



The Falkland Islands Government

The Fisheries Department Stanley Falkland Islands

Telephone: (500) 27260

Facsimile: (500) 27265

RESEARCH CRUISE ZDLT1-12-2018

RV Castelo

23-31 December 2018

Cruise Report

Patagonian toothfish - juvenile survey

Lee, B., Goyot, L., Ramos Castillejos, J. E., Hall, J., and Zawadowski, T.

1. Introduction

Understanding the spatial and temporal distribution and abundance patterns of species and their relationships with environmental variables is a key issue in fisheries ecology. This is particularly important during the early life-history stages, since settlement patterns of larvae, their distribution and abundance is the first step of a chain of successive events which culminate in the adult population structure (Grorud-Colvert and Sponaugle, 2009; Félix-Hackradt *et al.*, 2013; Cooper and Nichol, 2016).

Patagonian toothfish (*Dissostichus eleginoides*) have a complex life cycle composed of both pelagic and benthic life-history stages. In the Falkland Islands, mature toothfish are thought to spawn in waters >800 m over the eastern part of the Burdwood Bank (Laptikhovskiy, Arkhipkin and Brickle, 2006). During a protracted egg phase (3 months), larvae are distributed to shelf waters by the flow of the Falklands Current, a north flowing extension of the Antarctic Circumpolar Current originating in the Drake Passage. The Falklands Current divides into two streams to the southwest of the Falkland Islands: the stronger Falklands Current diverging to the east; and the Patagonian Current passing to the west (Croxall and Wood, 2002). These currents carry nutrient rich waters to upwell along the boundaries of the Patagonian Shelf particularly evident in the formation of two frontal zones along the shelf regions to the south of the Falkland Islands: the southern frontal zone (SF) near Beauchene

Island; and the western inshore front (WIF) to the southwest (Arkhipkin, Brickle and Laptikhovsky, 2013). The SF and WIF are highly productive providing fertile conditions for zooplankton production and are thought to serve as important recruitment areas for the rapid growth of toothfish larvae and the settlement of early juveniles onto the shelf. Over the next 5 to 10 years juveniles will undertake a characteristic down-slope ontogenetic migration into deeper slope waters where they will reach maturity and spawn. As such, these recruitment areas across the shelf to the south of the Falkland Islands, along with their associated down-slope migration pathways, therefore form a critical link in the life cycle trajectory associated with spawning adults on the Burdwood Bank.

The current research cruise (ZDLT1-12-2018) was a continuation of two previous surveys that were undertaken to investigate the distribution of juvenile toothfish around the Falkland Islands. An initial plankton survey was undertaken in November 2015 to investigate potential sources and pathways of toothfish eggs and larvae to the southern shelf region of the Falkland Islands. However, no toothfish eggs or larvae were found during this cruise. Previous results suggest that toothfish eggs and larvae are patchily distributed within the surface layers of the water column meaning that a high amount of effort is required to obtain erratic abundances of specimens (Evseenko, Kock and M, 1995; North, 2002). A second reason proposed was that the egg or larval phase of development occurs earlier than what was previously thought, and the timing of the research cruise was therefore not consistent with these phases of ontogenetic development.

A second survey was undertaken in January 2017, providing for at least 4 months for larvae and early juveniles to grow after hatching. During the survey, a quasi-stationary cyclonic eddy causing upwelling of transient zone waters was found to the north of Beauchene Island, consistent with the results of Arkhipkin et al. (2013). The eddy forced the shelf waters further offshore to the east of Beauchene Island. Within this region, a nursery ground of juvenile 0+ year class toothfish (10-12 cm total length) was found at depths between 70 and 120 m. In the most abundant areas, the density of juvenile toothfish reached >1000 specimens by 1 hr trawl. Habitats of 0+ year class of toothfish did not coincide with larger cohorts occurring in deeper waters (>170 m). That provided necessary separation of small and larger juveniles to prevent cannibalism. Despite obvious success, the survey did not reveal the time and locations of juvenile toothfish settlement on the shelf, as it should occur earlier in the season.

2. Aims and objectives

The aim of this study was to locate and investigate the timing, location, distribution and abundance of newly settled Patagonian toothfish recruits across two regions of high productivity to the southeast and southwest of the Falkland Islands. An oceanographic survey was undertaken in conjunction with this study to describe the oceanographic features that may influence the distribution and timing of settlement within the study region. The main objectives of the research survey were:

- To confirm the timing of age 0+ Patagonian toothfish settlement on the shelf to the south of the Falkland Islands.
- To describe and compare the distribution patterns of newly settled age 0+ and previous year recruits (age 1+) on the shelf regions to the south of the Falkland Islands.
- To estimate the density and relative abundance of juvenile Patagonian toothfish recruits on the shelf regions to the south of the Falkland Islands.
- To obtain environmental parameters to elaborate an oceanographic diagnosis based on data collected in the vicinity of each trawl station.

3. Materials and methods

3.1. Research vessel and study area

The research survey ZDLT1-12-2018 was conducted on board the F/V Castelo from 23-31 December 2018. The Department of Natural Resources-Fisheries owned bottom trawl fitted with rockhopper gear was used with FV Castelo's bottom doors (1800 kg, 3180 x 2480 cm). The code-end has a 90 mm mesh size which will be fitted with a 10-15 mm cod end liner. The MarPort Net Monitoring System will be used to monitor the geometry of the net.

Additional gear being utilised onboard the FV Castelo included:

- SeaBird SBE 25 CTDO

The geographic region of interest in this study covered the shelf region to the south and south-east of the Falkland Islands in waters between 50 and 200 m depth (Figure 1). The study region encompasses two frontal regions of high productivity: the southern front (SF) to

the south-east and the western inshore front (WIF) to the south-west of the Falkland Islands. The wide shelf regions falling between these two zones, to the south of the Falklands Sound was also be included in the study area.

3.2. Survey plan

As there is no previous data on distribution of toothfish larvae and small juveniles during their settlement period around the Falkland Islands, the survey will be done on an exploratory ad hoc basis, similarly to the previous survey carried out in January 2017. A minimum of five tows of 45 minute duration will be undertaken per day. The trawl duration will remain consistent for the duration of the survey. The aim is to complete a minimum of 31 trawls during the survey period.

The study area will be subdivided among equally spaced transect profiles. Depending on the extent of the shelf, each transect zone will be explored through a series of between 2 and 5 trawls extending from shallow (50-70 m depth), medium (70-110 m depth) and deep (110-170 m) waters Figure 1. The survey will begin to the east of the SF, working west until the westward extent of the WIF. The exact timing and location of individual stations will depend on results obtained from oceanographic stations and prior trawls in discussion with the fishing master regarding the nature of the sea-floor.

During evening hours, two to three casts of plankton net may be done at various depths located deeper, within and shallower than the main backscattering layer. The deployment of the plankton net will be dependent on catches achieved from daylight stations. No night time shifts/trawling are planned.

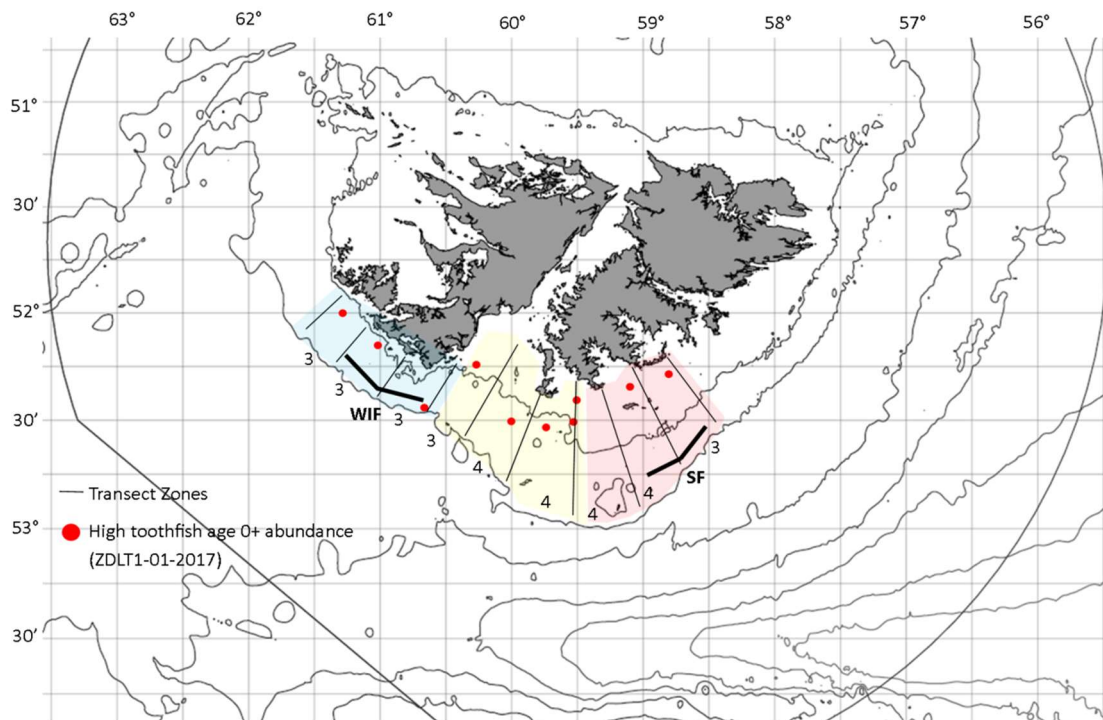


Figure 1: Map of the survey area with the proposed transect zones. Red dots indicate stations of high age 0+ toothfish abundance based on the ZDLT1-01-2017 research survey. Numbers reflect the optimum numbers of stations per transect zone.

3.3. Trawl information

The bridge officers should provide scientific staff with the geographical and meteorological information and note down in the corresponding sections of the station logs. It is also important that data on net performance and specific parameters are collected for every trawl.

3.4. Biological data

At each sampling station, all species caught will be identified and their total weights will be recorded using the electronic marine adjusted POLS balance. Random samples of 100 specimens will be taken from all finfish and squid species of interest. Total length, sex and stage of maturity will be recorded using an eight stage maturity scale for finfish, a six stage maturity scale for squid and a six stage maturity scale for Chondrichthyans. Otoliths will be extracted from a subsample covering the length distribution of the sampled specimens.

3.5. Oceanography

A single member of the research team will be responsible for ensuring the appropriate deployment of the CTD and care of the equipment.

Oceanographic casts with CTD (SBE-25, Sea-Bird Electronics Inc., Bellevue, USA) instrument, Serial No 0247, will be used to collect oceanographic data in the vicinity of all trawl stations. The CTD records pressure in dbar, temperature in °C, conductivity in $\text{m}^{\text{S}}/\text{cm}$, Oxygen Voltage and Fluorescence.

3.7. Personnel and Responsibilities

Personnel partaking in the research cruise were:

- Brendon Lee (Chief Scientist)
- Ludovic Goyot (Trawl survey)
- Jorge Eduardo Ramos Castillejos (Trawl survey and CTD deployment)
- Jack Hall (Trawl survey and training)
- Tomasz Zawadowski (Trawl survey and data handling)

4. Results

4.1. Patagonian toothfish (*TOO*, *Dissostichus eleginoides*)

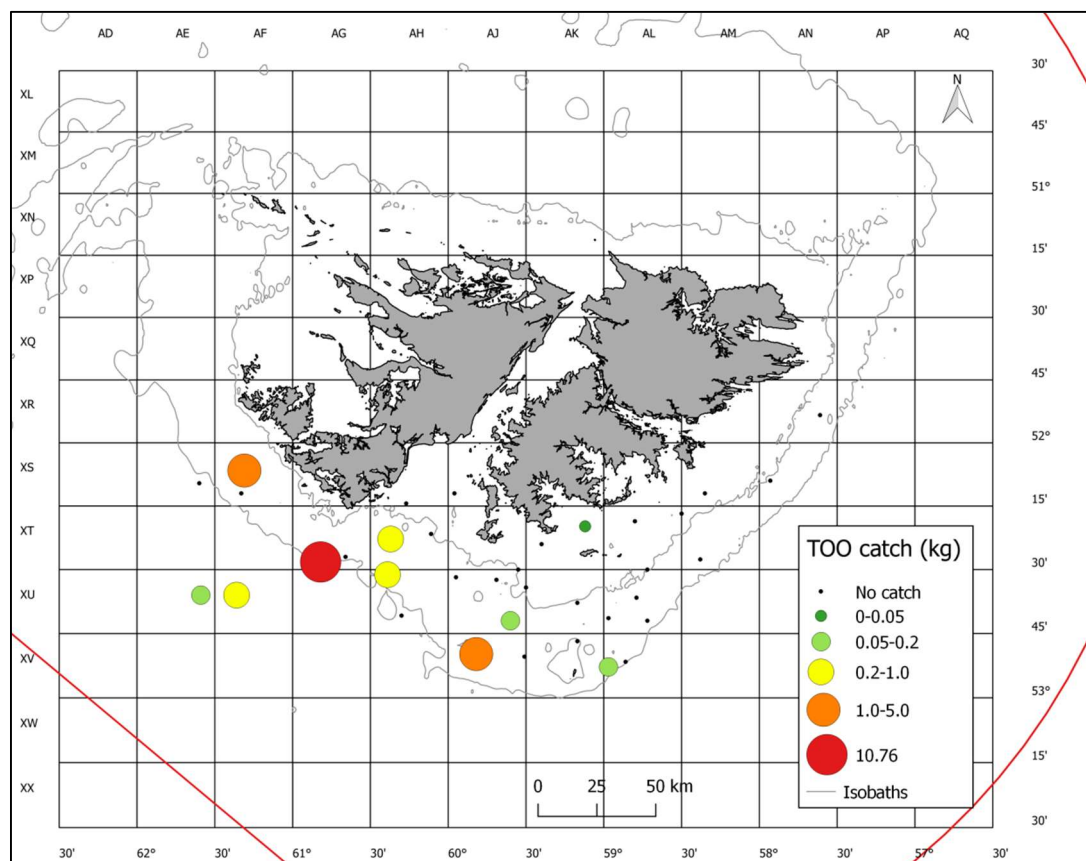


Figure 2: Distribution and catch (kg) of Patagonian toothfish (*TOO*, *Dissostichus eleginoides*) off southern Falkland Islands during December 2018.

A total of 19.23 kg of Patagonian toothfish ($n = 28$) was caught during December 2018. Most of the stations where TOO were caught were located off Southwestern Falkland Islands, with a trend of increasing abundance towards western longitudes and deeper stations (Figure 2). In shallow water stations (< 130 m), two individuals were collected and measured 14 and 45 cm TL. At intermediate depths (130–170 m), the range of size was 24–68 cm TL, with most individuals measuring 24 cm TL. In deeper waters (> 170 m), TOO size ranged between 28 and 68 cm TL, and the largest prevalence of individuals occurred at 45 cm TL (Figure 3). Most TOO were immature (stage I) or resting (stage II). Nearly 86% of the females were at resting maturity stage (stage II) and 14% females at immature stage (stage I). In contrast,

males had the opposite maturity frequency with 71% immature individuals (stage I) and 29% males at resting maturity stage (stage II; Figure 4).

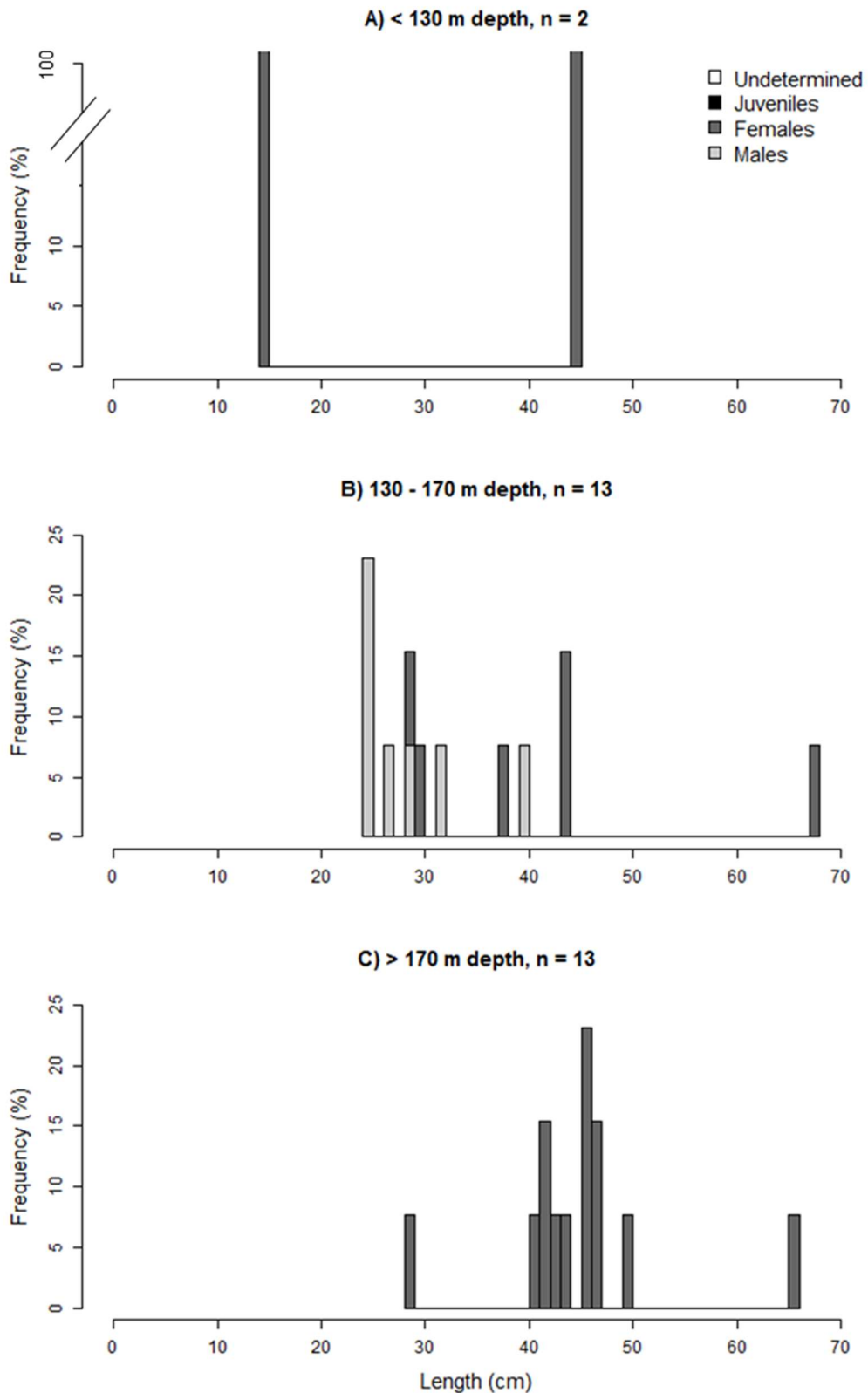


Figure 3: Length frequency distributions of Patagonian toothfish (TOO, *Dissostichus eleginoides*) sampled at A) shallow, B) intermediate, and C) deep water stations off southern Falkland Islands during December 2018.

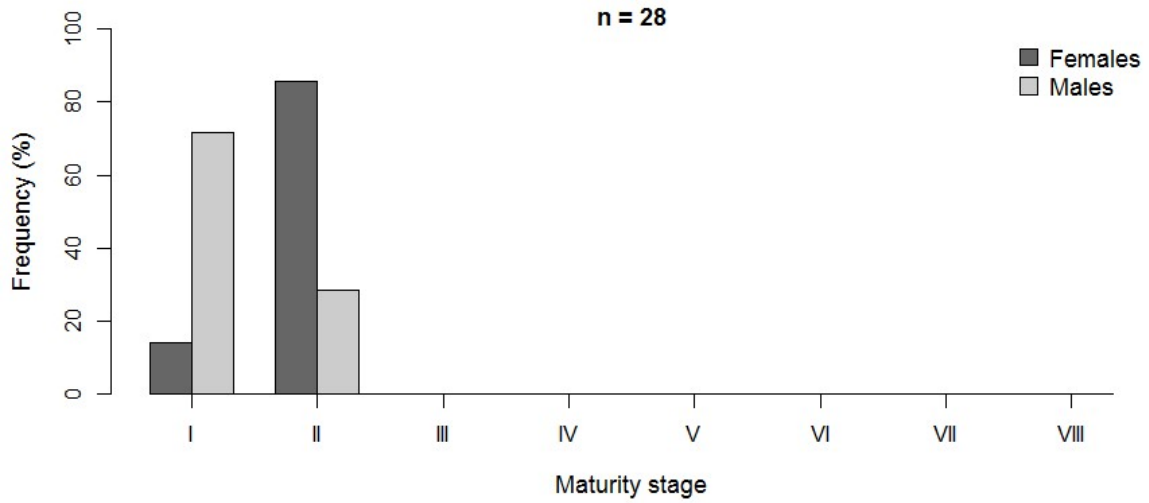


Figure 4: Maturity frequency distributions of Patagonian toothfish (TOO, *Dissostichus eleginoides*) sampled off southern Falkland Islands during December 2018.

Icefish (CHE, *Champscephalus esox*)

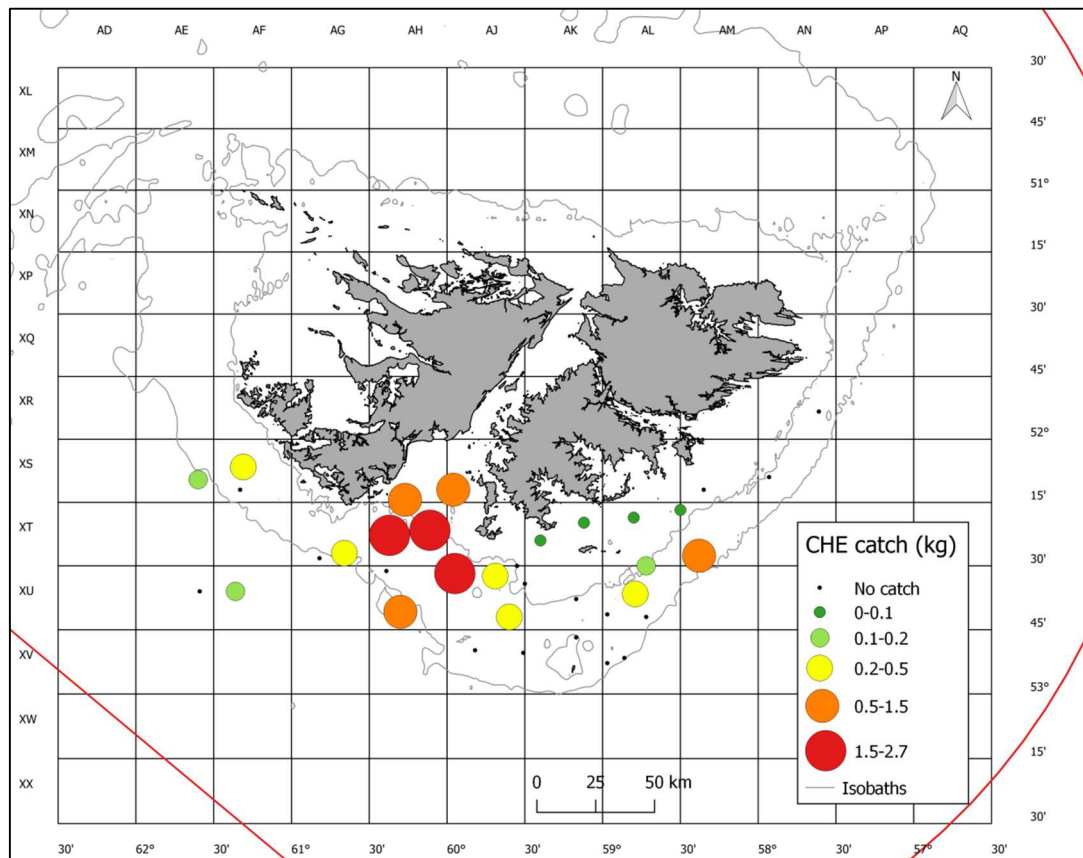


Figure 5: Distribution and catch (kg) of Icefish (CHE, *Champscephalus esox*) off southern Falkland Islands during December 2018.

A total of 153 Icefish were collected, with a total catch of only 12.0 kg. However, they seemed to be present in most of the study area with a higher density of individuals along the southern part of the Falkland Sound and in shallower waters (Figure 5). The size of fish in shallow water stations ranged from 8 to 39 cm TL, and the greater frequency of individuals occurred at 11 cm TL. Eight individuals ranging from 24 to 38 cm TL were collected at intermediate depths (130–170 m), whereas only two individuals were collected at deeper waters (> 170 m) and measured 36 and 37 cm TL (Figure 6). Most Icefish individuals were immature (stage I) during December 2018; approximately 64% of the females and 74% of the males were immature (stage I), whereas 36% of the females and 25% of the males were at resting maturity stage (stage II). Only 1% of the males were at recovering spent stage (stage VIII; Figure 7).

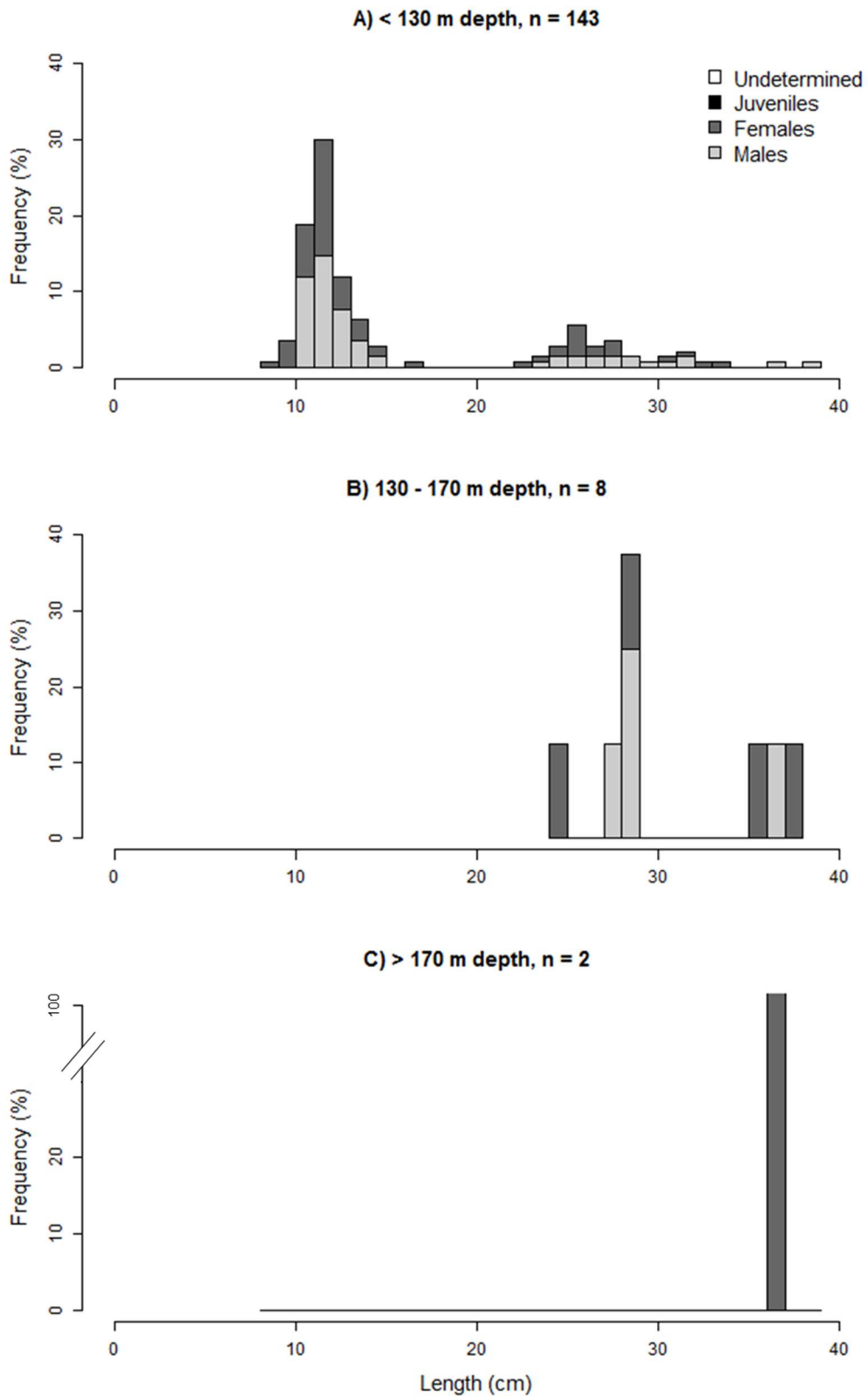


Figure 6: Length frequency distributions of Icefish (*CHE*, *Champscephalus esox*) sampled at A) shallow, B) intermediate, and C) deep water stations off southern Falkland Islands during December 2018.

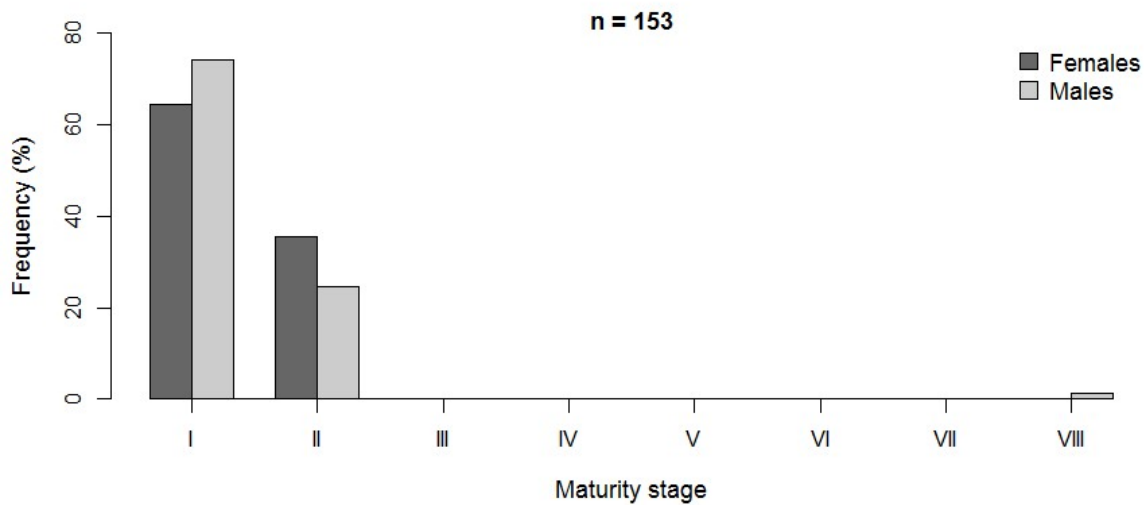


Figure 7: Maturity frequency distributions of Icefish (CHE, *Champsocephalus esox*) sampled off southern Falkland Islands during December 2018.

Banded whiptail (GRF, *Coelorinchus fasciatus*)

No Banded whiptail was collected in shallow and intermediate water stations; only a few individuals (n=26) were collected in deeper waters (> 170 m). GRF size ranged between 10 and 15 cm PAL, and the largest prevalence of individuals occurred at 13 cm PAL (Figure 8). Only females were present, mostly at resting maturity stage (stage II = 65%) and at early developing stage (stage III = 31%), with a few individuals at recovering spent stage (stage VIII = 4%; Figure 9).

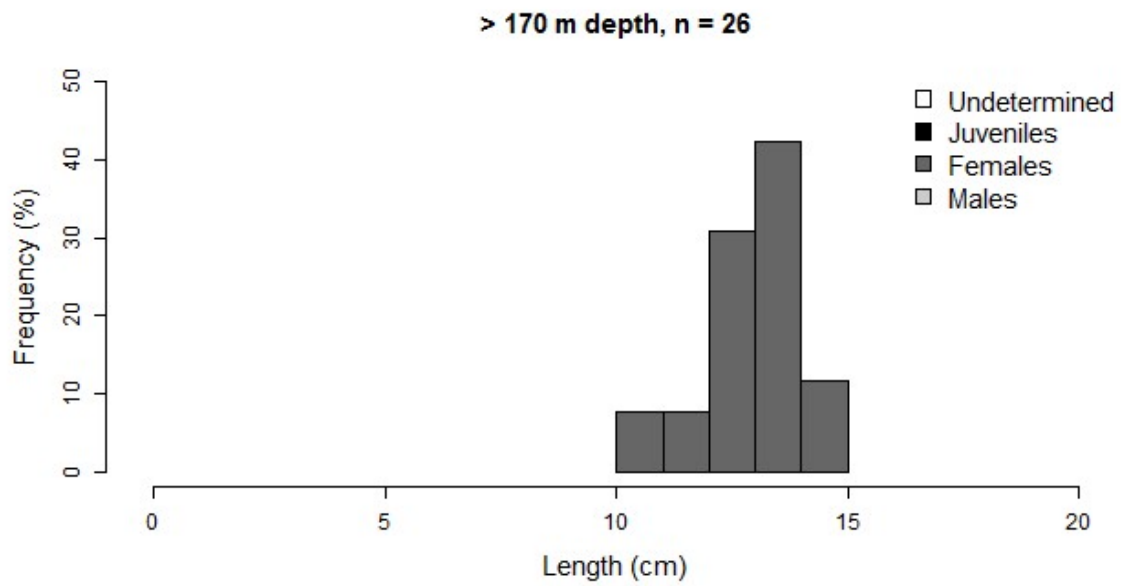


Figure 8: Length frequency distributions of Banded whiptail (GRF, *Coelorinchus fasciatus*) sampled at deep water stations off southern Falkland Islands during December 2018.

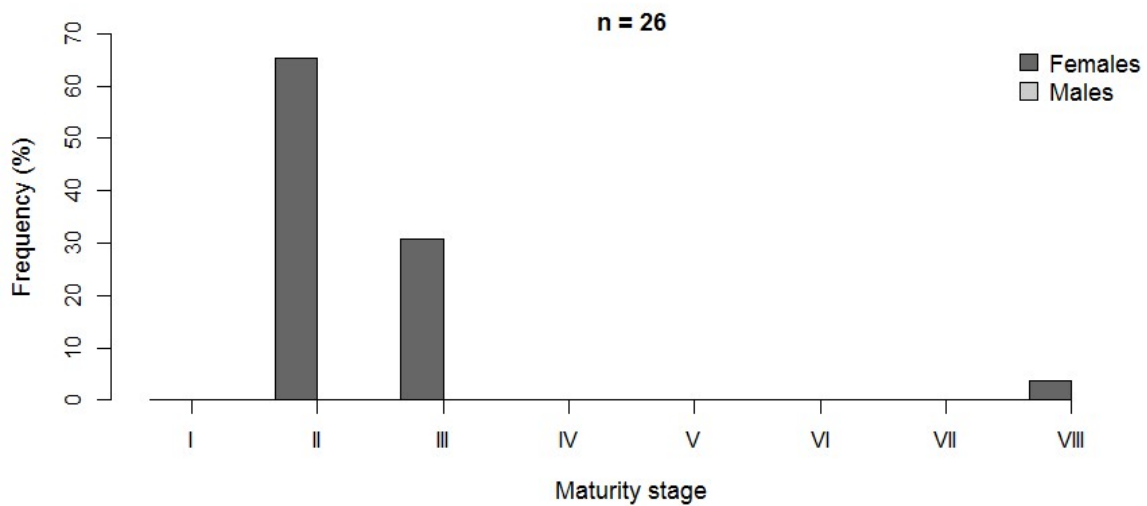


Figure 9: Maturity frequency distributions of Banded whiptail (GRF, *Coelorinchus fasciatus*) sampled off southern Falkland Islands during December 2018.

Falkland calamari (LOL, *Doryteuthis gahi*)

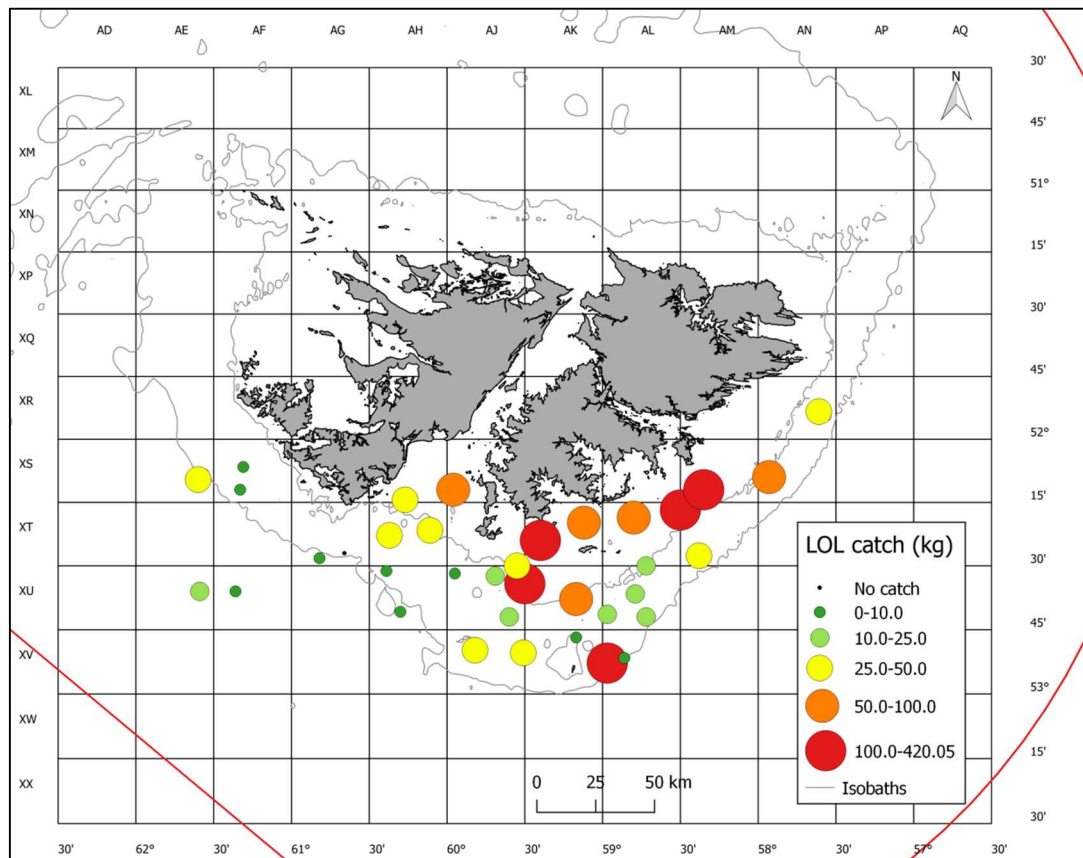


Figure 10: Distribution and catch (kg) of Falkland calamari (LOL, *Doryteuthis gahi*) off southern Falkland Islands during December 2018.

Falkland calamari were present throughout the whole study area, only absent at one station. A total of 2,023.3 kg was caught, with significantly higher densities in the eastern part, around and in the Loligo box (Figure 10). Length frequency distributions were similar at different fishing depths. A wider range of sizes (4–30 cm ML) was observed in shallow water stations (< 130 m), with greater frequency of individuals at 7–8 cm ML. At intermediate depths (130–170 m), the range of size decreased to 5–16 cm and most individuals measured 8 cm ML. In deeper waters (> 170 m), squid size ranged between 5 and 11 cm ML, and the largest prevalence of individuals occurred at 9 and 10 cm ML (Figure 11). Immature to spent *D. gahi* individuals were recorded; however, most individuals were young (females stage I = 36%; males stage I = 16%) or immature (females stage II = 38%; males stage II = 63%) and only few mature individuals were observed (females stage V = 16%; males stage V = 15%; Figure 12).

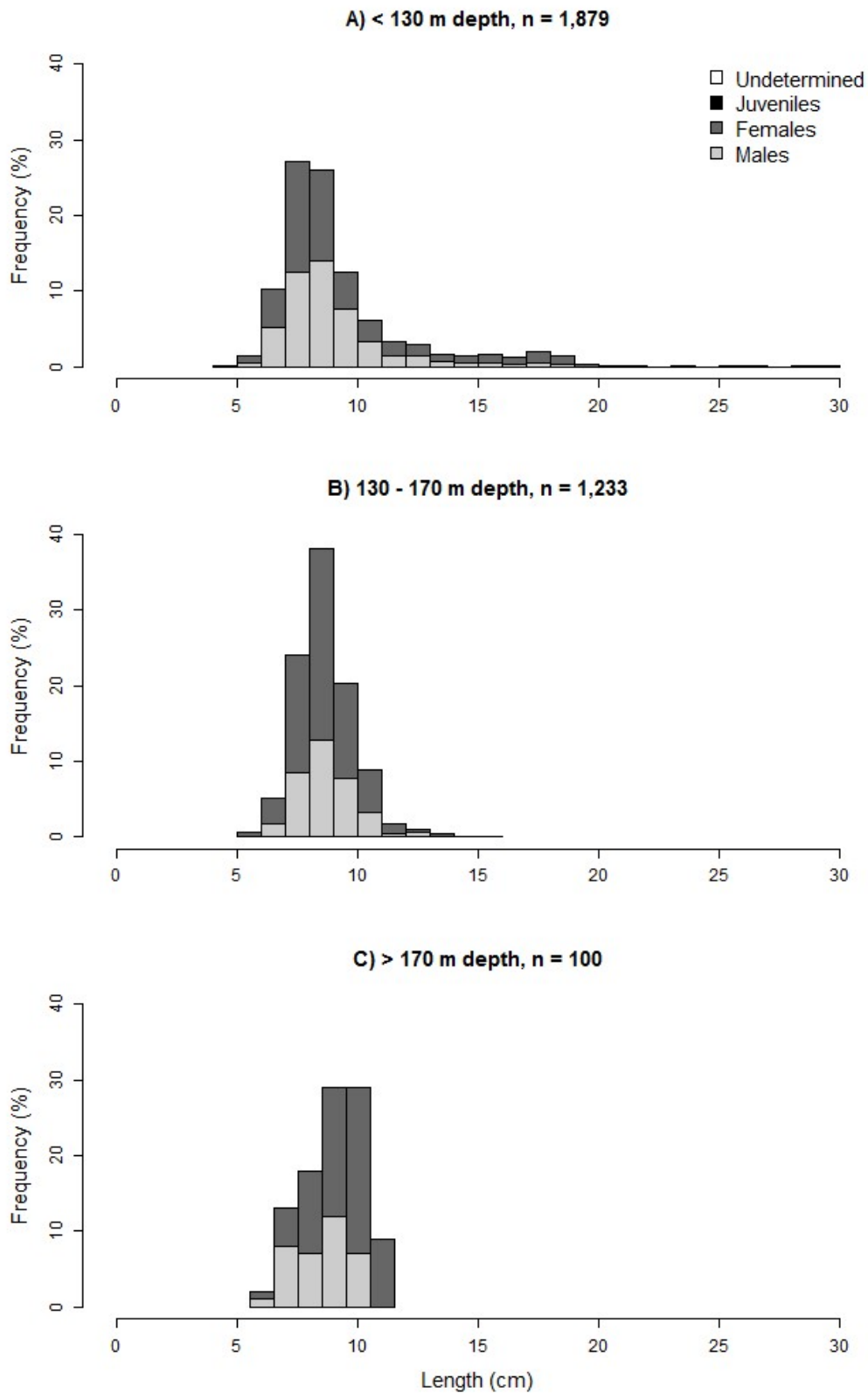


Figure 11: Length frequency distributions of Falkland calamari (LOL, *Doryteuthis gahi*) sampled at A) shallow, B) intermediate, and C) deep water stations off southern Falkland Islands during December 2018.

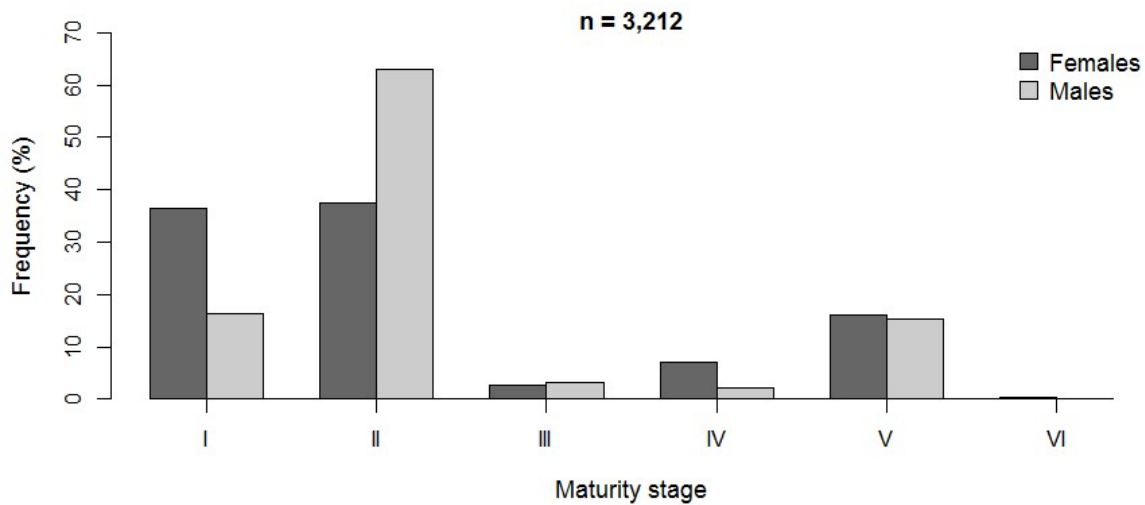


Figure 12: Maturity frequency distributions of Falkland calamari (LOL, *Doryteuthis gahi*) sampled off southern Falkland Islands during December 2018.

Kingclip (KIN, *Genypterus blacodes*)

Few Kingclip individuals were collected at different depths. In shallow water stations (< 130 m), only one individual was collected and measured 46 cm TL. At intermediate depths (130–170 m), most individuals (n=3) were 49 cm TL within a range of 49–85 cm TL. In deeper waters (> 170 m), size appeared to increase to 48–94 cm TL (Figure 13). Most KIN individuals were at resting maturity stage (females stage II = 84%; males stage II = 100%; Figure 14).

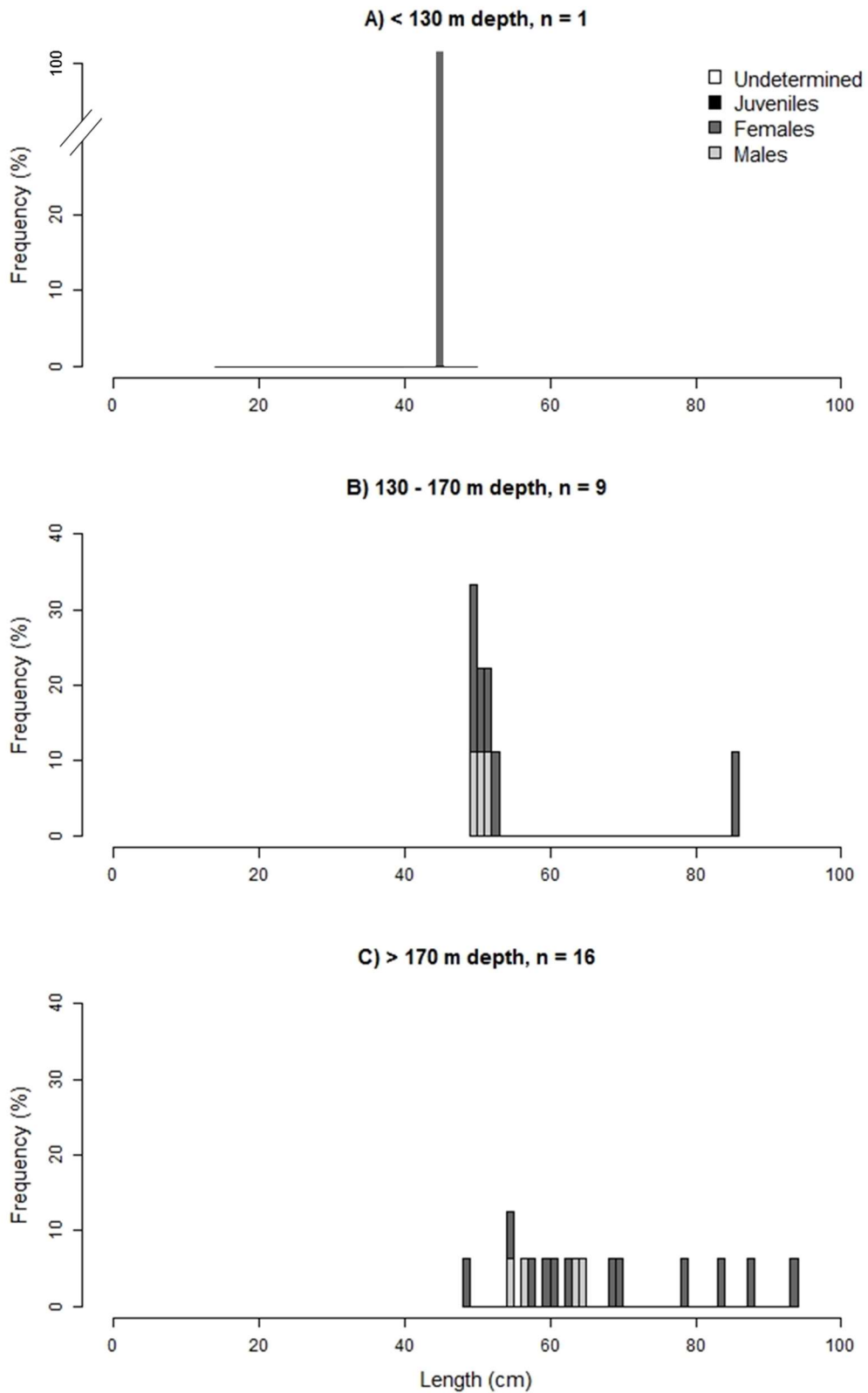


Figure 13: Length frequency distributions of Kingclip (KIN, *Genypterus blacodes*) sampled at A) shallow, B) intermediate, and C) deep water stations off southern Falkland Islands during December 2018.

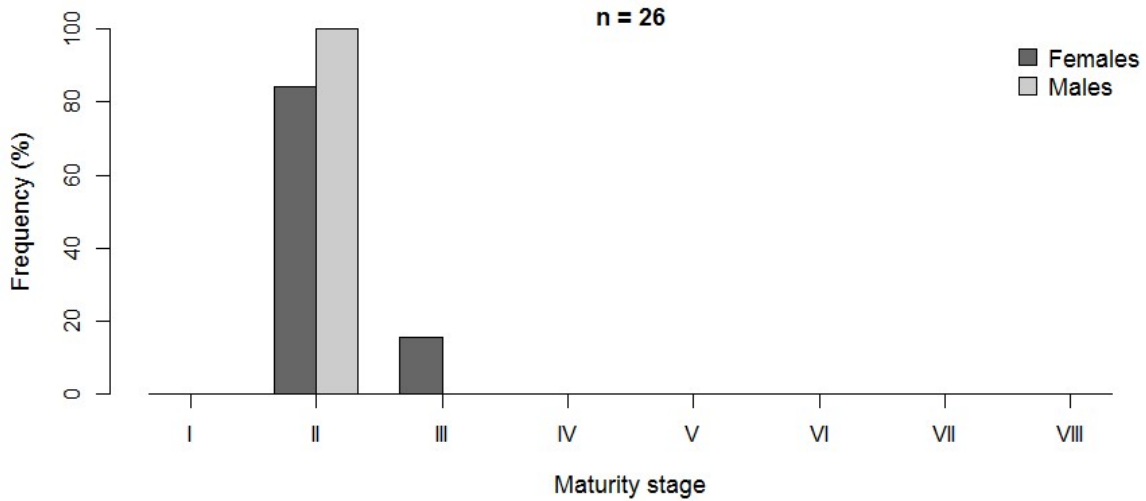


Figure 14: Maturity frequency distributions of Kingclip (KIN, *Genypterus blacodes*) sampled off southern Falkland Islands during December 2018.

Lobster krill (MUN, *Munida* spp)

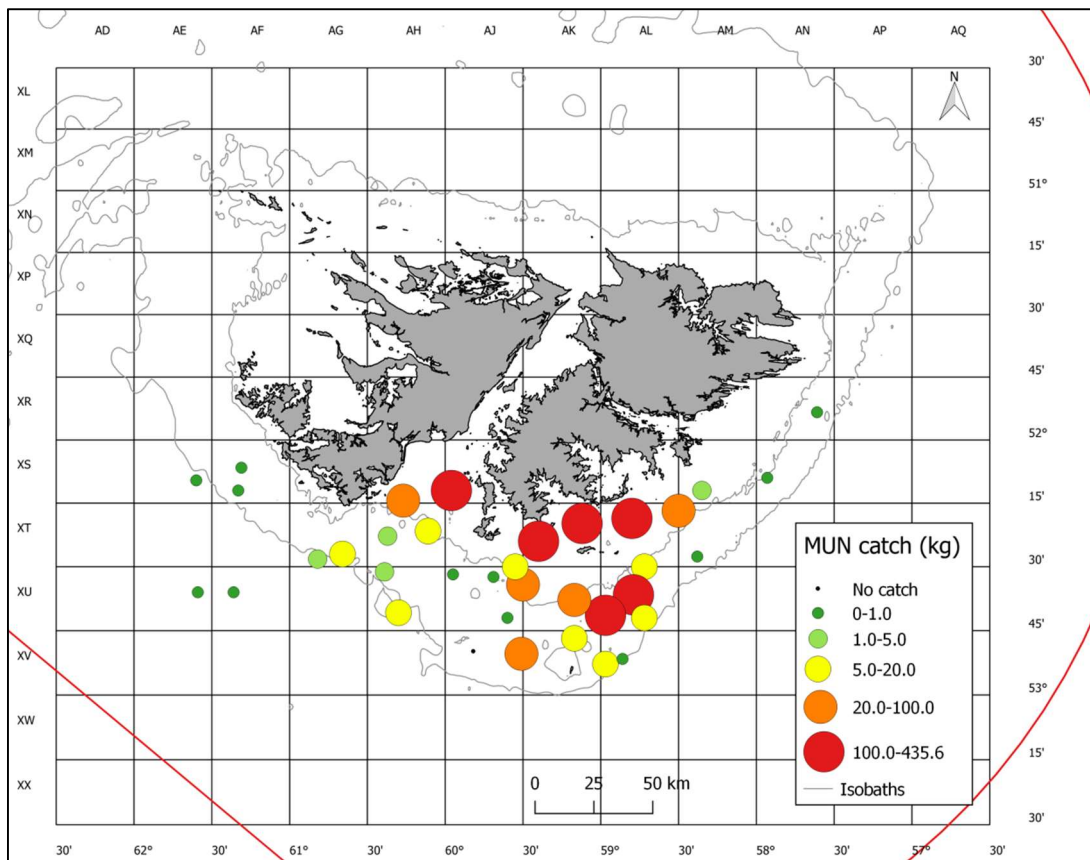


Figure 15: Distribution and catch (kg) of Lobster krill (MUN, *Munida* spp) off southern Falkland Islands during December 2018.

Approximately 1,329 kg of Lobster krill (mostly *Munida gregaria*) were caught during this campaign, at each but one station. Lobster krill was most abundant in shallower coastal stations off the south of the east island, with very low catches in the western and eastern stations of the survey (Figure 15). Only a subsample of Lobster krill individuals (n = 123) was measured in one shallow water station (< 130 m). The range of size for this species was 1.5–2.4 cm CL, with the majority of individuals at 2.1 cm CL (n = 30; Figure 16).

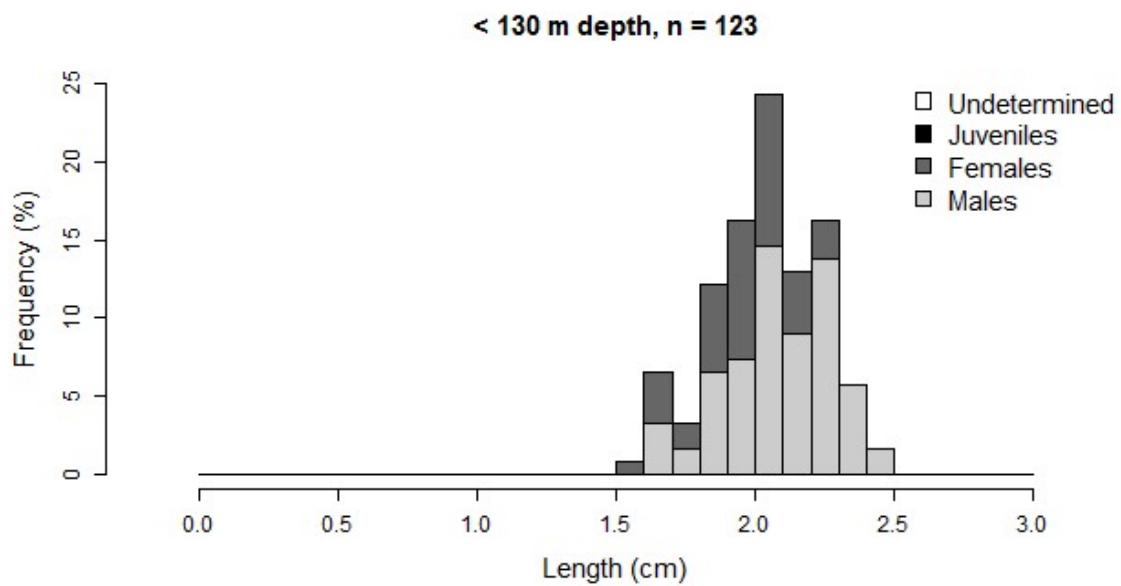


Figure 16: Length frequency distributions of lobster krill (MUN, *Munida gregaria*) sampled at shallow water stations off southern Falkland Islands during December 2018.

Rock cod (PAR, *Patagonotothen ramsay*)

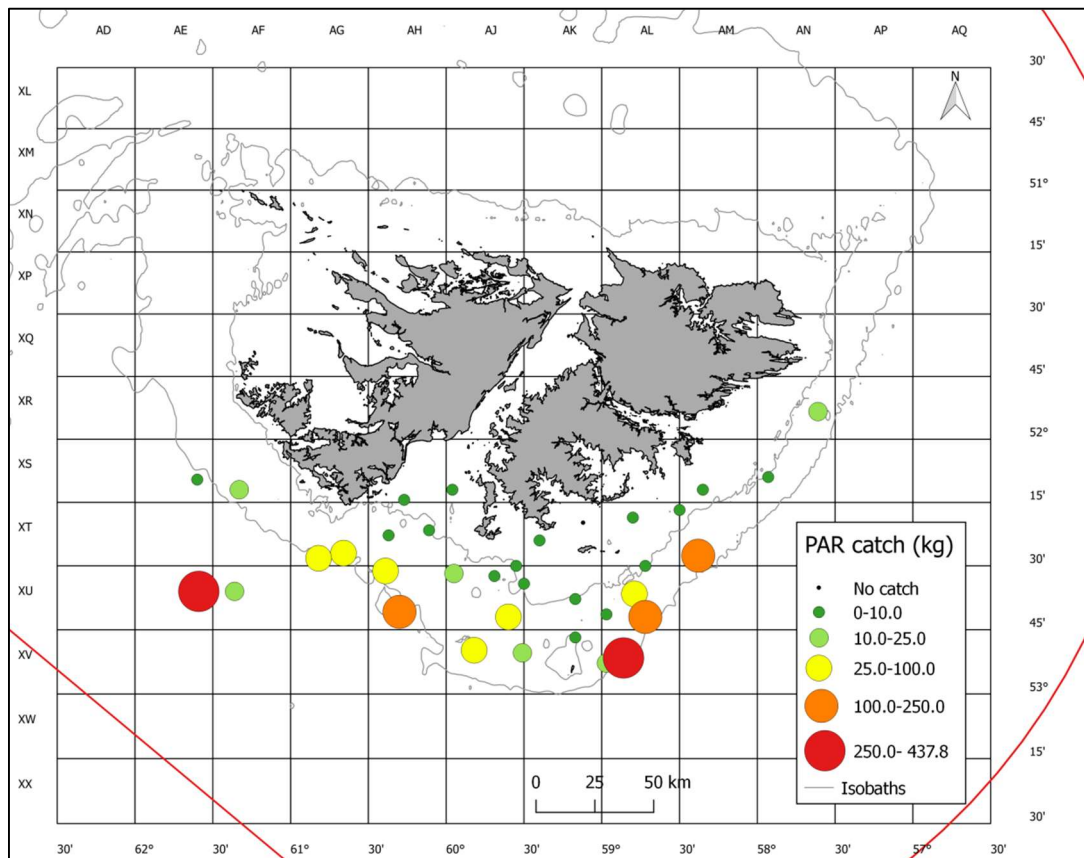


Figure 17: Distribution and catch (kg) of Rock cod (PAR, *Patagonotothen ramsay*) off southern Falkland Islands during December 2018.

Rock cod was omnipresent in the study area during December 2018. A total of 1,964.3 kg of rock cod was caught; the shallower coastal stations were less occupied by this species than the deeper stations regardless of the longitude sampled (Figure 17). In shallow water stations (< 130 m), size of fish ranged from 5 to 27 cm TL, with greater frequency of individuals around 15 cm TL. At intermediate depths (130–170 m), the range of size increased to 9–30 cm TL, with most individuals measuring approximately 15–17 cm TL. In deeper waters (> 170 m), rock cod size ranged between 9 and 35 cm TL, and the largest prevalence of individuals occurred at 17 cm TL, however individuals at 20–22 cm TL were also abundant (Figure 18). Immature and resting rock cod individuals were common during December 2018. Approximately 74% of the females were resting (stage II) and 26% were immature (stage I), whereas 60% of the males were resting (stage II) and 38% were immature (stage I). Only 2% of the males were at early developing stage (stage III; Figure 19).

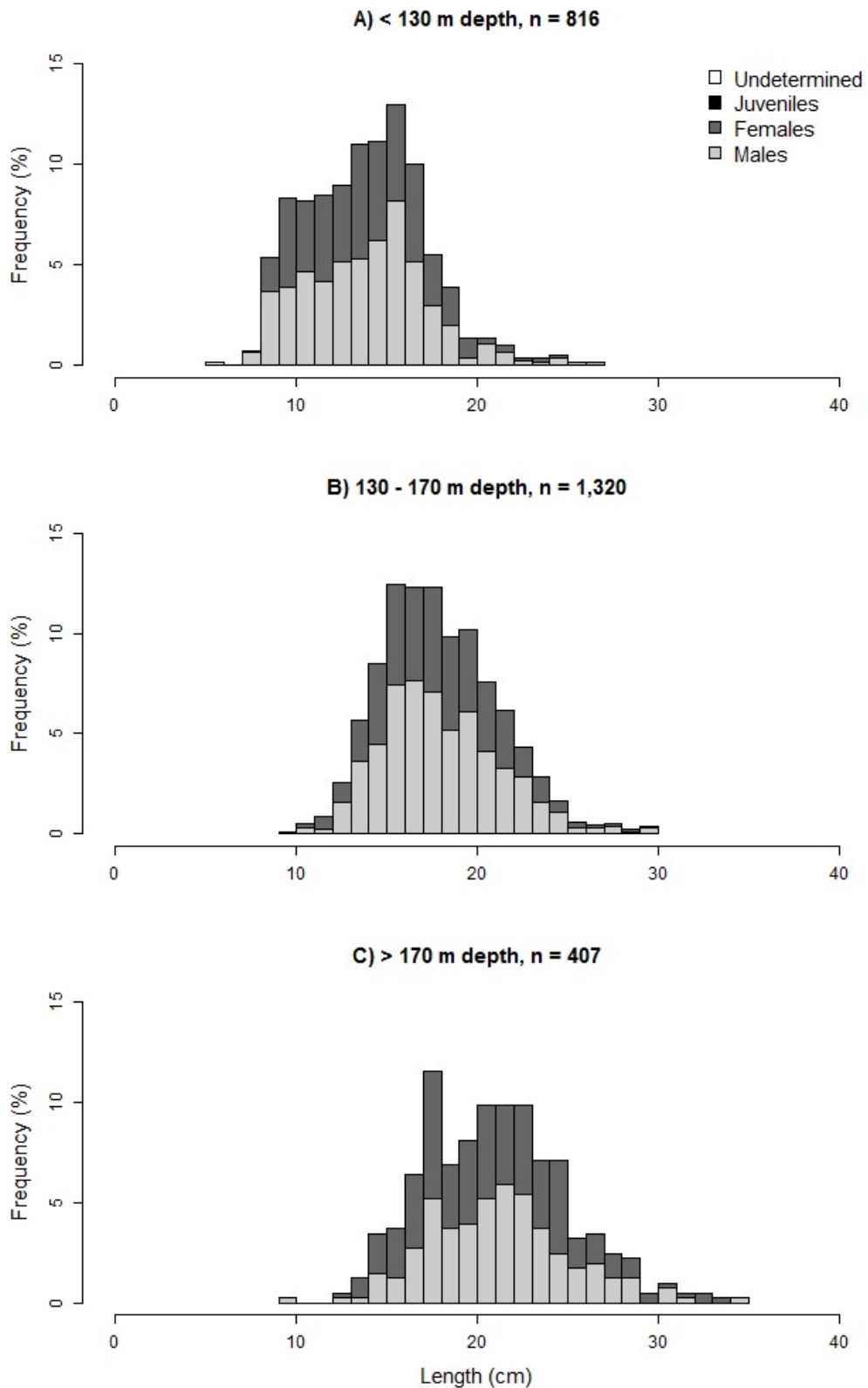


Figure 18: Length frequency distributions of Rock cod (PAR, *Patagonotothen ramsay*) sampled at A) shallow, B) intermediate, and C) deep water stations off southern Falkland Islands during December 2018.

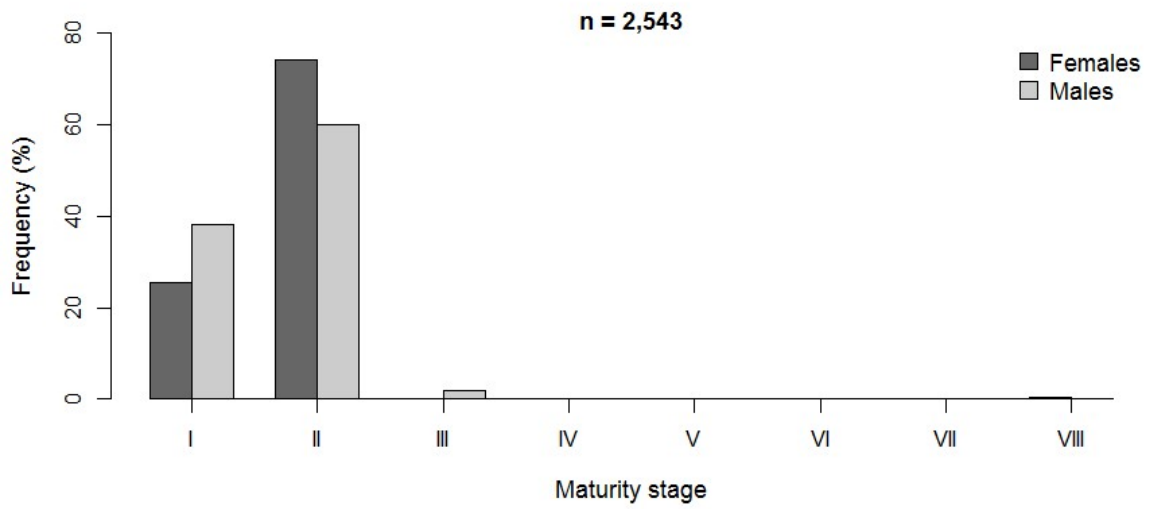


Figure 19: Maturity frequency distributions of Rock cod (PAR, *Patagonotothen ramsay*) sampled off southern Falkland Islands during December 2018.

Red cod (BAC, *Salilota australis*)

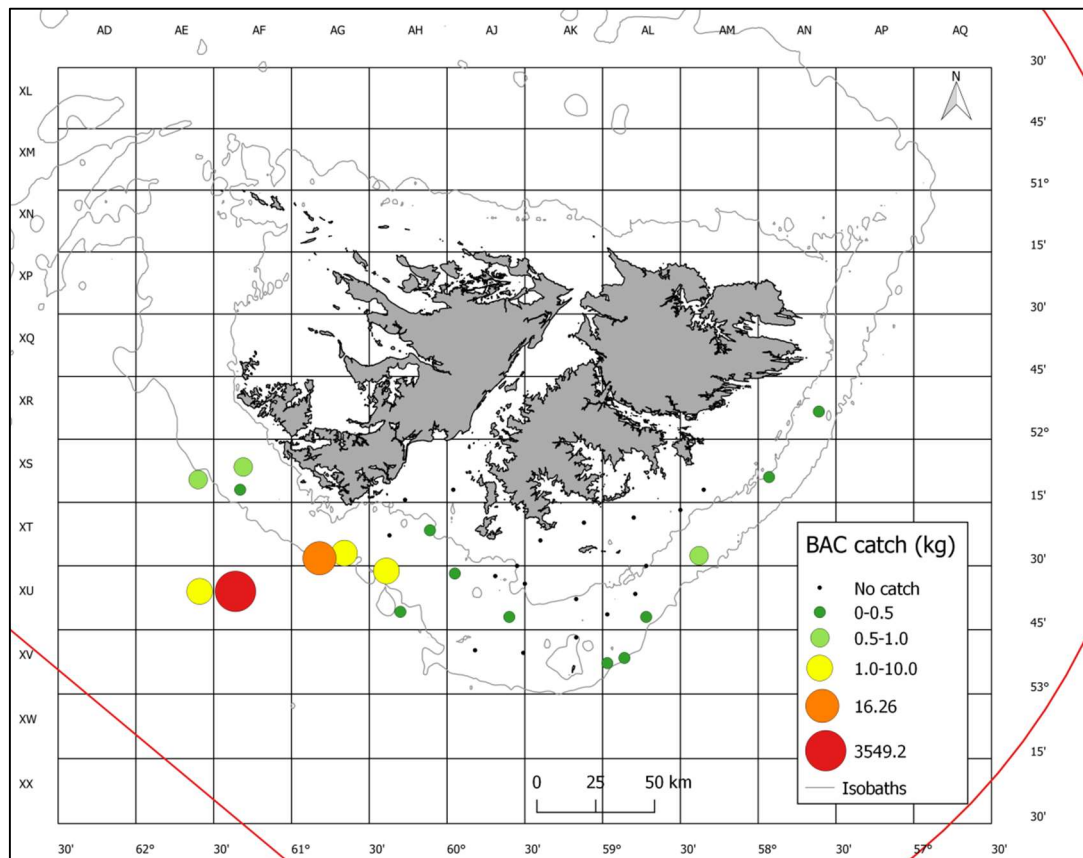


Figure 20: Distribution and catch (kg) of Red cod (BAC, *Salilota australis*) off southern Falkland Islands during December 2018.

Although present at several stations, red cod were scarce during December 2018. The total catch of 3,5954.7 kg is mainly due to the catch of one trawl (3,549.2 kg). Red cod was mostly present in western stations, with a slight increase of abundance correlated with the depth of the sample (Figure 20). No Red cod was collected in shallow water stations (< 130 m). In contrast, most individuals (n=148) were found at intermediate depths (130–170 m) and only a few individuals (n=35) were collected at deeper water stations (> 170 m). At intermediate depths, the range of size was 13–85 cm TL, with the greater frequency of individuals at approximately 40 cm TL. In deeper waters, Red cod size ranged between 14 and 74 cm TL, and the largest prevalence of individuals occurred at 23 cm TL (Figure 21). Immature to spent Red cod individuals were present during December 2018 (Figure 22). The greater frequency of females was at resting maturity stage (stage II); a few other females were immature (3%), early developing (9%), spent (2%), or recovery spent (7%).

Early developing males had the greatest frequency (34%), followed by resting (30%), and immature individuals (25%); only a few males were spent (2%) or recovery spent (3%).

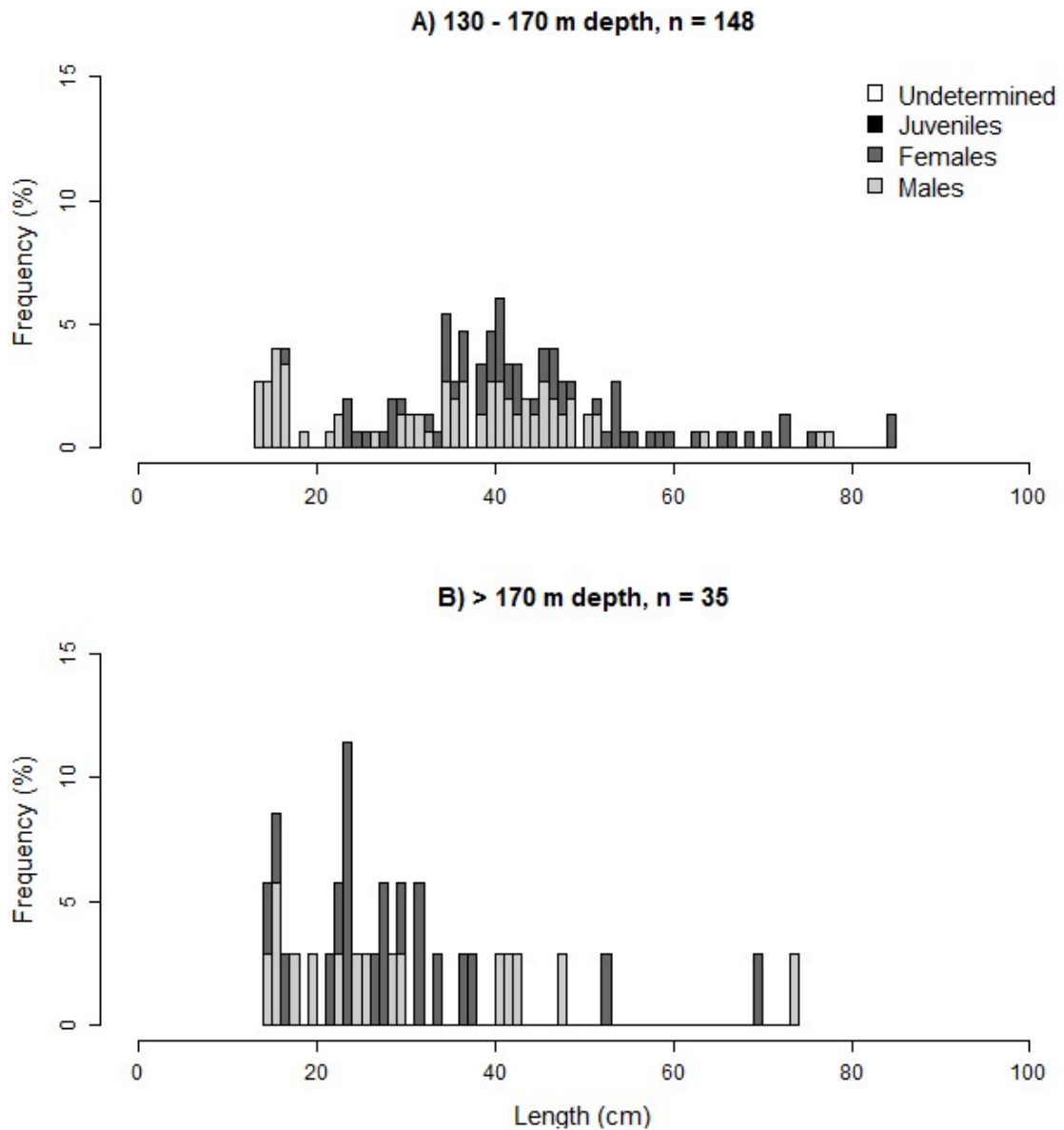


Figure 21: Length frequency distributions of Red cod (BAC, *Salilota australis*) sampled at A) intermediate and B) deep water stations off southern Falkland Islands during December 2018.

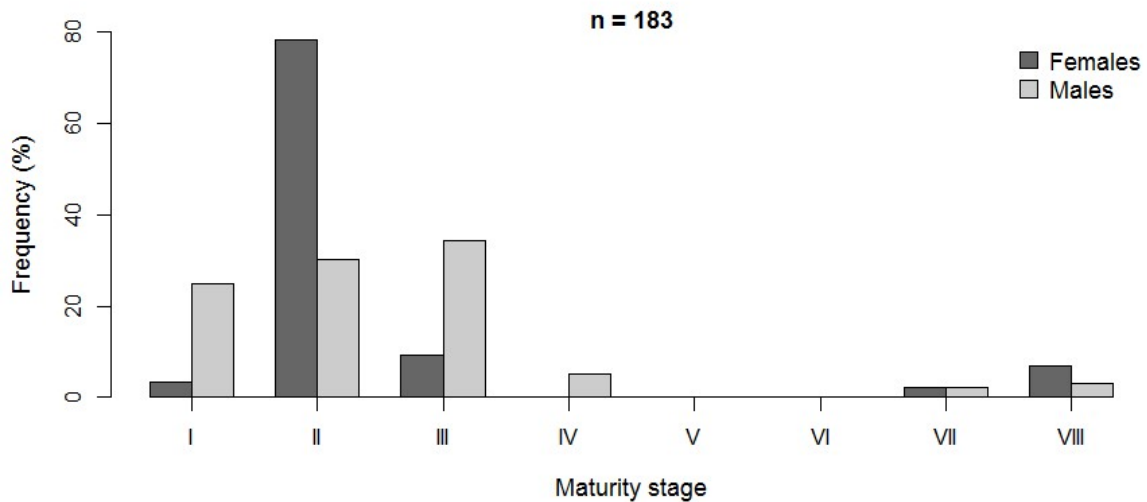


Figure 22: Maturity frequency distributions of Red cod (BAC, *Salilota australis*) sampled off southern Falkland Islands during December 2018.

5. Conclusion

No juvenile toothfish recruits or larvae were found during the research survey. Catch data indicates a potentially delayed or poor recruitment period for finfish species occurring over the southern shelf regions of the Falkland Islands, including rock cod and icefish. This may have been due to colder than average sea temperatures occurring during the time period resulting in higher egg or larval mortality. Further research and analyses are required to identify potential drivers of recruitment for juvenile Patagonian toothfish around the Falkland Islands.

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