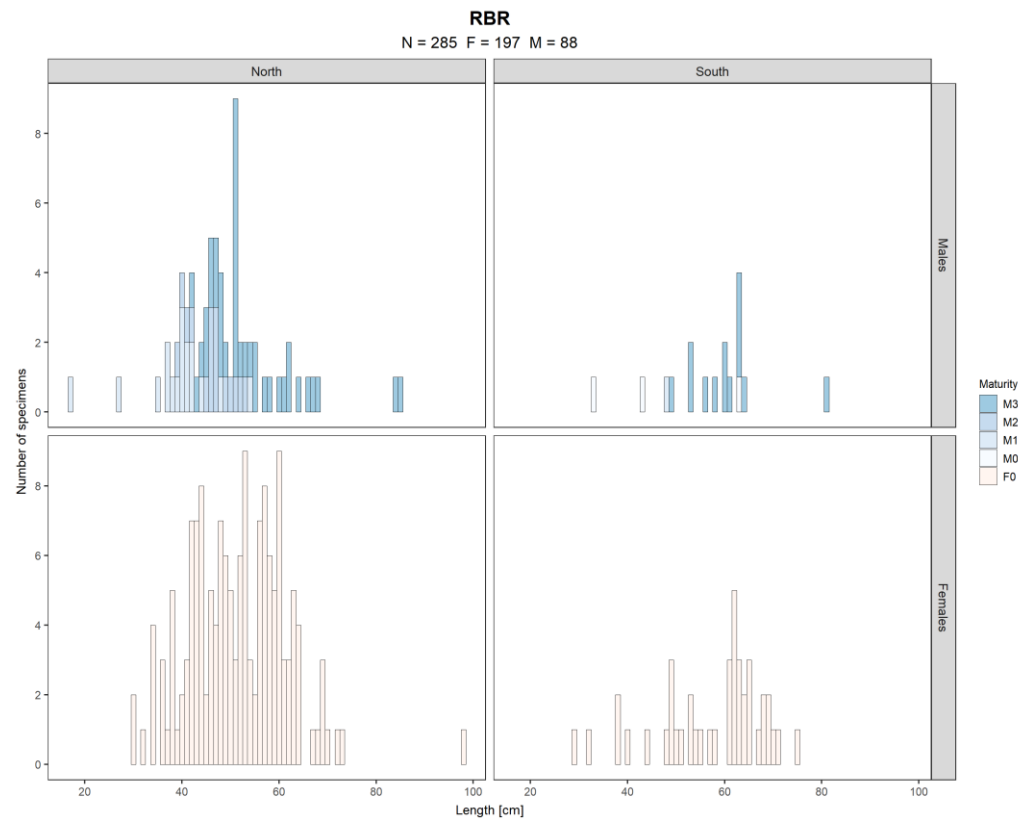


Figure 10. Diskwidth frequency distribution of female and male Broadnose Skate *Bathyrhaja brachyurops* captured in Northern vs. Southern sampling areas. -

Joined-fins Skate *Bathyrhaja cousseauae* (RBZ) showed a less-skewed sex distribution of 1.85F:1M, which while less skewed than the previous two species (Figure 11) was still statistically significant ( $X^2_{2df}$ ,  $P < 0.008$ ). Less than half of the skates were mature. Similar quantities of skates were captured in North and South regions. This fish was rare in captures and is considered a species of Least Concern by IUCN (Ref. 125652).

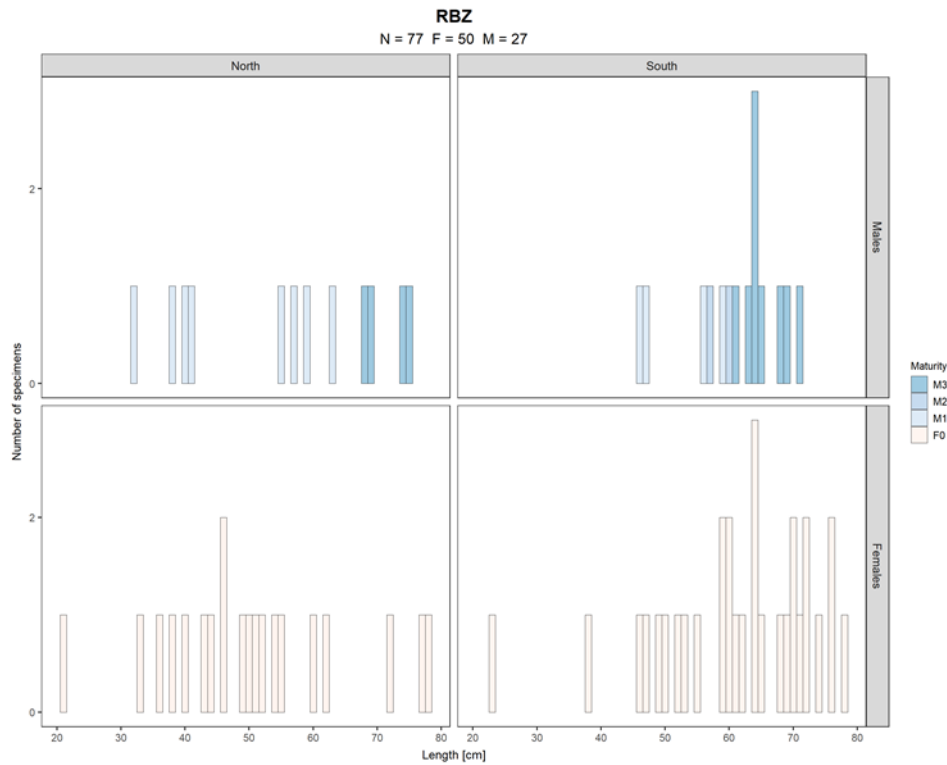


Figure 11. Diskwidth frequency distribution of female and male Joined-fins Skate, *Bathyraja cousseauae* (RBZ) captured in Northern vs. Southern sampling areas.

Argentine Skate *Dipturus argentinensis* (RDA) were large-sized individuals which look almost identical to immature RTR (Figure 12). The largest males and females were greater than 155 cm disk width. However, no reproductive skates were observed. Additionally, equal numbers of skates were observed in Northern vs. Southern Sites (Figs 4-6, 10). Sex ratio was not skewed in this species 1F:1.13M ( $X^2_{2df,0.05}$ ,  $P < 0.465$ ). Samples were retained for aging and DNA analysis. RDA is considered a Data Deficient species by IUCN (ref. 125652).

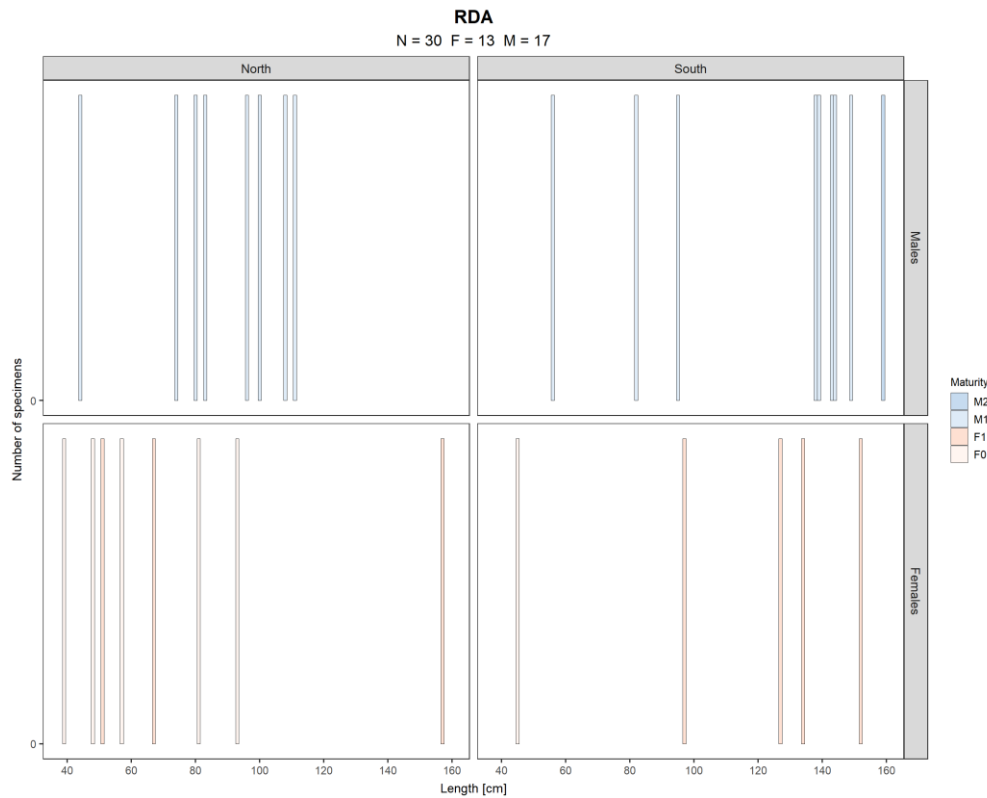


Figure 12. Diskwidth frequency distribution of female and male Argentine Skate *Dipturus argentinensis* (RDA) captured in northern vs. Southern sampling areas.

The Southern Thorny Skate, *Amblyraja doellojuradoi* (RDO) were very small-sized individuals ranging in disk width from 16 to 38 cm (Figure 13). Like RDA, RDO were observed in similar number in the North and the South. Males over 30 cm were largely reproductively mature, while reproductive state was not assessed for females. Sex ratios were 1.6F:1M and therefore were not skewed significantly ( $X^2_{2df,0.05}$ ,  $P < 0.07$ ). Almost no skate were of a size of commercial importance (> 35 cm). This species is considered a species of Least Concern by IUCN (ref. 125652).

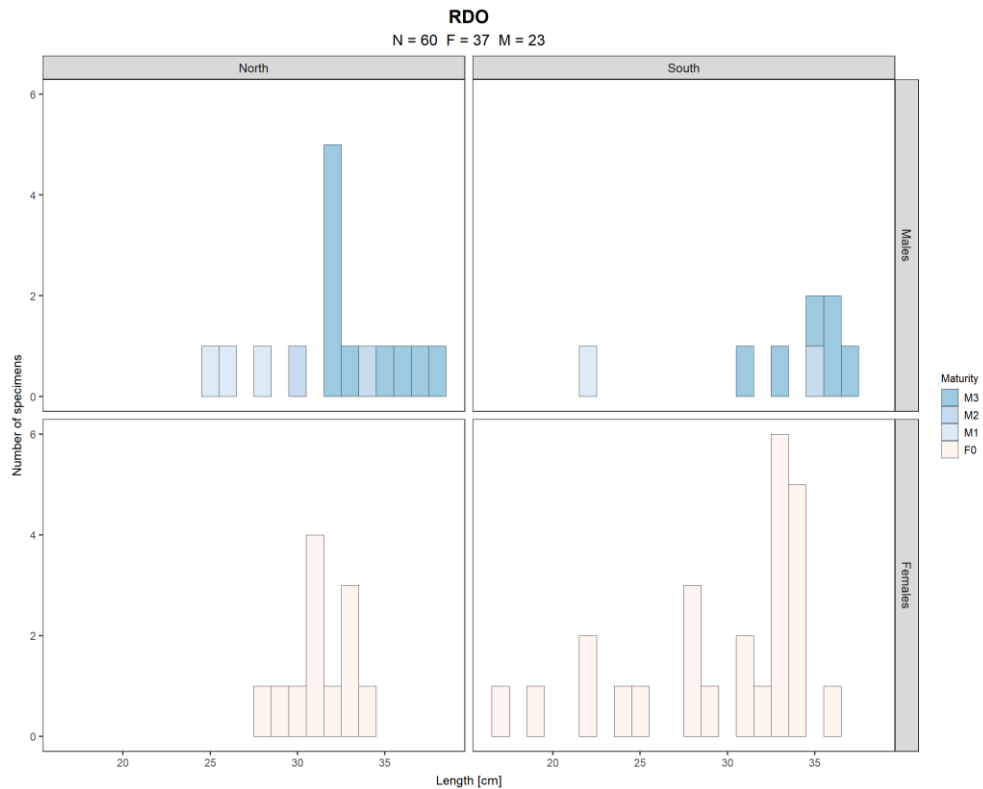


Figure 13. Diskwidth frequency distribution of female and male the Southern Thorny Skate *Amblyraja doellojuradoi* (RDO) captured in Northern vs. Southern sampling areas.

The Graytail Skate *Bathyraja griseocauda* (RGR) were common at both Northern and Southern trawl stations (Figures 5-7, 14). They ranged widely in size. Consequently, a large number of these skates were sampled including very large reproductive-size individuals and fishes over 90 cm disk width. Sex ratio was 0.94F:1M and therefore were not skewed significantly ( $\chi^2_{2df,0.05}$ ,  $P = 0.48$ ). The Graytail Skate was the largest component of the Rajid catch in the Falkland Island from 1993 to 2001 (Wakeford et al. 2004). More than 2/3 of the fish captured were of a commercial size (> 35 cm). Graytail Skate was caught in higher numbers in the South vs. the North. This species has been classed as an Endangered Species by the IUCN (Redlist Ref. 125652), as of February 8, 2019.

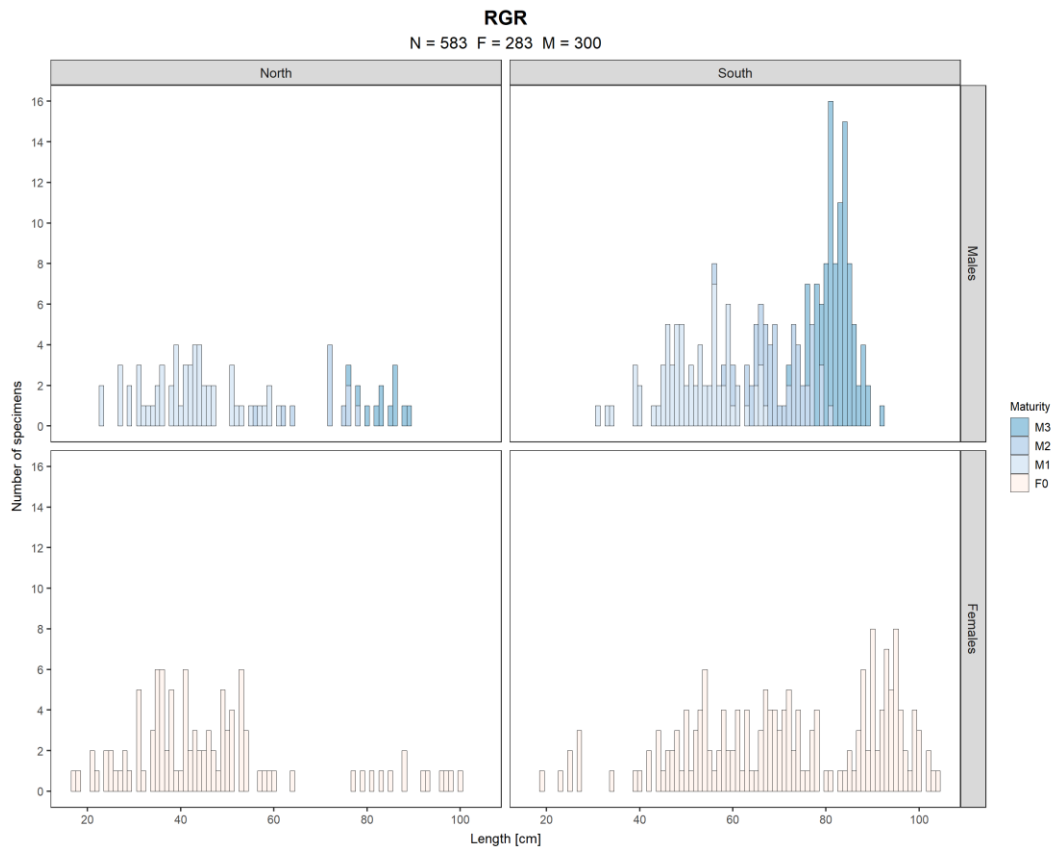


Figure 14. Diskwidth frequency distribution of female and male Graytail *Bathyrāja griseocauda* (RGR) captured in Northern vs. Southern sampling areas.

The Patagonian Skate *Bathyrāja macloviana* (RMC) were much more abundant in the North than in the South (Figures 5-7, 15). The majority of male skates were of reproductive size, with fully developed claspers, which was surprising considering the Northeast region is open to fishing. Sex ratio was 1.826F:1M and therefore were skewed towards females ( $X^2_{2df}$ ,  $P = 0.02$ ). Few fish were of commercial size (>35 cm). This species is classified by the IUCN as Near Threatened (ref. 125652).

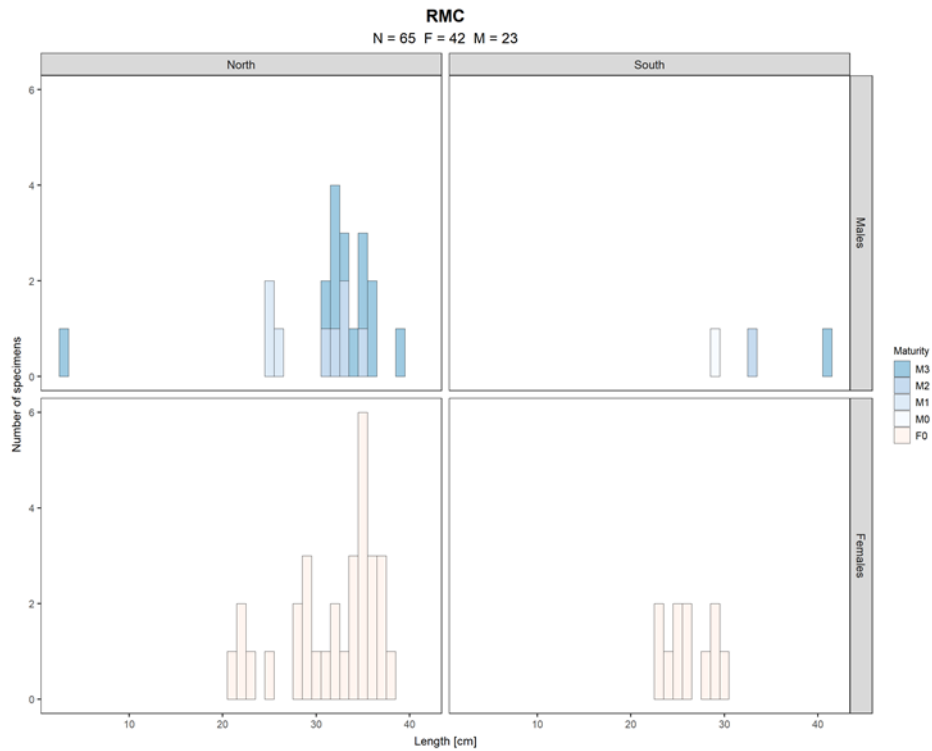


Figure 15. Diskwidth frequency distribution of female and male Patagonian Skate *Bathyraja macloviana* (RMC) captured in Northern vs. Southern sampling areas.

Size distributions appeared to differ between Northern and Southern sampling transects for the Multispine Skate *Bathyraja multispinus* (RMU), with the sample containing larger reproductive size males and females in the South and a more even distribution of small to large fish in the Northern sites (Figure 5-7, 16). This may be a reflection of the Southeast region being closed to fishing. Sex ratio of the skates were not skewed at 1.05F:1M ( $\chi^2_{2df}$ ,  $P = 0.17$ ). Almost all fish were of commercial size (>35 cm). RMU is classified as Near Threatened by IUCN (Ref. 125652).

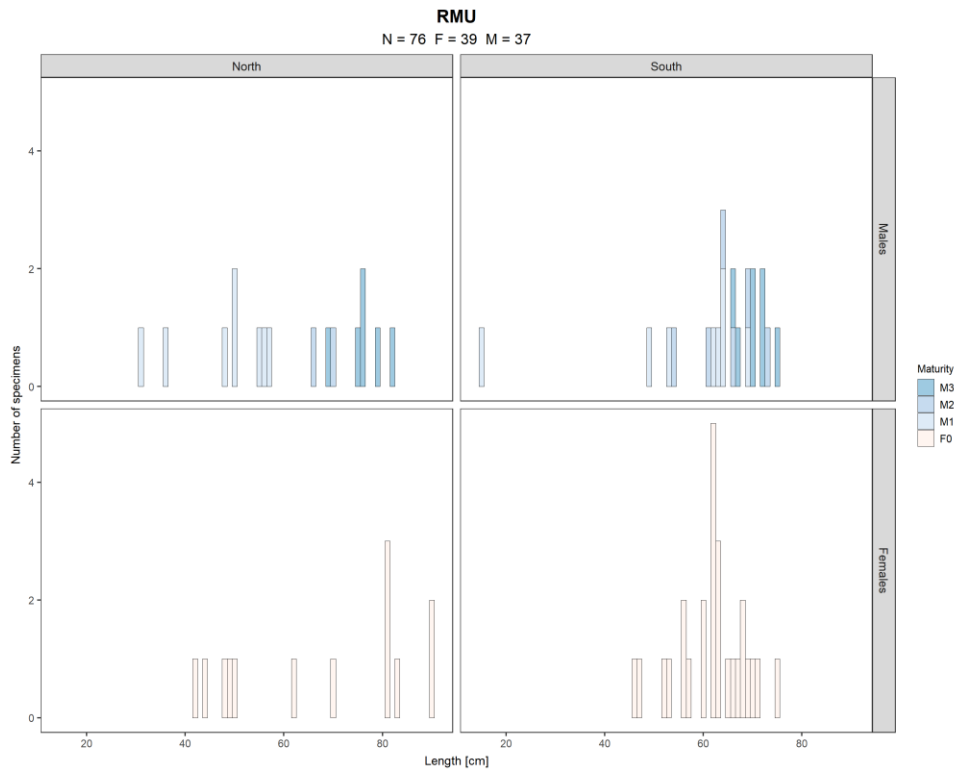


Figure 15. Diskwidth frequency distribution of female and male Multispine Skate *Bathyrhaja multispinus* (RMU) captured in Northern vs. Southern sampling areas.

The Cuphead Skate *Bathyrhaja scaphiops* (RSC) were much more abundant in Southern trawls vs. Northern trawls (Figures 5-7, Figure 17). In particular RSC were much more abundant in the Southwest, which made the primary contributions of the total number of RSC caught (Figure 7, 17). In addition, a larger number of males were reproductive in the South (Figure 17). The sex ratio of the Cuphead Skate was not skewed at 1.2F :1M ( $X^2_{2df}$ ,  $P = 0.10$ ). Almost all fish caught in both regions were of commercial size (>35 cm) in the unfished Southwest site. Juveniles were also present in the catches suggesting on-going recruitment. Despite its extremely restricted range (it is limited to Falkland Island waters), this species is classified as one of Least Concern by the IUCN (Ref 125652).

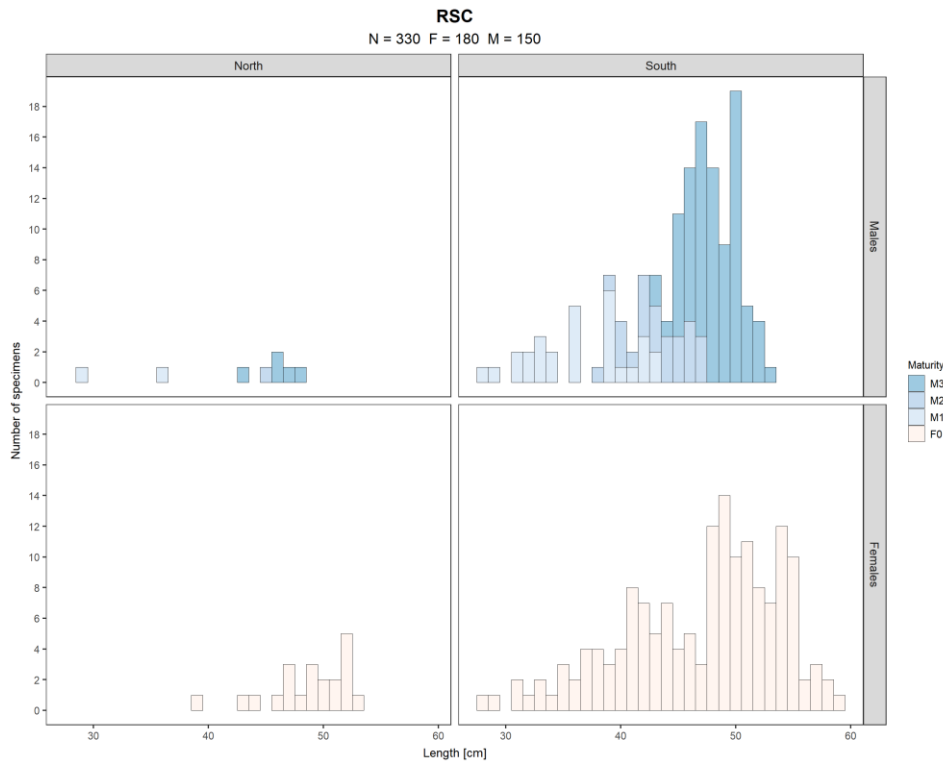


Figure 17. Diskwidth frequency distribution of female and male Cuphead Skates *Bathyraja scaphiops* (RSC) captured in Northern vs. Southern sampling areas.

### *Bony fishes and Invertebrates*

The 400 mm DMC trawl net retained some larger bony fishes and invertebrates including large numbers of Crested or Ridgescale Ratfish (*M. carinatus*), and hookarm squid *O. ingens*, *M. hubbsi* and Patagonian toothfish *Dissostichus eleginoides* (Table 5).

In particular, significant numbers of the Ridgescale Rattail (*M. carinatus*) were caught in the 400 mm diamond mesh codend trawls, primarily in trawls 937- 940 (Southeast region) (Figure 18, Table 5). This species is perhaps the most commonly captured grenadier in the Southern hemisphere (McMillian et al. 2012). Ridgescale Rattails were a large portion of the total catch in these trawls (26.6 % and 86 % of non-skate species caught) using the 400 mm DM codend, with 5079.2 kg landed and 15 kg of discards (0.29.5%) (Table 4). No other species were abundant in nets with this

configuration. Very few fish (15 kg or 0.29 %) were discarded. The subsample of fishes taken for analysis from the 400 mm DM codend were strongly skewed toward large reproductive females at 36F: 1 M (Fig. 14) which were either Spent or in a Resting phase ( $X^2_{2df}$ ,  $P < 0.0001$ ). The size distribution and proportion mature was indicative of the large mesh size of the codend and was largely made of mature Rattails (grenadiers) (Table 5, Fig 14). Some of the smallest females and the single male were immature fishes.

Considerable numbers of the large, greater hooked squid *O. ingens* were also captured as were smaller numbers of common Hake *Merluccius hubbsi* and Patagonian Toothfish (Table 5).

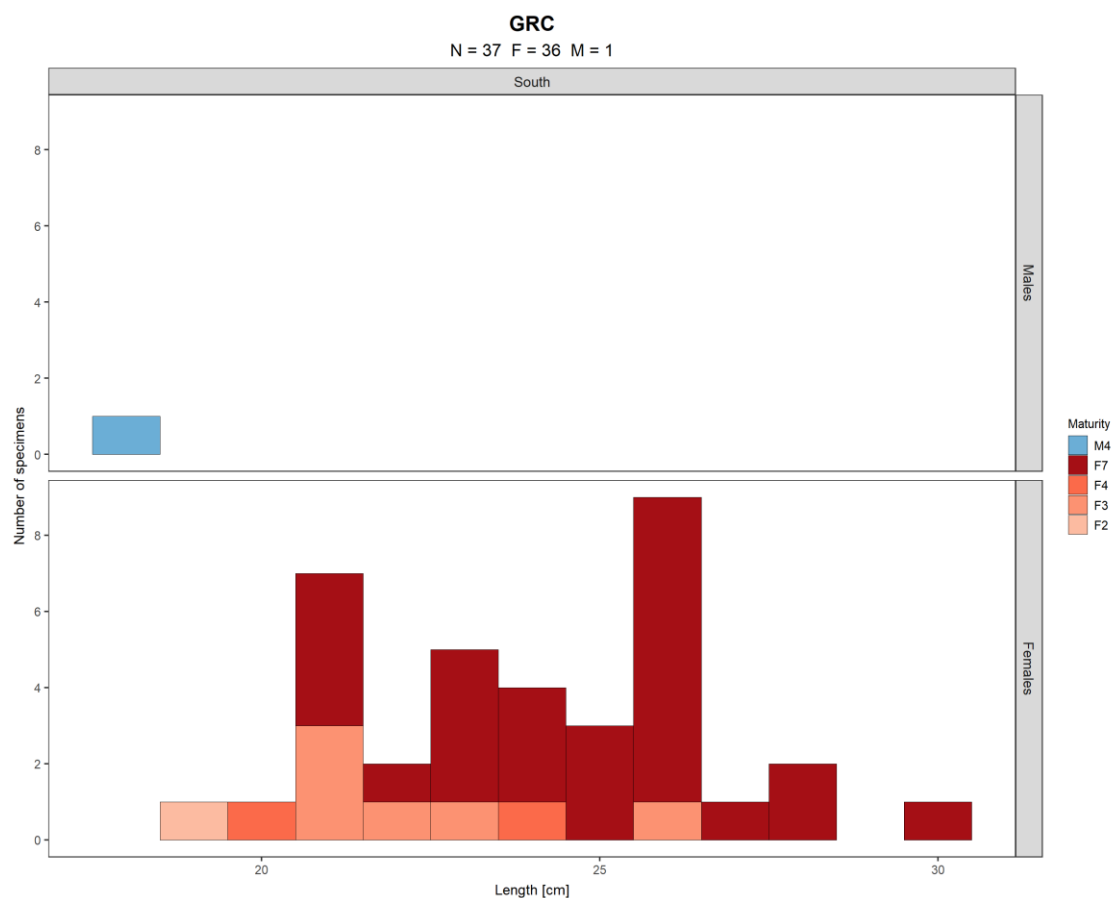


Figure 18. Length Frequency distribution and maturity of a randomized sub-sample of Ridgescale Rattail (*M. carinatus*) caught using a demersal otter trawl with a 400 mm diamond mesh codend.

Table 5. Non – skate catch with the 400 mm diamond-mesh codend otter trawl net from October 18 – 29, 2022.

| Code | Latin Name                      | Total Catch<br>[kg] | Total Discard<br>[kg] | Percent<br>[%] |
|------|---------------------------------|---------------------|-----------------------|----------------|
| GRC  | <i>Macrourus carinatus</i>      | 5079.2              | 15.0                  | 26.6           |
| ING  | <i>Onykia ingens</i>            | 224.2               | 224.2                 | 1.2            |
| HAK  | <i>Merluccius hubbsi</i>        | 217.4               | 28.5                  | 1.1            |
| TOO  | <i>Dissostichus eleginoides</i> | 173.8               | 0.0                   | 0.9            |
| BAC  | <i>Salilota australis</i>       | 83.0                | 1.0                   | 0.4            |
| LOL  | <i>Doryteuthis gahi</i>         | 80.0                | 0.0                   | 0.4            |
| MAM  | <i>Neoachirosetta milfordi</i>  | 14.2                | 14.2                  | 0.1            |
| WHI  | <i>Macruronus magellanicus</i>  | 13.0                | 0.0                   | 0.1            |
| PAT  | <i>Merluccius australis</i>     | 4.5                 | 0.0                   | <0.1           |
| KIN  | <i>Genypterus blacodes</i>      | 3.4                 | 0.0                   | <0.1           |
| MLA  | <i>Muusoctopus longibrachus</i> |                     |                       | <0.1           |
|      | <i>akambei</i>                  | 2.1                 | 2.1                   |                |
| MAR  | <i>Martialia hyadesi</i>        | 1.4                 | 1.4                   | <0.1           |
| PEN  | <i>Pennatulacea</i>             | 1.0                 | 1.0                   | <0.1           |
| COT  | <i>Cottunculus granulosus</i>   | 0.9                 | 0.9                   | <0.1           |
| PAR  | <i>Patagonotothen ramsayi</i>   | 0.3                 | 0.3                   | <0.1           |
| ARR  | <i>Arctozenus risso</i>         | 0.03                | 0.03                  | <0.1           |
| PYM  | <i>Notophycis marginata</i>     | 0.01                | 0.01                  | <0.1           |

### 110 mm Diamond Mesh codend Sampling

A dense, false bottom signature was observed on the bottom sonar display of the vessel. Upon discussion between the captain and the SIC, it was decided to install a 110 mm diamond mesh codend (DMC) liner in the codend of the demersal otter trawl to examine the community composition of this sonar reflection. Four trawls were conducted at stations 949-952 using the 110 mm DM liner in the codend of the net to examine the sonar reflection. CPUE rates were highly inflated by the catch of adult Southern Blue Whiting *M. australis* (BLU) for trawls 949 – 952 ( $\bar{x} = 8183.30 \pm 6244.06$  kg·h<sup>-1</sup>, Figure 18). In addition to BLU, 1482 kg of Argentine Hake, 513 kg Ridgescale Rattail, 84.91 kg of Rock Cod, and 5 kg of Redfish (*Sebastes oculatus*) were also caught (Figure 19). In three of the trawl sets, short 1.5 – 3.33 h trawls captured varying amounts of almost pure schools of BLU (transects 949 – 951 ( $\bar{x} = 8183.30 \pm 6244.06$  kg·h<sup>-1</sup>, Figure 20). Trawls captured commercially abundant and mature BLU at stations 949-951 (Figure 19 and 20, Table 5). The fourth trawl (952) yielded few BLU but did capture

some skates (Figure 20, Table 5). However, this trawl had a low corresponding CPUE (Fig 20). Future monitoring will need to examine the persistence of this population. Sizes of BLU showed a strongly bimodal distribution (Figure 20). The smaller-sized fish centred around 20 cm in length were all immature for both females and males. While almost the entirety of the male fish in the second, larger distribution peak were mature and in Spent or Recovering maturity stages. Females were of similar sizes regardless of the liner DMC, and a relatively high proportion of the larger females (1/3) had gonads in a resting phase, while the remainder were either Spent, or Recovering Spent. Juvenile females and males were also caught in the 110 mm DMC trawls (Figure 20).

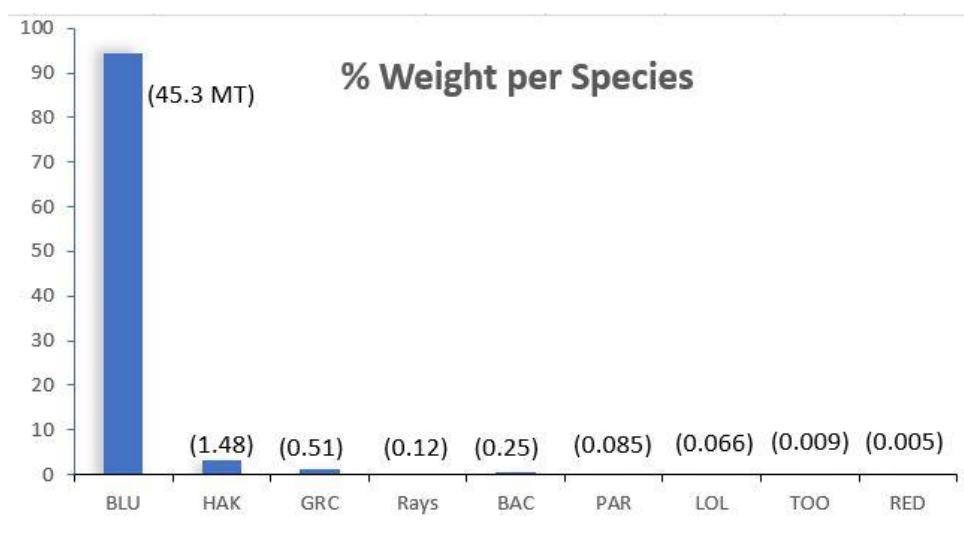


Figure 19. Proportion of landings by species (Metric tons) from 110 mm SMC otter trawl.

A comparison of BLU captured with the 400 DMC showed male fish that were generally all spent or recovering spent regardless of size. While most of the few females captured were also spent. Females were very limited in numbers with this larger net mesh.

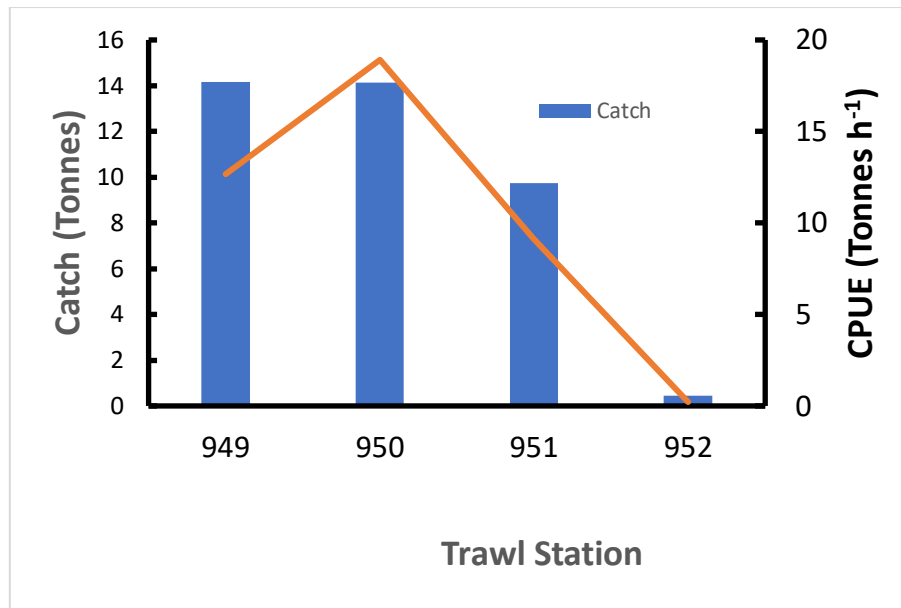


Fig 20. Blue Whiting (*M. australis*) Catch and CPUE captured South of East Falkland by demersal otter trawl, with a 110 mm diamond mesh codend liner.

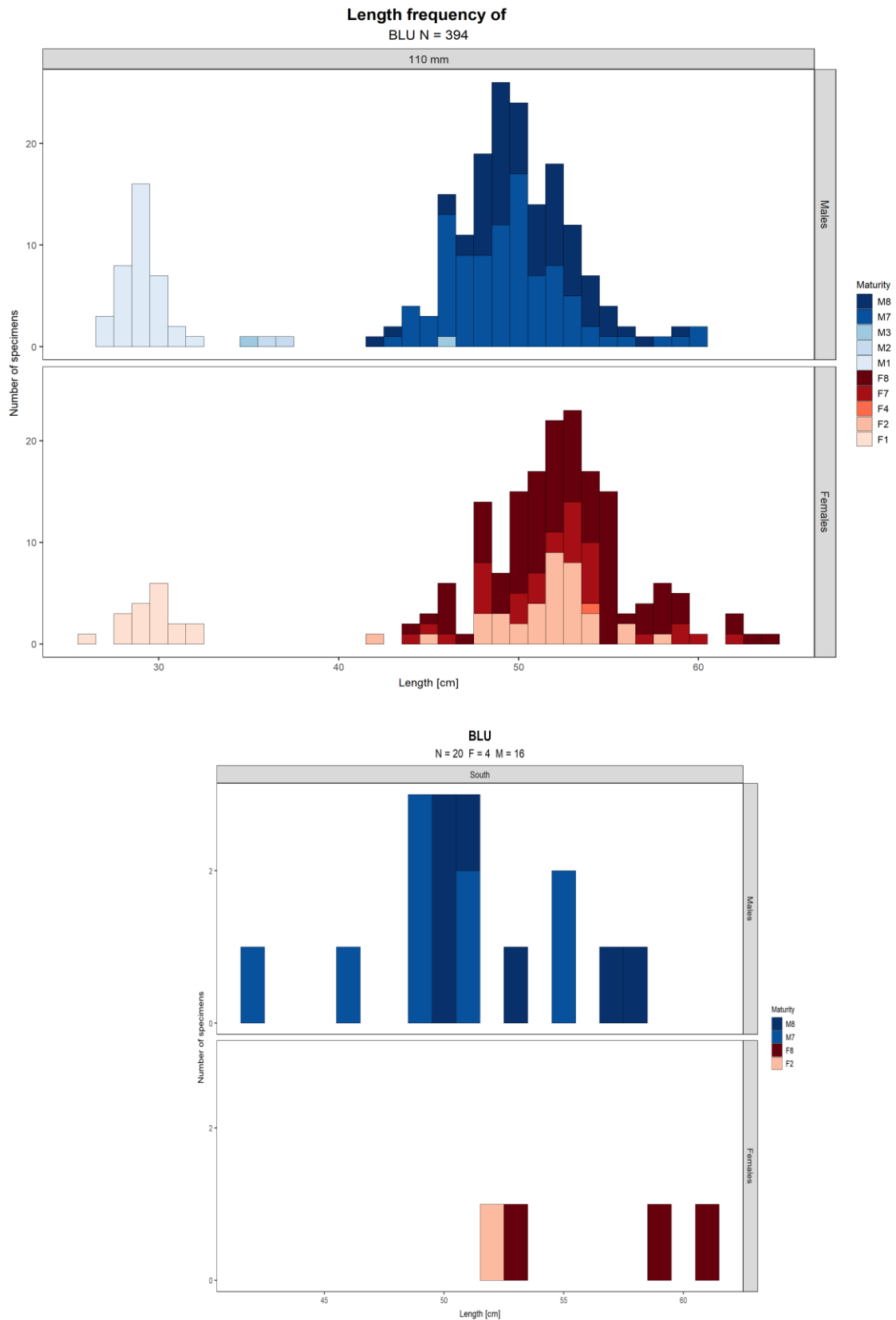


Figure 20. Length frequency and maturity of Blue Whiting (*M. australis*) captured by otter trawl with 110 mm DMC (Top). 400 mm DMC (bottom).

Table 6. Catch (kg) from 110 mm diamond mesh codend collected from trawls in the Southeast region (stations 949-952).

| Species Name                    | Code | Catch (kg) | Discards (kg) | % Catch |
|---------------------------------|------|------------|---------------|---------|
| <i>Micromesistius australis</i> | BLU  | 45339.6    | 8.7           | 94.2    |
| <i>Merluccius hubbsi</i>        | HAK  | 1482       | 0             | 3.1     |
| <i>Macrourus carinatus</i>      | GRC  | 513.8      | 0             | 1.1     |
| <i>Salilota australis</i>       | BAC  | 250.5      | 0.5           | 0.5     |
| <i>Patagonotothen ramsayi</i>   | PAR  | 84.91      | 34.9          | 0.2     |
| <i>Doryteuthis gahi</i>         | LOL  | 66         | 0             | 0.1     |
| <i>Dipturus lamillai</i>        | RFL  | 25.7       | 0             | 0.1     |
| <i>D. lamillai</i>              |      |            |               |         |
| <i>Bathyraja brachyurops</i>    | RBR  | 12.8       | 0             | <0.1    |
| <i>Dissostichus eleginoides</i> | TOO  | 9.02       | 0             | <0.1    |
| <i>Sebastes oculatus</i>        | RED  | 5          | 0             | <0.1    |
| <i>B. griseocauda</i>           | RGR  | 3.3        | 0             | <0.1    |
| <i>B. albomaculata</i>          | RAL  | 0.3        | 0             | 0.7     |
| <i>B. macloviana</i>            | RMC  | 2.1        | 2.1           | <0.1    |
| <i>Amblyraja doellojuradoi</i>  | RDO  | 0.6        | 0.6           | <0.1    |
| <i>B. cousseauae</i>            | RBZ  | 0.5        | 0             | <0.1    |

While seven species of skate were caught in the smaller (110 mm SM codend) net, these differences in the species composition likely reflect differences in effort rather than catchability, given that the species captured in the fine mesh net were a subset of the catch with the large mesh net (Figure 22 and Table 6). As with the 400 mm DMC, only one trawl (952) had significant catches of skates. That being said, White-spotted Skates (RAL) were by far the most abundant skates captured in the 110 mm trawl (88%), while in the 400 mm trawl large Yellow-nose (RFL) and Grey-tail Skates (RGR) comprised 74% of the catch.

It is of particular interest that trawls 949-951 were devoid of skates, however, some skates were caught at trawl station 952 and were dominated numerically *Dipturus lamillai*, *Bathyraja grisocaudata*, and *B. brachyurops*. In particular, *D. lamillai* made up a total of 30 % of the total of the total number, and 57 % of the 45.3 kg catch by weight (Fig. 22). This is very similar to the catch with the 400 mm SMC in the same

region, which was larger but also dominated by RFL by both number and weight. This demonstrates little selectivity of mesh size on catch composition.

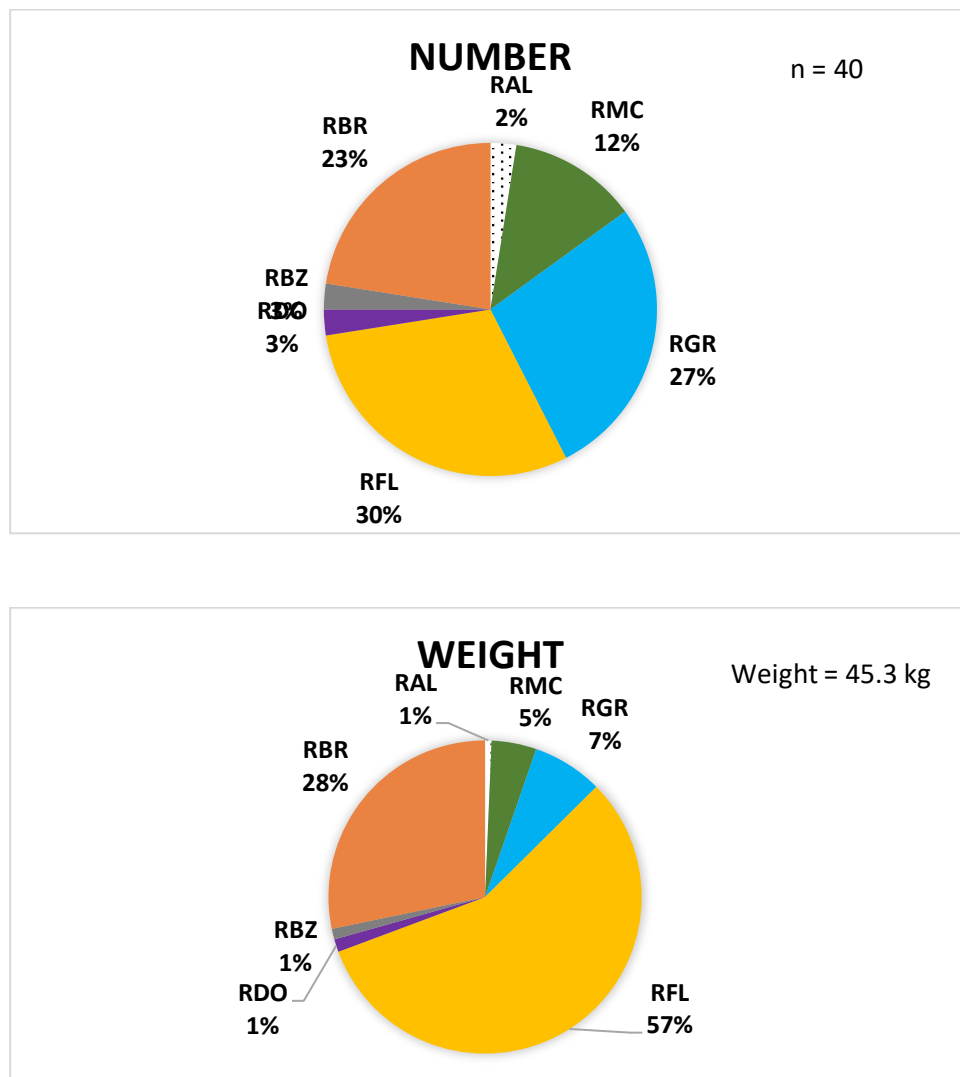


Figure 22. Skate species composition of trawl 952 (110 mm DM codend) by Number and by Weight from Southeast region.

## **Conclusions**

1. Catch weight of skates with the commercial-sized 400 mm or a smaller finfish mesh (110 mm) were not sufficient to support a directed fishery in the closed area South of 51 °S currently or areas North of 51 °S. Reasons for this are a likely a combination of previous exploitation, on-going by-catch, coupled with the low reproductive rate and lack of immigration.
2. The use of different sized codend meshes (400 mm vs. 110 mm,) in the codend of the bottom trawl resulted in similar species composition of skates but differential catches of finfishes. The use of 400 mm DMC reduced the bycatch of finfishes such as blue whiting relative to the 110 mm DMC but did not reduce the capture of Ridgescale Rattail, which were caught in both net sizes.
3. Regional differences in catch were apparent in terms of size of catch. The largest catches were in the Southwest region, which has been closed to skate fishing since 1996. RBR and RMC were relatively more abundant in catches from Northeast sites, while RFL, RGR, and RSC were more prevalent in catches from Southwest trawl stations.
4. In addition, one species captured, RGR, is considered to be an Endangered Species and another two RBR and RFL are classed as Near threatened species by IUCN. Inclusion of these species in catch could lead to problems in terms of markets.

## **Recommendations**

1. Capture rates of mature skates in the present study were at too low levels to permit commercial scale harvest. We cannot presently maintain a skate fishery. [The closure of the Southwest region below 51 °S appears to have helped the populations of skates in that area, however, numbers and species richness were not substantially greater.
2. Large catches of Ridgescale Rattail were observed, however, the low reproductive indices of this species and other grenadiers makes them poor candidates for fisheries worldwide (Devine et al. 2012)
3. Commercially abundant post-spawning Blue Whiting were captured in the southern region. Fishes were likely involved in an alimentary (feeding) migration. We will need to further monitor for the seasonal presence of these fishes.

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