Live Wrasse Fishery Investigations 2018

Fishery Dependent Sampling Survey Field Report 2018

Completed by: Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA)
Authors: Stephanie Sturgeon, Annie Jenkin, Colin Trundle, Kate Owen and Hilary Naylor

Document History			
Version	Date	Author	Change
0.1	17/12/2018	S Sturgeon	Document creation
0.2	08/01/2019	S Sturgeon	Inclusion of results
0.3	07/02/2019	S Sturgeon	Inclusion of repeat strings
0.4	25/03/2019	A Jenkin, K Owen & C Trundle	QA

CIFCA Live Wrasse Fishery Investigations 2018
This report may be cited as:

Sturgeon, S., Jenkin, A., Trundle, C., Owen, K. and Naylor, H. 2018. Live Wrasse Fishery Investigations 2018. Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA), Hayle.

This document has been produced by Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA)

Cornwall IFCA
Chi Gallos
Hayle Marine Renewables Business Park
North Quay
Hayle
Cornwall
TR27 4DD

Tel: 01736 336842
Email: enquiries@cornwall-ifca.gov.uk

Contents

Glossary of terms vii
1 Introduction 1
2 Fishery Developments 1
3 Methodology 2
3.1 Data Collection 2
3.2 Analysis Methodology 3
3.3 Catch Descriptors 4
3.3.1 CPUE (no. of fish/10 traps) 4
3.3.2 Length Frequency 4
3.3.3 Spawning State and size at maturity 4
3.4 Environmental Variables 4
3.4.1 Seasonality 4
3.4.2 Depth Categories 5
3.4.3 Tidal Range 5
3.4.4 Nights lie 6
3.5 Repeat strings 6
4 Results 7
4.1 Effort Summary 7
4.2 Species Composition 8
4.2.1 Geographic Location 8
4.3 Catch per unit effort (CPUE) 8
4.4 Length Frequency 9
4.5 Spawning State 9
4.6 Repeat Strings 10
4.6.1 Area A 10
4.6.2 Area B 14
4.6.3 Area C 24
4.6.4 Area D 28
5 Discussion 34
6 References 36

List of Figures

Figure 1: Carapax wrasse trap (source: carapax.se) 2
Figure 2: Escape gap fitted to a wrasse trap. 2
Figure 3: Content of a wrasse trap being sorted 3
Figure 4: Measuring a ballan wrasse 3
Figure 5: Geographic areas A, B, C and D used for analysis of 2018 wrasse fishery dependent study data 4
Figure 6: Maximum tidal range per day, based on tidal heights for Falmouth, for 2018. The median line is the average tidal range of 3.9m, all ranges above this have been deemed spring tides, and all below have been deemed neap tides. 5
Figure 7: Illustration of tidal range categories 6
Figure 8: Species composition by geographic areas A- D, A (n=325), B (n=1803), C (n=0), and D (n=1556) in 2018. 8
Figure 9: Total length frequency box plot for all ballan wrasse sampled in 2018. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range. 9
Figure 10: Total length frequency box plot for all corkwing sampled in 2018. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range. 9
Figure 11: Total length frequency box plot for all goldsinny sampled in 2018. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range. 9
Figure 12: Total length frequency box plot for all rock cook sampled in 2018. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range. 9
Figure 13: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string A1. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range. 11
Figure 14: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string A2. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 12
Figure 15: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string A3. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 12
Figure 16: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string A4. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 13
Figure 17: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string A5. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range. 13
Figure 18: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B11. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 16
Figure 19: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B12. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 16
Figure 20: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B4. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range. 17
Figure 21: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B6. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 17
Figure 22: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B7. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range. 18
Figure 23: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B1. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range. 18
Figure 24: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B9. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 19

Figure 25: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B13. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 19
Figure 26: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B15. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 20
Figure 27: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B8. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 20
Figure 28: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B16. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 21
Figure 29: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B5. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range. 21
Figure 30: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B14. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 22
Figure 31: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B10. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 23
Figure 32: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B3. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 23
Figure 33: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B2. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile and error bars show range. 24
Figure 34: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string C5. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range. 25
Figure 35: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string C4. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range. 26
Figure 36: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string C2. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 26
Figure 37: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string C1. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range. 27
Figure 38: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string C3. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 27
Figure 39: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D8. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 29
Figure 40: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D3. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 29
Figure 41: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D2. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 30
Figure 42: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D5. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 30

Figure 43: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D6. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 31
Figure 44: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D7. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 32
Figure 45: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D1. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 32
Figure 46: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D4. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 33
Figure 47: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D9. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers. 33

List of Tables

Table 1: Summary of the number of traps sampled in each geographic location by month, data has been formatted; high values per month for each area are in dark grey, lowest values are white. 7
Table 2: Summary of the number of traps sampled in each geographic location by depth category, tidal range category and nights lie, data has been formatted; high values per environmental category for each area are in dark grey, lowest values are white..... 7
Table 3: Catch per unit effort (CPUE) (per species/10 traps) per species by geographic area A-D..... 8
Table 4: Summary of proportions spawning fish to non-spawning sampled in the 2018 survey. "-" Indicates when samples were not taken, or no fish sampled were assessed for spawning. Data has been formatted; high values per month for each species are in dark grey, lowest values are white. 10
Table 5: Summary of minimum total length of spawning fish observed for each species sampled in the 2018 surveys. "-" Indicates when no fish sampled were spawning..... 10
Table 6: Summary of repeat strings in area A with numbers of ballan and proportion of total catch, mean total length ballan size and catch per unit effort (CPUE) (no. of ballan/ 10 traps). "-" Indicates when average size was not calculated when fish numbers were less than two. 11
Table 7: Summary of repeat strings in area B with numbers of ballan and proportion of total catch, mean total length ballan size and catch per unit effort (CPUE) (no. of ballan/ 10 traps). "-" Indicates when average size was not calculated when fish numbers were less than two. 14
Table 8: Summary of repeat strings in area C with numbers of ballan and proportion of total catch, mean total length ballan size and catch per unit effort (CPUE) (no. of ballan/ 10 traps). "-" Indicates when average size was not calculated when fish numbers were less than two. 24

Glossary of terms

Catch descriptors: The collective term used for the different metrics that have been used to describe the catch, namely catch per unit effort, and length frequency distribution.

Environmental variables: The collective term used for the different influences which have been considered as possible factors affecting catch, namely month, area, charted depth, tidal range and number of nights lie.

Nights Lie: The numbers of nights since the traps were baited.

Sampled (Fish): All fish that were retained in traps were identified to species level, measured to the nearest 0.5cm, and where possible, gender identified and assessed for spawning. This is referred to as being 'sampled'

Sampled (Traps): All traps that were hauled during the survey were 'sampled', all wrasse species were 'sampled' and associated data recorded.

String(s): A collection of traps, between generally 10 to 30 traps, set together on one back rope.

Trap(s): The individual fish traps used for catching wrasse.

1 Introduction

Wrasse spp. have been found to be particularly effective as cleaner fish (Bjordal, 1988) and are now used as part of many salmon production company's sea lice control strategies to complement the more traditional chemical treatments. Although having been practiced in Scotland and off the Norwegian coast for nearly 30 years, the fishing for and retaining of live wrasse to supply the salmon production industry with cleaner fish is an extremely new and innovative fishery to the south west of England. Concerns for the long term effectiveness of current chemical treatments and the impact of those chemicals to the wider marine environment has seen measures introduced to restrict their use. Additionally, the industry has recognised the economic benefits of using cleaner fish rather than a dependence on chemical controls. The restrictions applied to the use of chemical treatments and increased used of cleaner fish has seen salmon production companies beginning to source wrasse from further afield than Scotland to maintain supply without exhausting local stocks (L Bennett, R Hawkins pers. comm. 2017). In Cornwall fishing for wrasse using traps began as very small scale experimental fishing during 2014. Those initial trials have led to the fishermen who carried out those early experiments to now almost wholly rely on the fishery for their income.

Cornwall Inshore Fisheries and Conservation Authority (IFCA) Scientific Officers have carried out sampling on-board the commercial wrasse fishing vessels since 2016. The results of the catch sampling program for 2017 were presented in Street *et al.* (2017b). Additionally independent sampling effort on-board Cornwall IFCA survey vessel, Tiger Lily VI, has been carried out in 2016 (Street *et al.,* 2016), 2017 (Street *et al.,* 2017a) and 2018 (Sturgeon *et al.,* 2018). This report describes the sampling effort carried out by Cornwall IFCA Scientific Officers during 2018.

2 Fishery Developments

The live wrasse fishery in Cornwall IFCA district was between the middle of April through to the end of October in 2018. Cornwall IFCA introduced Live Wrasse Fishery Guidance[1] in September 2017 which included guidance conditions for minimum and maximum conservation reference sizes (MCRS), closed fishing areas and closed seasons. There have been some changes to the fishery since it was reported on in November 2017 (Street *et al.,* 2017b).

Currently three vessels are retaining only ballan wrasse between 16 cm and 28 cm. However, there was a reduction in demand from one of the salmon production companies for ballan wrasse in 2018 which resulted in a drop in fishing effort for these three vessels. For one vessel, it was a reduction of 44% in effort (number of days).

The vessels working in Plymouth Sound have changed, with one leaving the fishery and two more entering, making the current total of vessels working out of Plymouth five. In 2018, one vessel was fishing solely in Cornwall IFCA district, one solely in the Devon and Severn IFCA district and the other three vessels fishing in both districts. These are retaining four species of wrasse (ballan, corkwing, goldsinny and rock cook), with ballan ≥16 cm, and the three other species ≥12 cm. Earlier this year, Devon and Severn IFCA introduced amendments to the Potting Permit Conditions within their Potting Permit Byelaw to change the MCRS for corkwing from between 12 cm and 23 cm to 14 cm and 18 cm that can only be retained within their district. Additionally, Devon and Severn IFCA closed fishing season for wrasse changed from 1st April to 30th June to 1st May to 15th July (inclusive) in their district. Although Cornwall IFCA have guidance on a closed season for wrasse, from 1st April to 30th June, east of Rame Head, the majority of the vessels were fishing solely within the

[1] Available: https://secure.toolkitfiles.co.uk/clients/17099/sitedata/Code_of_practice/live-wrasse-fishery-guidnece.pdf

Cornwall IFCA district during this period through to August and after this time had strings in both Devon and Severn IFCA and Cornwall IFCA district. The research report for the live wrasse fishery in Devon and Severn IFCA district (Plymouth Sound) for 2018 is reported in Curtin and West (2018).

3 Methodology

Cornwall IFCA Scientific Officers continued the at sea sampling survey design from 2017 (Street *et al.,* 2017b), with the aim of developing an understanding of the fishery within the Cornwall IFCA district, through observation of fishing activity and dialogue with fishermen, and to collect baseline data on the current population of wrasse retained in the fishery, through catch sampling and analysis of the data.

3.1 Data Collection

Sampling was carried out by Cornwall IFCA Scientific Officers on-board fishing vessels operating within the Cornwall IFCA district. The number of strings and traps hauled per trip varied depending on vessel and day. All local fishers currently involved in the fishery use wrasse traps manufactured by Carapax[2] (Figure 1). These traps are composed of small mesh netting with a self-closable parlour entrance; each trap is 72 cm L x 40 cm W x 28 cm H, and weighs 3.7 kg when supplied. The majority of traps have escape gaps fitted (Figure 2).

Figure 1: Carapax wrasse trap (source: carapax.se)

Figure 2: Escape gap fitted to a wrasse trap.

When a string was hauled a hand held GPS was used to record the vessel track and the time and position of the start and end of string, information on when the trap was set and the bait used were obtained from the fishermen and recorded. The string was recovered to deck and sorted trap by trap. Each trap was emptied into a fish box (Figure 3) and the wrasse were taken one by one and placed on to a measuring board. Once on the measuring board the fish were measured to the nearest 0.5 cm (Figure 4), identified to species level and for all species, except ballan, the sex (male/female) was recorded where visual identification of gender was possible.

[2] http://en.carapax.se/creelspotstraps/cleaning-wrasse-traps/wrasse-trap.html

Figure 3: Content of a wrasse trap being sorted

Figure 4: Measuring a ballan wrasse

The spawning state were also recorded, where the total body length was over 5 cm. This was assessed through 'stripping'; applying gentle pressure to the abdomen and inspecting milt or roe. Once measured the fish were transferred to two separate containers in a fish box with fresh seawater flowing through, one for the fish being retained and one for the fish were being returned to the sea. At the end of the each string the retained fish were transferred to a bait-well with artificial kelp, and all by-caught fish were returned to the sea as close as possible to where they were caught and the fish that loitered at the surface were protected from gull predation.

3.2 Analysis Methodology

Analysis has been conducted and reported on, following on from the initial analysis in Street *et al.* (2017b), with recommendations made of further analysis and improvements on the data collection methodology.

All Cornwall IFCA data, and data provided by Devon and Severn IFCA from their complementary survey in Plymouth Sound (Cornwall IFCA district only), were pooled into one dataset. Data was separated into four geographic areas, labelled A, B, C and D, to investigate homogeneity in wrasse populations between geographic areas. Data in each geographic area was separated further for repeat strings. The boundaries of these areas are shown in Figure 5. Note the boundary of area D has been amended from Street *et al.* (2017b) where it previously extended east to Yealm Head.

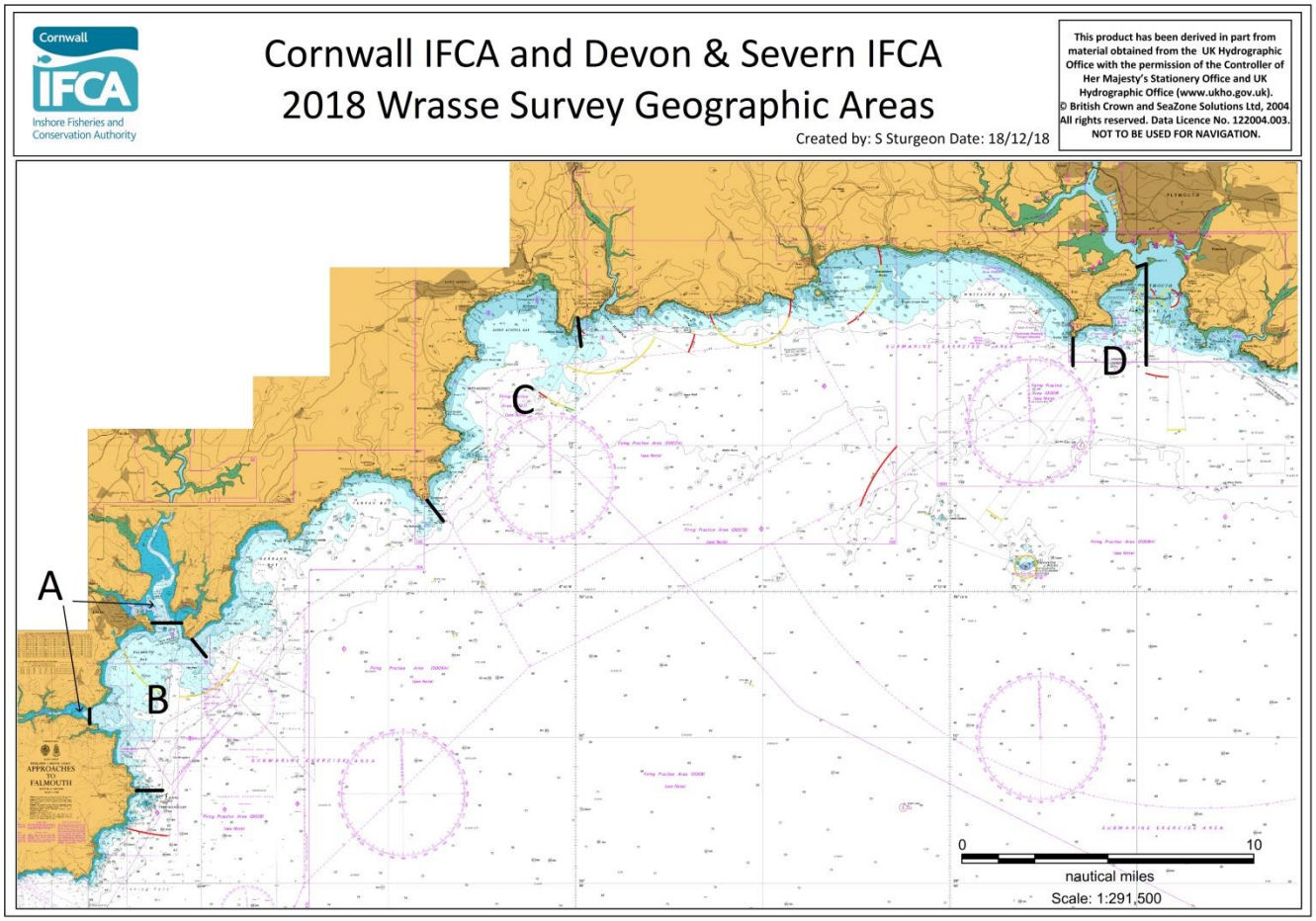


Figure 5: Geographic areas A, B, C and D used for analysis of 2018 wrasse fishery dependent study data

3.3 Catch Descriptors

3.3.1 CPUE (no. of fish/10 traps)

Catch per unit effort (CPUE) was calculated by:

CPUE (no. of fish/10 traps) = (F_x/T_x)*10

Where F_x is the number of fish sampled in category *x*, and T_x is the number of traps sampled in category *x*.

3.3.2 Length Frequency

Length frequency data has been presented as box plots with points for median total length, boxes representing inter quartile ranges and error bars representing maximum and minimum values recorded.

3.3.3 Spawning State and size at maturity

Spawning state was assessed and recorded for all species by both Cornwall IFCA and Devon & Severn IFCA. Proportions of spawning fish to non-spawning fish sampled per month were calculated to indicate peak spawning months. The minimum length recorded for spawning individuals of each species is presented.

3.4 Environmental Variables

3.4.1 Seasonality

Data were grouped by survey month and investigated for spawning season.

3.4.2 Depth Categories

All vessel track data was filtered to times when the vessel was hauling sample strings. Tracks for each sample string were uploaded onto MapInfo Pro (Version 17) and overlain on admiralty charts. Each string was then assigned a depth category as described below;

1- The majority of the string falls within 0 to 5 m depth contours.

2- The majority of the string falls within 5 to 10 m depth contours.

3- The majority of the string falls outside of 10 m depth contour.

3.4.3 Tidal Range

Following anecdotal reports of the impact of tidal range on catch rates it was decided to investigate this influence on the survey data.

Maximum predicted tidal range was calculated for every calendar day of 2018 based on maximum and minimum predicted tide heights for Falmouth (Mylor Yacht Harbour Tide Timetable, 2018). The average range was calculated to be 3.9 m, values above this were deemed to be spring tides, and values below this were deemed to be neap tides (Figure 6).

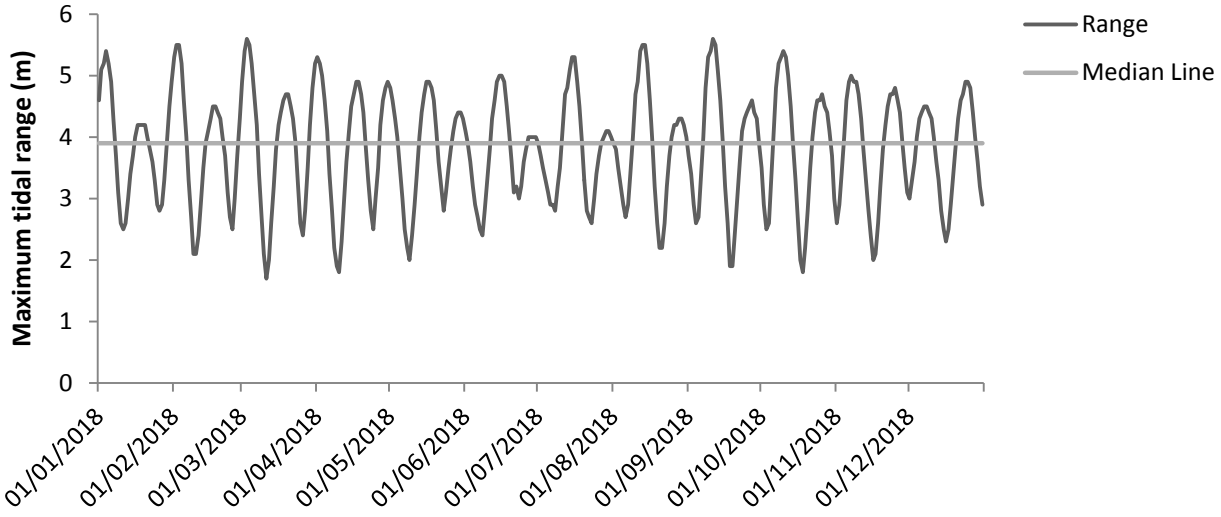
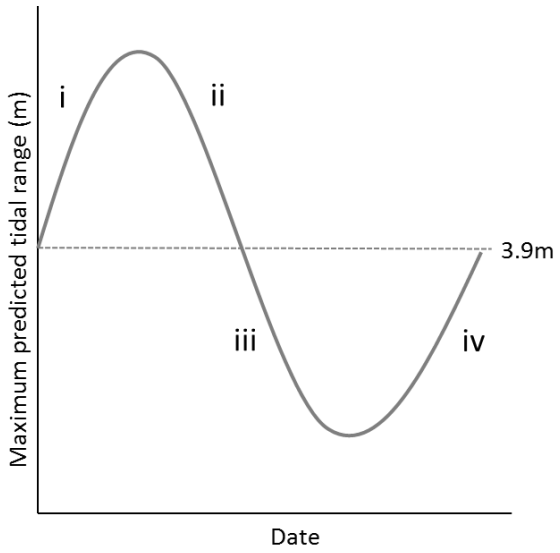


Figure 6: Maximum tidal range per day, based on tidal heights for Falmouth, for 2018. The median line is the average tidal range of 3.9 m, all ranges above this have been deemed spring tides, and all below have been deemed neap tides.

Following this, the maximum tidal range for a day was subtracted from the previous day's maximum tidal range resulting in a positive or negative value, indicating if the tidal range was increasing or decreasing (Figure 7). These two metrics combined give the following four categories which were assigned to each sample based on the survey date:



i Tidal range greater than 3.9 m and increasing

ii Tidal range greater than 3.9 m and decreasing

iii Tidal range less than 3.9 m and decreasing

iv Tidal range less than 3.9 m and increasing

Figure 7: Illustration of tidal range categories

3.4.4 Nights lie

Data were grouped by the number of night's lie.

3.5 Repeat strings

All sample strings were plotted in MapInfo Pro and strings in repeat locations (<50 m maximum distance apart) were grouped and listed with attribute data. These were then further filtered to groups of strings from the same vessel, with similar environmental variables; number of traps, tidal range and nights lie. The resultant groups/pairs of strings were analysed, investigating the catch composition, average total length and CPUE (no. of fish/10 traps) of fish sampled. Analysis was carried out for ballan, goldsinny, corkwing and rock cook wrasse in each geographic area.

Analysis of total length (cm) was carried out in R Version 3.4.2 (R Core Team, 2017). Data was checked for normality visually and with the Shapiro-Wilk test for normality. The Mann-Whitney U test was carried out to test for differences between the total lengths of fish in repeat string pairs. For repeat strings with three samples, the Kruskal-Wallis test was carried out.

4 Results

A total of 3,684 wrasse belonging to five species; ballan, cuckoo, goldsinny, corkwing and rock cook (*Labrus mixtus*, Linnaeus, 1758), were sampled during the 2018 survey period by Cornwall IFCA and Devon & Severn IFCA (3,053 and 631[3] respectively). This comprised of 387 ballan, 98 cuckoo, 1,222 goldsinny, 1,093 corkwing and 884 rock cook. Due to the low sample numbers of cuckoo wrasse, this species has been excluded from individual species analysis.

4.1 Effort Summary

For areas A and B, sampling effort for 2018 was 4% (four surveys) of the total days fished, compared to 6% (11 surveys) in 2017 and 4% (six surveys) in 2016. No surveys were carried out in area C for 2018 compared to eight surveys in 2017 and two in 2016. A total of seven surveys were carried out in area D for Cornwall IFCA district only, compared to 21 surveys in 2017 for both Cornwall IFCA and Devon and Severn IFCA districts (area D extended to Yealm Head).

Sampling was not even between geographic areas or the other environmental variables considered in this study. Table 1 outlines the number of traps sampled in each geographic location by month and Table 2 summarises effort in the remaining environmental variables which have been investigated in this study.

Table 1: Summary of the number of traps sampled in 2018 for each geographic location by month, data has been graded by colour scale; highest values per month for each area are in dark grey, lowest values are white.

	No. of traps										
		Month									
Area	Total	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
A	60				10		30			20	
B	322				40	81	60			141	
C	0										
D	834					300		509	25		

Table 2: Summary of the number of traps sampled in 2018 for each geographic location by depth category, tidal range category and nights lie, data has been graded by colour scale; highest values per environmental category for each area are in dark grey, lowest values are white.

	No. of traps												
	Depth Category			Tidal Range				Nights Lie					
Area	1	2	3	i	ii	iii	iv	<1	1	2	3	4	5	7
A	60				10		50			60				
B	162	160			40	81	201		20	221	81			
C														
D	296	269	269	235	301	160	138		621	213				

[3] Survey data from Devon and Severn IFCA is from samples only within Cornwall IFCA district.

4.2 Species Composition

4.2.1 Geographic Location

Species composition varied between geographic areas (Figure 8), with the most difference in area A, compared to areas B and D. No further analysis was carried out for species composition due to low sample data between environmental variables.

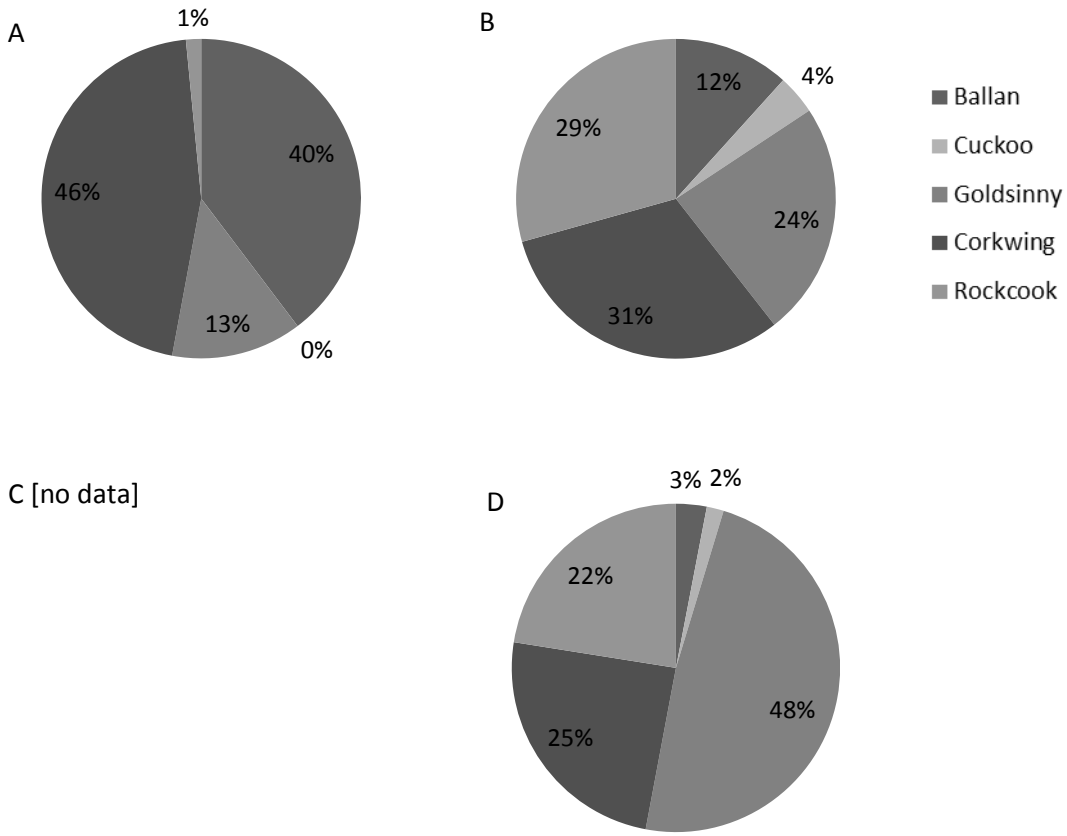


Figure 8: Species composition by geographic areas A- D, A (n=325), B (n=1803), C (n=0), and D (n=1556) in 2018.

4.3 Catch per unit effort (CPUE)

CPUE (no. of fish/10 traps) varied by area for all wrasse species (Table 3). Ballan and corkwing had the highest CPUE in area A, whereas area D had the lowest CPUE for all species.

Table 3: Catch per unit effort (CPUE) (per species/10 traps) per species by geographic area A-D in 2018. "-" Indicates no data.

Species	A	B	C	D
Ballan	21.5	6.55	-	0.56
Corkwing	24.67	17.48	-	4.58
Rock Cook	0.83	16.43	-	4.2
Goldsinny	7.17	13.29	-	9

4.4 Length Frequency

Below is the overall total length frequency data for all fish sampled by species between the four areas (Figure 9 to Figure 12).

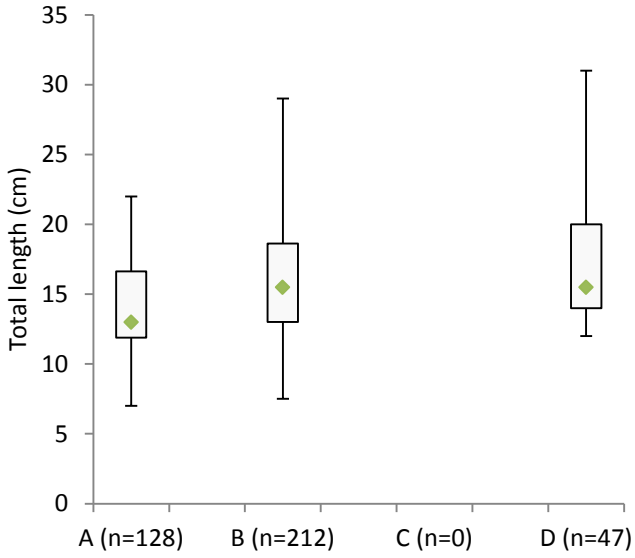


Figure 9: Total length frequency box plot for all ballan wrasse sampled in 2018. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.

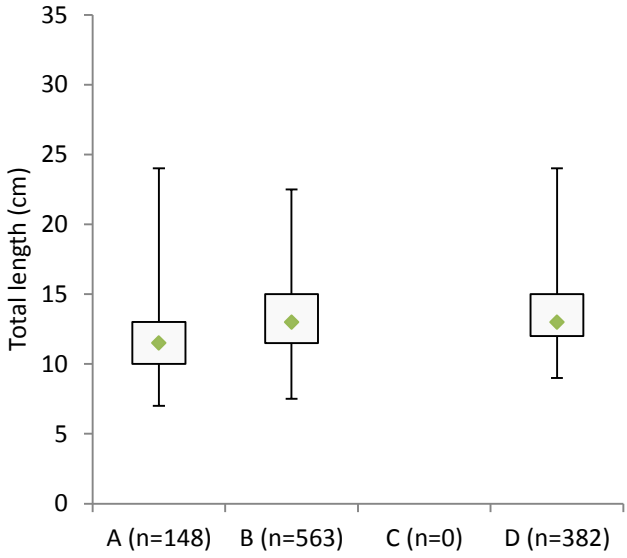


Figure 10: Total length frequency box plot for all corkwing sampled in 2018. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.

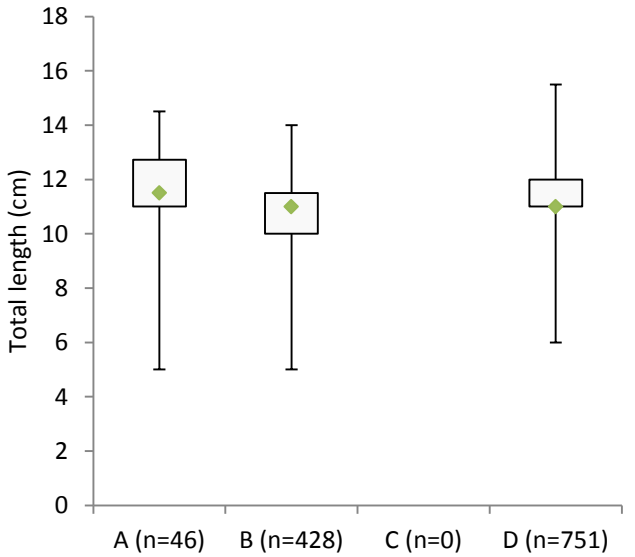


Figure 11: Total length frequency box plot for all goldsinny sampled in 2018. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.

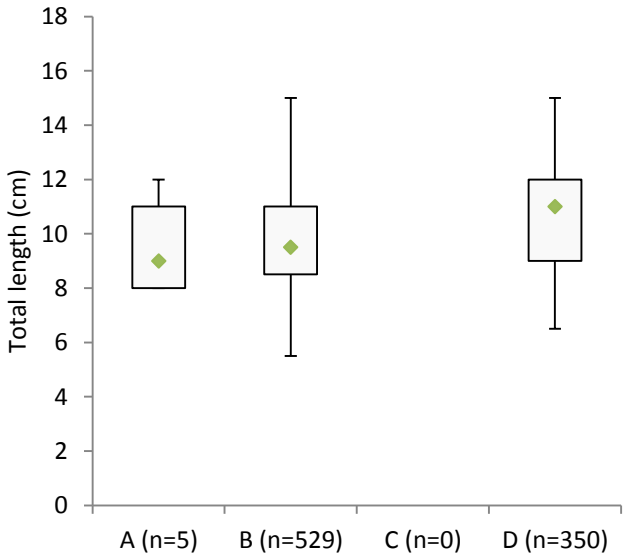


Figure 12: Total length frequency box plot for all rock cook sampled in 2018. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.

4.5 Spawning State

Overall, spawning wrasse were observed from May to August 2018 (Table 4), with a peak in spawning for corkwing, rock cook and goldsinny in June (12.5%, 40.2% and 11.63% respectively). No ballan were observed spawning. A total of 28 ballan, 203 corkwing, 226 rock cook and 442 goldsinny were excluded from the proportions of spawning fish as it was unknown if they had been stripped.

Table 4: Summary of proportions spawning fish to non-spawning sampled in 2018. "-" Indicates when samples were not taken, or no fish sampled were assessed for spawning. Data has been formatted; high values per month for each species are in dark grey, lowest values are white.

Species	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct
Ballan	-	-	-	-	-	-	-	-	-
Corkwing	-	-	-	0.00%	12.50%	1.55%	0.00%	-	0.00%
Rock Cook	-	-	-	0.00%	46.08%	20.51%	5.88%	-	0.00%
Goldsinny	-	-	-	2.33%	6.34%	3.16%	0.00%	-	0.00%

The minimum total lengths (cm) of spawning wrasse sampled are summarised in Table 5. No ballan were observed spawning.

Table 5: Summary of minimum total length of spawning fish observed for each species sampled in 2018. "-" Indicates when no fish sampled were spawning.

Species	Minimum total length of spawning individual (cm)	
	Male	Female
Ballan	-	-
Corkwing	20	9.5
Rock Cook	8	8.5
Goldsinny	11	10

4.6 Repeat Strings

Repeat strings, where strings have been sampled in repeat locations have been analysed from 2016 to 2018. The repeat strings were grouped by geographic areas A to D. Out of a total of 372 strings surveyed over the three years, 118 were identified as repeat strings (31.7%). Of this, 78 strings were comparable in terms of environmental variables.

4.6.1 Area A

A total of 10 strings, in five repeat pairs, were identified in area A (Table 6). The total length of ballan, goldsinny, corkwing and rock cook wrasse for each repeat string can be seen in Figure 13 to Figure 17. It should be noted that sample sizes (number of wrasse) were relatively small for the analysis and so comparisons between samples should be treated with caution. CPUE varied between repeat pairs and species and there was no clear trend between samples (Table 6).

For four string pairs the median total length of ballan was higher in the second sample and total length of ballan was significantly different for string A1 ($U_{14,11}$= 38.5, p= <0.05), A2 ($U_{48,84}$= 1540, p= <0.05) and A3 ($U_{26,35}$= 299.5, p= <0.05). No analysis could be conducted for string A5 due to low ballan numbers.

The median total length of goldsinny was higher in the second sample for A2 and A4 and lower in the second sample for A5. The total length was significantly different for strings A2 ($U_{6,3}$= 0, p= <0.05) and A4 ($U_{3,13}$= 0, p= <0.01). No analysis could be conducted for goldsinny in strings A1 and A3.

Corkwing median total length was higher and significantly different in string A2 ($U_{106,204}$= 6467.5, p= <0.001)and A3 ($U_{54,107}$= 1244, p= <0.001). No analysis could be conducted for strings A1 and A5 for corkwing.

No analysis could be conducted for rock cook due to low numbers.

Table 6: Summary of repeat strings in area A from 2016 to 2018 with catch per unit effort (CPUE) (no. of fish/ 10 traps) of ballan, goldsinny, corkwing and rock cook.

String ID	Sample	Date	No. Days	CPUE			
				Ballan	Goldsinny	Corkwing	Rock cook
A1	**1**	01/08/17		14.00	2.00	18.00	0.00
	2	12/09/17	42	11.00	0.00	2.00	0.00
A2	**1**	01/08/17		48.00	6.00	106.00	0.00
	2	12/09/17	42	84.00	3.00	204.00	0.00
A3	**1**	01/08/17		26.00	3.00	54.00	0.00
	2	12/09/17	42	35.00	0.00	107.00	0.00
A4	**1**	10/10/17		14.00	3.00	3.00	0.00
	2	22/10/18	377	6.00	13.00	46.00	43.00
A5	**1**	20/09/16		2.00	15.00	18.00	0.00
	2	04/05/18	591	0.00	6.00	1.00	1.00

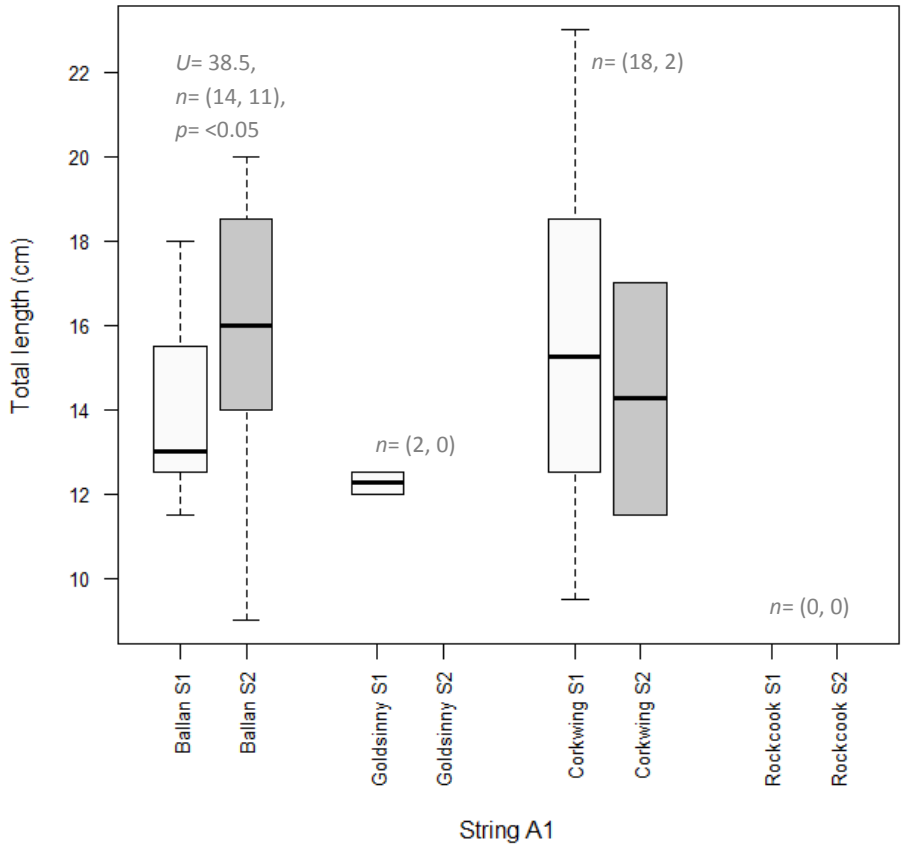


Figure 13: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string A1. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range.

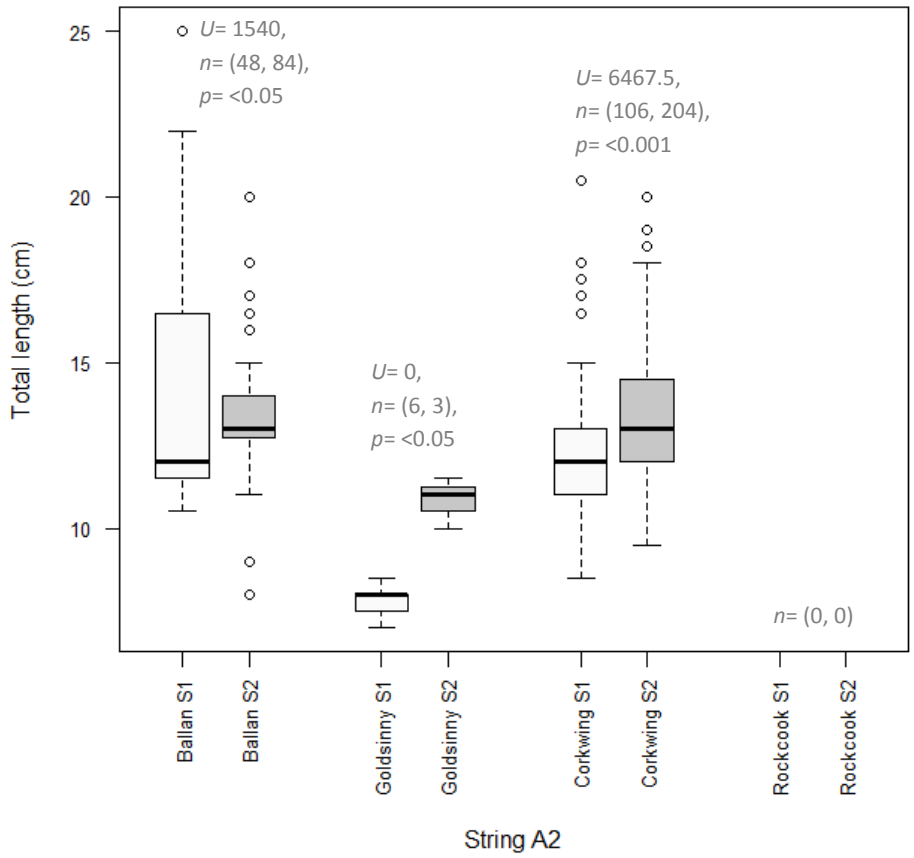


Figure 14: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string A2. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

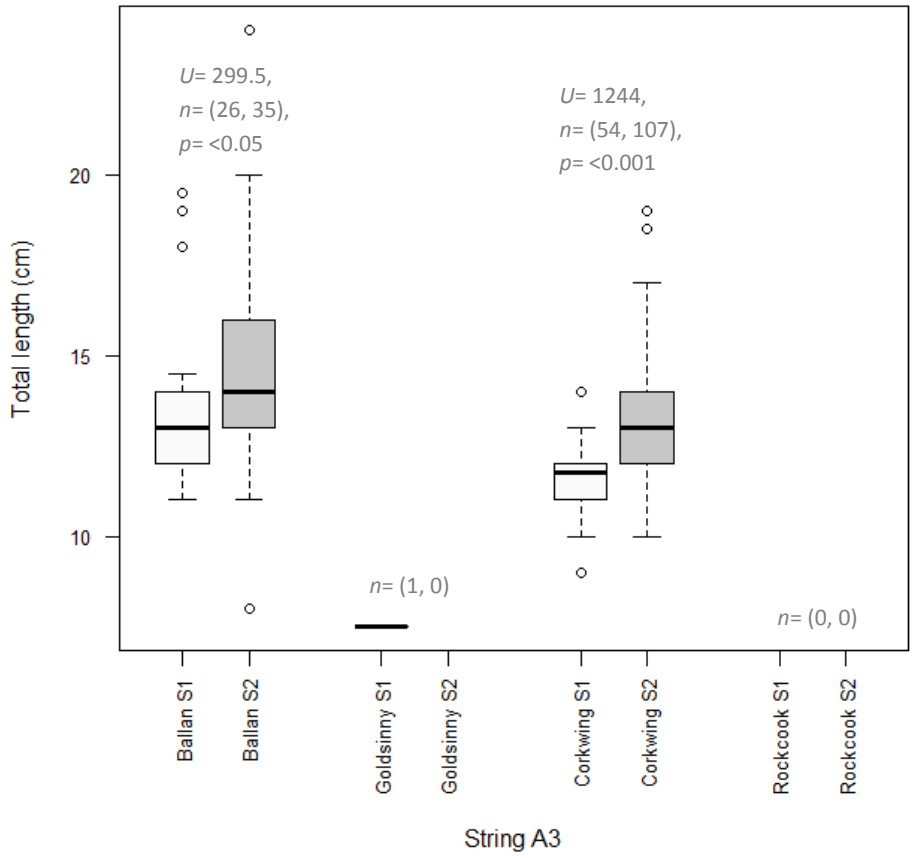


Figure 15: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string A3. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

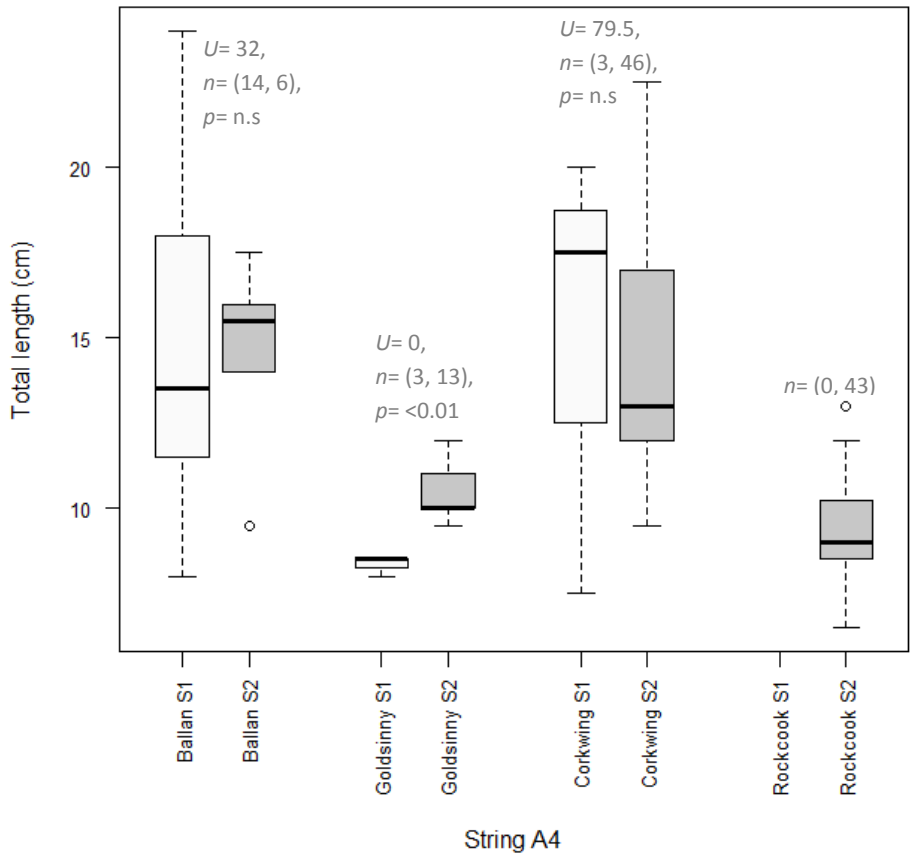


Figure 16: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string A4. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

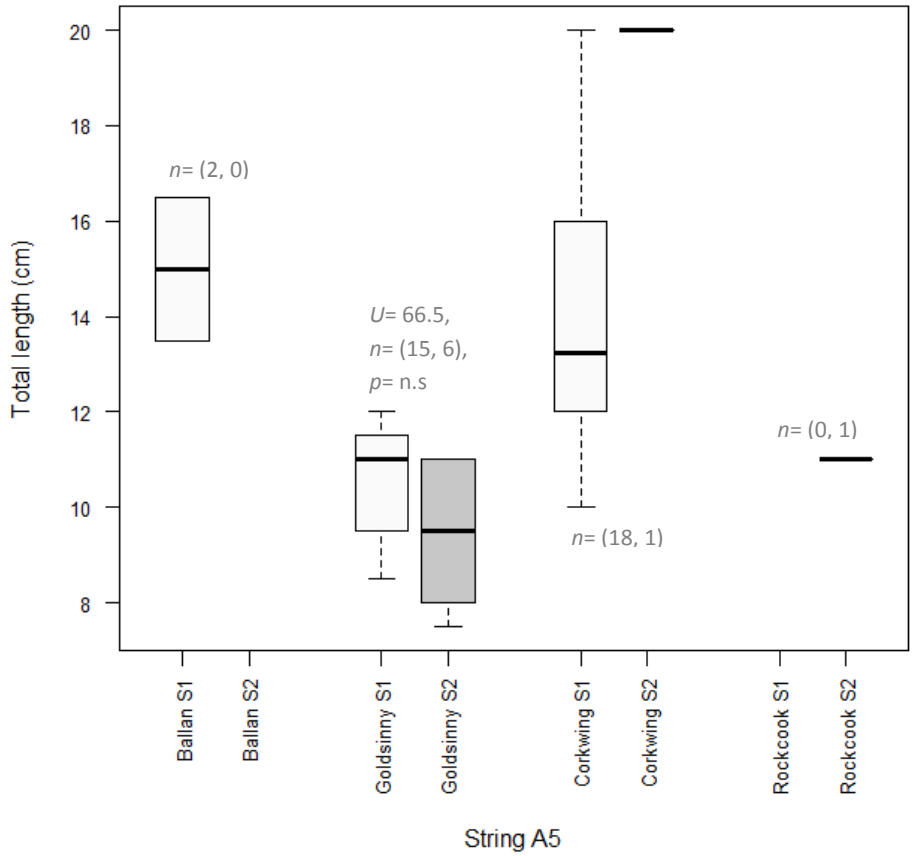


Figure 17: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string A5. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range.

4.6.2 Area B

A total of 35 strings, made up of 13 repeat pairs (Table 7) and three repeat groups (Table 8), were identified in area B. The total length of ballan, goldsinny, corkwing and rock cook wrasse for each repeat pair can be seen in Figure 18 to Figure 30, and for each repeat group can be seen in Figure 31 to Figure 33. Strings are ordered by number of days (Table 7 and Table 8) and the time between samples ranged from 27 to 459 days.

It should be noted that sample sizes (number of wrasse) were relatively small for the analysis and so comparisons between samples should be treated with caution. Comparisons of CPUE for each species between repeat pairs and groups showed no overall pattern (Table 7 and Table 8).

For ballan wrasse no analysis could be conducted for strings B13, B15 and B5 due to low ballan numbers. Samples in string B8 (Figure 27) were significantly different ($U_{8,10}$= 65.5, p= <0.05) with a lower median total length in the second sample.

There was a significant difference in total length for goldsinny repeat string B14 ($U_{25,39}$= 269, p= <0.01) with the median total length higher in the second sample. For goldsinny no analysis could be carried out in repeat pairs B12 and B16.

No analysis could be conducted for corkwing in repeat pairs B4, B7, B1, B13, B15 and B5. In repeat pair B9 the total length was significantly different ($U_{24,19}$= 104, p= <0.01) and the median total length higher in the second sample.

The differences in total length were significant for repeat strings B11 ($U_{74,54}$= 1056, p= <0.001) and B4 ($U_{4,3}$= 12, p= <0.05) for rock cook. No analysis could be carried out for repeat pairs B12, B7, B9, B13, B15, B5 and B14 for rock cook due to low numbers.

For all remaining repeat pairs there were no significant differences between total lengths.

For all repeat string groups (three samples) there were no significant differences in total lengths for ballan, goldsinny, corkwing and rock cook. No analysis could be conducted for corkwing and rock cook in B2 due to low numbers.

Table 7: Summary of repeat strings with two samples in area B from 2016 to 2018 with catch per unit effort (CPUE) (no. of fish/ 10 traps) of ballan, goldsinny, corkwing and rock cook.

String ID	Sample	Date	Days	CPUE			
				Ballan	Goldsinny	Corkwing	Rock cook
B11	**1**	14/03/17	27	11.00	19.00	7.00	74.00
	2	10/04/17	27	6.00	28.00	14.00	54.00
B12	**1**	03/07/17	29	9.00	2.00	4.00	2.00
	2	01/08/17	29	7.00	2.00	4.00	2.00
B4	**1**	08/05/17	39	8.00	27.00	8.00	4.00
	2	16/06/17	39	3.00	16.00	1.00	3.00
B6	**1**	19/05/17	45	4.55	7.27	13.64	15.45
	2	03/07/17	45	5.45	6.36	8.18	7.27
B7	**1**	16/06/17	46	3.00	6.00	0.00	1.00
	2	01/08/17	46	3.00	14.00	19.00	6.00
B1	**1**	20/02/17	88	7.00	9.00	10.00	3.00
	2	19/05/17	88	2.00	11.00	1.00	16.00
B9	**1**	13/07/18	101	6.00	7.00	24.00	32.00
	2	22/10/18	101	13.00	5.00	19.00	1.00
B13	**1**	04/05/18	171	1.00	8.00	1.00	1.00
	2	22/10/18	171	17.00	12.00	58.00	15.00
B15	**1**	10/10/17	206	12.00	25.00	6.00	8.00
	2	04/05/18	206	0.00	20.00	0.00	2.00
B8	**1**	14/03/17	210	8.00	14.00	27.00	11.00
	2	10/10/17	210	10.00	8.00	4.00	7.00
B16	**1**	16/05/16	280	4.00	16.00	5.00	22.00
	2	20/02/17	280	3.00	3.00	4.00	4.00
B5	**1**	16/06/17	355	0.91	2.73	3.64	7.27
	2	06/06/18	355	1.00	4.00	0.00	0.00
B14	**1**	12/09/17	405	6.00	25.00	4.00	0.00
	2	22/10/18	405	8.18	35.45	19.09	18.18

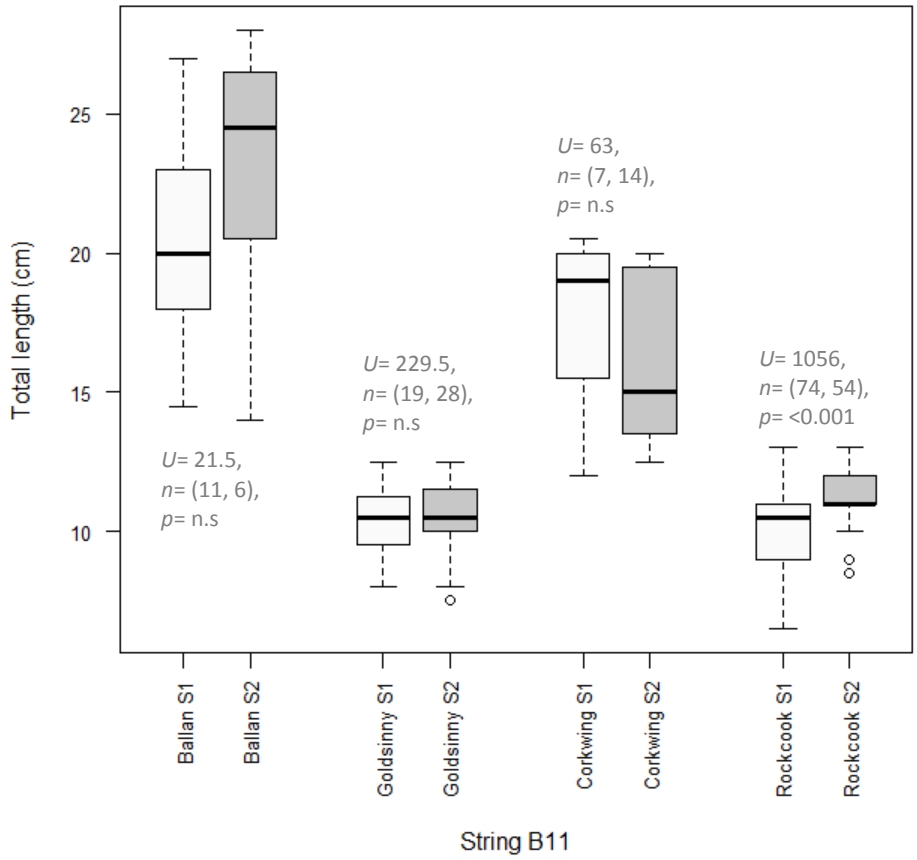


Figure 18: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B11. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

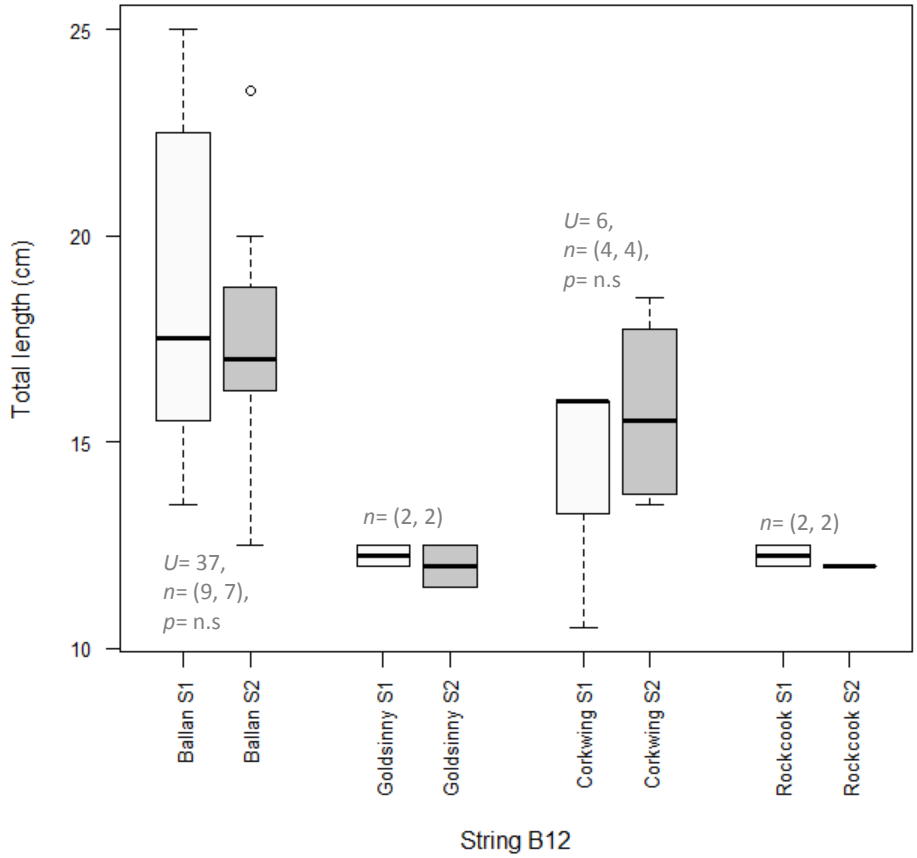


Figure 19: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B12. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

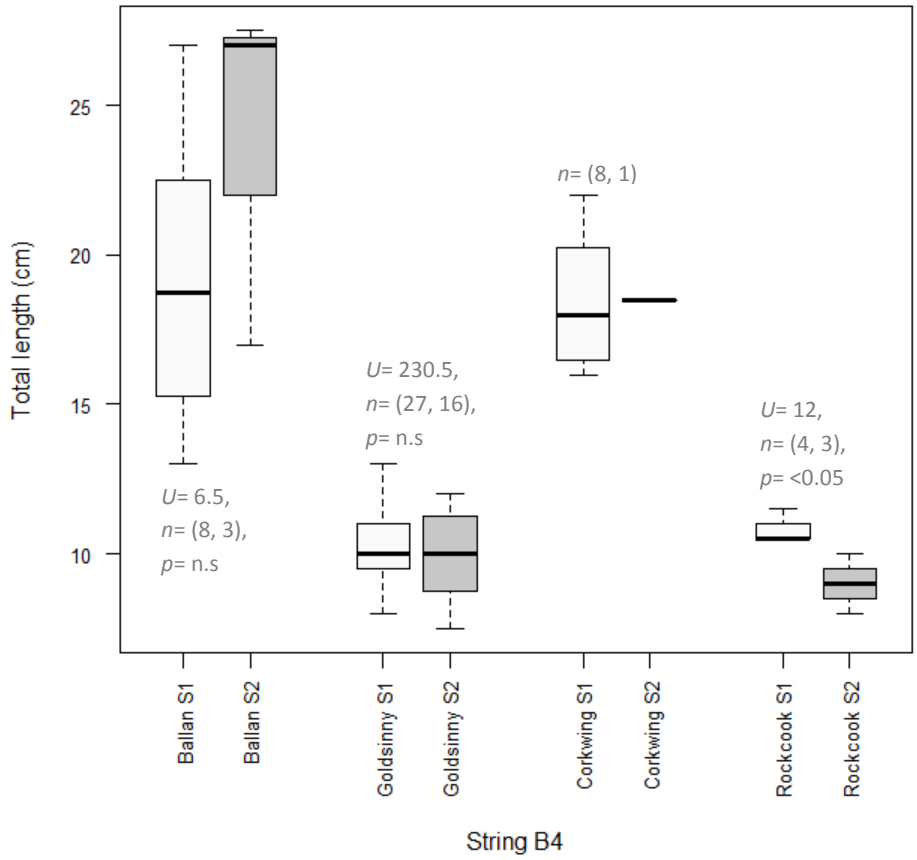


Figure 20: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B4. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range.

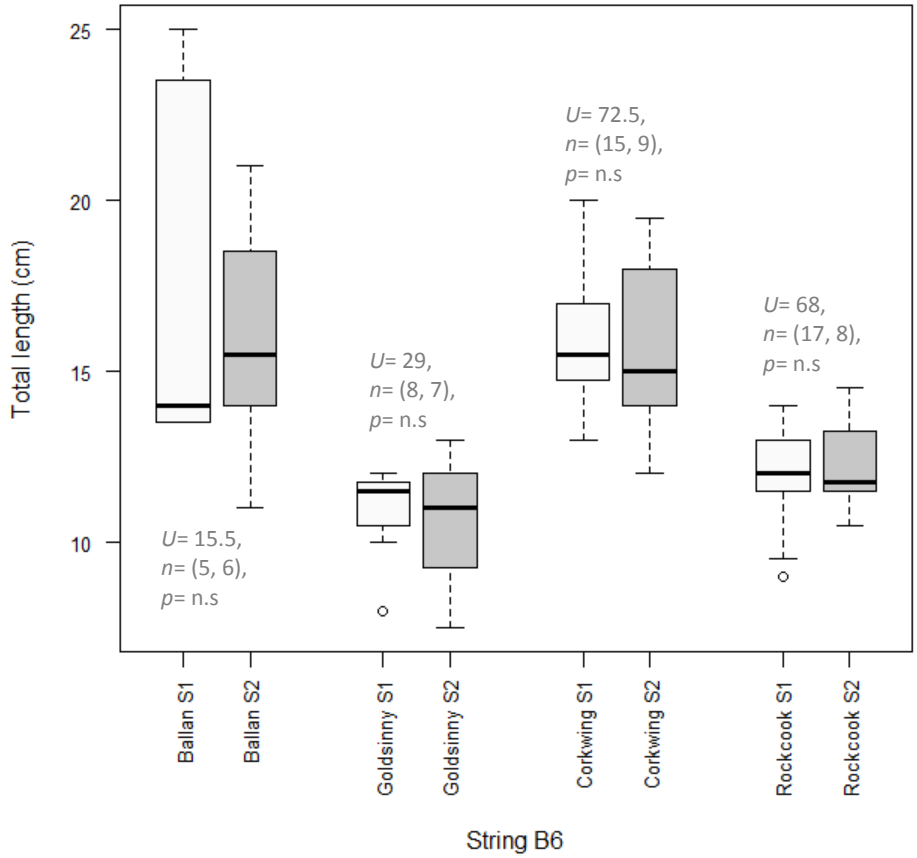


Figure 21: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B6. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

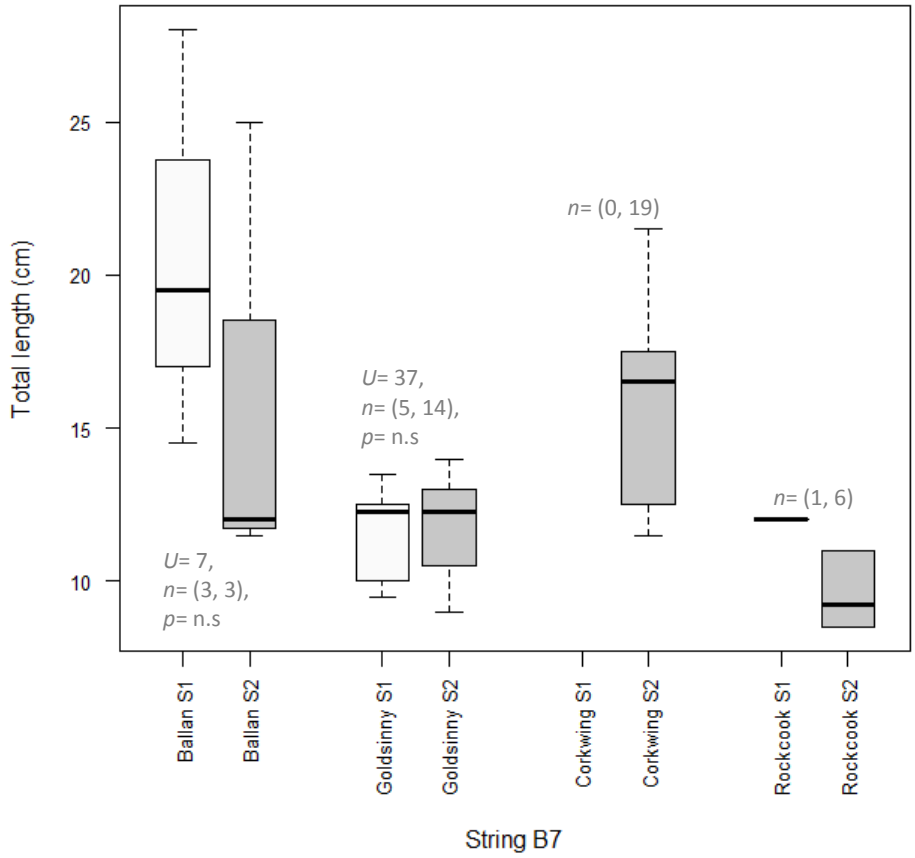


Figure 22: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B7. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range.

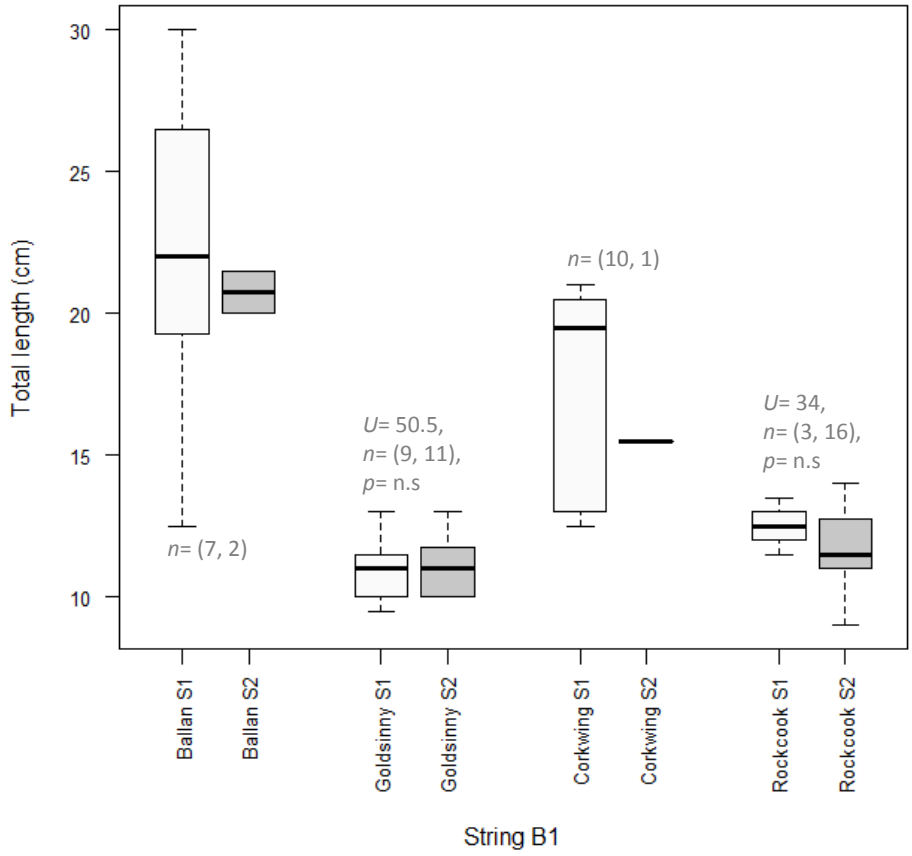


Figure 23: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B1. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range.

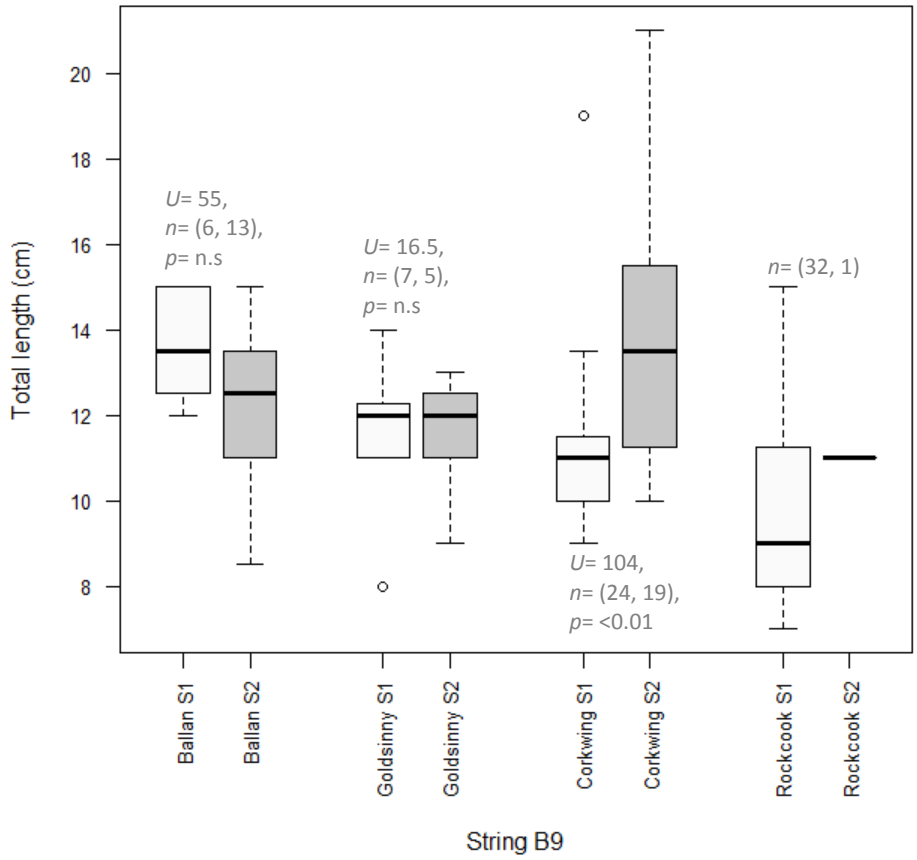


Figure 24: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B9. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

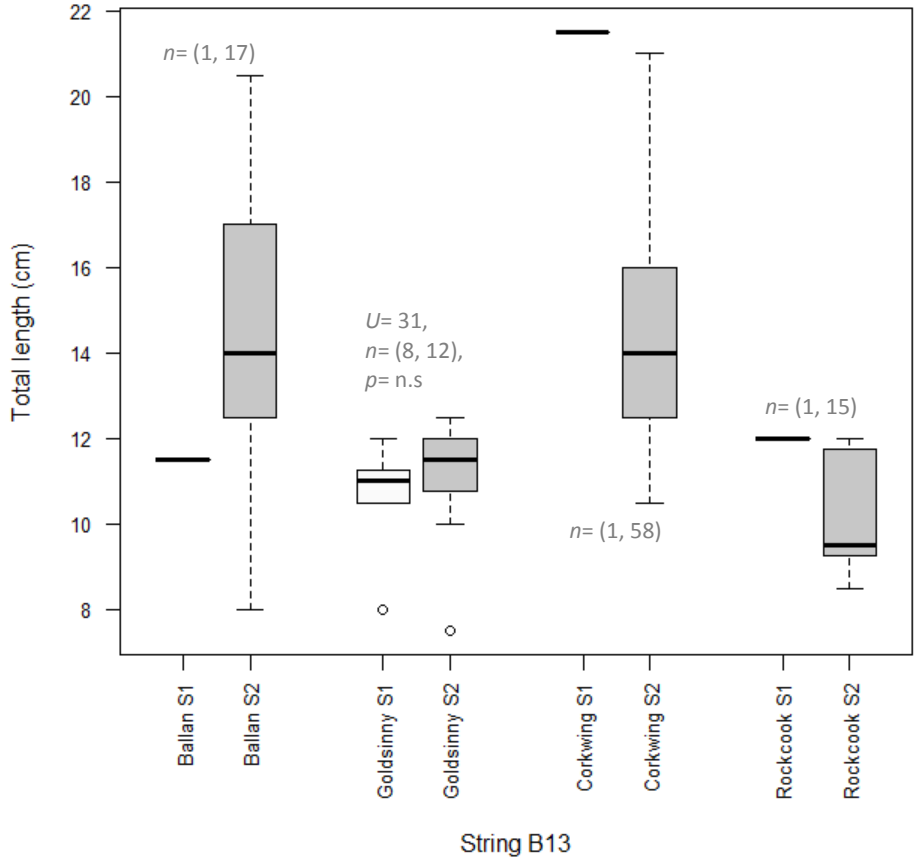


Figure 25: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B13. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

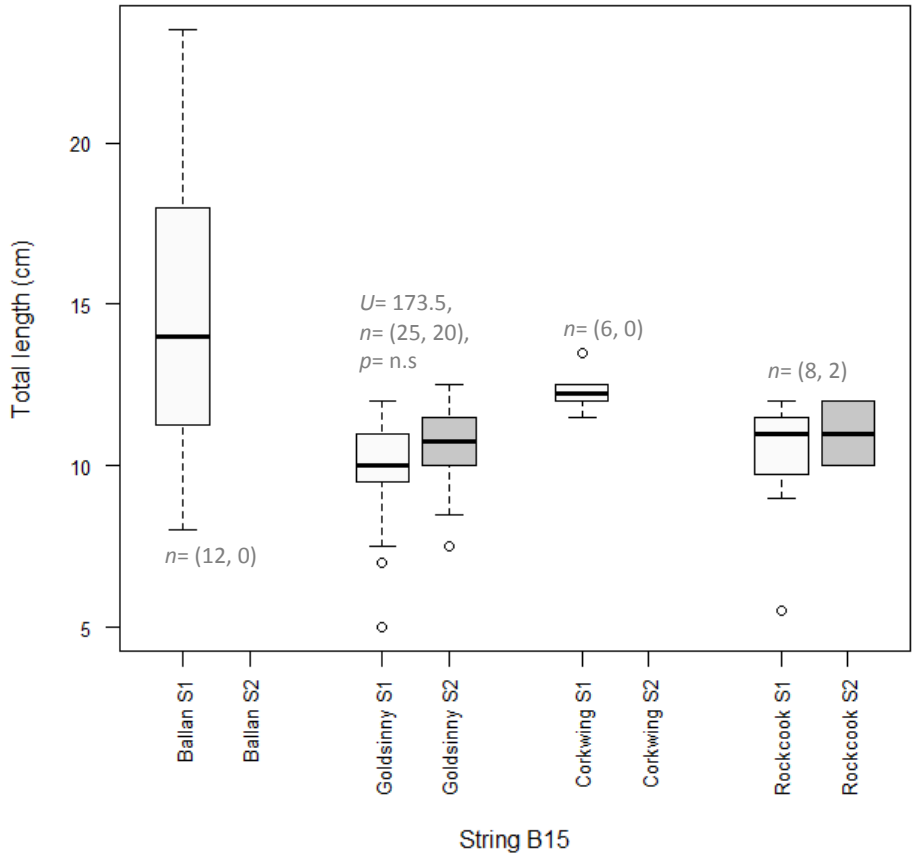


Figure 26: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B15. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

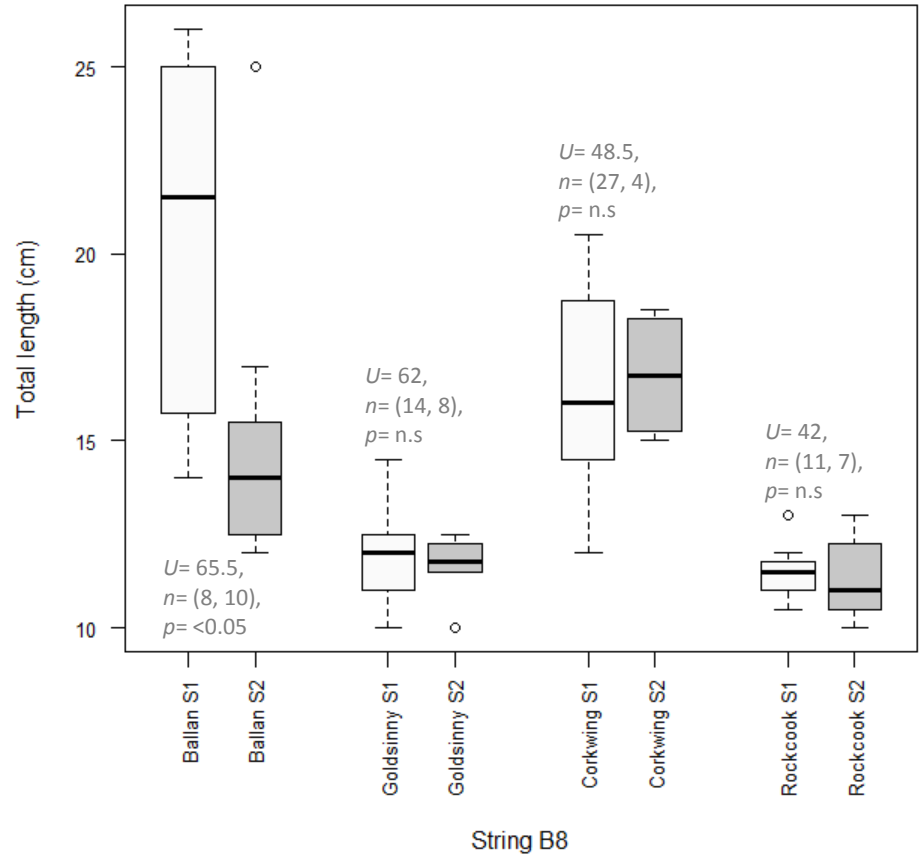


Figure 27: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B8. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

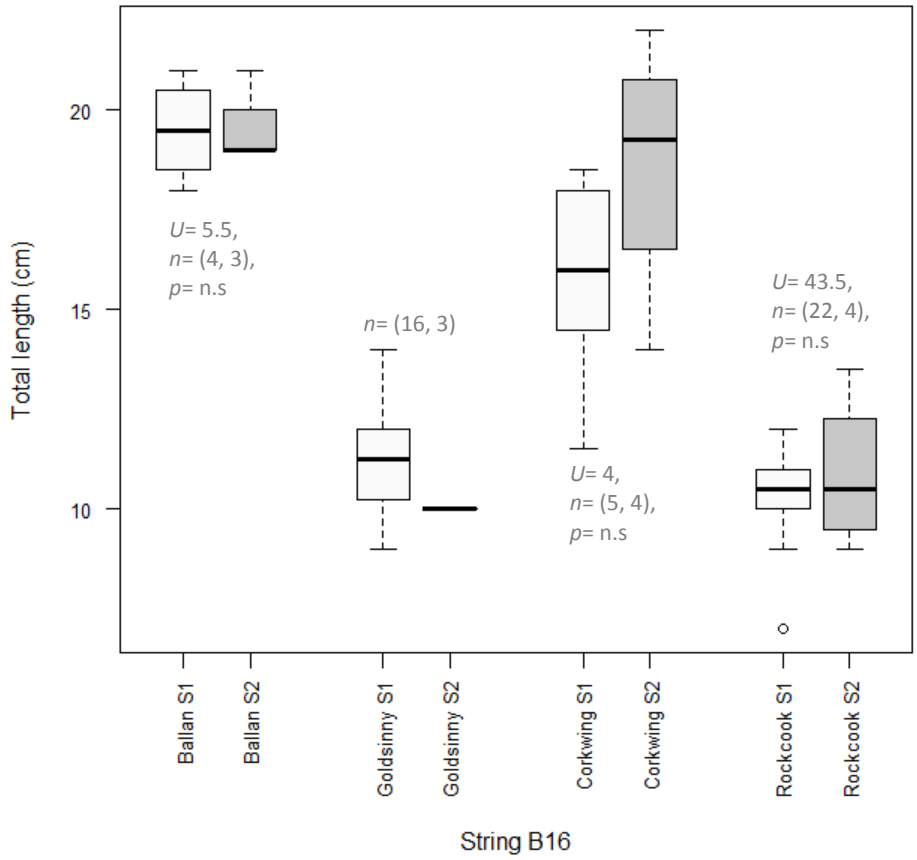


Figure 28: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B16. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

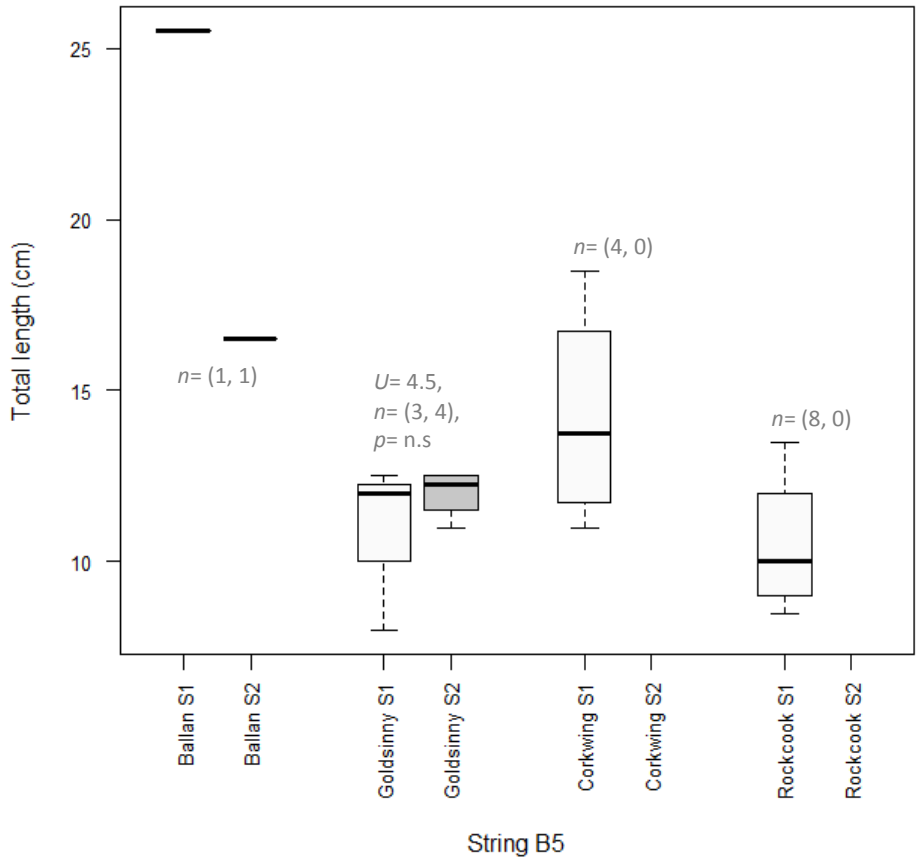


Figure 29: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B5. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range.

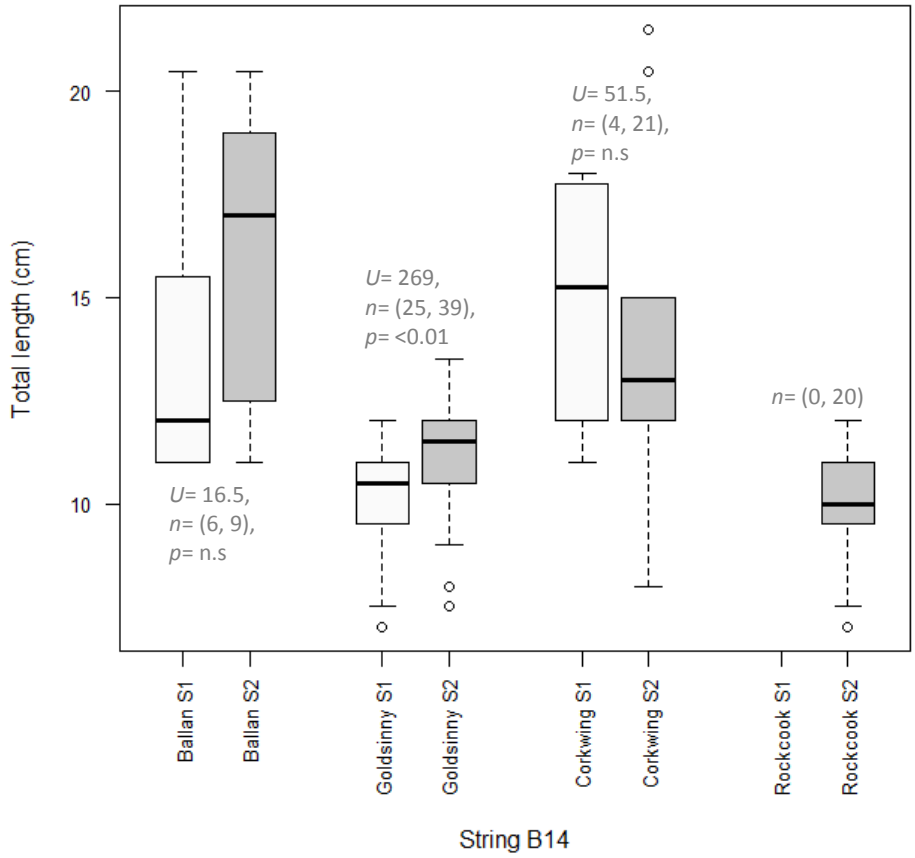


Figure 30: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B14. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

Table 8: Summary of repeat strings with three samples in area B from 2016 to 2018 with catch per unit effort (CPUE) (no. of fish/ 10 traps) of ballan, goldsinny, corkwing and rock cook.

String ID	Sample	Date	Days	CPUE			
				Ballan	Goldsinny	Corkwing	Rock cook
B10	**1**	14/03/17		7.00	47.00	11.00	11.00
	2	10/04/17	27	5.00	21.00	4.00	10.00
	3	13/07/18	459	10.00	14.00	5.00	3.00
B3	**1**	14/03/17		10.00	39.00	4.00	3.00
	2	08/05/17	55	5.00	24.00	5.00	3.00
	3	13/07/18	431	1.00	13.00	2.00	9.00
B2	**1**	20/02/17		6.00	8.00	2.00	0.00
	2	01/08/17	162	3.00	15.00	0.00	0.00
	3	06/06/18	309	6.00	6.00	0.00	8.00

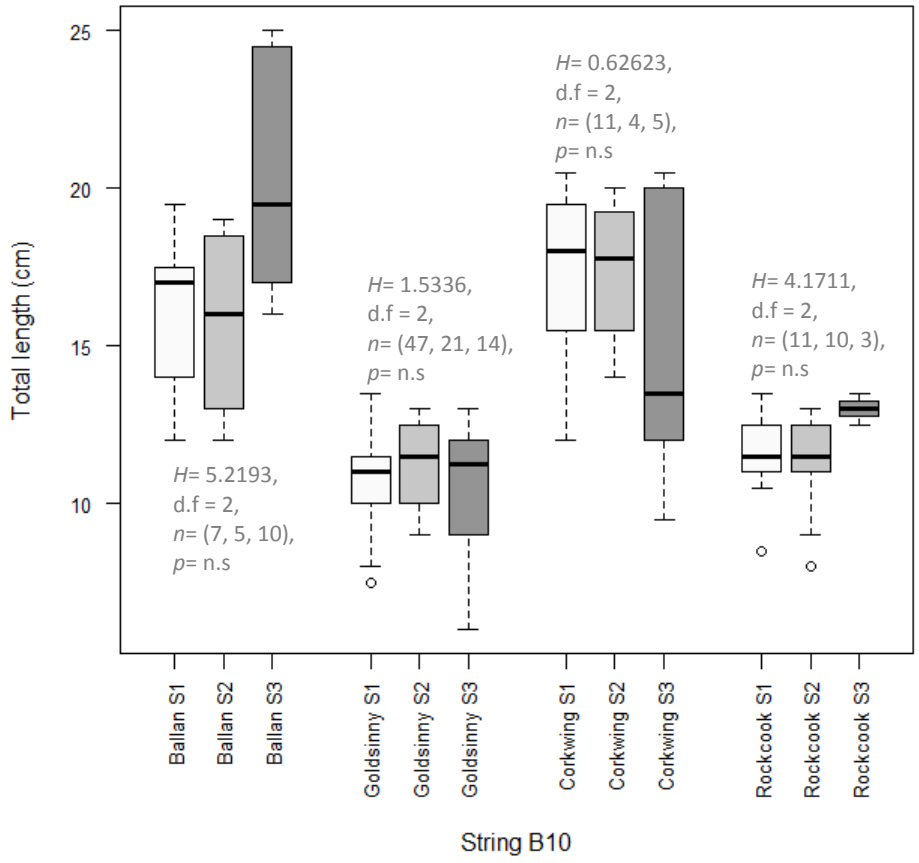


Figure 31: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B10. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

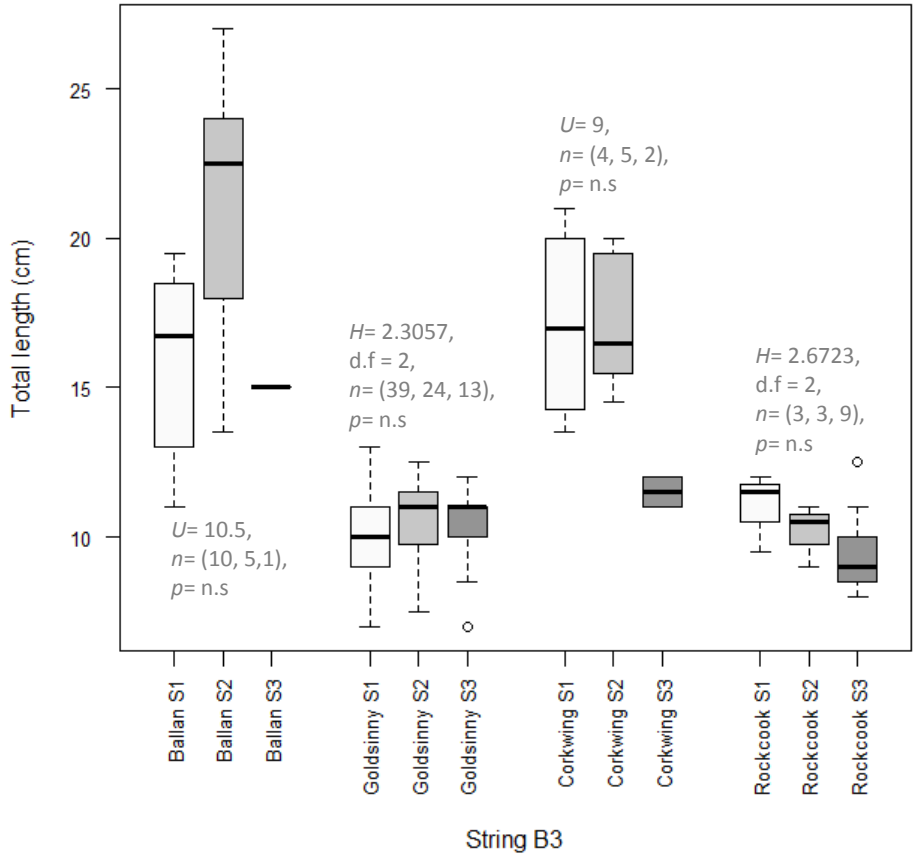


Figure 32: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B3. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

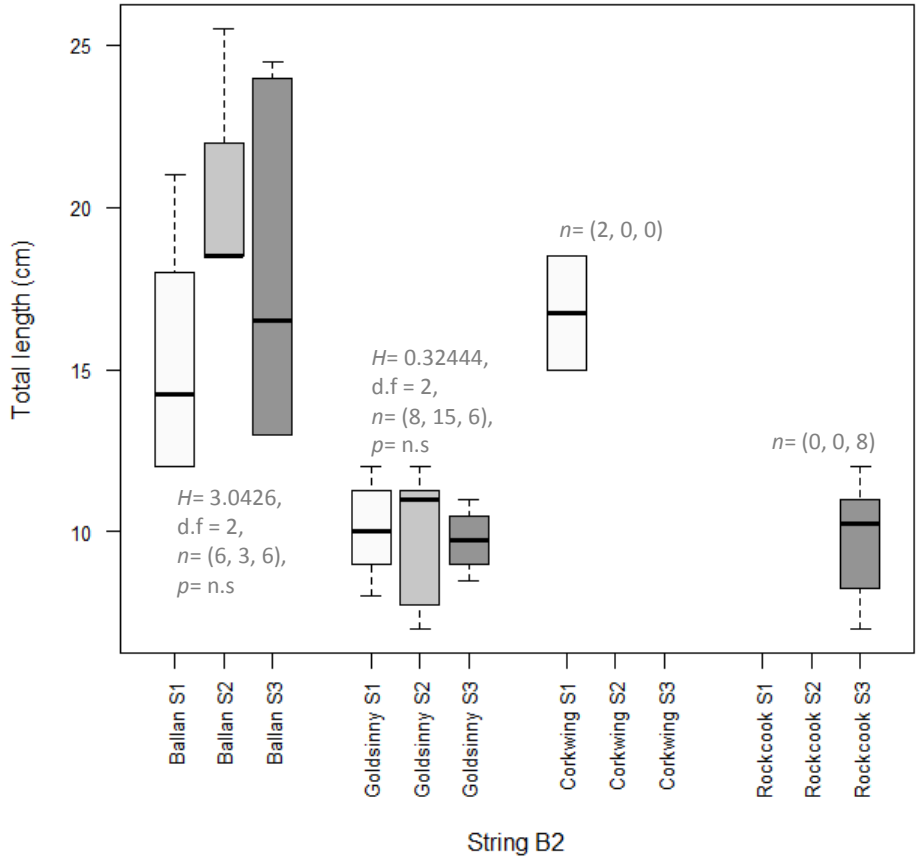


Figure 33: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string B2. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile and error bars show range.

4.6.3 Area C

A total of 10 strings, in five repeat pairs, were identified in area C (Table 9). The total length of ballan, goldsinny, corkwing and rock cook wrasse for each repeat string can be seen in Figure 34 to Figure 38. Strings are ordered by number of days (Table 9) and the time between samples ranged from 15 to 145 days. It should be noted that sample sizes (number of wrasse) were relatively small for the analysis and so comparisons between samples should be treated with caution. CPUE varied between repeat pairs and species with no clear pattern between samples (Table 9).

For ballan analysis could not be conducted for string pairs C1 and C2. The remaining repeat strings were not significantly different in total length (C5, C4 and C3).

There were no significant differences in total length for goldsinny in repeat strings C4, C2 and C3, and no analysis could be carried out for goldsinny for string pairs C5 and C1.

Repeat string C1 was significantly different for corkwing ($U_{10,4}$= 4.5, p= <0.05) with median average size larger in second sample. No analysis could be carried out for C2 and the remaining repeat strings were not significantly different for corkwing.

For rock cook no analysis could be carried out for C5, C2 and C1 due to low numbers. There were no significant differences in total length for rock cook in repeat strings C4 and C3.

Table 9: Summary of repeat strings with two samples in area C from 2016 to 2018 with catch per unit effort (CPUE) (no. of fish/ 10 traps) of ballan, goldsinny, corkwing and rock cook.

String ID	Sample	Date	Days	CPUE			
				Ballan	Goldsinny	Corkwing	Rock cook
C5	**1**	24/07/17		4.00	1.00	5.00	0.00
	2	08/08/17	15	5.00	1.00	12.00	10.00
C4	**1**	22/03/17		4.00	4.00	5.00	6.00
	2	18/04/17	27	4.00	13.00	4.00	18.00
C2	**1**	22/03/17		2.00	7.00	0.00	2.00
	2	02/05/17	41	1.00	9.00	3.00	3.00
C1	**1**	19/10/16		6.00	0.00	10.00	0.00
	2	13/03/17	145	1.00	3.00	4.00	0.00
C3	**1**	19/10/16		4.00	14.00	22.00	10.00
	2	13/03/17	145	5.00	9.00	5.00	10.00

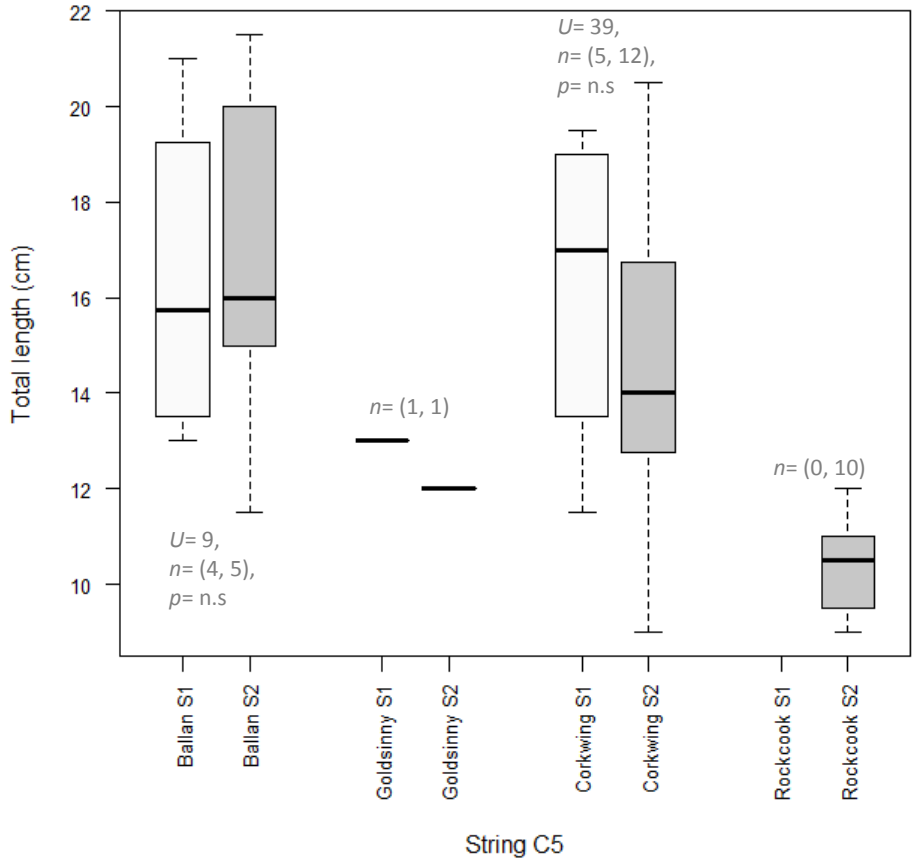


Figure 34: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string C5. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range.

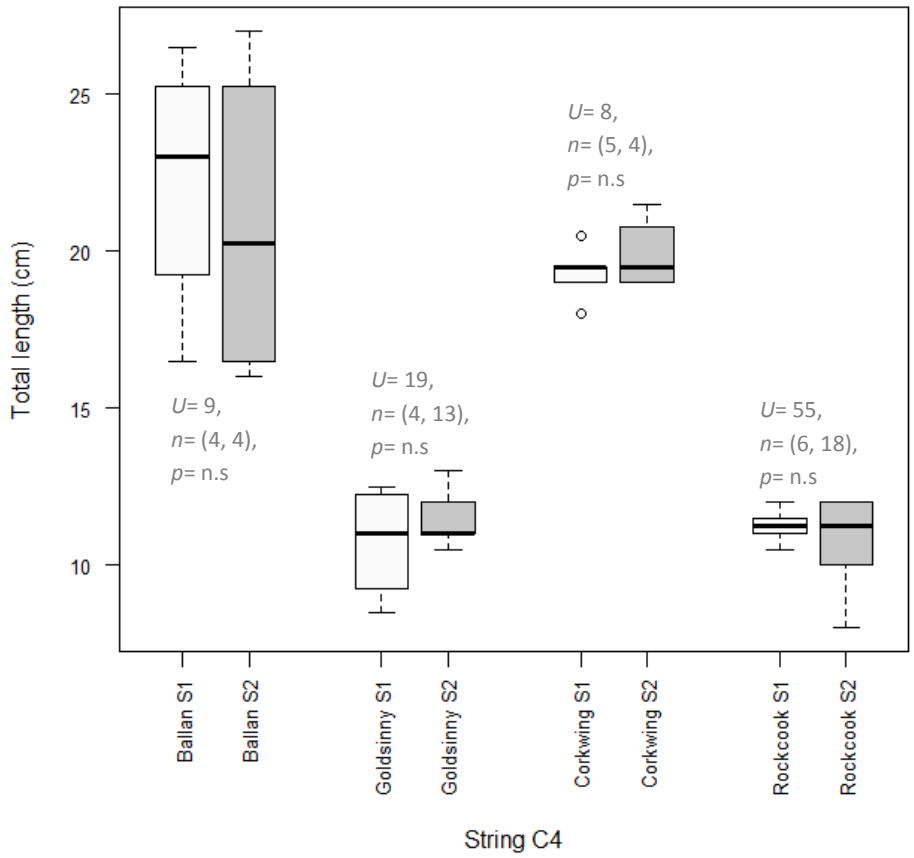


Figure 35: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string C4. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range.

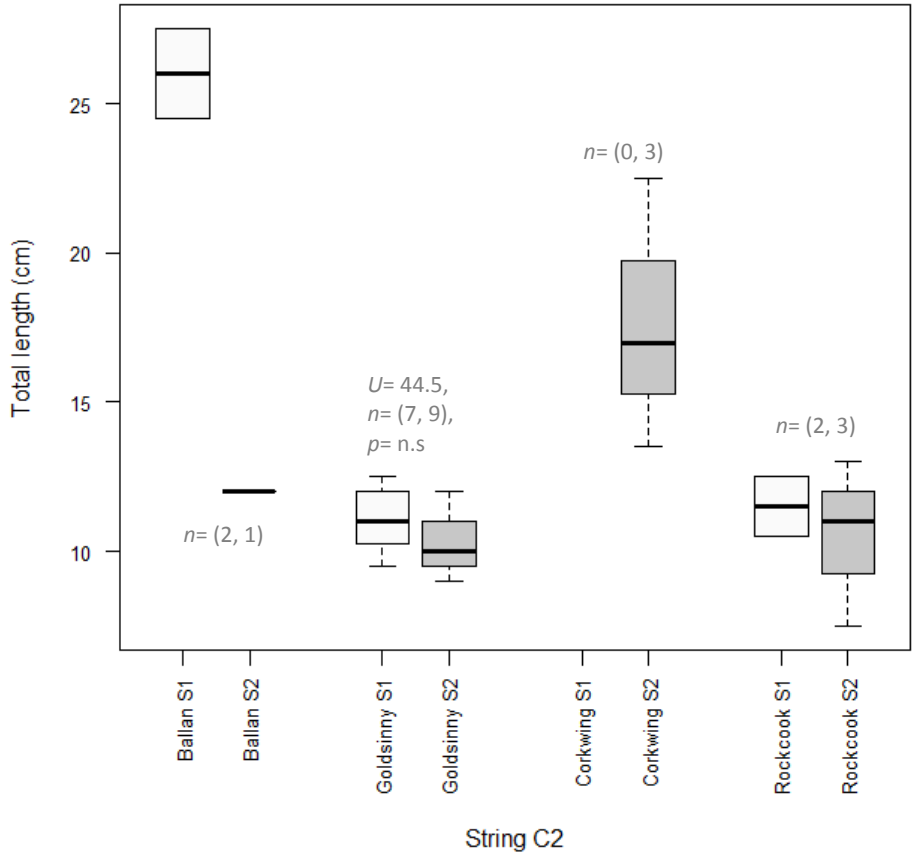


Figure 36: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string C2. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

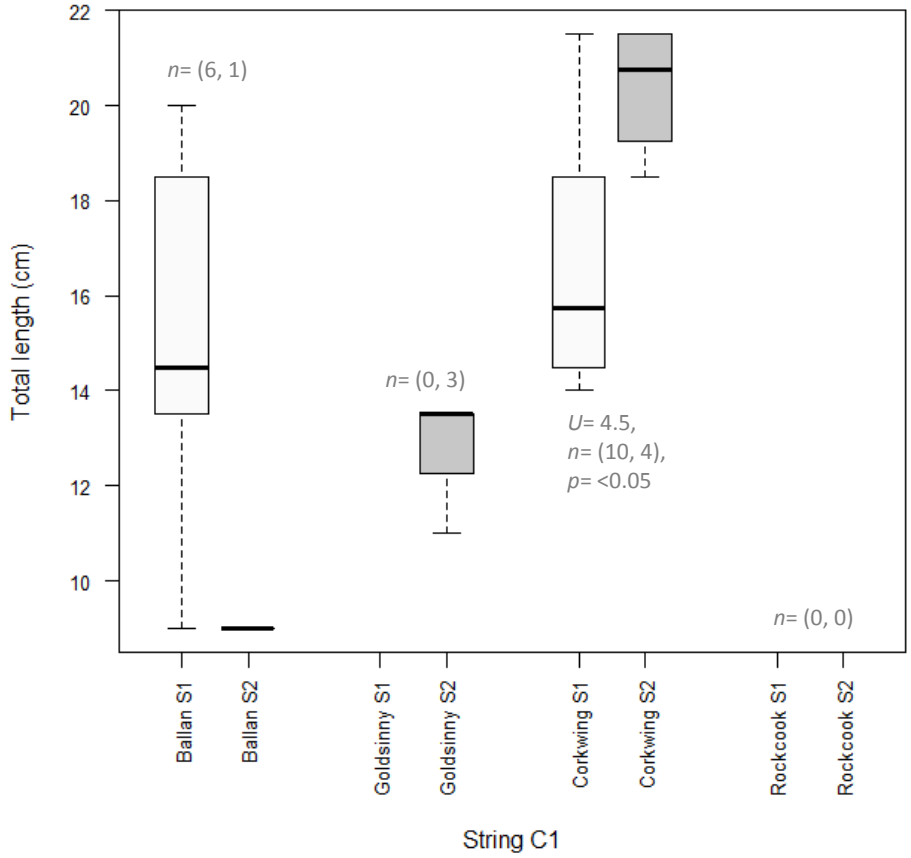


Figure 37: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string C1. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile and error bars show range.

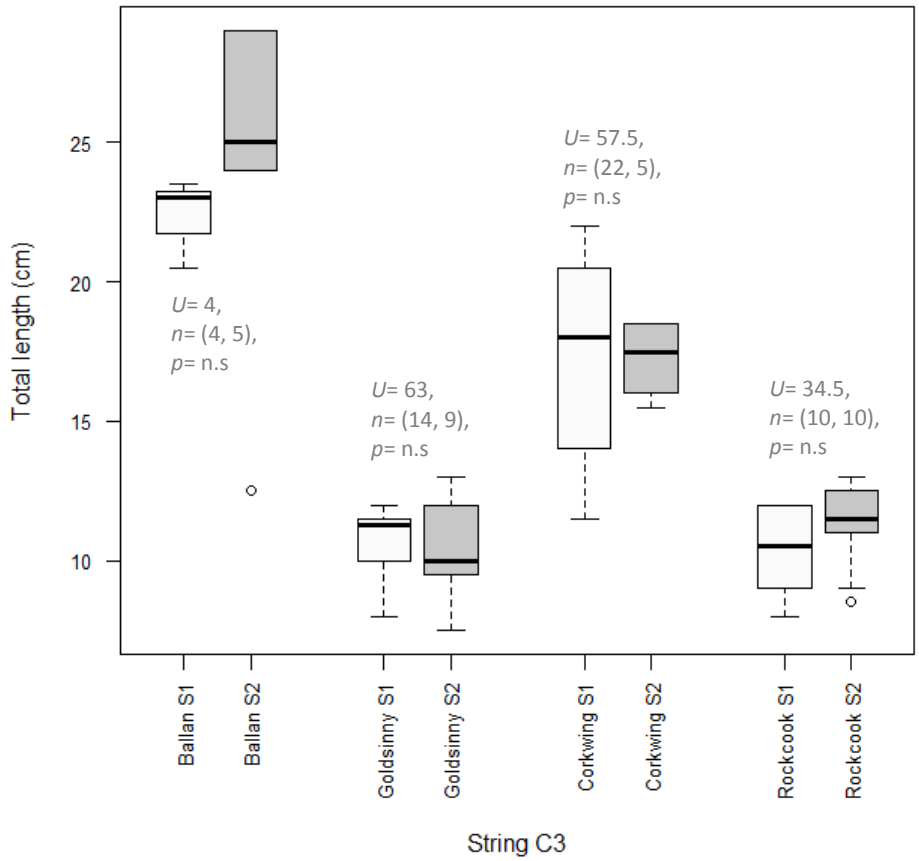


Figure 38: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string C3. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

4.6.4 Area D

A total of 23 strings, in four repeat pairs (Table 10) and five repeat groups (Table 11), were identified in area D. The total length of ballan, goldsinny, corkwing and rock cook wrasse for each repeat pair can be seen in Figure 39 to Figure 42, and for each repeat group can be seen in Figure 43 to Figure 47. Strings are ordered by number of days (Table 10 and Table 11) and the time between samples ranged from 26 to 369 days.

It should be noted that sample sizes (number of fish) were relatively small for the analysis and so comparisons between samples should be treated with caution. Analysis could not be conducted for strings D8 for ballan and corkwing, D5 for goldsinny and D7 for rock cook. Numbers of fish varied between samples and comparisons of CPUE between repeat strings showed no overall pattern (Table 10 and Table 11).

For ballan, goldsinny and rock cook the median total length was lower in all second repeat pairs (Figure 39 to Figure 42) and significantly different in string D3 for goldsinny ($U_{86,61}$= 3791, p= <0.001) and rock cook ($U_{34,85}$= 2676.5, p= <0.001) and D2 for rock cook ($U_{7,22}$= 127.5, p= <0.001). Corkwing varied, with median total length being higher in the second sample for string D5 ($U_{24,25}$= 184, p= <0.05).

Ballan median total length reduced for each sample in all the repeat groups (Figure 43 and Figure 47). All species showed a reduction in median total length for strings D1 and D9, with a significant difference for goldsinny (D1: H= 34.02, p= <0.001; D9: H= 29.71, p= <0.001) and rock cook (D1: H= 11.35, p= <0.01; D9: H= 15.58, p= <0.001) in both strings. In string D4 the median total length were significantly different for corkwing (H= 13.23, p= <0.01) and rock cook ($U_{47,16}$= 20, p= <0.001).

Table 10: Summary of repeat strings with two samples in area D from 2017 to 2018 with catch per unit effort (CPUE) (no. of fish/ 10 traps) of ballan, goldsinny, corkwing and rock cook.

String ID	Sample	Date	Days	CPUE			
				Ballan	Goldsinny	Corkwing	Rock cook
D8	**1**	13/07/17		0.74	14.07	14.44	4.44
	2	08/08/17	26	0.37	13.70	0.00	6.30
D3	**1**	06/09/17		7.21	20.00	6.74	7.91
	2	04/10/17	28	2.38	14.52	1.19	20.24
D2	**1**	26/08/17		0.88	7.65	1.18	2.06
	2	24/09/17	29	5.29	4.41	7.06	6.47
D5	**1**	26/08/17		1.61	2.90	7.74	2.90
	2	24/09/17	29	1.94	0.65	8.06	2.26

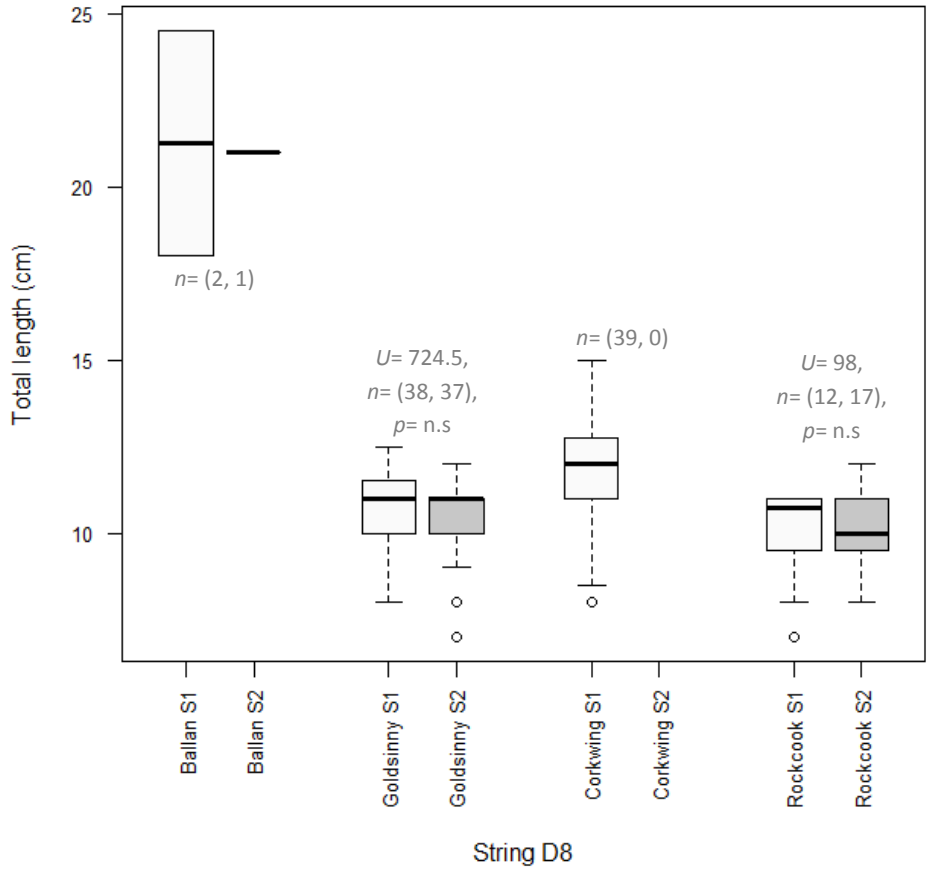


Figure 39: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D8. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

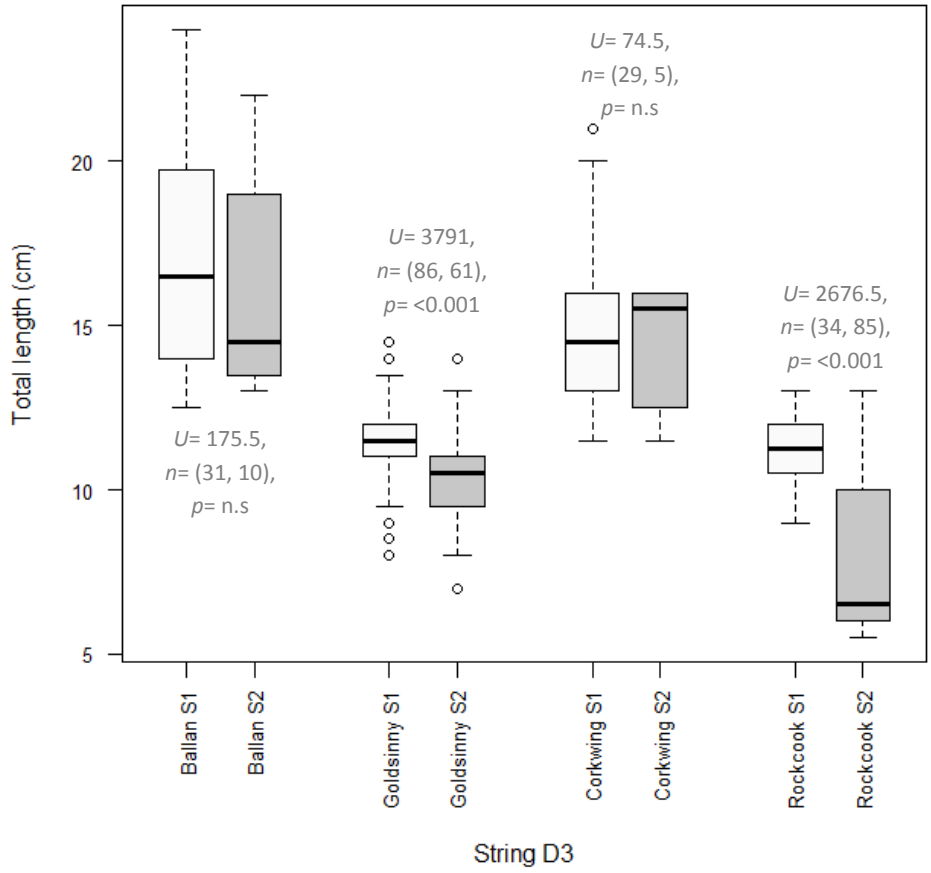


Figure 40: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D3. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

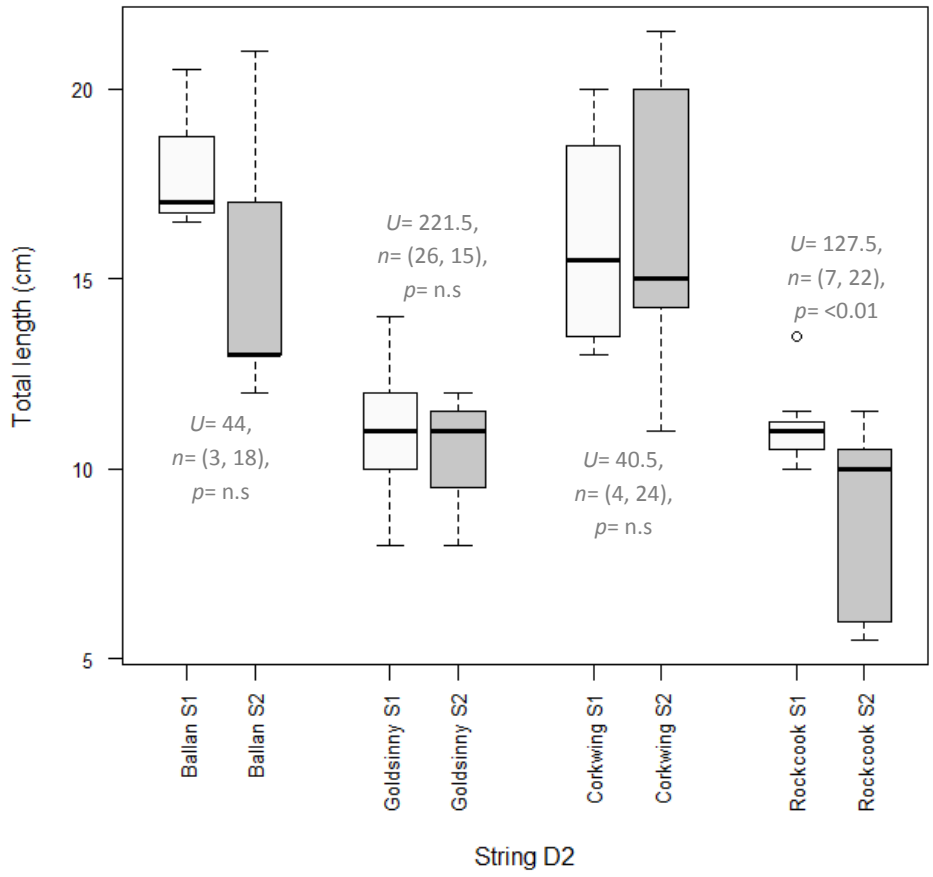


Figure 41: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D2. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

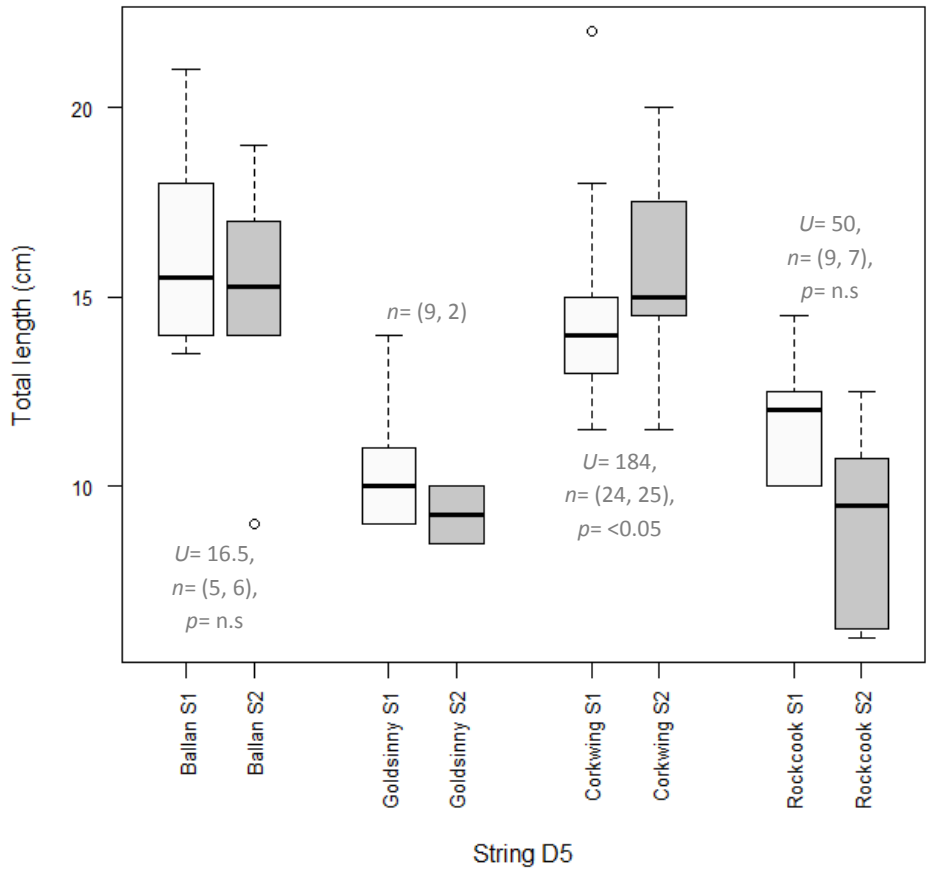


Figure 42: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D5. Data is grouped by sample number (S1 and S2). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

Table 11: Summary of repeat strings with three samples in area D from 2017 to 2018 with catch per unit effort (CPUE) (no. of fish/ 10 traps) of ballan, goldsinny, corkwing and rock cook.

String ID	Sample	Date	Days	CPUE			
				Ballan	Goldsinny	Corkwing	Rock cook
D6	**1**	26/08/17		2.20	3.20	4.20	0.20
	2	24/09/17	29	2.60	2.40	5.80	1.40
	3	04/10/17	10	5.10	8.57	9.18	2.86
D7	**1**	26/08/17		1.11	13.33	6.67	0.00
	2	24/09/17	29	4.44	10.74	4.81	0.00
	3	04/10/17	10	4.44	7.78	3.33	1.48
D1	**1**	08/08/17		2.06	16.47	1.76	2.94
	2	06/09/17	29	4.41	9.41	6.76	3.53
	3	04/10/17	28	1.43	8.00	4.29	4.00
D4	**1**	06/09/17		1.29	1.61	12.26	0.65
	2	04/10/17	28	1.94	5.48	7.74	15.16
	3	30/08/18	330	2.31	1.54	4.10	4.10
D9	**1**	13/07/17		2.33	7.21	0.70	9.77
	2	26/08/17	44	1.16	6.74	0.47	4.19
	3	30/08/18	369	1.63	9.30	2.09	12.79

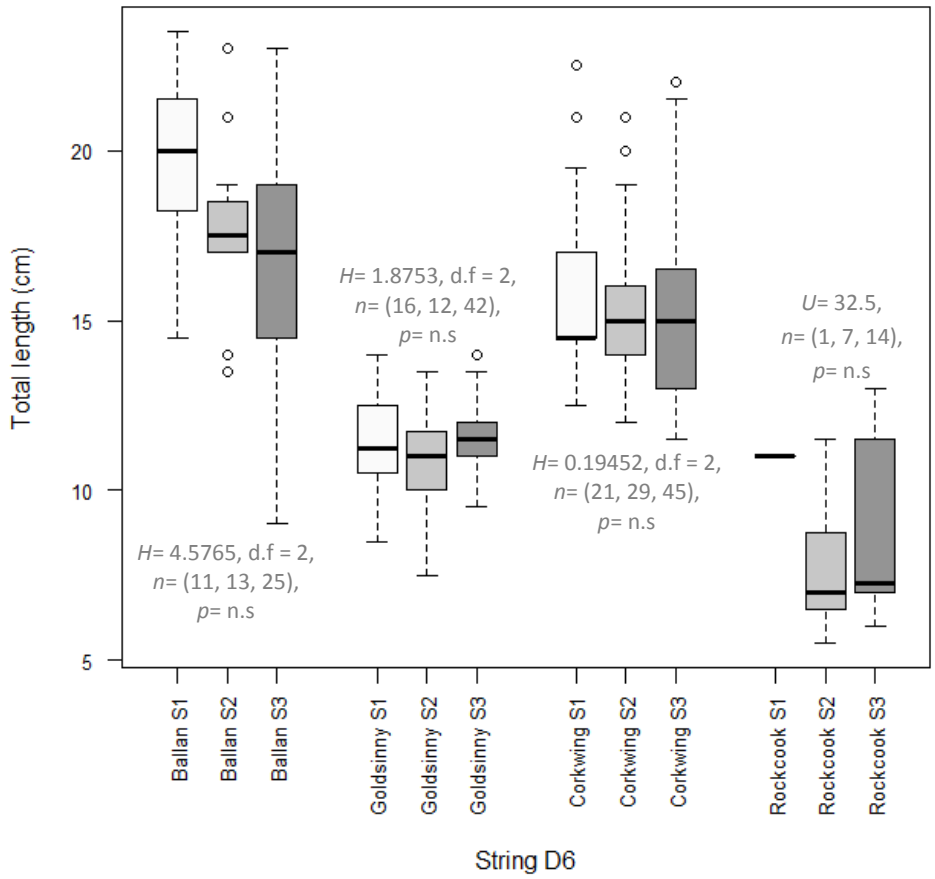


Figure 43: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D6. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

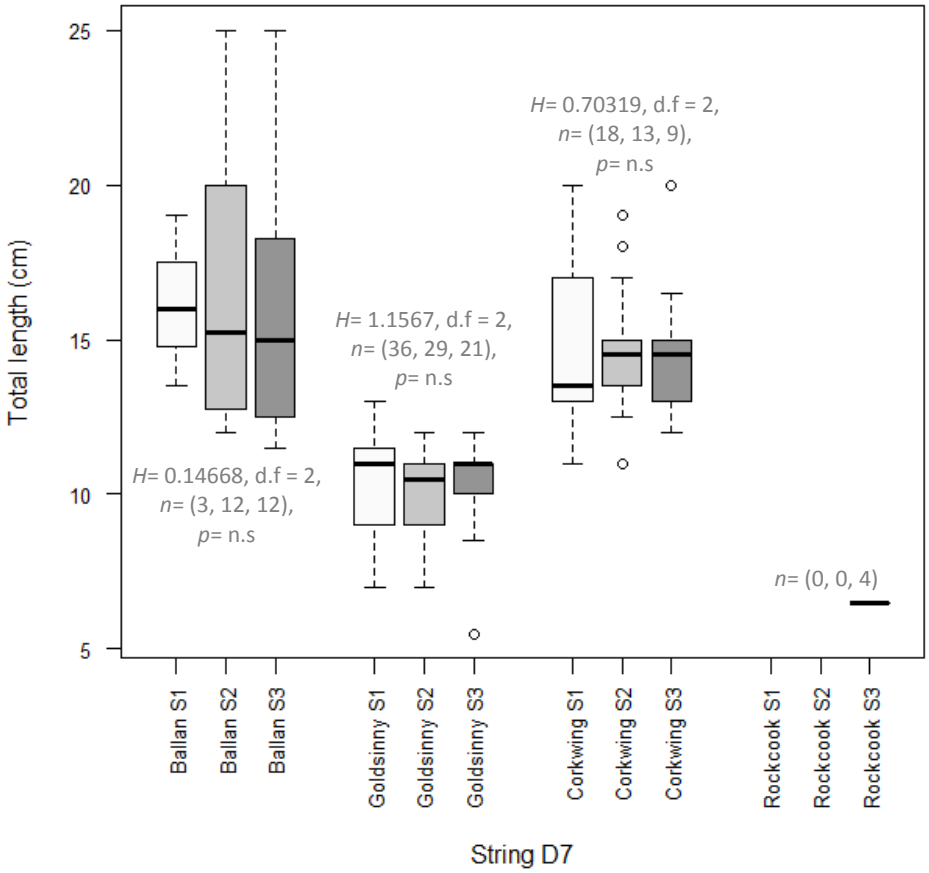


Figure 44: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D7. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

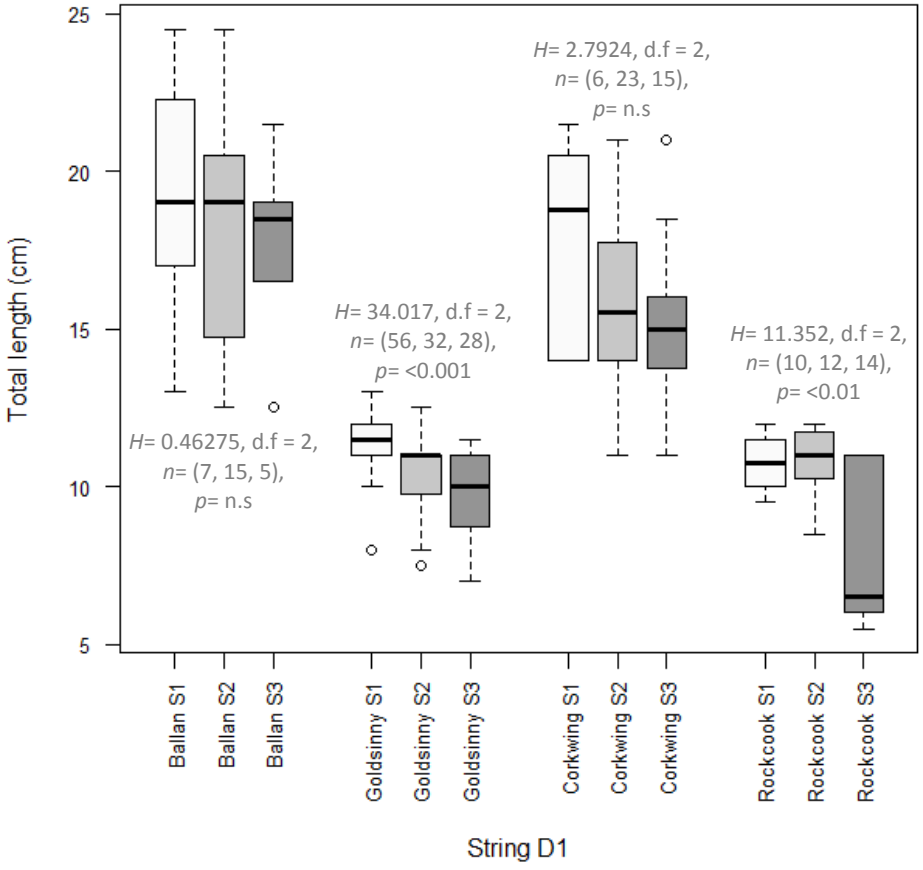


Figure 45: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D1. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

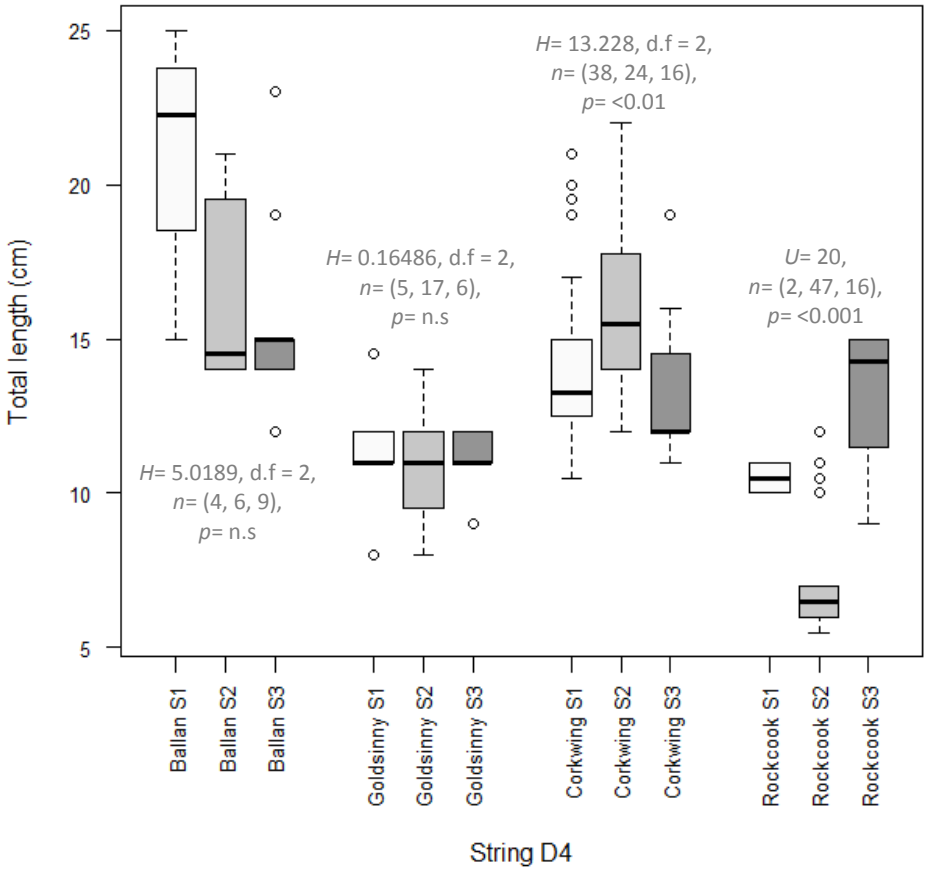


Figure 46: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D4. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

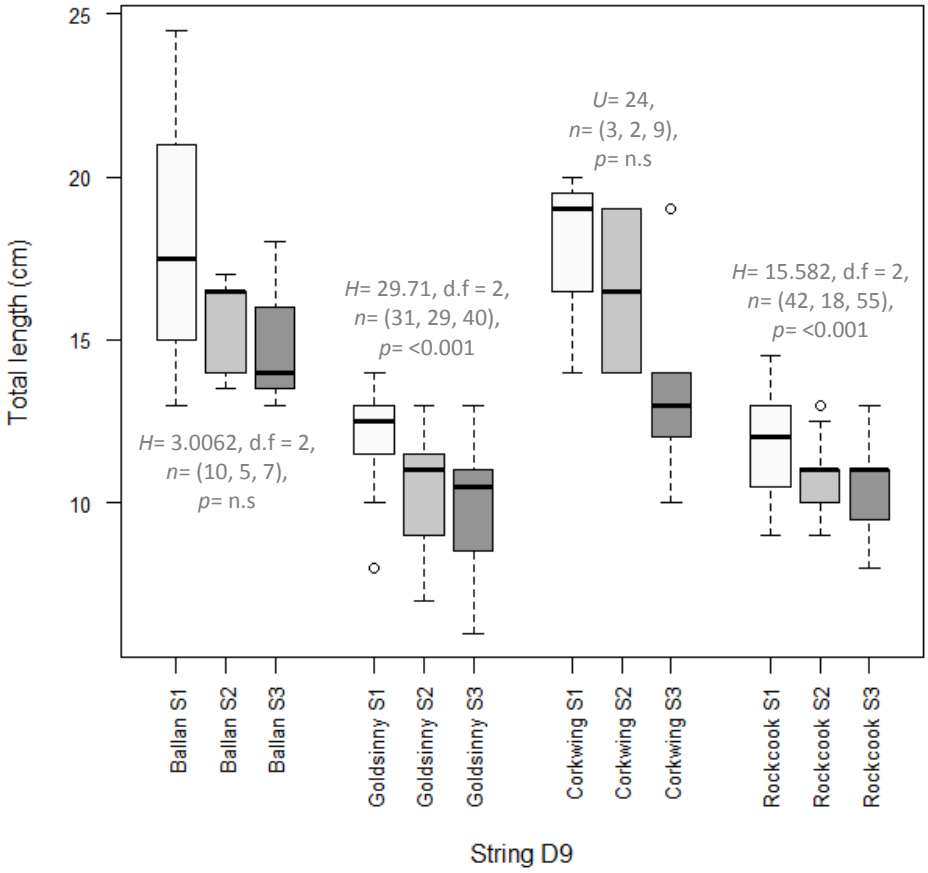


Figure 47: Total length in cm for ballan, goldsinny, corkwing and rock cook wrasse sampled in repeat string D9. Data is grouped by sample number (S1, S2 and S3). Stripes show median, boxes show inter-quartile, error bars show range and hollow circles show outliers.

5 Discussion

The catch sampling survey effort for 2018 was reduced compared to 2017. A reduction in fishing effort from some vessels reduced opportunity for surveys in areas A to C. For area D, surveys were only within the Cornwall IFCA district (Figure 5) whereas, 2017 analysis included surveys within the Devon and Severn IFCA district too. The catch sampling effort was scaled down due to other work commitments and the dataset from 2017 highlighted that there were limitations with the catch sampling survey to enable monitoring if fishery induced changes to wrasse populations may be observed (Street et al., 2017b). Therefore independent sampling effort on-board Cornwall IFCA survey vessel, Tiger Lily VI, has been carried out to estimate population sizes locally (Sturgeon *et al.,* 2018) and this will be continued into 2019.

As a result of the reduced survey effort in depth analysis per species and by environmental variable categories, comparable to 2017, could not be completed. Species compositions by geographic areas were relatively similar to 2017 for areas B and D. The proportion of ballan and goldsinny in area A increased in 2018 which could be related to differences in survey effort seasonally. Similarly to 2017, broad scale CPUE varied by area (Table 3). However CPUE per species cannot be directly compared with 2017 due to differences in survey effort, season and areas fished locally.

For spawning state analysis there were low fish numbers for proportions compared to last year. No surveys were carried out in April and September so these months cannot be ruled out for potential spawning individuals. Compared to 2017, there was a reduction in the proportion of fish spawning in May which may have been due to lower water temperatures during the beginning of 2018.

The minimum total length of spawning corkwing, goldsinny and rock cook were similar to 2017. However, two rock cook males at 8 cm were spawning and one corkwing female at 9.5 cm was observed spawning. Both are lower than the minimum length recorded in 2017. Sex ratios were not reported as the sample data was too low per area.

Due to the nature of the survey, following the fishery, there were very few strings in repeat locations and 21% of the total strings surveyed over the three years were comparable in terms of environmental variables. From literature it is clear that there can be differences in catch composition based on very small spatial scales, even just a few metres (Skiftesvik *et al*., 2015) therefore data which could be used to observe changes in the fish populations over time were limited.

All species were analysed for each geographic area even though only ballan are targeted in areas A, B and C. This was to compare if there were noticeable changes to CPUE and total length for goldsinny, corkwing and rock cook in area D compared to the other areas. It was hypothesised that the median total length of targeted wrasse species would decrease over time and hence be lower in the second and third samples of repeat string pairs/ groups as fishing is likely to affect population structure through the removal of larger wrasse (Darwall *et al.,* 1992).

The results of the repeat strings for geographic areas A to D varied. In areas A, B and C currently ballan are only targeted and there was one repeat string (B7) which was significantly different and lower median total length in the second sample. Conversely, in area A, ballan were found to have a higher median total length in the second sample of four of the repeat strings. For goldsinny, corkwing and rock cook in areas A, B and C the size ranges varied, many had low numbers where analysis could not be carried out and for the remaining repeat strings there was no clear trend of median total length.

In area D ballan, goldsinny, corkwing and rock cook are all targeted. For ballan, goldsinny and rock cook the median total length was lower in all second repeat pairs. Corkwing varied for all repeat string pairs/ groups with no clear trend of changes in median total length. In the repeat groups, ballan median total length reduced for each sample and all species showed a reduction in median total length for strings D1 and D9. However, very few repeat strings were significantly different. These results for area D indicates the observed trend of lower median total length may be a result of fishing pressure on the larger individuals. Effort (number of vessels) has been higher in area D which may be why a decreased median total length has been identified for all the species in this area compared to the other three geographic areas. There are, however, many limitations with the repeat strings analysis which should be considered and these are discussed below.

For each repeat string there were small sample sizes for analysis so differences in samples should be treated with caution. These repeat strings could not be classed as replicates and grouped by geographic areas as there would be differences in environmental variables (e.g. depth, nights lie and tide) and also natural differences in size and catch composition spatially between repeat pairs/ groups. Curtin and West (2018) saw differences in catch composition per 1 km² grid squares across Plymouth Sound (area D). Additionally, the small sample sizes meant that the total length of each species could not take sex into account. There are known size differences between sexes of wrasse species, with sneaker males, corkwing sexual size dimorphism (Halvorsen *et al.*, 2016a) and sex change in ballan (protogynous hermaphrodite). Additionally, corkwing males have a higher catch probability in baited traps than females (Halvorsen *et al.*, 2016b). There would also be differences during the spawning season, with lower capture probability during nest guarding and increases in CPUE possibly due to a peak in energy demand pre/ post spawning (Street *et al.,* 2017b). These differences could be potentially skewing the data between samples.

Street *et al.* (2017b) and Curtin and West (2018) identified seasonal changes in CPUE, length frequency and catch composition for all species. The repeat string pairs/ groups do not take into account temporal changes in catch descriptors between each sample and therefore comparisons between samples may be unreliable. Additionally, other environmental variables are likely to have a significant influence on the data e.g. weather conditions and temperature (Darwall *et al.,* 1992, Gjøsæter 2002).

The use of a maximum 50 m range between repeat string samples may be too large with small scale habitat changes. Within each repeat string pair/ group it is likely, that even on a small spatial scale, that a wide range of substrates, exposures and depths are encompassed which has not been addressed but have been reported to result in great differences in species composition (Rodrigues *et al.,* 2015, Skiftesvik *et al*., 2015 and Sayer *et al*., 1993).

The repeat strings do not take into account fishing activity that could have occurred before, in-between and after samples which can skew the data. Previously, in 2016 corkwing, rock cook and goldsinny were targeted and retained as well as ballan in areas A, B and C and male corkwing were retained for a couple of months in 2017. Comparisons of CPUE between repeat string samples showed no trend and changes in the fishery are too complex to decipher with many variables attributing to fluctuations in CPUE and potentially masking trends in the data.

The analysis of repeat strings has highlighted the complex nature of wrasse ecology and the difficulties in assessing, if any, fishery induced changes in the live wrasse fishery. Cornwall IFCA will continue to monitor and assess the live wrasse fishery. The Cornwall IFCA Live Wrasse Fishing (Limited Permit) Byelaw 2018 came into force in February 2019. The byelaw limits the number of permits to five, meaning there will be a reduction in vessels fishing for live wrasse in Cornwall IFCA district. The byelaw requires permit holders to submit monthly wrasse catch and fishing effort details to the Authority. This will provide detailed information on landings per unit effort (LPUE) and spatial effort. The monthly permit returns and the continued catch sampling surveys will enable monitoring of the live wrasse fishery. The catch sampling surveys provide data on fine scale spatial effort which aids Habitat Regulation Assessments (HRAs) for Fal and Helford Special Area of Conservation (SAC) and Plymouth Sound and Estuaries SAC and an opportunity to liaise with the fishers.

6 References

Bennet L. Loch Duart Ltd Cleaner Fish Co-ordinator. Personal communications during 2017.

Bjordal A. 1988. Cleaning symbiosis between wrasse (Labridae) and lice infested salmon (*Salmo salar*) in mariculture. International Council for the Exploration of the Sea, Mariculture Committee 188/F 17. 8 pages.

Curtin, S and West, L. 2018. Live wrasse fishery in Devon and Severn IFCA District - Research Report November 2018. Devon and Severn Inshore Fisheries and Conservation Authority.

Darwall, W. R. T., Costello, M. J., Donnelly, R., and Lysaght, S. 1992. Implications of life-history strategies for a new wrasse fishery. Journal of Fish Biology, 41: 111–123.

Gjøsteter J. 2002. Fishery for goldsinny wrasse (*Ctenolabrus rupestris*) (Labridae) with pots along the Norwegian Skagerrak coast. Sarsia 87:83-90.

Halvorsen, K.T., Sørdalen, T.K., Durif, C., and Vøllestad, L.A. 2016a. Male-biased sexual size dimorphism in the nest building corkwing wrasse (*Symphodus melops*): implications for a size regulated fishery. ICES Journal of Marine Science 73(10).

Halvorsen, K.T., Vøllestad, A.,Espeland, S.H., Sørdalen T.K, Skiftesvik, A.B., and Olsen E.M. 2016b Size and sex selective harvesting of wrasse (*Symphodus melops*) with sexual growth dimorphism. ICES Journal of Marine Science 74 (3).

Hawkins R. Marine Harvest Scotland Cleaner Fish Co-ordinator. Personal communications. January 2017.

Mylor Yacht Harbour Tide Timetable, 2018. Complimentary Copy.

R Core Team. 2017. R: A language and environment for statistical computing. R Foundation for statistical Computing, Vienna, Austria. Available from: www.R-project.org

Rodrigues, D., Costa, B.H., Cabral, H.N., and Goncalves, E.J. 2015. Habitat associations and behavioural patterns of Symphodus spp. (Pisces: Labridae). acta ethologica 18(3).

Sayer, M.J.D., Gibson, R.N., and Atkinson, R.J.A. 1993. Distribution and density of populations of goldsinny wrasse (*Ctenolabrus rupestris*) on the west coast of Scotland. Journal of Fish Biology, 43 (Supplement A): 157-167.

Skiftesvik, A. B., Durif, C. M. F., Bjelland, R. M., and Browman, H. I. 2015. Distribution and habitat preferences of five species of wrasse (Family Labridae) in a Norwegian fjord. – ICES Journal of Marine Science, 72: 890–899.

Street, K., Jenkin, A., Trundle, C. and Naylor, H. 2017a. Fishery independent wrasse sampling. Cornwall Inshore Fisheries and Conservation Authority (CIFCA). Hayle.

Street, K., Trundle, C., Jenkin, A. and Naylor, H. 2017b. Live Wrasse Fishery Investigations 2016 – 2107, A Report to Cornwall IFCA Authority Meeting December 2017. Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA), Hayle.

Sturgeon, S., Jenkin, A., Trundle, C., Owen, K. and Naylor, H. 2018. Wrasse tagging Veryan Bay pilot survey report 2018. Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA). Hayle.