Live wrasse fishery investigations 2016 – 2017

A report to Cornwall IFCA Authority Meeting December 2017 Incorporating the results of the 2017 wrasse catch sampling program

Completed by: Cornwall Inshore Fisheries and Conservation Authority (Cornwall IFCA)

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CIFCA Live wrasse fishery investigations 2016 - 2017
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Executive Summary

Sea lice have been recognised as the major health risk in salmon mariculture. All salmon producers are required to have sea lice management strategies in place that can be implemented as soon as numbers of lice reach the trigger figures. Concerns over the potential for resistance to traditional organophosphorus pesticide treatment to develop have led to the introduction of measures limiting their use. There is also a cost consideration when using such treatments to control sea lice, both in terms of the direct cost of the treatment and the indirect costs of the additional time it takes to grown on salmon following repeated treatments as feeding regimes are interrupted.

In the late 1980's wrasse species were successfully trialled as an alternative and cost effective approach to sea lice control. Early use of wrasse was developed in Scotland as well as Norway; however the practice in Scotland stopped rapidly following the identification of furunculosis in a single wrasse. After more than a decade of limited use, wrasse began to be used in greater numbers and began an integral part of salmon producers' sea lice control strategies. As more wrasse were being required some producers have looked further afield than Scotland to maintain a supply of wrasse.

The fishery for live wrasse began in Cornwall in 2015 but developed during 2016. Through negotiation, officers were able to set up a catch sampling program that has been conducted aboard commercial fishing vessels. The program continued through 2017 at a higher level of intensity. The aim of the sampling was to provide a baseline of wrasse population data in the areas where the fishery was being exploited. It became clear during the sampling that there are many variables affecting catch rates. The variables include, weather, tide state, positioning of the fishing gear and the length of time the gear is set, among many others.

This report provides a background to the fishery for live wrasse in the Cornwall IFCA district and the current practices from catch to delivery. The report also provides a summary of the catch sampling effort carried out during 2017 and demonstrates initial analysis of the results of the data obtained during the surveys.

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Glossary of terms

(Fish) Sampled: 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’

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

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

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.

This report describes the sampling effort carried out by Cornwall IFCA Scientific Officers during 2016 and 2017 along with the results of the catch sampling program and recommendations for potential future survey methodologies.

2 Background

Sea lice, particularly the species *Lepeophtheirus salmonis and Caligus elongates,* have been identified as the major health risk to salmon in aquaculture (Pike and Wadsworth, 2000). Both *L. salmonis* and *C. elongates* are ectoparasites that attach to and feed over the epidermis of the host fish. The lesions caused by lice as they feed can lead to excessive body fluid loss and ultimately death to the affected fish if the infestation is not managed (Wooten *et al.*, 1989). At times it is possible for sea lice to proliferate rapidly showing as many as 80 lice per fish prior to control with medicinal treatments or cleaner fish (L. Bennet, pers. comm. 2017). Marine Scotland regulations require that all salmon production companies regularly report the lice status at each of their sea cage sites through the Scottish Salmon Producers' Organisation (SSPO). There are numbers of lice per fish that trigger management responses; less than 3 adult female lice/fish requires no further measures, - reporting level (above 3LPF), the Fish Health Inspectorate (FHI) will increase the monitoring of that site and continue to do so until either the average adult female sea lice is below or at 3, - if levels exceed (8 adult female LPF), the FHI will put into motion the agreed action plan, failing to bring lice numbers below 3 within 4 weeks of the initial report will result in a letter of warning, failing to reduce numbers below 3LPF within 2 weeks shall result in an enforcement notice being issued. This enforcement notice from the FHI/ Marine Scotland has the authority to force treatment or harvesting the site depending on the severity. To date it is understood that Marine Scotland have not had to resort to the use of an enforcement notice (L. Bennet, pers. comm. 2017). As well as being a health issue to the fish directly, there is an associated cost of sea lice management to the industry which in 1999 was estimated as being around 30M EUR in Scotland alone (Sinnott, 1999). Reliance on the use of chemical treatments used in both 'bath' and feed applications has raised concerns of the possibility of increasing resistance to the active chemicals. To combat this, the Scottish Environment Protection Agency are now setting maximum amounts of treatment, particularly SLICE™ that can be used in any area (L Bennet, pers. comm. 2017). SLICE™ is the marketing name for emamectin benzoate which is a pesticide that is administered as a feed additive. It can accumulate in sediments potentially becoming toxic to other marine life, particularly crustaceans[1]. It was quoted to officers that the cost of treating a sea pen of around 40,000 smolts can exceed £20,000 (L Bennett, pers. comm. 2017).

Investigations into alternative sea lice control strategies in the late 1980's showed wrasse had the potential be an effective, natural agent to manage sea lice infestations (Bjordal. 1988). Early trials in Norway showed promise and were replicated in Scotland. At that time, the larger species of cuckoo (*Labrus mixus*) and ballan (*Labrus bergylta*), were thought to be too aggressive to the salmon so the smaller species of corkwing (*Symphodus melops*), goldsinny (*Ctenolabrus rupestris*) and rock cook (*Centrolabrus exoletus*) were used. Treatments for other salmon health problems such as furunculosis, a bacterial septicaemia caused by the bacterium *Aeromonas salmonicida,* were not available to the industry during the early use of wrasse. Therefore as soon as furunculosis was identified in a single wrasse, the use of wrasse as cleaner fish in Scotland stopped effectively immediately because of fears of the introduction of disease. Around 2010, with general treatments and vaccines being more available, the salmon production industry again began looking at using wrasse as part of their lice control strategies (Hempleman, 2017). The economic and environmental benefits of reducing the use of traditional organophosphorus treatments to control sea lice along with increasingly restrictive regulations for their use are now driving an increasing demand for wrasse.

Wrasse *spp.* to be used as cleaner fish have been predominantly sourced from the wild although culturing techniques are being developed by some of the salmon production companies (R Hawkins, pers. comm. 2017). One particular example is Otter Ferry Seafish who have the capability of producing up to 200,000 wrasse and 650,000 lumpfish per cycle (Fish Farmer. Vol 40, No 8). Early trials to assess the viability of live wrasse capture carried out on the north coast of Cornwall were not particularly successful and have not been repeated. Later trials in 2015 on the south coast were considerably more successful and identified that there was potential for a fishery. Fish that have been taken from the south west have been assessed to be of very good quality and the lower latitude provides a longer fishing season than in Scotland (L. Bennet, R Hawkins, pers. comm. 2017).

The literature review highlighted that fisheries for live wrasse could have a significant impact to the populations of wrasse within the areas where they were being targeted. The addition of this new fishery to the Cornwall IFCA district has led to considerable effort being directed towards assessing the impact of the fishery to the target species and ultimately to the ecosystems where the fish are targeted. As no directed fishery previously existed for wrasse, there are no species specific management measures. It is usually only cuckoo and ballan wrasse that are occasionally retained in pot and net fisheries as a bycatch, they are then either discarded or used as bait (CT pers obs). Wrasse spp. are generally viewed as being too small to be edible or just plain inedible so only very small niche markets exist for human consumption. Unlike other traditional fin fish fisheries, the wrasse fishery provides a live product through to the end 'consumer'. Accordingly, the fishermen involved in the fishery treat the wrasse with the utmost care from catch to delivery. Methods of catch handling and storing have been continually adapted to increase the welfare and therefore the survival of individuals once caught (Cornwall IFCA Scientific Officers, personal obs.).

[1] More information available at: https://ecologyaction.ca/files/images-documents/file/Marine/Backgrounder_sea_lice_pesticides.pdf 12/10/17

Section 153 of the Marine and Coastal Access Act 2009 places an obligation on IFCAs to ensure the exploitation of sea fishery resources is carried out sustainably. IFCAs must take into consideration not only the impact of an activity to the marine environment but also the economic benefits of the activity when making management decisions.

In 2016, with section 153 in mind, Cornwall IFCA scientific officers began a program of catch sampling aboard vessels that were targeting wrasse. The initial sampling was carried out in 2016 over a number of occasions enabling officers to refine the methodology. Then in 2017, the intensity of the sampling increased to provide baseline data of species distribution, catch rates and to attempt to estimate the main spawning periods for each of the wrasse *spp*. Additional catch sampling was carried from the Authority's survey vessel using similar fishing gear but in areas that had previously not been targeted as part of the wrasse fishery. This additional element of the study was envisaged to provide baseline information of species composition, and is not reported in this document.

3 Fishery Developments

It appears that the fishery for live wrasse began in the south west and especially Cornwall, with approaches made by salmon production companies to fishermen in the area. To our understanding these approaches were made via third party relationships rather than the salmon producers directly contacting fishermen. The salmon producers and fishermen have what could almost be described as a contract, whereby a salmon producer will supply the traps and the fishermen then supply that producer with the requirement of the producer. It should be noted that unlike traditional fin fisheries, there is no open market for live wrasse where fish are sold to the highest bidder at auction.

The fishery is exploited using lightweight fish traps known as wrasse traps. They are rectangular in shape with a hard eyed mouth opposite each other on each of the long vertical sides; both eyes are leading to the same chamber. The mouths of the traps are approximately the same size as would be found on an otter guard (Cornwall IFCA Principal Scientific Officer, personal obs.) meaning the traps are selective to exclude bigger fish and the larger ballan wrasse. Approximately a third of the trap is a parlour end which is accessed by a soft eyed chute. Even with some modifications, the traps do not exceed 10kg each. One of the long vertical sides opens as a door allowing access to all parts of the trap. The traps are fished in strings of varying number, depending on the vessel and where the fishing is taking place but most generally in tens. The strings of traps are rigged in a similar manner to the more traditional creels set for crustaceans. Each trap has a bridle at the opposite end to the parlour with a plastic 'spinner' threaded through it. The traps can then be attached to the long back line by 'straps' which are approximately 1.5 meters in length and spliced through the back line at approximately ten fathom intervals (approximately 18.2 meters). The strings of traps are identified by surface markers attached one at each end of the back line. Each fisherman has their own means of ensuring the lightweight traps have minimal movement.

The traps are set with a variety of baits, all known to attract wrasse species. The bait is placed in the parlour to entice the fish through the one way entrance where they are retained. To reduce the numbers of undersized individuals retained in the parlour, escape gaps have been added to nearly all traps being used in the district. The traps are set in locations thought to be suitable wrasse habitat. Some fishermen spend considerable amounts of time trying to locate and plot suitable habitats to ensure they fish as efficiently as possible. The length of time the traps are left before hauling again can vary between fishermen, locations and on the weather forecast but is generally between one and seven nights.

Weather plays a significant role in the decision to re-bait and set the traps, poor weather can lead to the traps moving about on the sea bed which can in turn lead to any fish retained sustaining injuries making them undesirable for transport. When poor weather is forecast, the fishermen will shoot the gear back without bait and with the door left open.

Transport also plays a significant role in the supply chain. It is around 750 miles from Cornwall to the current destination of the fish and it is during transport that the fish are probably at the most risk of mortality at any time from being captured to being released into the sea pens. Some of the initial deliveries resulted in mortalities that neither the fishermen nor the producers were happy with. Collaboratively both parties worked to reduce the mortalities; reducing the vehicle size and numbers of fish being transported at any one time was a significant improvement. Reducing the vehicle size from an eight wheeler large goods vehicle (LGV) which has a typical gross vehicle weight of 32 tonnes, to a flatbed van type vehicle with a gross vehicle weight of less than 3.5 tonnes means that the differences in the relevant vehicle driving regulations allows the vehicle to make the journey in less time. The latest development has been to install chilling equipment to the transport tanks to gradually reduce water temperature throughout the journey to the local water temperature at the salmon farm. At this time it thought by officers to be exceedingly unlikely for anyone to purchase their own traps then try to sell their catch, fishermen need the direct involvement of a salmon producer as the end consumer.

During the very early stages of the fishery in Cornwall IFCA district, all species were retained with minimum sizes being based on the size of fish that would be retained in the sea pens. After the first year some of the fishermen involved suggested that a minimum size across the range of species should be set at 120mm as they were concerned about the sustainability of a fishery based on the smaller sizes. Although 120mm length is larger than the reported sizes at maturity for goldsinny, corkwing and rock cook species, it is smaller than the reported sizes at maturity for ballan and cuckoo (Darwall *et al* 1992).

One of the salmon producers taking wrasse from the Cornwall district had been monitoring of the efficacy of wrasse in the sea cages. Their trial work showed that not only did ballan wrasse appear to show the best survival during transport, they were the most effective species as cleaner fish and they exhibited the best survival throughout a salmon cycle (L Bennett pers. comm. 2017).

Currently two vessels are retaining only ballan wrasse >16cm, and vessels working in Plymouth Sound are retaining four species of wrasse (ballan, corkwing, goldsinny and rock cook), ballan >15cm and the remaining three species >12cm.

4 Methodology

Cornwall IFCA scientific officers designed an at sea sampling survey, built on the 2016 methodology, 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. This report describes the survey methodology, and analysis to date.

4.1 Data Collection

Sampling was carried out by CIFCA Scientific Officers on-board fishing vessels operating within the CIFCA district. Between 3 and 15 strings of 10 to 27 traps were hauled per trip alongside other fishing activities. All local fishermen 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 72cm L x 40cm W x 28cm H, and weighs 3.7kg 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 recorded 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 0.5cm (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. Table 1 shows examples of male and females of corkwing, rock cook and goldsinny wrasse, cuckoo wrasse's gender was also recorded, however no images were taken.

Figure 3: Content of a wrasse trap being sorted

Figure 4: Measuring a ballan wrasse

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

Table 1: Examples of the variation between males and females for corkwing, rock cook and goldsinny wrasse.

Male and female corkwing. Photo from a survey on 13/3/17

Male and female goldsinny. Photo from a survey on 24/05/17

Male and female rock cook. Photo from a survey on 24/05/17

From May onwards the spawning state of four species of wrasse (corkwing, goldsinny, rock cook and cuckoo) were also recorded, where the total body length was over 5cm. This was assessed through 'stripping'; applying gentle pressure to the abdomen and inspecting milt or roe. Ballan wrasse were not stripped in the CIFCA survey, this is due to the possibility of compromising the health of the high value fish. 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 by a waving flag above them.

Devon and Severn IFCA followed the same methodology; however they also 'stripped' ballan wrasse.

4.2 Analysis Methodology

Initial analysis has been conducted and reported on, with recommendations made of further analysis of the current data set, which will be reported on when complete, 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, 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. The boundaries of these areas are shown in Figure 5.

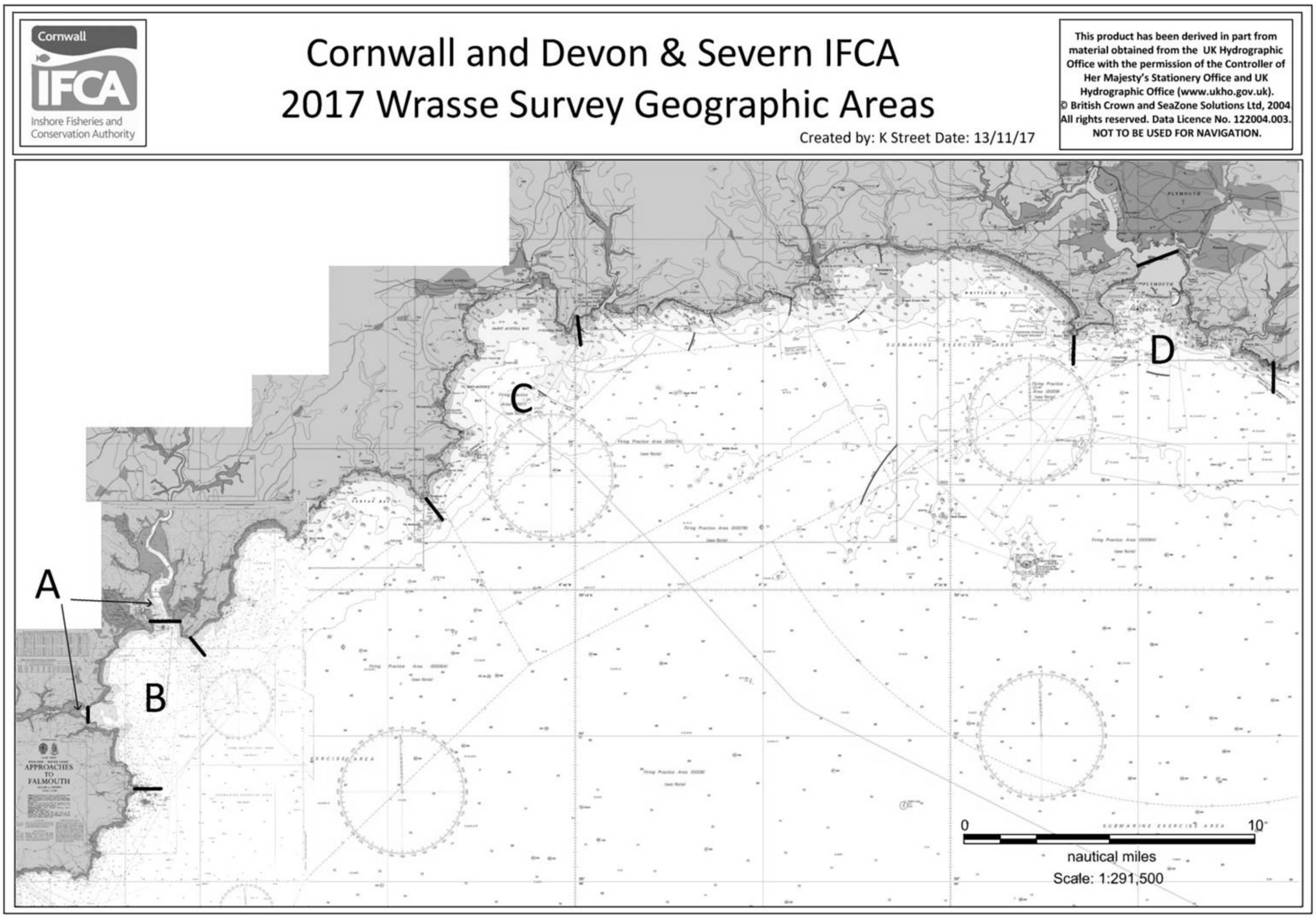


Figure 5: Geographic areas A, B, C and D used for analysis of 2017 wrasse fishery dependent study data

For each area data has been investigated using three catch descriptors against four environmental variables, listed in Table 2.

Table 2: Summary of catch descriptors and environmental variables investigated during 2017 survey

	Seasonality	Depth Categories	Tidal Range	Nights Lie
Catch per unit effort (CPUE)	x	x	x	x
Length Frequency	x	x	x	x
Species Composition	x	x	x	x
Sex Ratios	x			
Spawning State	x			

4.3 Catch Descriptors

4.3.1 CPUE (no. of fish/10 traps)

Catch per unit effort 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.*

4.3.2 Length Frequency

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

4.3.3 Species Composition

χ^2 tests were carried out to determine whether species composition was significantly different between geographic areas and environmental variable categories.

4.3.4 Sex Ratios and size at maturity

Sex was assessed and recorded for four species; cuckoo, corkwing, rock cook and goldsinny wrasse. Sex ratios were assessed by month.

4.3.5 Spawning State

Spawning state was assessed and recorded for four species by Cornwall IFCA; cuckoo, corkwing, rock cook and goldsinny, Devon & Severn IFCA also assessed ballan wrasse. 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.

4.4 Environmental Variables

4.4.1 Seasonality

Data were grouped by survey month and investigated using all five catch descriptors with relevant statistical analysis carried out, as described in sections 4.3.1 to 4.3.3.

4.4.2 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 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 5m depth contours

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

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

Data was investigated using three catch descriptors (species composition, length frequency, and CPUE) with relevant statistical analysis carried out, as described in sections 4.3.1 to 4.3.3).

4.4.3 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 2017 based on maximum and minimum predicted tide heights for Falmouth (Mylor Yacht Harbour Tide Timetable, 2017). The average range was calculated to be 3.9m, values above this were deemed to be spring tides, and values below this were deemed to be neap tides (Figure 6).

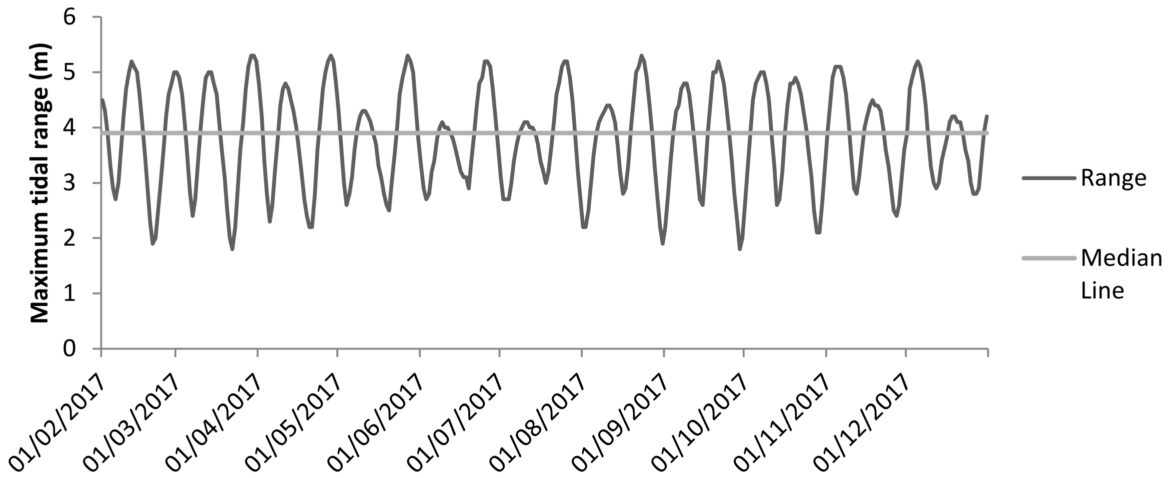
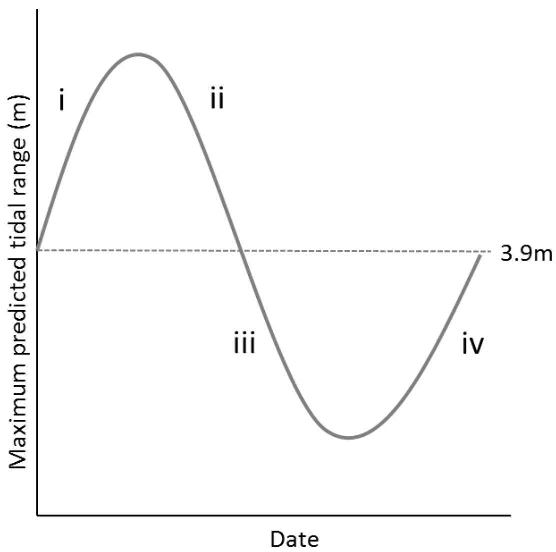


Figure 6: Maximum tidal range per day, based on tidal heights for Falmouth, for 2017. The median line is the average tidal range of 3.9m, all ranges above this have been deemed spring tides, and all below have been deemed neap tides.

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 3.9m and increasing

ii Tidal range greater than 3.9m and decreasing

iii Tidal range less than 3.9m and decreasing

iv Tidal range less than 3.9m and increasing

Figure 7: Illustration of tidal range categories

Data was investigated using three catch descriptors (species composition, length frequency, and CPUE) with relevant statistical analysis carried out, as described in sections 4.3.1 to 4.3.3).

4.4.4 Nights lie

Data were grouped by the number of night's lie; strings which had less than one nights lie were omitted from analysis. Data was investigated using three catch descriptors (species composition, length frequency, and CPUE) with relevant statistical analysis carried out, as described in sections 4.3.1 to 4.3.3.

5 Results

A total of 12,789 wrasse belonging to five species; ballan, cuckoo, goldsinny, corkwing and rock cook (*Labrus mixtus*, Linnaeus, 1758), were collected during the 2017 sampling period by Cornwall IFCA and Devon & Severn IFCA (8,185 and 4,604[3] respectively). This comprised of 1,601 ballan, 235 cuckoo, 4,508 goldsinny, 3,242 corkwing and 3,203 rock cook. Due to the low sample numbers of cuckoo wrasse, this species has been excluded from individual species analysis.

5.1 Effort Summary

Sampling was not even between geographic areas, or the other environmental variables considered in this study. Table 3 outlines the number of traps sampled in each geographic location by month, and Table 4 summarises effort in the remaining environmental variables which have been investigated in this study.

Table 3: 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

	No. of traps									
		Month								
Area	Total	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
A	260	20		10	20			71	70	69
B	927	111	151	141	182	101	91	90	20	40
C	870		230	120	120	70	90	120		120
D	2617			305		701	593	464	370	184

Table 4: 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. Note 187 traps sampled in area D had no data on the number of nights lie attributed to them and have therefore been omitted from analysis of the influence catch of varying nights lie.

	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	250	10		30	69	161			20	20	80	61	79	
B	556	361	10	242	191	403	91		191	304	392	10	30	
C	420	400	50	470		400			30	540	200	100		
D	1103	1417	97	554	989	857	217	20	1991	146	162	47	25	39

[3] Six sample strings of traps (250 fish) have been removed from analysis due to missing attribute data.

5.2 Species Composition

5.2.1 Geographic Location

Species composition varied significantly between geographic areas (χ^2 test, χ^2=4245, *p*>0.001, Figure 8). The species composition in area A was highly different to the three other areas, with the most abundant species being corkwing and ballan (69 and 26% respectively). Two cuckoo wrasse were sampled (0.09% of total wrasse sampled) and one rock cook (0.04% of total wrasse sampled).

When χ^2 is applied only to areas B, C and D species composition also varies significantly (χ^2 test, χ^2=245, *p*>0.001), however similarly for these three areas goldsinny are the most abundant species ranging from 35 to 47% of total wrasse sampled, followed by rock cook (26 to 32%), corkwing (12 to 19%), ballan (8 to 11%) and cuckoo (1 to 4%).

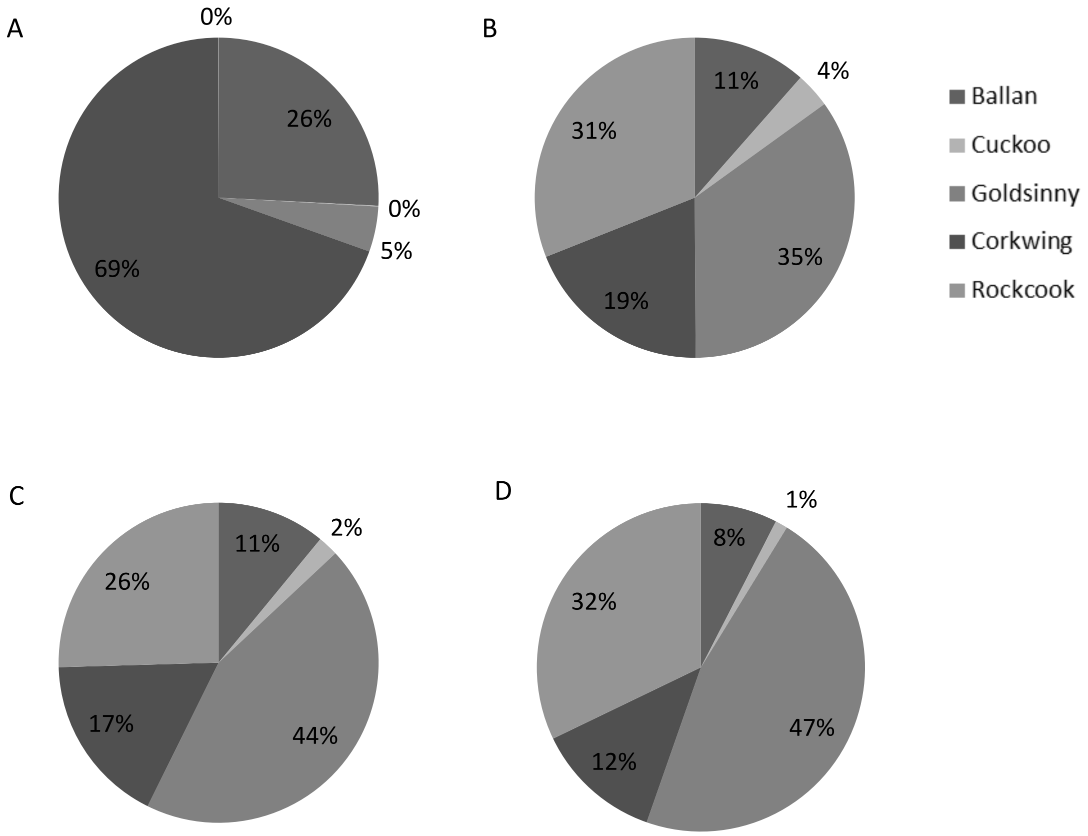


Figure 8: Species composition by geographic areas A- D, A (n=2279), B (n=3807), C (n=1996), and D (n=4707).

5.2.2 Month

Species composition varied significantly by month for each geographic area A-D (χ^2 test, χ^2=329,441,201,973, respectively, all *p*>0.001), (Figure 9).

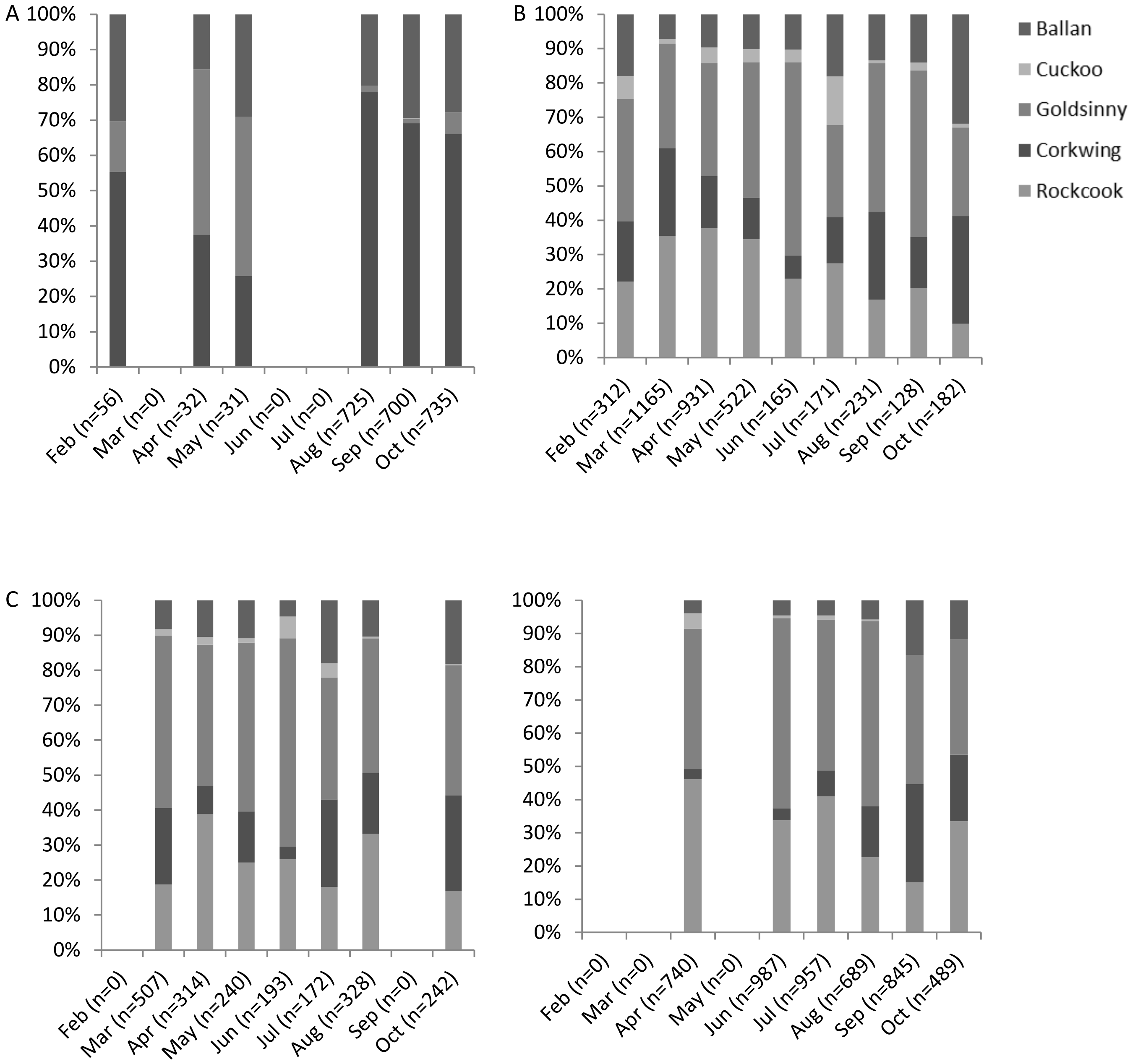


Figure 9: Species composition by geographic area A-D, grouped by month.

5.2.3 Charted Depth

In area A corkwing were the most abundant species in both depth categories 1 and 2 (69 to 86%), ballan wrasse were the next abundant species (14 to 26%), no samples were recorded in depth category 3. χ^2 could not be carried out on samples from area A or B with confidence due to low Expected Values (Figure 10, A1 to A3 and B1 to B3).

Species composition varied significantly with depth category for areas C and D (χ^2 test, χ^2=161,475 respectively, *p*>0.001).

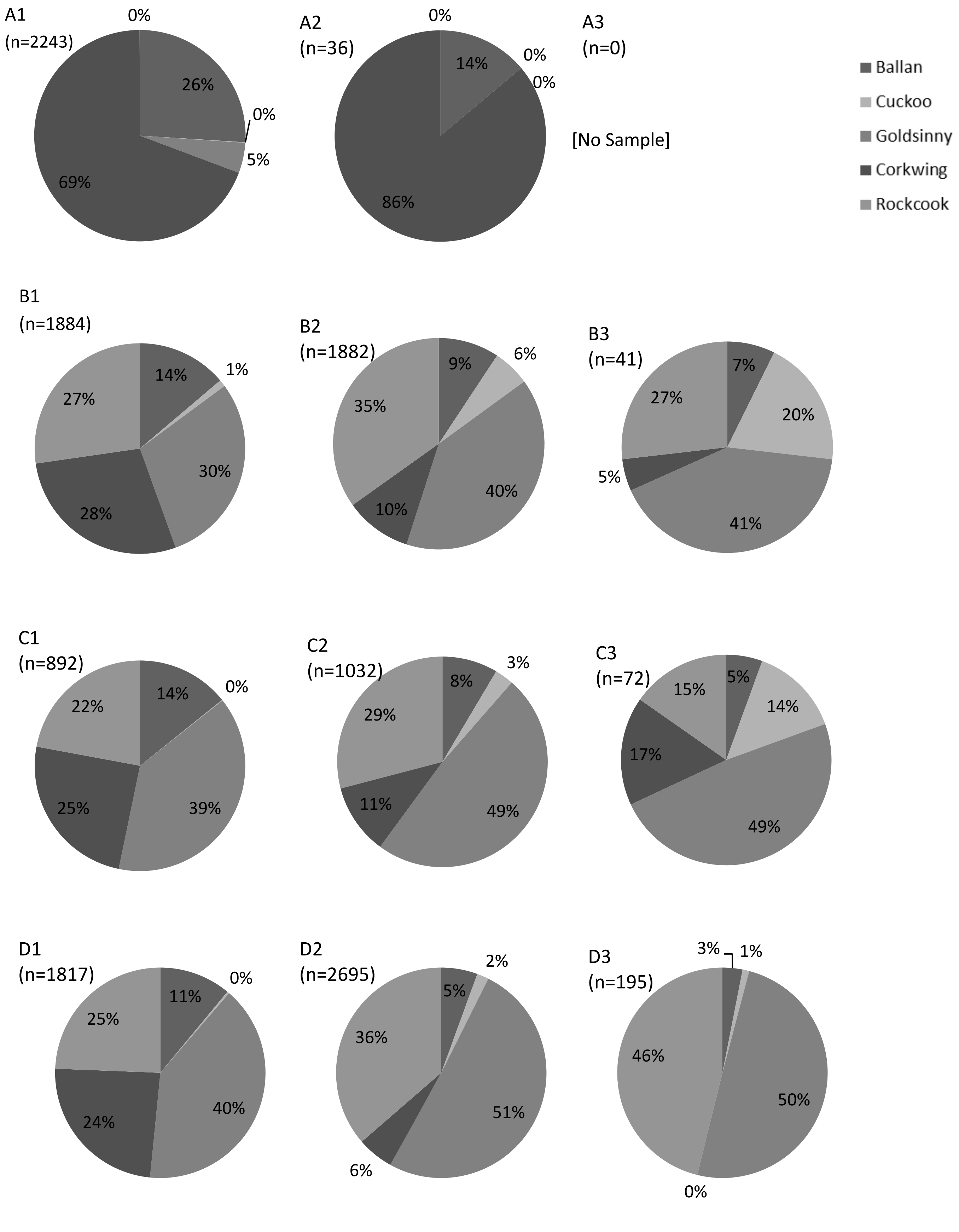


Figure 10: Species composition by geographic areas A-D, grouped by depth category 1-3.

5.2.4 Tidal range

Figure 11 shows varying species composition with tidal range, these were all significantly different geographic areas B-D (χ^2 test, χ^2=949, 50, 325, respectively, p>0.001). For area A χ^2 could not be carried out with confidence due to low Expected Values.

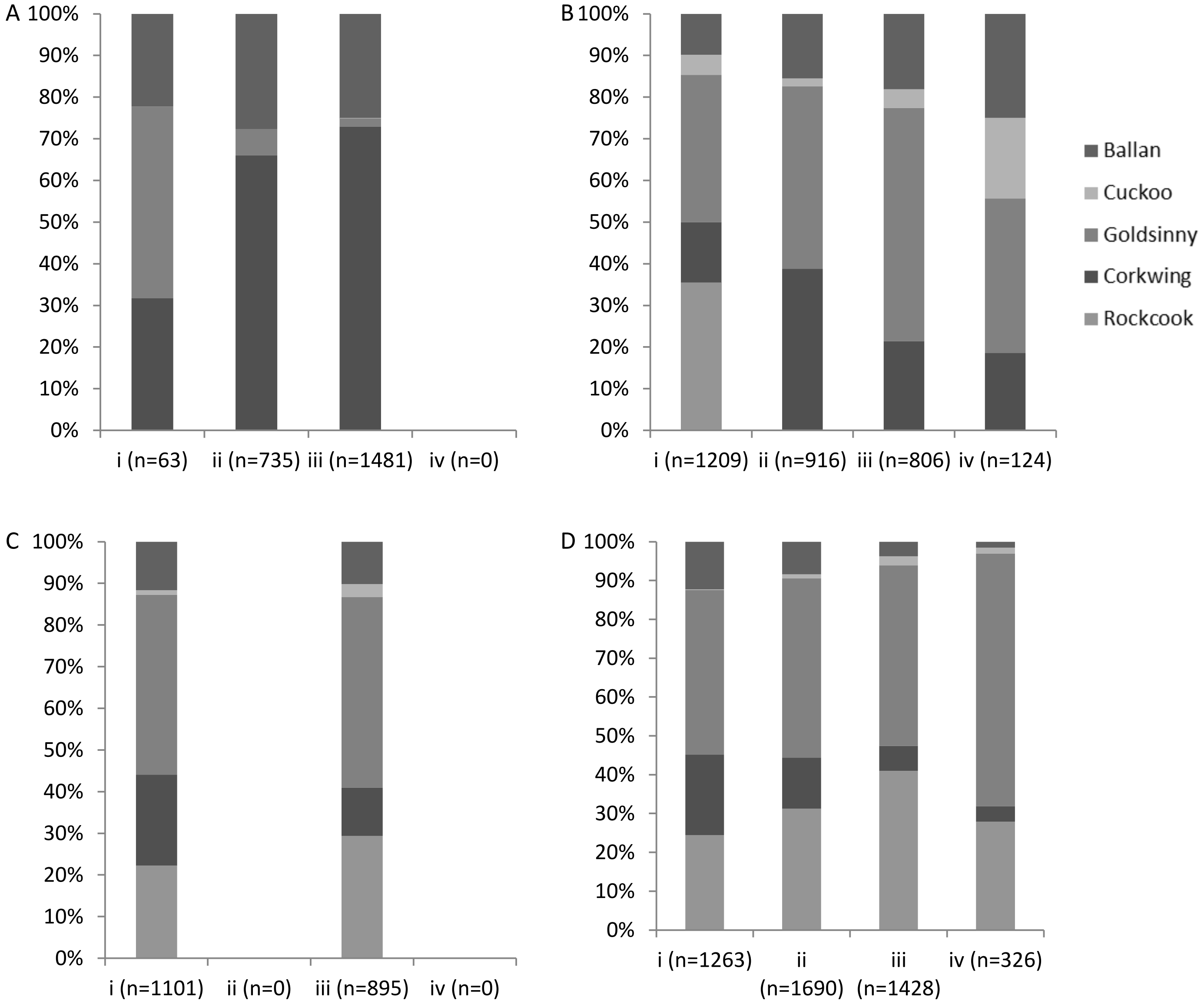


Figure 11: Species composition by geographic areas A-D, by tidal range, i-iv.

5.2.5 Nights Lie

Species composition was significantly different between differing nights lie in areas B and C (χ^2 test, χ^2= 251, 44, respectively, p>0.001, Figure 12). For area A and D Expected Values were too low for χ^2 test to be carried out with confidence.

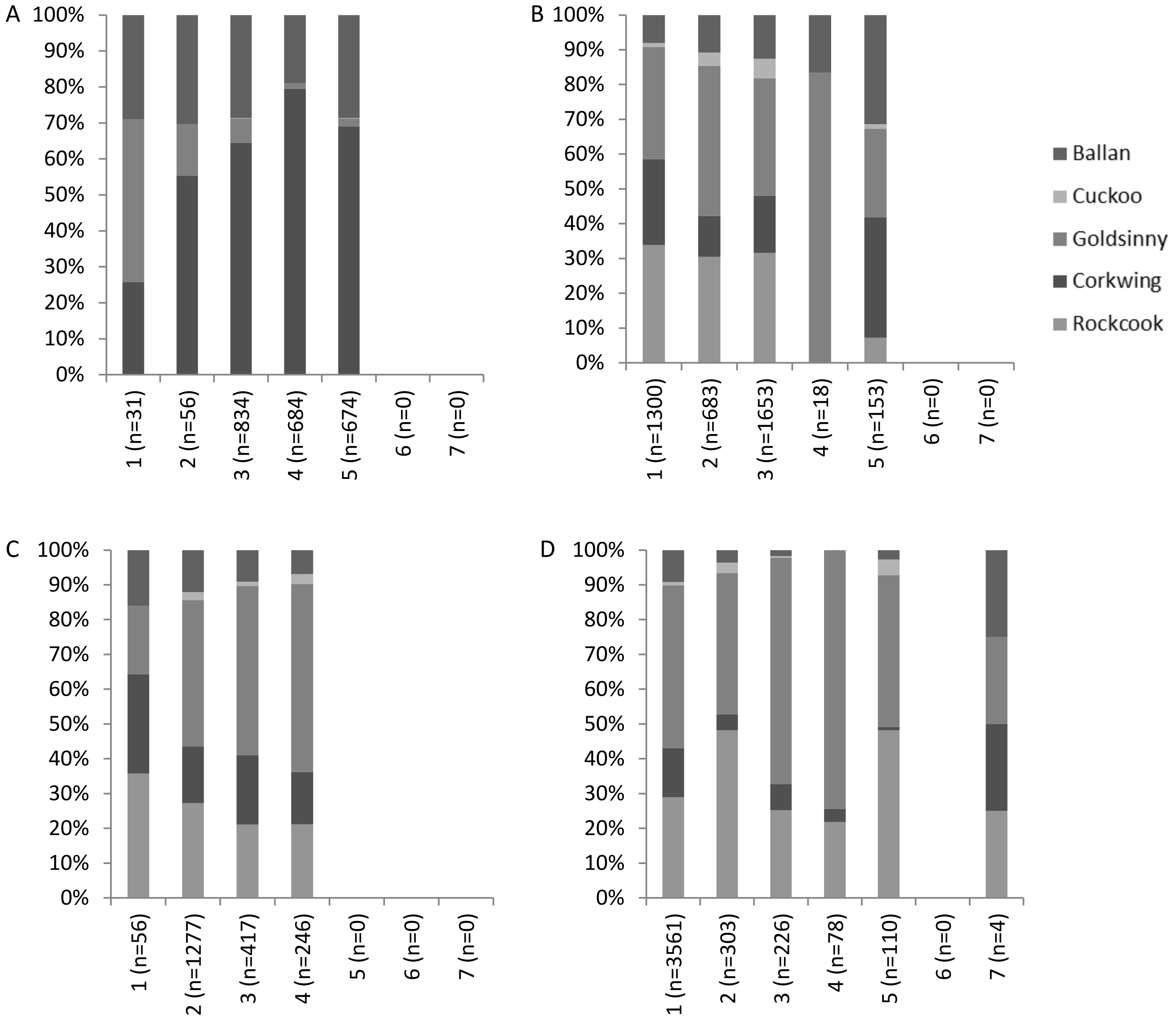


Figure 12: Species composition by geographic area A-D, grouped by number of nights lie. Note, the total n number for area D is smaller than reported n numbers for this geographic area as strings with less than one nights lie have been omitted from analysis.

5.3 Catch per unit effort (CPUE)

CPUE (no. of fish/10 traps) varied by area for all wrasse species (Table 5).

Table 5: Catch per unit effort (CPUE) (per species/10 traps) per species by geographic area A-D

Species	A	B	C	D
Ballan	22.62	4.72	2.52	1.27
Corkwing	60.92	7.83	3.95	2.25
Rock Cook	0.04	12.74	5.84	5.78
Goldsinny	4.0	14.31	10.16	8.38

5.4 Length Frequency

Below is the overall length frequency data for all fish sampled by species (A: ballan, B: corkwing, C: goldsinny, D: rock cook) (Figure 13).

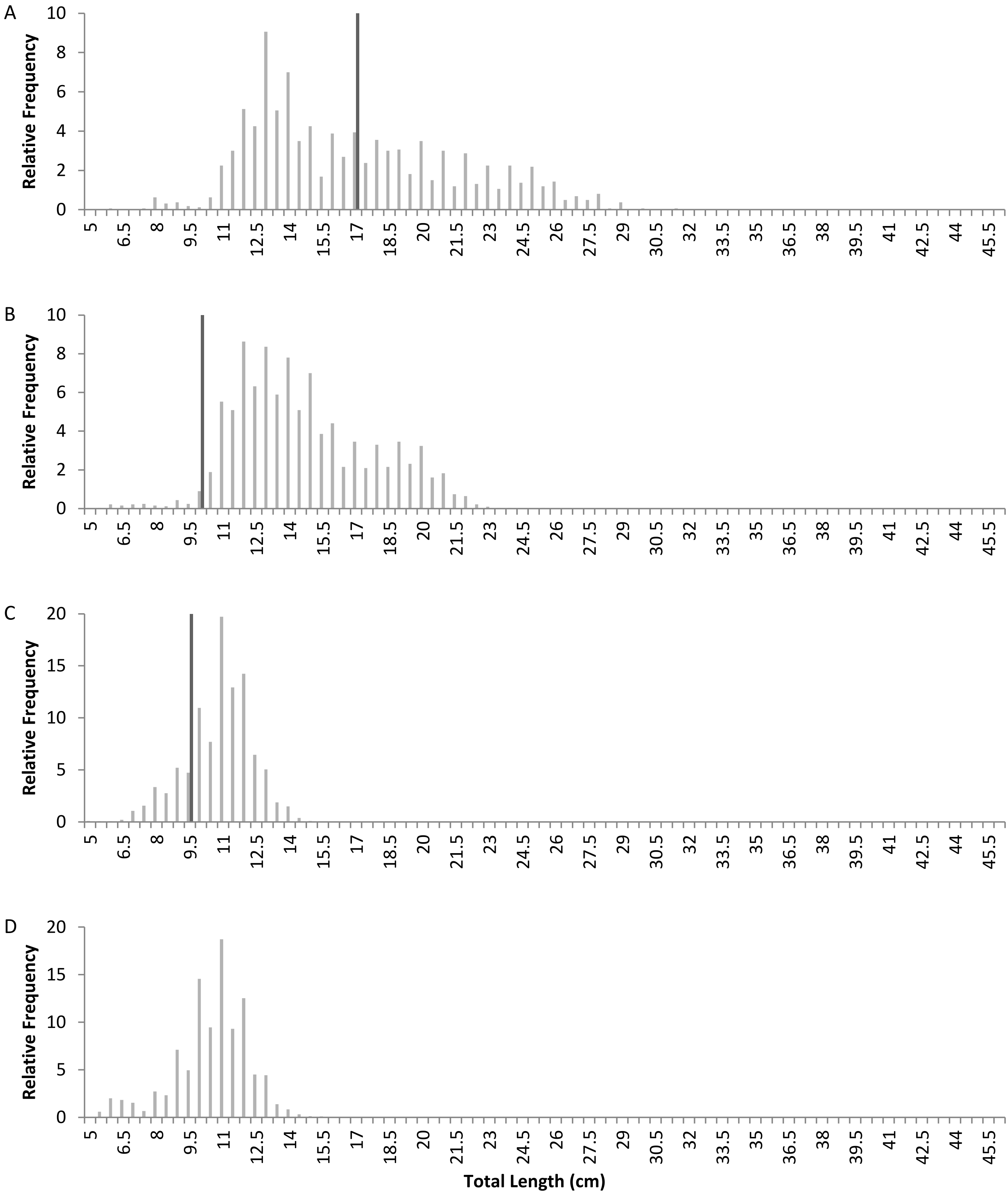


Figure 13: Overall total length frequency plot of all fish sampled wrasse sampled, A ballan wrasse (n=1601), B corkwing (n=3242), C goldsinny (n=4508) and D rock cook (n=3201), during the 2017 Cornwall IFCA and D&S IFCA fishery dependent surveys. The dark grey line indicates average size at maturity as cited in Darwall et al., (1992). Note the y axis in graph C and D are of a different scale.

5.5 Spawning Season

Overall, spawning wrasse were observed from April to October (Table 6), with peak in spawning for corkwing in June (14.58%), rock cook and goldsinny in May (40.2% and 11.63% respectively). Detailed results for each species are presented in the relevant species section.

Table 6: Summary of proportions spawning fish to non-spawning sampled in the 2017 survey. "-" Indicates when samples were not taken, or no fish sampled were assessed for spawning.

Species	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct
Ballan	-	-	-	-	-	-	-	-	-
Corkwing	-	-	0.00%	8.33%	14.58%	2.94%	0.00%	0.13%	0.29%
Rock Cook	-	-	0.00%	40.20%	22.25%	14.41%	0.52%	0.00%	0.00%
Goldsinny	-	-	0.32%	11.63%	4.77%	4.20%	0.21%	0.00%	0.00%

5.6 Size at maturity and sex ratios

Table 7 summarises the minimum total lengths (cm) of spawning wrasse sampled, this varied from 8.5cm for male and female rock cooks, to 20cm for a female ballan wrasse.

Table 7: Summary of minimum total length of spawning fish observed for each species sampled in the 2017 survey

Species	Minimum total length of spawning individual (cm)	
	Male	Female
Ballan	-	20
Corkwing	12.5	10.5
Rock Cook	8.5	8.5
Goldsinny	10	9

Table 8 summarises sex ratios observed in the 2017 survey. Detailed results for each species are presented in the relevant species section.

Table 8: Summary of sex ratios by month, proportion of males to female,"-" indicates where no data was collected, or sex was not recorded for samples.

Species	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct
Corkwing	-	0.46	0.50	0.53	0.54	0.66	0.79	0.66	0.60
Rock Cook	-	-	-	0.41	0.68	0.87	0.66	0.67	0.48
Goldsinny	-	-	0.00	0.57	0.47	0.55	0.35	0.17	0.36

5.7 Analysis by species

5.8 Ballan wrasse (*Labrus bergylta*)

A total of 1601 ballan wrasse were sampled by Cornwall IFCA and Devon & Severn IFCA (1,245 and 356 respectively); A (n=588), B (n=438), C (n=219), and D (n=356).

The mean average total length of all ballan wrasse sampled was 17.01cm, with a minimum of 6cm, and maximum of 31.5cm.

5.8.1 Geographic Location

Length frequency distributions appear between the four areas, with area A showing the greatest difference, with a smaller mean average size (Figure 14). CPUE (no. of fish/10 traps) is very different between the three areas, with the highest in area A (Figure 15).

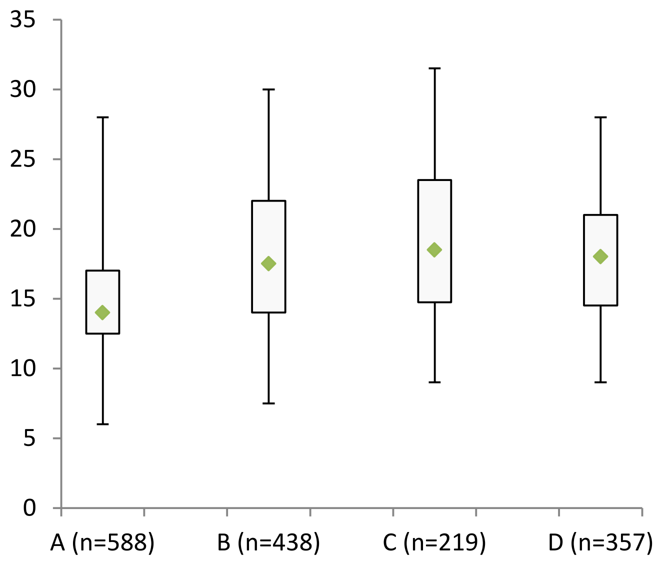
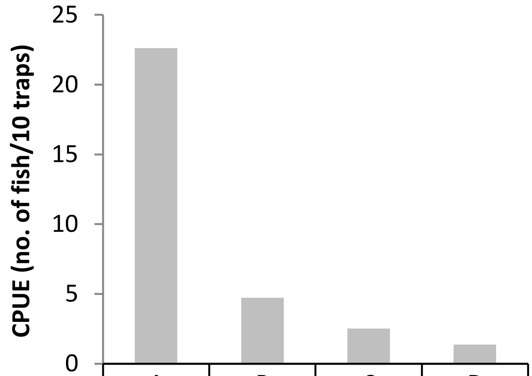


Figure 14: Total length frequency box plot for all ballan wrasse sampled during the 2017 survey. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.



	A	B	C	D
CPUE (no. of fish/10 traps)	22.62	4.72	2.52	1.36
No. of ballans	588	438	219	356
No. of traps	260	927	870	2617

Figure 15: Catch per unit effort (CPUE) (no. of fish/10 traps) for all ballan wrasse sampled during the 2017 survey, grouped by geographic area A-D.

The mean average total length of ballan wrasse in area A is 14.8cm, B is 18.11cm, C is 19.07cm and D is 18.01cm. The proportion of fish below the average size at maturity (taken as 17cm, the average of 16-18cm cited in Darwall *et al.*, 1992) was higher for area A than the other three areas; 0.79 and an average of 0.49 for the three remaining geographic areas. The proportion of fish below the current minimum size, as dictated by one of the salmon farms, 16cm, is 0.69 in area A and an average of 0.34 for the remaining 3 areas.

5.8.2 Seasonality

All geographic areas show an increase in CPUE (no. of fish/10 traps) from August to October (Figure 16), with a decrease in catch rates in June (no data was collected in area A, in June and July).

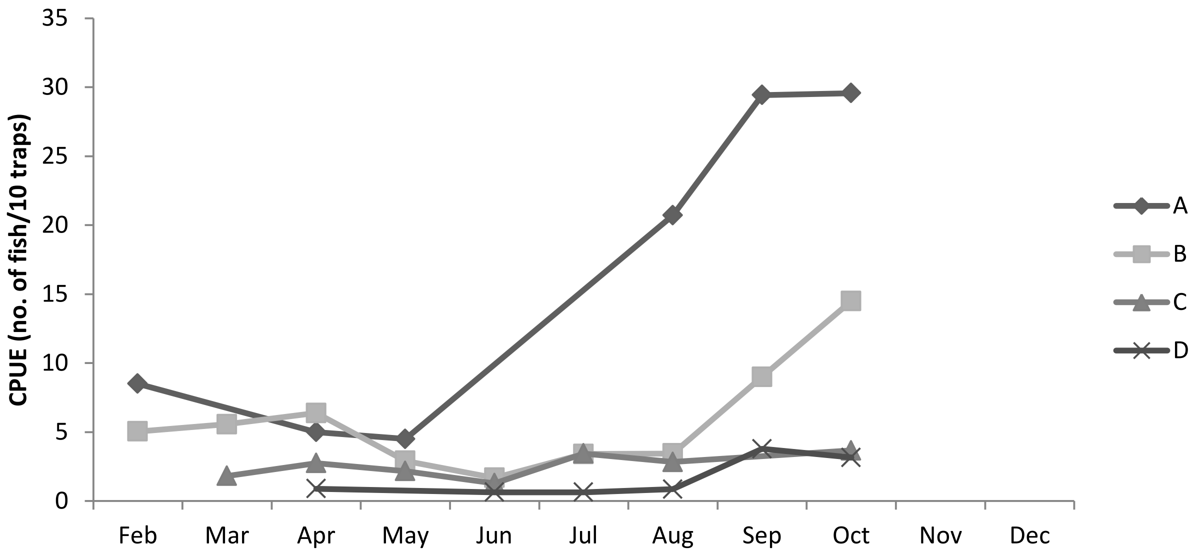


Figure 16: Monthly catch per unit effort (CPUE) (no. of fish/10 traps) of ballan wrasse by geographic location A-D.

Length frequency distributions were varied by month for all geographic areas (Figure 17).

It appears that in areas B, C and D the mean average length of ballan wrasse decreases in the later part of the survey; from July to October. This will be investigated further with statistical analysis.

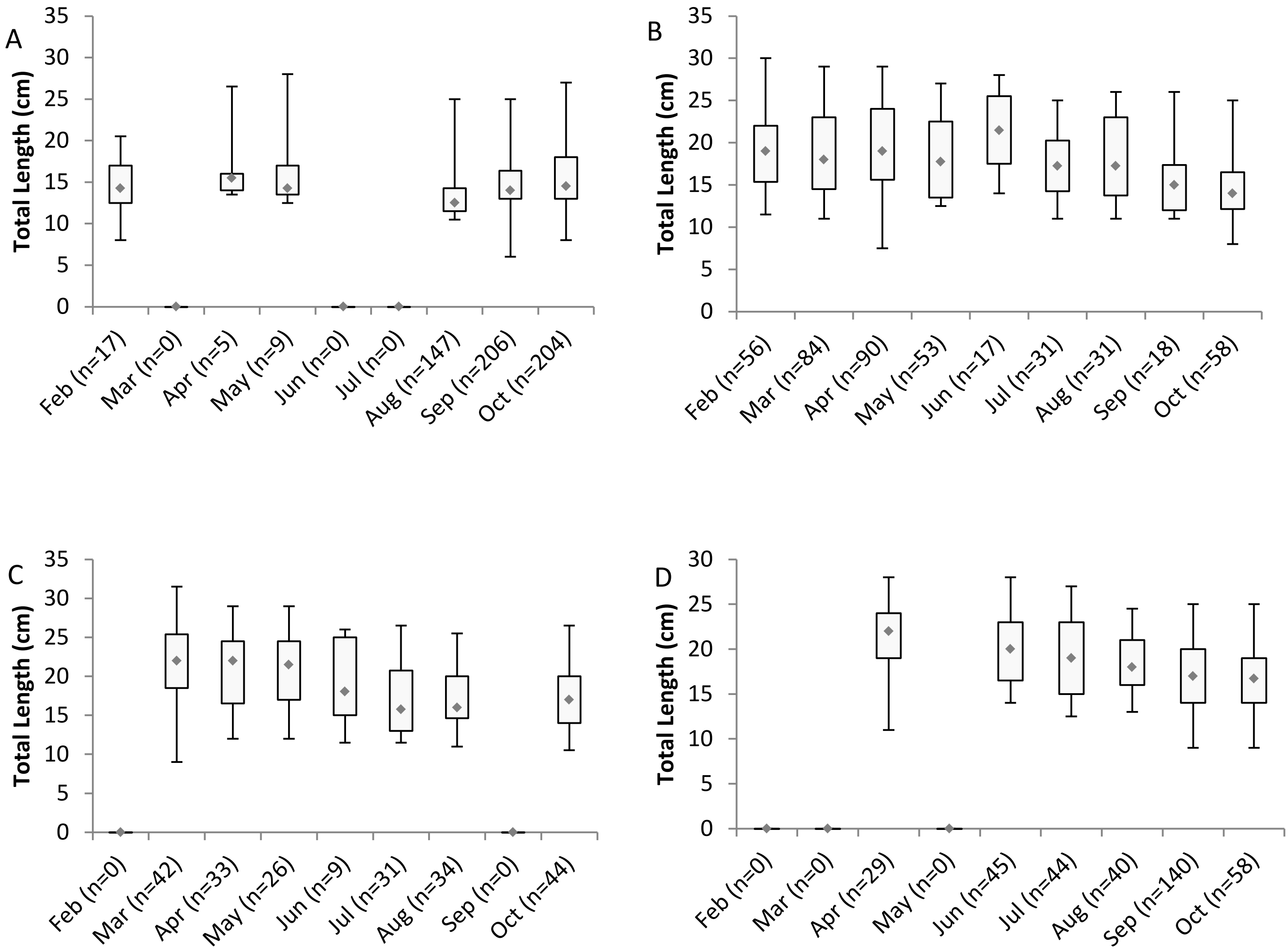


Figure 17: Total length box plots for all ballan wrasse sampled in the 2017 survey, grouped by month, for areas A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.

5.8.3 Spawning

As part of the Cornwall IFCA survey ballan wrasse were not routinely checked for spawning. Devon and Severn IFCA sampled 355 ballan wrasse, one ballan (female) was found to be spawning in June.

5.8.4 Sex Ratios

Gender could not be determined on ballan wrasse therefore no data were collected.

5.8.5 Charted Depth

In area A the majority of the traps observed were within depth category 1 (Figure 18), resulting in a small sample size of ballan wrasse in the category 2, and no samples in category 3 (Figure 18, Figure 19). This bias in sampling effort and small sample size makes comparison between the samples unreliable.

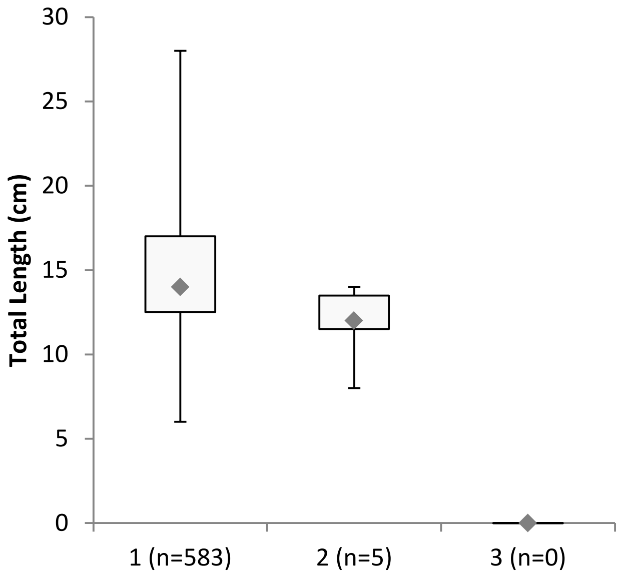
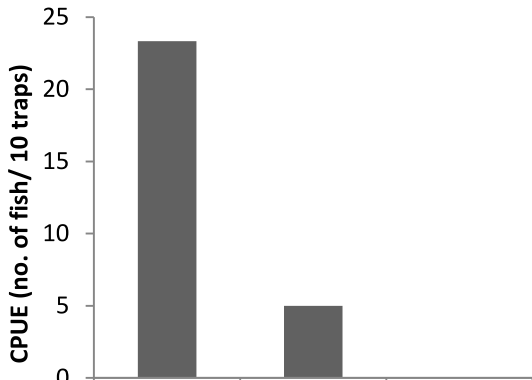


Figure 18: Box plot showing ballan wrasse size distribution for area A, by depth category 1-3. Points represent median, boxes represent the inter-quartile range and error bars represent range.



	1	2	3
CPUE (no. of fish/10 traps)	23.32	5	0
No. of traps	250	10	0
No. of Ballan	583	5	0

Figure 19: Catch per unit effort (CPUE) (no. of fish/10 traps) of ballan wrasse for area A, by depth category 1-3.

In area B, mean average lengths of the fish sampled in depth category 1 was smaller than for category 2; 17.74cm and 18.66cm respectively, with a slightly larger range of data in category 2 (Figure 20). The sampling effort in depth categories 1 and 2 were; 556 and 361 traps respectively (Figure 21), giving very similar total CPUE (per 10 traps); 4.68 and 4.85 respectively. The sample size for depth category 3 was too small for analysis of total CPUE (per 10 traps) or length frequency distribution (Figure 21).

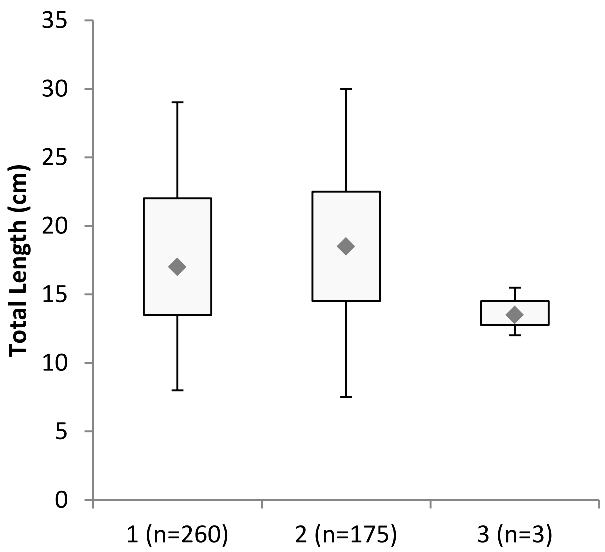
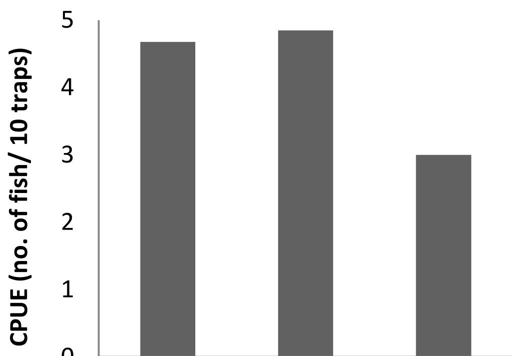


Figure 20: Box plot showing ballan wrasse size distribution for area B, by depth category 1-3. Points represent median, boxes represent the inter-quartile range and error bars represent range.



	1	2	3
CPUE (no. of fish/10 traps)	4.68	4.85	3.00
No. of traps	556	361	10
No. of Ballan	260	175	3

Figure 21: Catch per unit effort (CPUE) (no. of fish/10 traps) of ballan wrasse for area B by depth category 1-3.

As with area B the average length was slightly higher for depth category 2, 19.86cm, than category 1, 18.52cm (Figure 22). Similarly to area A and B, in area C sampling was biased to depth categories 1 and 2, with little effort in category 3 (Figure 23).

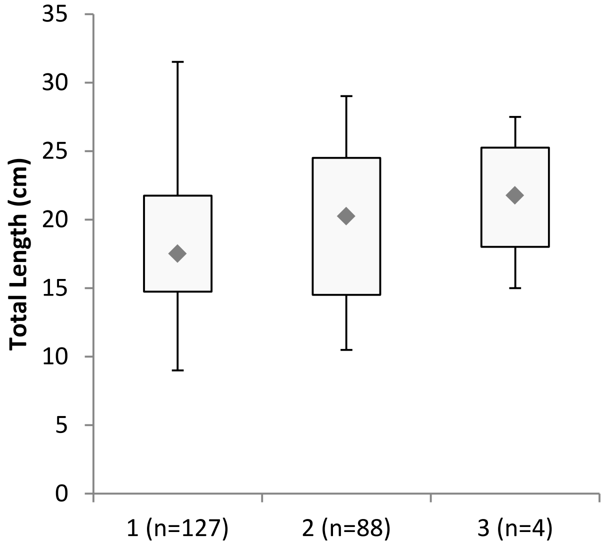
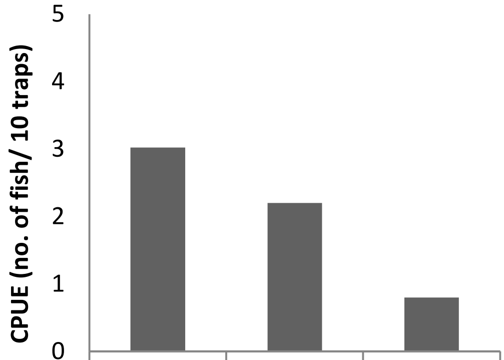


Figure 22: Box plot showing ballan wrasse size distribution for area C, by depth category 1-3. Points represent median, boxes represent the inter-quartile range and error bars represent range.



	1	2	3
CPUE (no. of fish/10 traps)	3.02	2.20	0.80
No. of traps	420	400	50
No. of Ballan	127	88	4

Figure 23: Catch per unit effort (CPUE) (no. of fish/10 traps) of ballan wrasse for area C, by depth category 1-3.

As in areas B and C, in area D the average size for fish in depth category 2 was larger than in category 1, 18.50cm for category 2 and 17.62cm for category 1 (Figure 24). A similar trend was observed as with areas A, B and C, where there is very little data for depth category 3 (Figure 25).

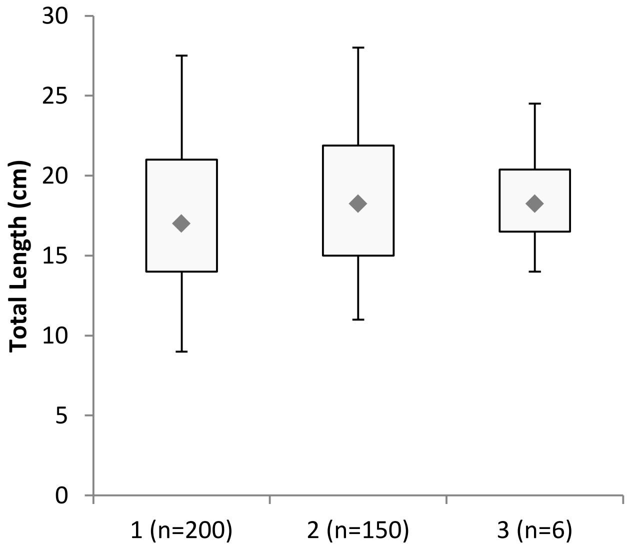
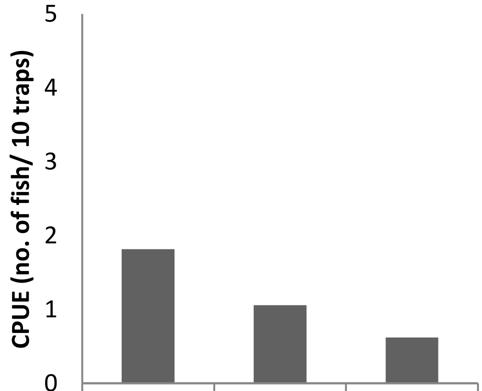


Figure 24: Box plot showing ballan wrasse size distribution for area D, by depth category 1-3. Points represent median, boxes represent the inter-quartile range and error bars represent range.

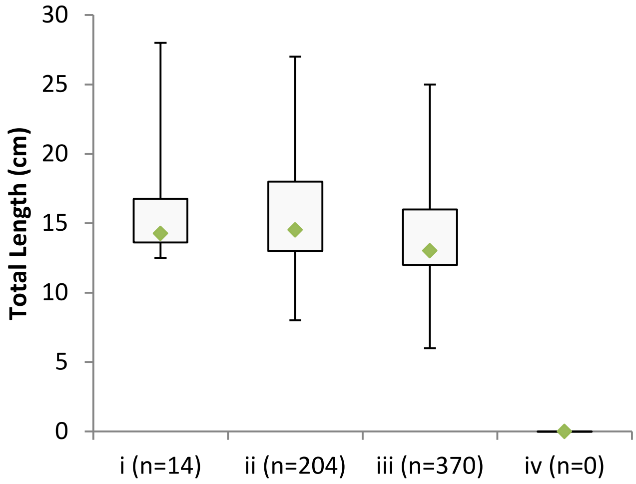


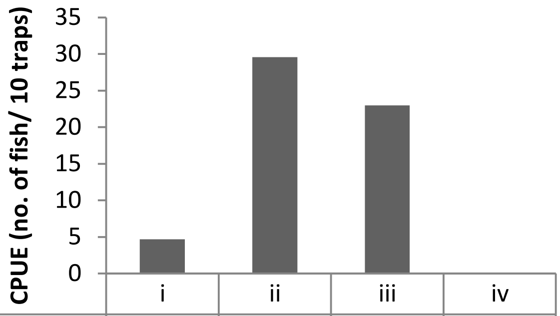
	1	2	3
CPUE (no. of fish/10 traps)	1.81	1.06	0.62
No. of traps	1103	1417	97
No. of Ballan	200	150	6

Figure 25: Catch per unit effort (CPUE) (no. of fish/10 traps) of ballan wrasse sampled in area D, by depth category 1-3.

5.8.6 Tidal Range

In area A the average size of ballan wrasse is slightly smaller, for category iii, 14.35, compared to the other tidal range categories (Figure 26), 16.78cm and 15.51cm for i and ii respectively. The highest sampling effort was in category ii (Figure 27), with no sampling effort during iv.



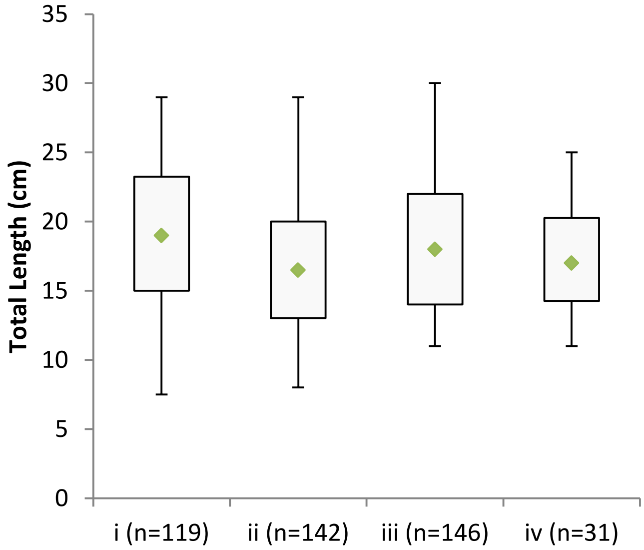


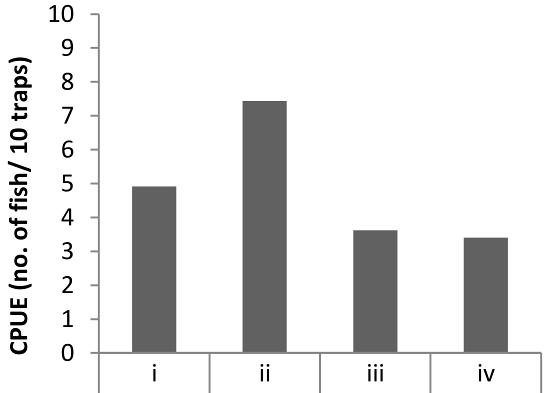
	i	ii	iii	iv
CPUE (no. of fish/10 traps)	4.67	29.57	22.98	0.00
No. of traps	30	69	161	0
No. of Ballan	14	204	370	0

Figure 26: Box plot showing ballan wrasse size distributions sampled in area A, grouped by tidal range. Points represent median, boxes represent the inter-quartile range and error bars represent range.

Figure 27: Catch per unit effort (CPUE) (no. of fish/10 traps) of ballan wrasse sampled in area A, grouped by tidal range.

In area B length frequency distribution varies with tidal range category (Figure 28), and CPUE (no. of fish/10 traps) is highest in category ii (Figure 29).



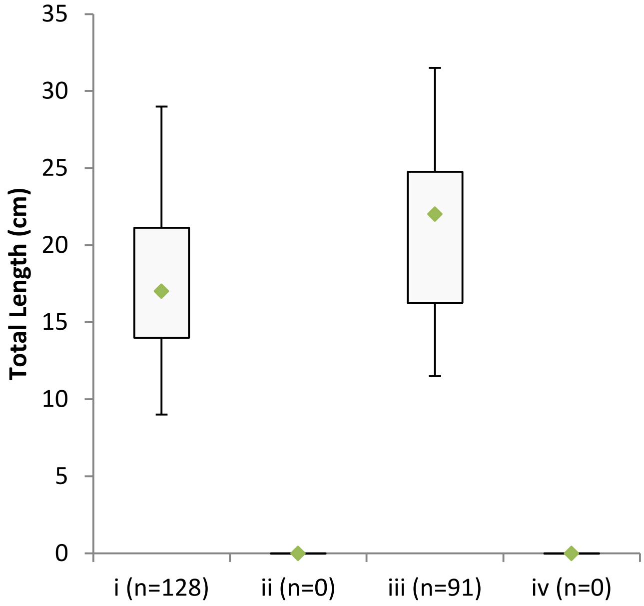


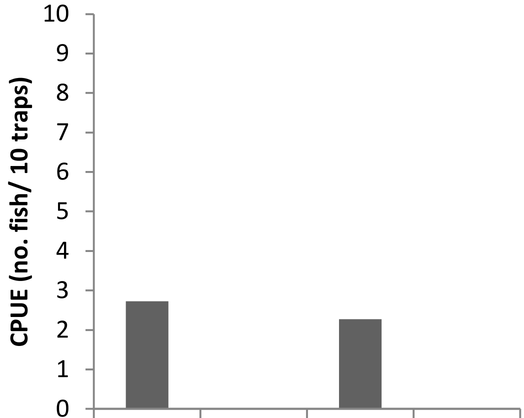
	i	ii	iii	iv
CPUE (no. of fish/10 traps)	4.92	7.43	3.62	3.41
No. of traps	242	191	403	91
No. of Ballan	119	142	146	31

Figure 28: Box plot showing ballan wrasse size distributions sampled in area B, grouped by tide state. Points represent median, boxes represent the inter-quartile range and error bars represent range.

Figure 29: Catch per unit effort (CPUE) (no. of fish/10 traps) of ballan wrasse sampled in area B, grouped by tide state.

The mean average length of ballan sampled in category iii was higher, 20.81cm in area iii and 17.84cm i (Figure 30). In area C sampling effort was split between only two tidal range categories; i and ii, with similar total CPUE 2.72 and 2.28 respectively (Figure 31).



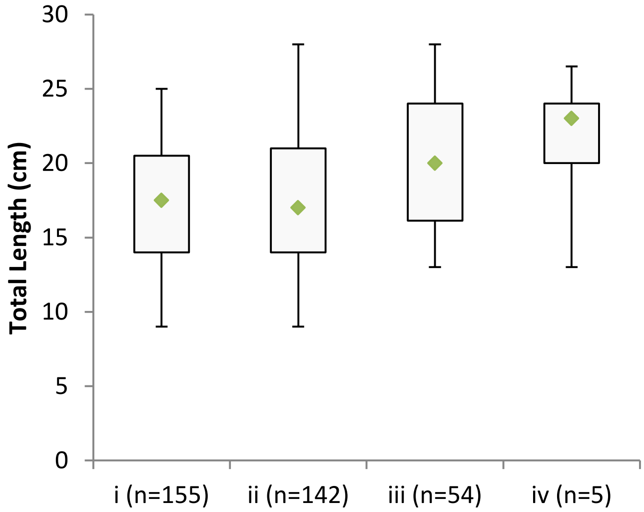


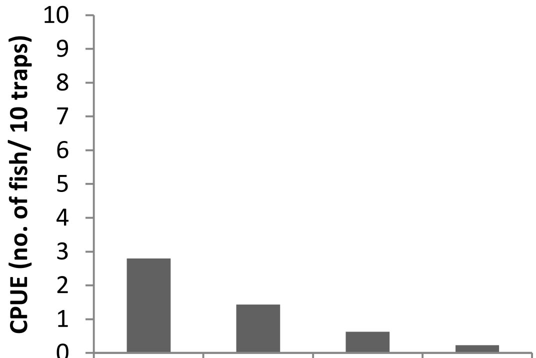
	i	ii	iii	iv
CPUE (no. of fish/10 traps)	2.72	0.00	2.28	0.00
No. of traps	470	0	400	0
No. of Ballan	128	0	91	0

Figure 30: Box plot showing ballan wrasse size distributions sampled in area C, grouped by tidal range categories. Points represent median, boxes represent the inter-quartile range and error bars represent range..

Figure 31: Catch per unit effort (CPUE) (no. of fish/ 10 traps) sampled in area C, grouped by tidal range categories.

Mean average total length was highest in categories iii and iv (Figure 32). In area D CPUE (no. of fish/ 10 traps) was greater during spring tides (i and ii), than neap tides (iii and iv), (Figure 33).





	i	ii	iii	iv
CPUE (no. of fish/10 traps)	2.80	1.44	0.63	0.23
No. of traps	554	989	857	217
No. of Ballan	155	142	54	5

Figure 32: Box plot showing ballan wrasse size distributions sampled in area D, grouped by tidal range categories. Points represent median, boxes represent the inter-quartile range and error bars represent range.

Figure 33: Catch per unit effort (CPUE) (no. of fish/ 10 traps) of ballan wrasse sampled in area D, grouped by tidal range categories.

5.8.7 Nights Lie

The length frequency distributions vary between different numbers of night lie in area A (Figure 34). Total CPUE also varied between differing nights lie with a general trend of increasing CPUE with increasing nights lie (Figure 35).

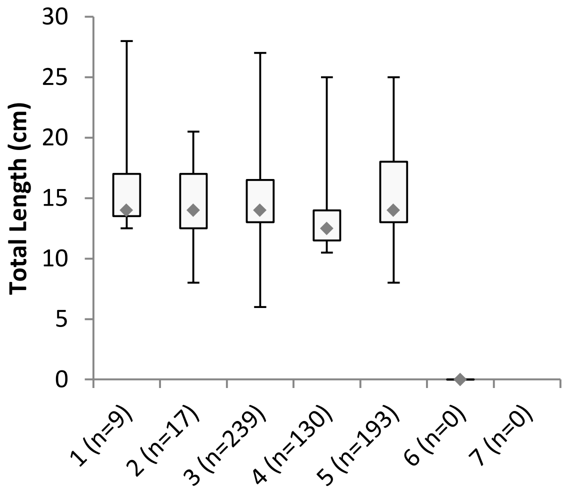
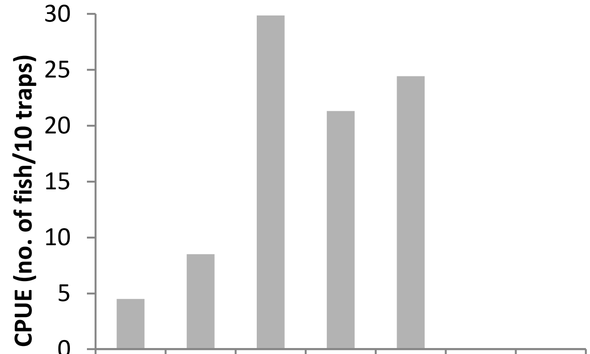


Figure 34: Box plot showing ballan wrasse size distribution for area A, by number of nights lie of the traps. Points represent median, boxes represent the inter-quartile range and error bars represent range.



	1	2	3	4	5	6	7
Total CPUE (per 10 traps)	4.50	8.50	29.88	21.31	24.43	0.00	0.00
No. of traps	20	20	80	61	79	0	0
No. of Ballan	9	17	239	130	193	0	0

Figure 35: Catch per unit effort (CPUE) (no. of fish/ 10 traps) of ballan wrasse for area A, grouped by number of nights lie of the traps.

For Area B the length frequency distributions varied with nights lie (Figure 36). Area B sampling effort was biased to two and three nights lie, 304 and 392 traps respectively (Figure 37), total CPUE was highest for five nights lie, however sampling effort was far lower than for other nights lie, making comparisons unreliable.

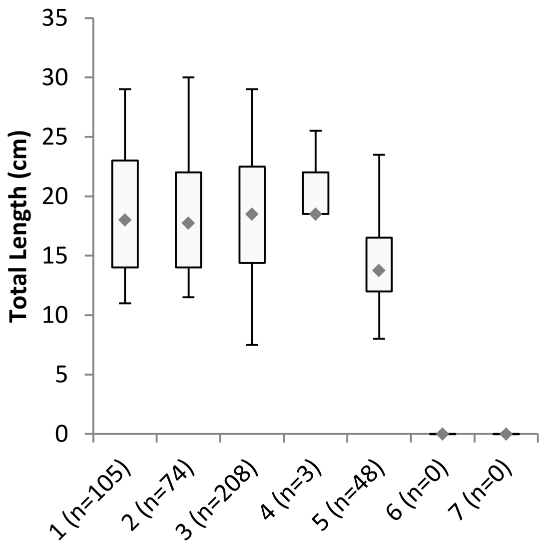
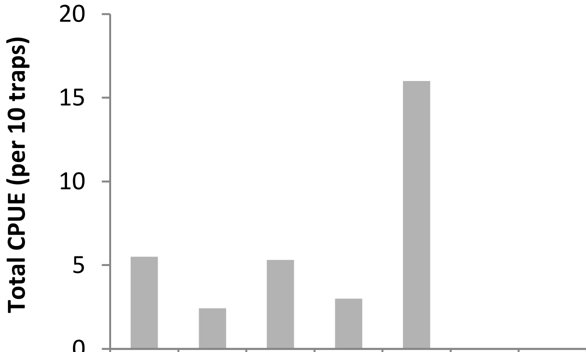


Figure 36: Box plot showing ballan wrasse size distribution for area B, by number of nights lie of the traps. Points represent median, boxes represent the inter-quartile range and error bars represent range.



	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	5.50	2.43	5.31	3.00	16.00	0.00	0.00
No. of traps	191	304	392	10	30	0	0
No. of Ballan	105	74	208	3	48	0	0

Figure 37: Catch per unit effort (CPUE) (no. of fish/ 10 traps) for area B grouped by number of nights lie of the traps. Note, all samples for five nights lie were in collected in October, when catch rates were higher than other months.

Area C length frequency distributions varied (Figure 38), with larger fish caught with increasing nights lie. Total CPUE decreased with nights lie (Figure 39).

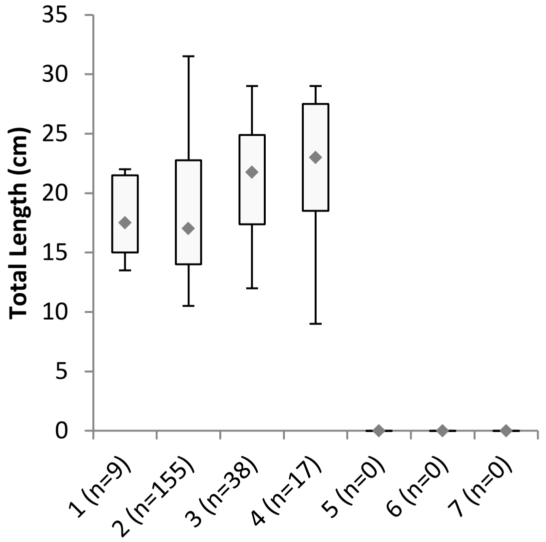
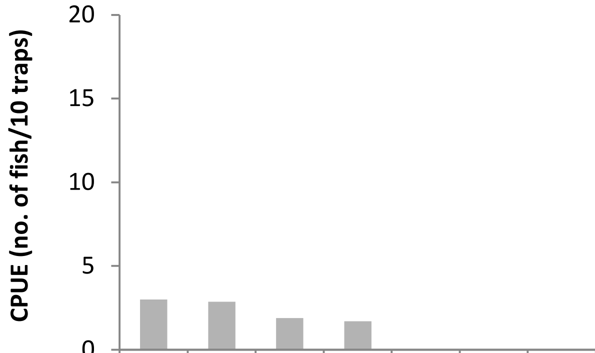


Figure 38: Box plot showing ballan wrasse size distribution for area C, by number of nights lie of the traps. Points represent median, boxes represent the inter-quartile range and error bars represent range.



	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	3.00	2.87	1.90	1.70	0.00	0.00	0.00
No. of traps	30	540	200	100	0	0	0
No. of Ballan	9	155	38	17	0	0	0

Figure 39: Catch per unit effort (CPUE) (no. of fish/ 10 traps) for area C, grouped by number of nights lie of the traps.

In area D sample numbers were small for two or more nights lie (<11 samples per nights lie, Figure 41) and therefore no analysis could be carried out on length frequency distributions (Figure 40). Total CPUE decreased with the number of nights lie for one through to three nights, however the trend does not continue for subsequent nights lie (Figure 41).

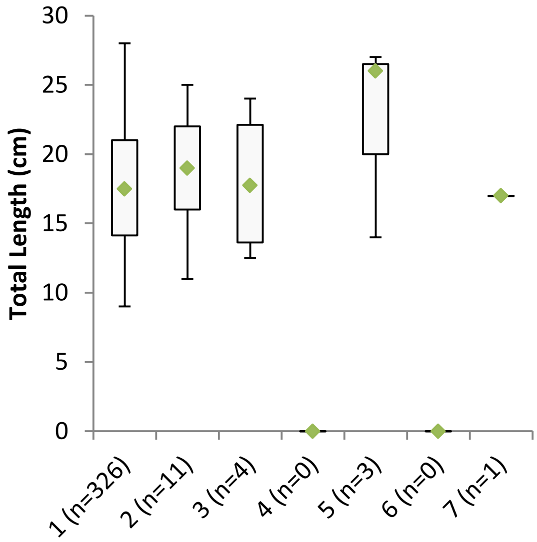
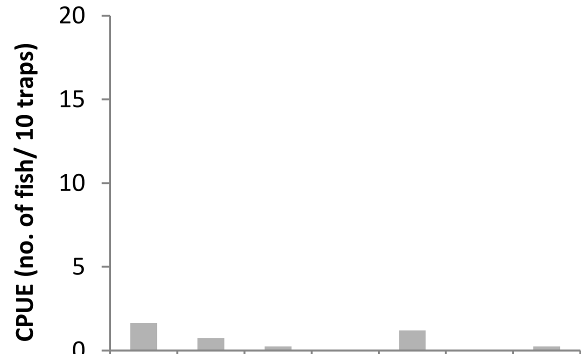


Figure 40: Box plot showing ballan wrasse size distribution for area D, by number of nights lie of the traps. Points represent median, boxes represent inter-quartile and error bars represent range.



	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	1.64	0.75	0.25	0.00	1.20	0.00	0.26
No. of traps	1991	146	162	47	25	0	39
No. of Ballan	326	11	4	0	3	0	1

Figure 41: Catch per unit effort (CPUE) (no. of fish/ 10 traps) for area D grouped by number of nights lie of the traps.

5.9 Corkwing wrasse (*Symphodus melops*)

A total of 3242 corkwing wrasse were sampled by Cornwall IFCA and Devon & Severn IFCA (2654 and 588 respectively); A (n=1584), B (n=726), C (n=344), and D (n=592).

The mean average total length of all corkwing wrasse sampled was 14.86cm, with a minimum of 5cm, and maximum of 25.5cm.

5.9.1 Geographic Location

The average length frequency for area A is very different from the other three areas, with a lower mean average total length (Figure 42). The CPUE (no. of fish/10 traps) is highest for area A (Figure 43).

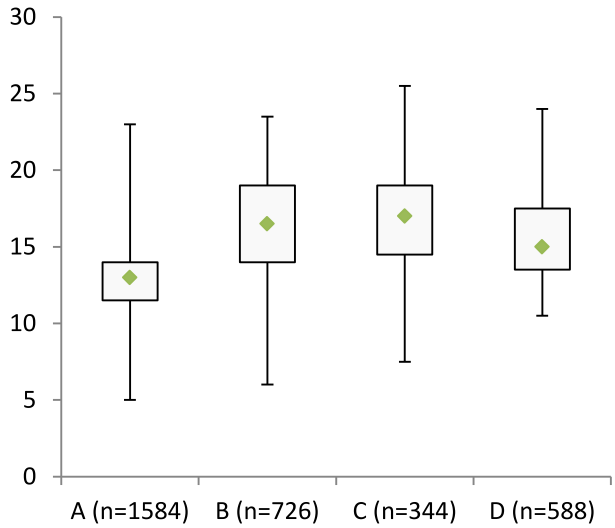
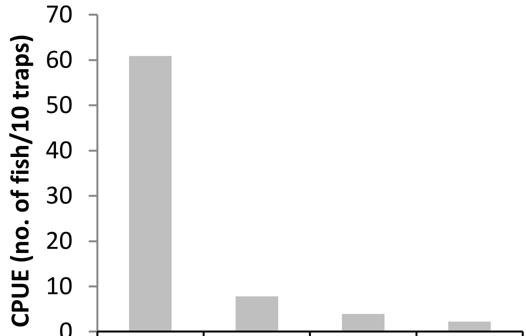


Figure 42: Total length frequency box plot for all corkwing sampled during the 2017 survey. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.



	A	B	C	D
CPUE (no. of fish/10 traps)	60.92	7.83	3.95	2.25
No. of corkwing	1584	726	344	588
No. of traps	260	927	870	2617

Figure 43: Catch per unit effort (CPUE) (no. of fish/10 traps) for all corkwing sampled during the 2017 survey, grouped by geographic area A-D.

The mean average total length for area A is 13.15cm, B is 16.39cm, C is 16.74cm and D is 15.52cm. The proportion of fish below the average size at maturity (taken as 10cm, cited in Darwall *et al.*, 1992) was below 0.05 for all areas (0.03, 0.01, 0.01, 0 respectively). The proportion of fish below the current minimum size, as dictated by the salmon farms, 12cm was highest for area A than the three remaining areas (0.26, 0.05, 0.05, 0.06 respectively).

5.9.2 Seasonality

CPUE (no. of fish/10 traps) decreased for all four areas in May and June with an increase from July to October (Figure 44).

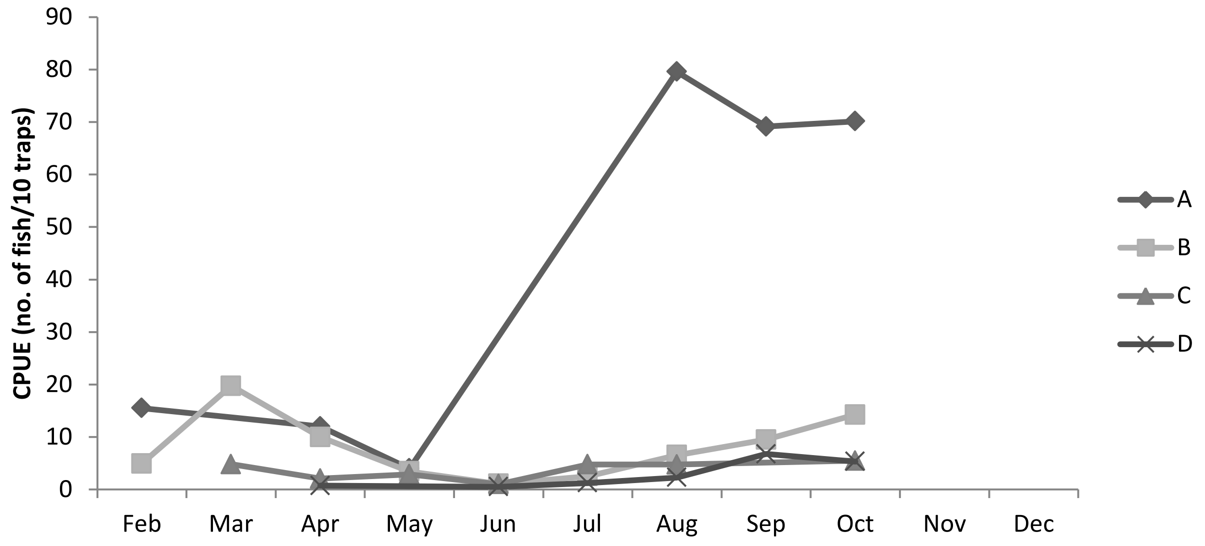


Figure 44: Monthly CPUE (no. of fish/10 traps) of corkwing wrasse by geographic location A-D.

All areas appear to show an overall decrease in average size with advancing months (Figure 45).

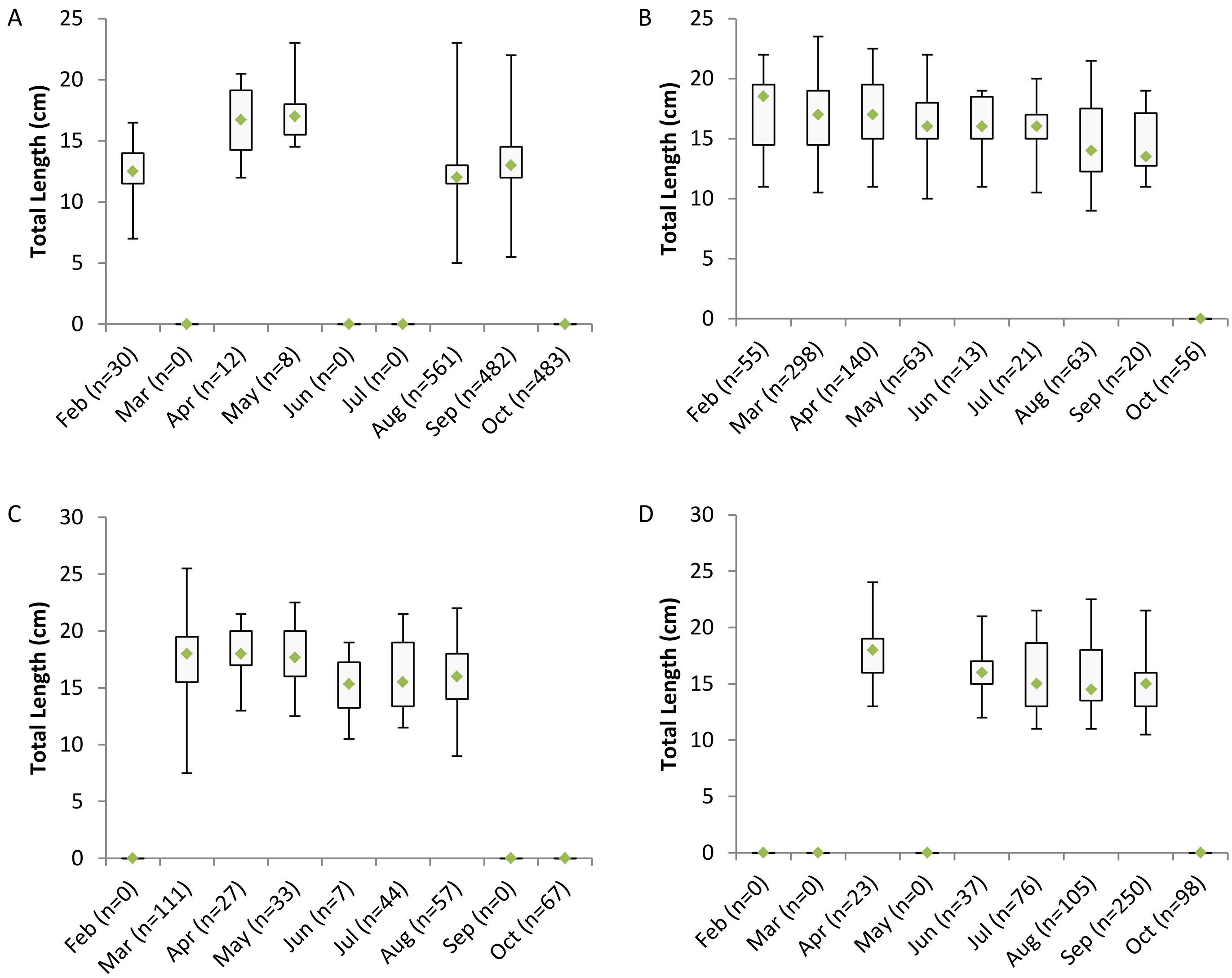


Figure 45: Total length box plots for all corkwing wrasse sampled in the 2017 survey, grouped by month, for areas A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.

5.9.3 Spawning

Spawning fish were sampled between May and July across the four areas (Figure 46).

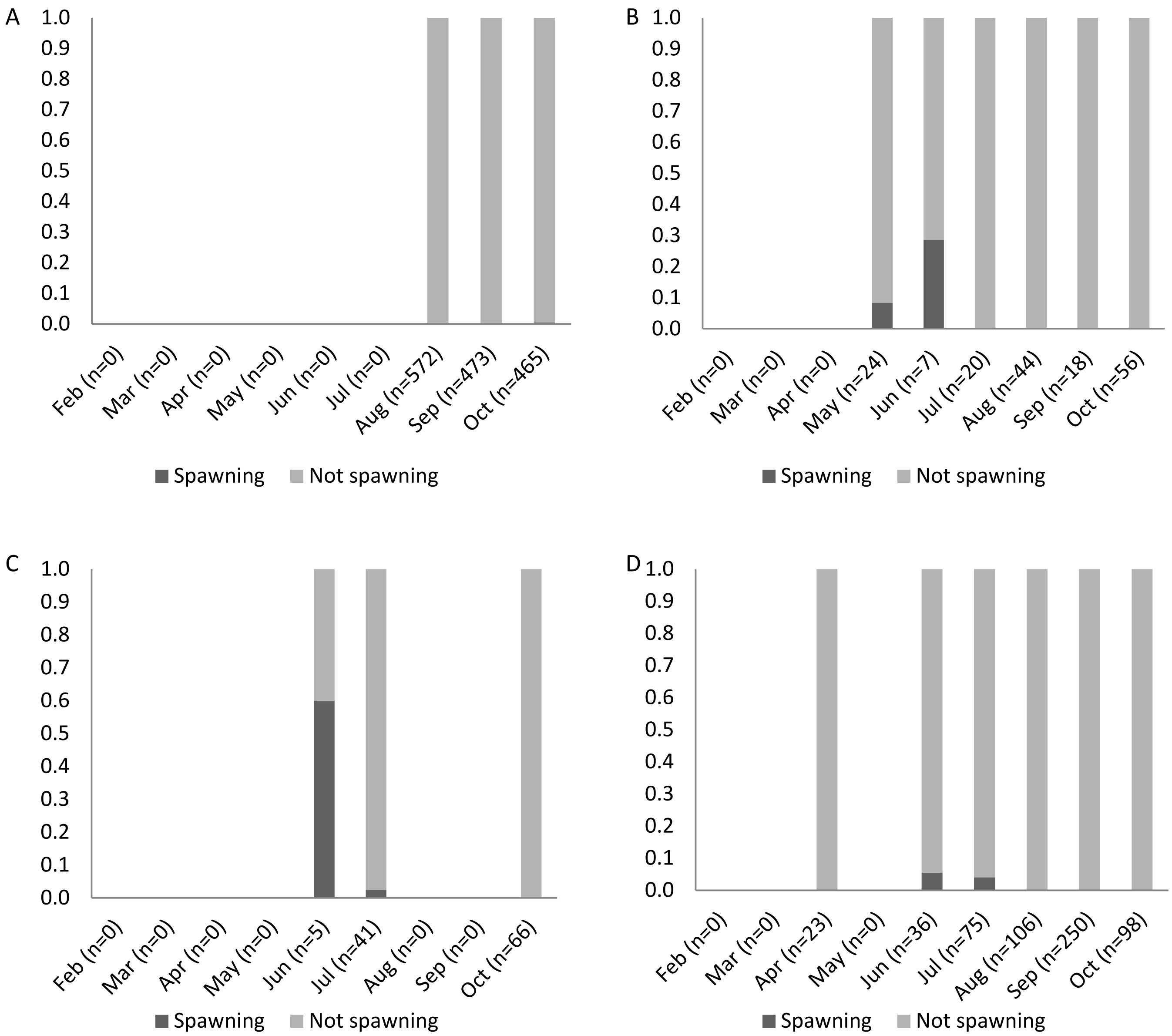
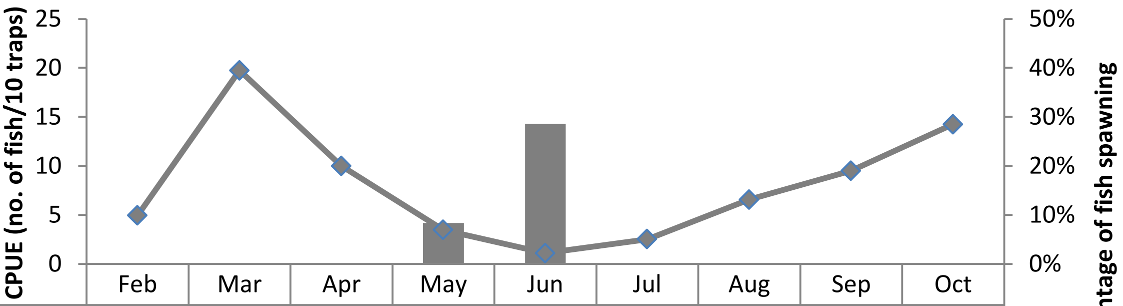


Figure 46: Proportion of spawning corkwing wrasse to non-spawning corkwing in areas A to D by month.

5.9.4 CPUE (no. of fish/10 traps) and spawning time

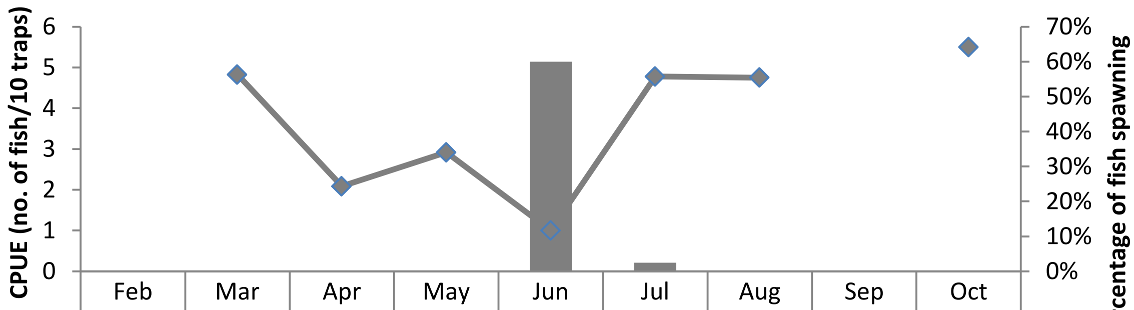
Spawning state and CPUE (no. of fish/10 traps) have been plotted together for areas where spawning fish were sampled (B, C and D). In all three areas a drop in CPUE (no. of fish/10 traps) coincides with the highest percentages of spawning fish (Figure 47).

B



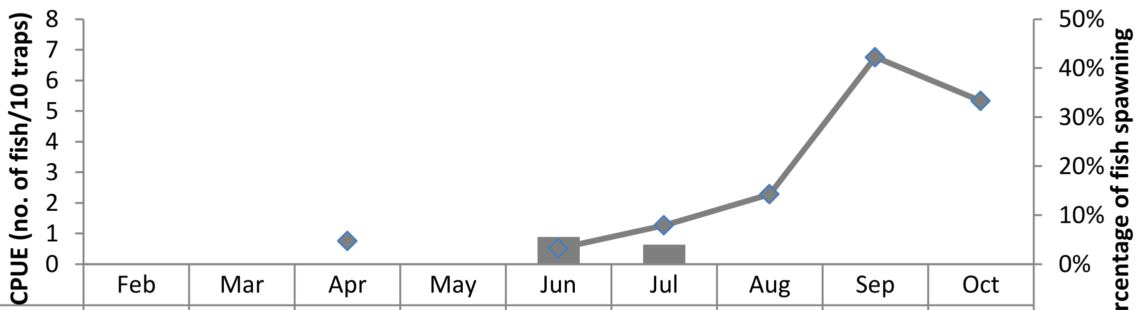
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of fish spawning				8%	29%	0%	0%	0%	0%
CPUE	4.95	19.74	10.00	3.46	1.09	2.53	6.56	9.50	14.25

C



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of fish spawning	0%	0%	0%	0%	60%	2%	0%	0%	0%
CPUE		4.83	2.08	2.92	1.00	4.78	4.75		5.50

D



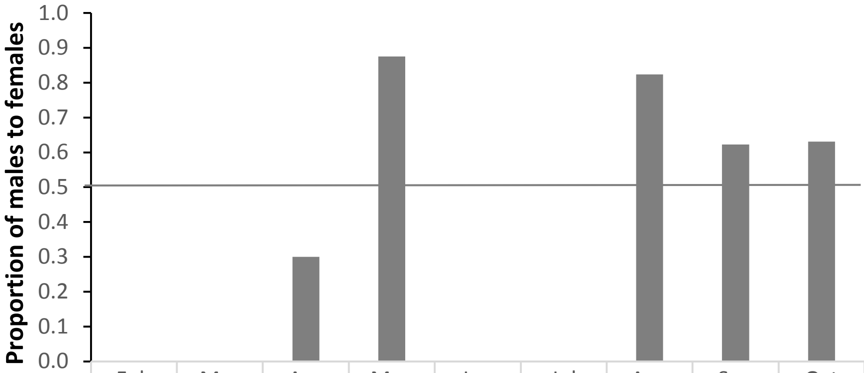
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of fish spawning	0%	0%	0%	0%	6%	4%	0%	0%	0%
CPUE			0.75		0.51	1.26	2.28	6.76	5.33

Figure 47: CPUE (no. of fish/10 traps) plotted with percentage of corkwing spawning for areas B, C and D. Area A has been omitted due to no spawning fish being sampled.

5.9.5 Sex Ratios

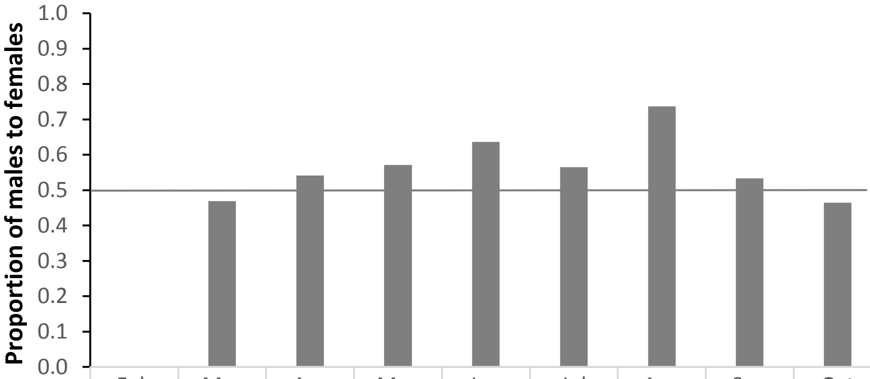
The proportion of males peaked in August in area B and D, and July for area C (Figure 48). In area A there was a higher proportion of males in May, however sample numbers were very low, potentially making the data less reliable.

A



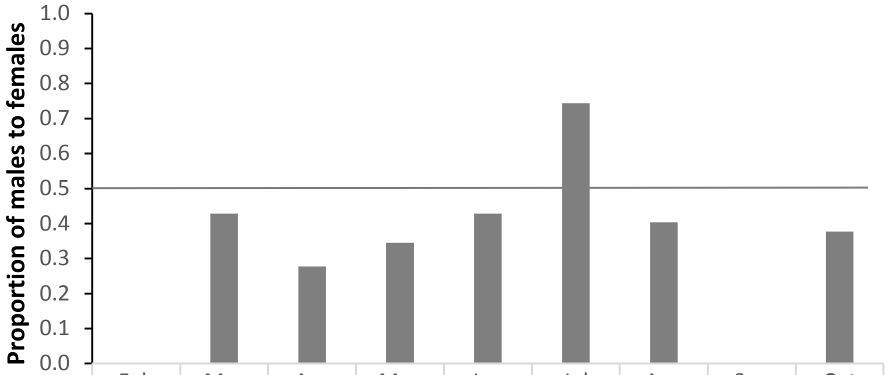
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.00	0.30	0.88	0.00	0.00	0.82	0.62	0.63
Male	0	0	3	7	0	0	440	261	285
Female	0	0	7	1	0	0	94	158	167
Unknown	31	0	2	0	0	0	31	65	32

B



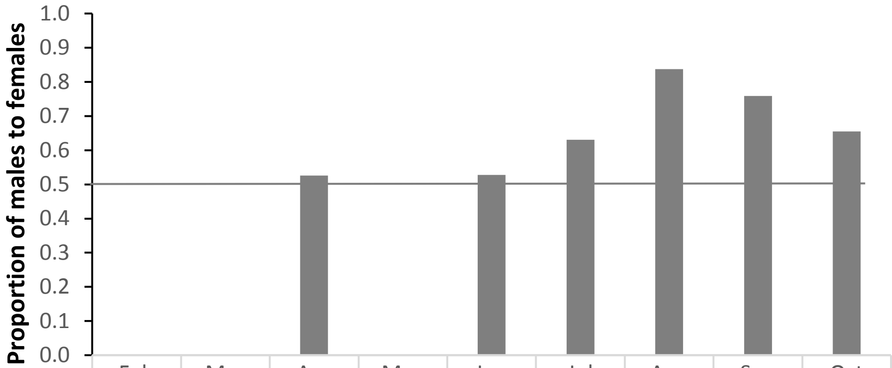
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.47	0.54	0.57	0.64	0.57	0.74	0.53	0.46
Male	0	129	66	36	7	13	42	8	26
Female	0	146	56	27	4	10	15	7	30
Unknown	55	23	19	0	0	0	2	4	1

C



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.43	0.28	0.34	0.43	0.74	0.40	0.00	0.38
Male	0	42	5	10	3	32	23	0	23
Female	0	56	13	19	4	11	34	0	38
Unknown	0	13	7	6	0	0	0	0	5

D



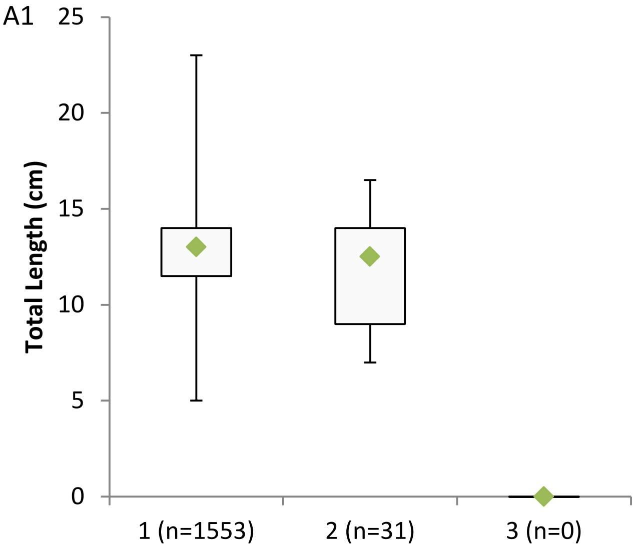
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.00	0.53	0.00	0.53	0.63	0.84	0.76	0.66
Male	0	0	10	0	19	41	67	145	57
Female	0	0	9	0	17	24	13	46	30
Unknown	0	0	4	0	0	10	26	59	11

Figure 48: Sex ratios of corkwing wrasse by month in areas A to D.

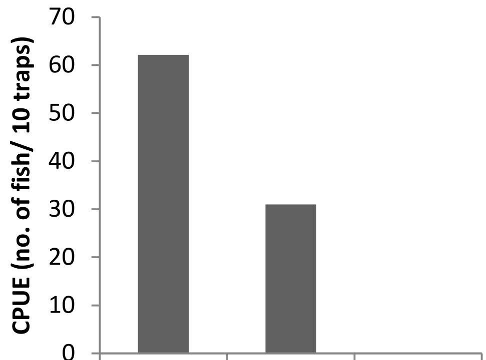
5.9.6 Charted Depth

Areas B, C and D show an increase in mean average total length between depth categories 1 and 2 (Figure 49, A1 to D1). All four areas show a decrease in CPUE (no. of fish/10 traps) with increasing depth (Figure 49, A2 to D2).

A1

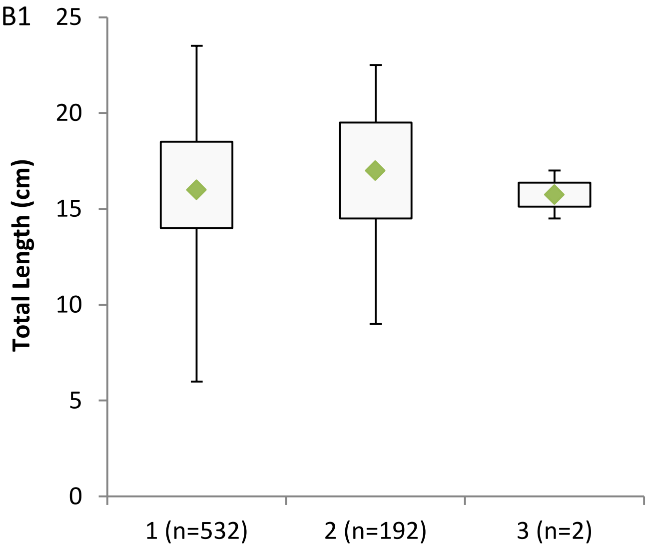


A2

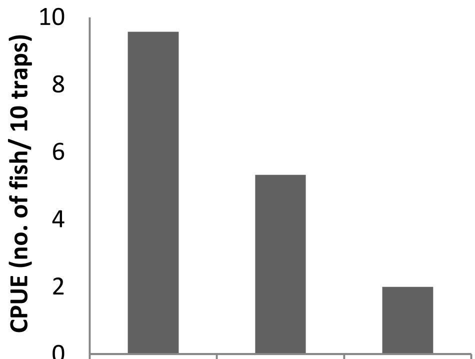


	1	2	3
CPUE (no. of fish/10 traps)	62.12	31	0
No. of traps	250	10	0
No. of corkwing	1553	31	0

B1

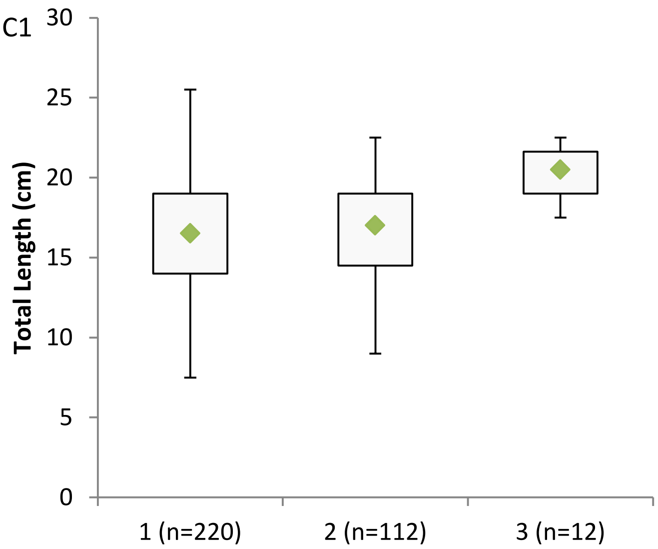


B2

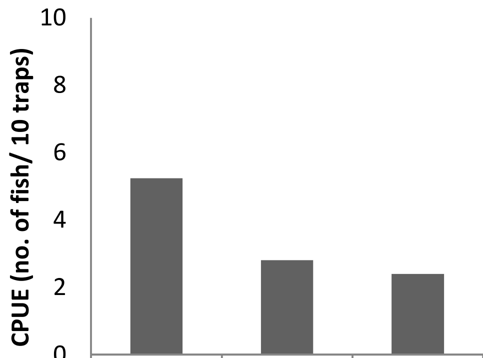


	1	2	3
CPUE (no. of fish/10 traps)	9.57	5.32	2.00
No. of traps	556	361	10
No. of corkwing	532	192	2

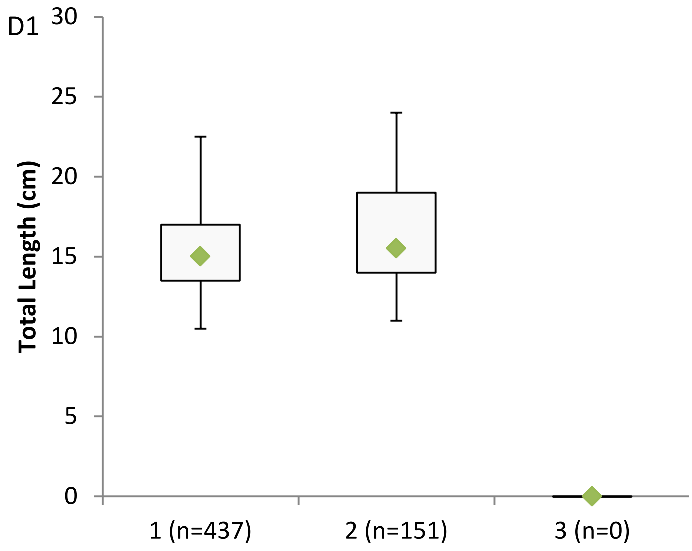
C1

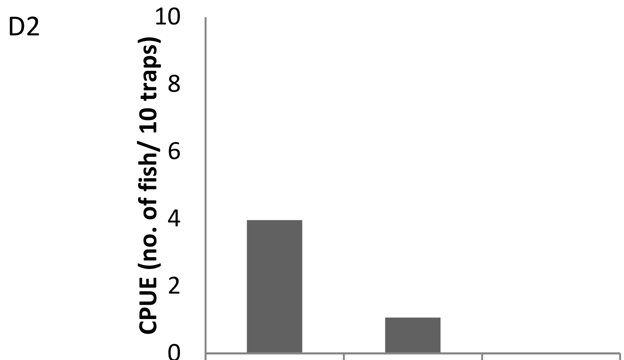


C2



	1	2	3
CPUE (no. of fish/10 traps)	5.24	2.80	2.40
No. of traps	420	400	50
No. of corkwing	220	112	12



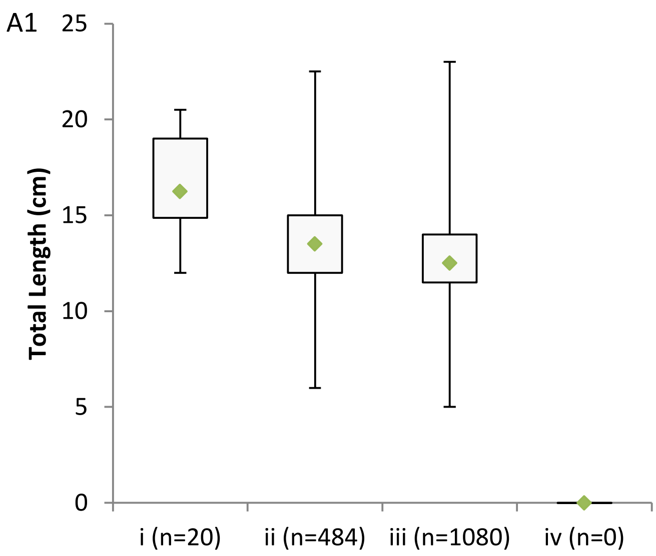


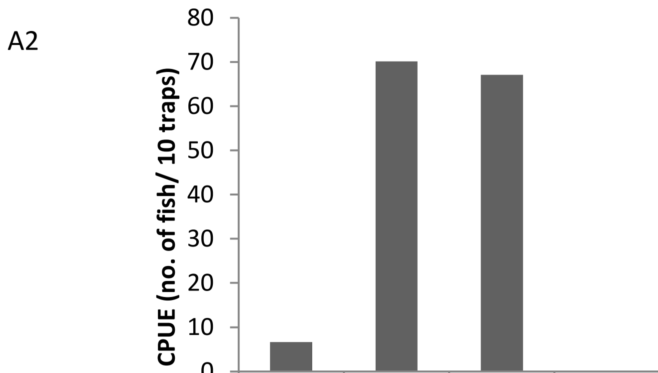
	1	2	3
CPUE (no. of fish/10 traps)	3.96	1.07	0.00
No. of traps	1103	1417	97
No. of corkwing	437	151	0

Figure 49: Plots A1 to D1 are box plots showing corkwing wrasse length frequency distribution by area A to D, by depth categories 1 to 3, points represent median, boxes represent the interquartile range and error bars represent range. Charts A2 to D2 are Catch per unit effort (CPUE) (no. of fish/10 traps) of corkwing wrasse for areas A to D by depth category 1 to 3.

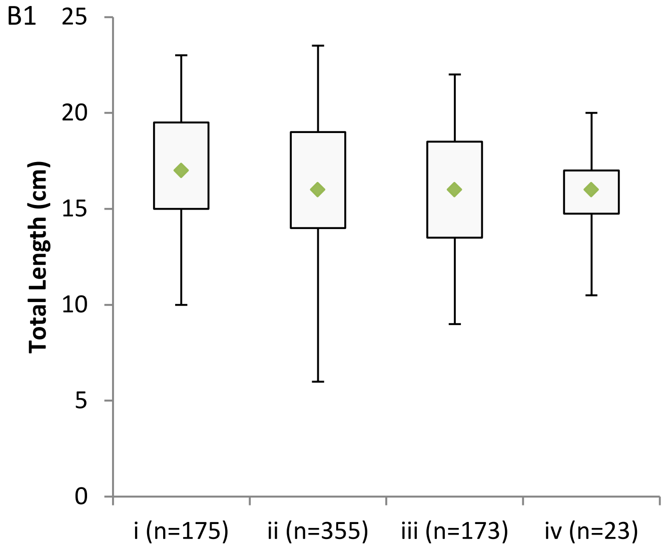
5.9.7 Tidal range

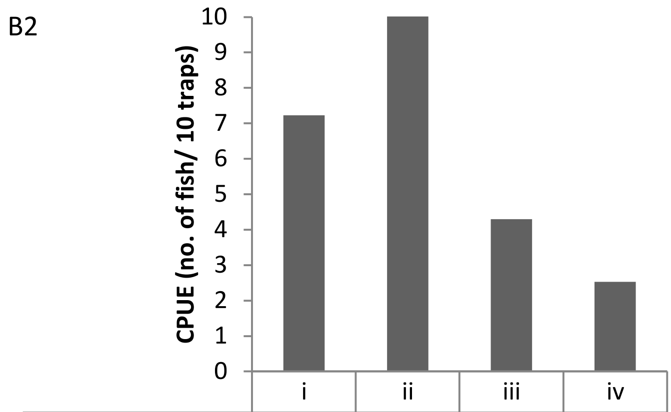
In area A CPUE (no. of fish/10 traps) was higher in tidal states ii and iii (Figure 50, A2), with smaller mean average total lengths (Figure 50, A1) (note the small sample size for tidal state i). In contrast for areas C and D tidal state i yielded the highest CPUE (no. of fish/10 traps), with slightly lower mean average size for fish sampled (Figure 50, C1&2, and D1&2). In area B CPUE was highest in tidal state ii (Figure 50, B2).



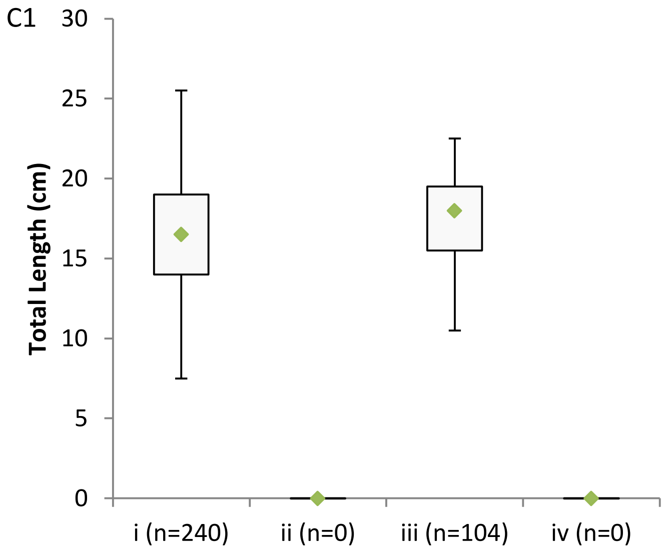


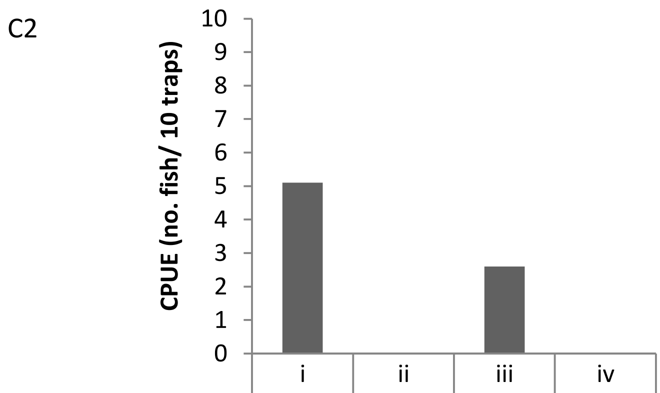
	i	ii	iii	iv
CPUE (no. of fish/10 traps)	6.67	70.14	67.08	0.00
No. of traps	30	69	161	0
No. of corkwing	20	484	1080	0



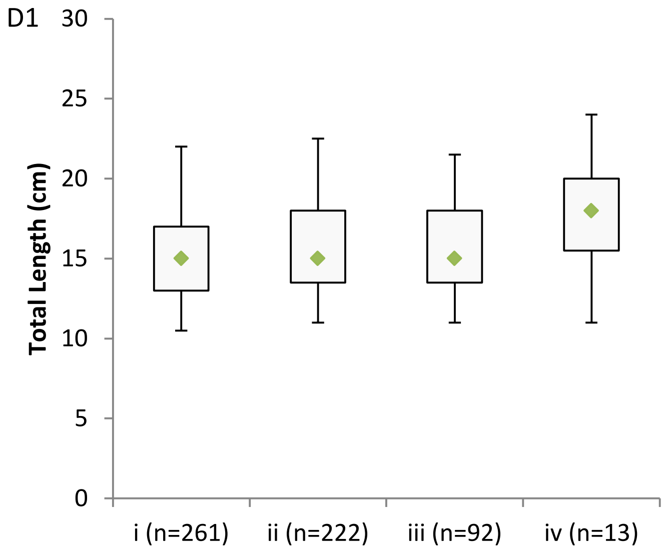


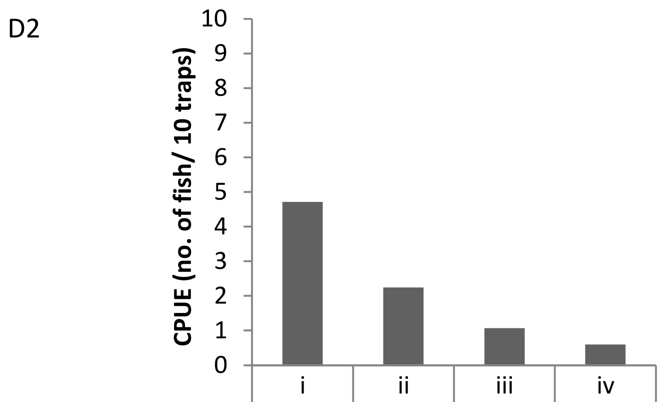
	i	ii	iii	iv
CPUE (no. of fish/10 traps)	7.23	18.59	4.29	2.53
No. of traps	242	191	403	91
No. of corkwing	175	355	173	23





	i	ii	iii	iv
CPUE (no. of fish/10 traps)	5.11	0.00	2.60	0.00
No. of traps	470	0	400	0
No. of corkwing	240	0	104	0



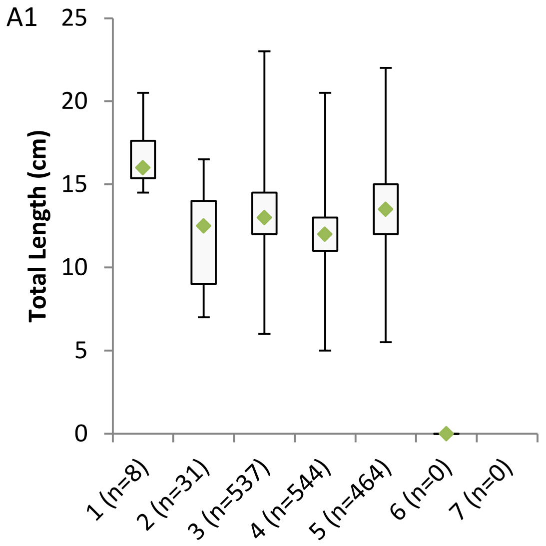


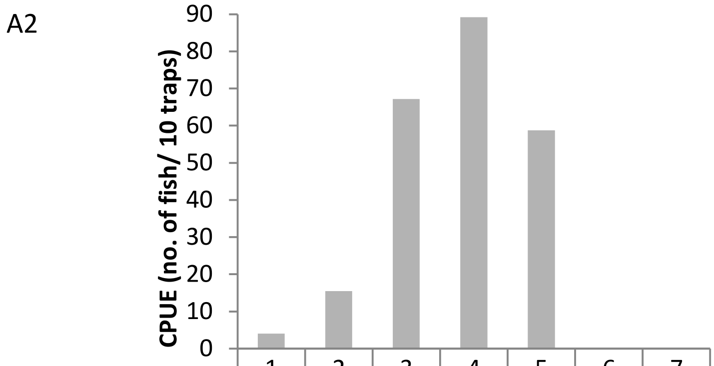
	i	ii	iii	iv
CPUE (no. of fish/10 traps)	4.71	2.24	1.07	0.60
No. of traps	554	989	857	217
No. of corkwing	261	222	92	13

Figure 50: Plots A1 to D1 are box plots showing corkwing wrasse length frequency distribution by area A to D, by tidal range categories I to iv , points represent median, boxes represent the interquartile range and error bars represent range. Charts A2 to D2 are catch per unit effort (CPUE) (no. of fish/10 traps) of corkwing wrasse for areas A to D by tidal range category I to iv.

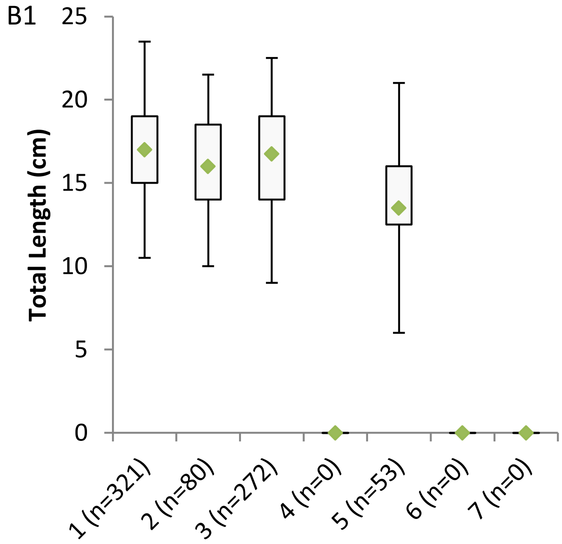
5.9.8 Nights Lie

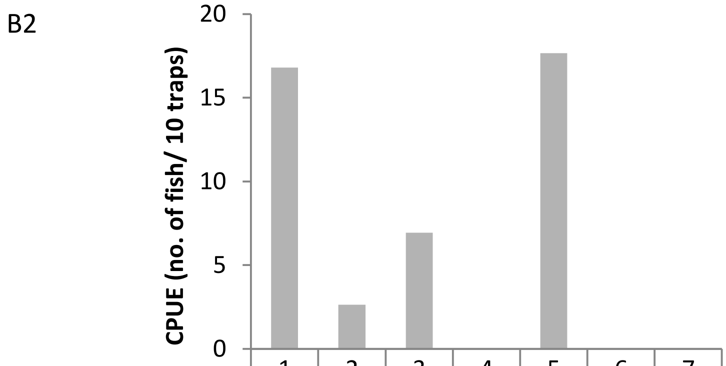
Length frequency distributions varied with increasing nights lie for all areas (Figure 51, A1 to D1). CPUE increases with increasing nights lie in area A, and decreases in area D, there are no obvious trends in areas B and C (Figure 51, A2 to D2).



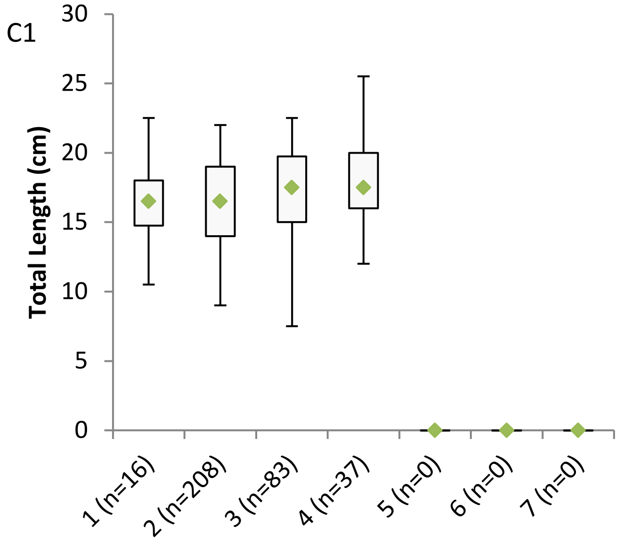


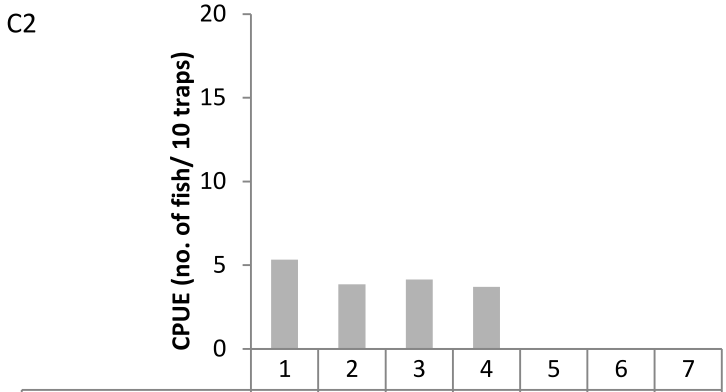
	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	4.00	15.50	67.13	89.18	58.73	0.00	0.00
No. of traps	20	20	80	61	79	0	0
No. of corkwing	8	31	537	544	464	0	0



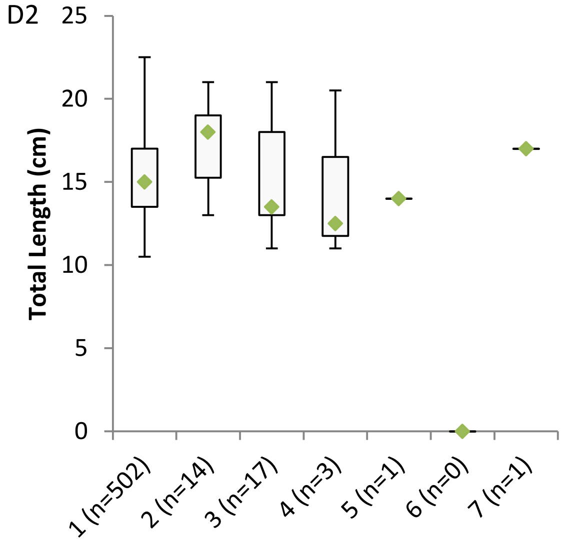


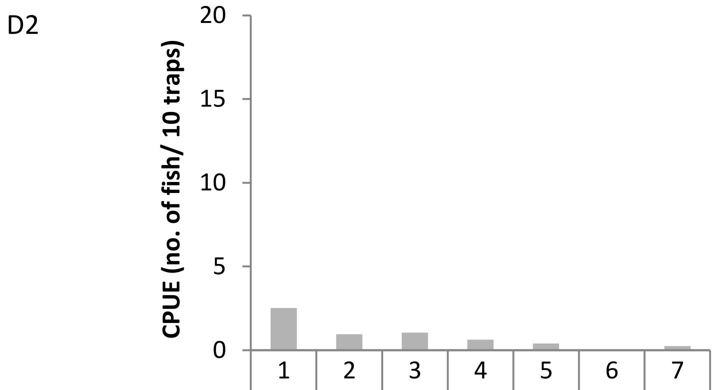
	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	16.81	2.63	6.94	0.00	17.67	0.00	0.00
No. of traps	191	304	392	10	30	0	0
No. of corkwing	321	80	272	0	53	0	0





	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	5.33	3.85	4.15	3.70	0.00	0.00	0.00
No. of traps	30	540	200	100	0	0	0
No. of corkwing	16	208	83	37	0	0	0





	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	2.52	0.96	1.05	0.64	0.40	0.00	0.26
No. of traps	1991	146	162	47	25	0	39
No. of corkwing	502	14	17	3	1	0	1

Figure 51: Plots A1 to D1 are box plots showing corkwing wrasse length frequency distribution by area A to D, by nights lie, points represent median, boxes represent the interquartile range and error bars represent range. Charts A2 to D2 are catch per unit effort (CPUE) (no. of fish/10 traps) of corkwing wrasse for areas A to D by nights lie.

5.10 Goldsinny wrasse (*Ctenolabrus rupestris*)

A total of 4509 goldsinny wrasse were sampled by Cornwall IFCA and Devon & Severn IFCA (2395 and 2114 respectively); A (n=104), B (n=1329), C (n=884), and D (n=2194).

The mean average total length of all goldsinny sampled was 10.9cm, with a minimum of 5cm, and maximum of 16.5cm.

5.10.1 Geographic Location

The total length frequency appears to be similar for all four geographic areas, however this has not been tested for significance (Figure 52). CPUE (no. of fish/10 traps) was highest for area B and lowest for area A, (Figure 53).

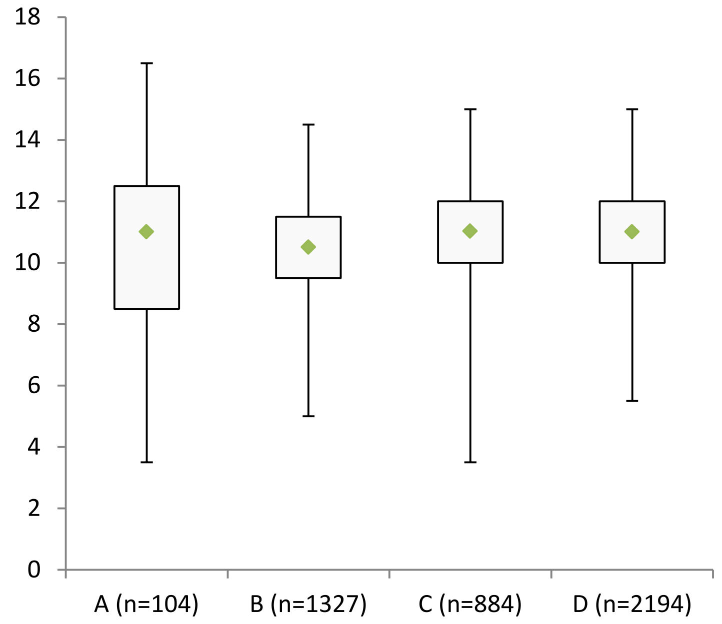
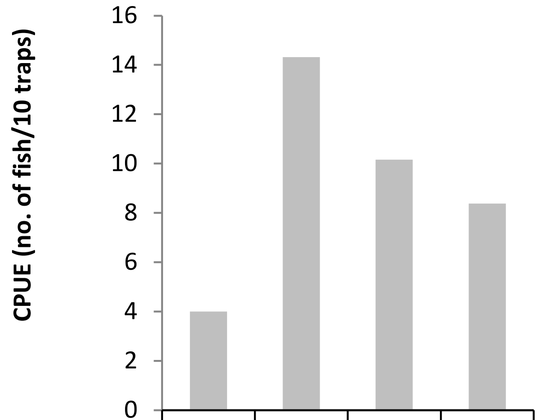


Figure 52: Total length frequency box plot for all goldsinny sampled during the 2017 survey. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.



	A	B	C	D
CPUE (no. of fish/10 traps)	4.00	14.31	10.16	8.38
No. of goldsinny	104	1327	884	2194
No. of traps	260	927	870	2617

Figure 53: Catch per unit effort (CPUE) (no. of fish/10 traps) for all goldsinny sampled during the 2017 survey, grouped by geographic area A-D.

5.10.2 Seasonality

CPUE (no. of fish/10 traps) varied the least in area D (minimum 7.3 fish/10 traps, maximum 10.2 fish/10 traps), and the largest range was in area A (minimum 1.1 fish/10 traps, maximum 15fish/10 traps), (Figure 54).

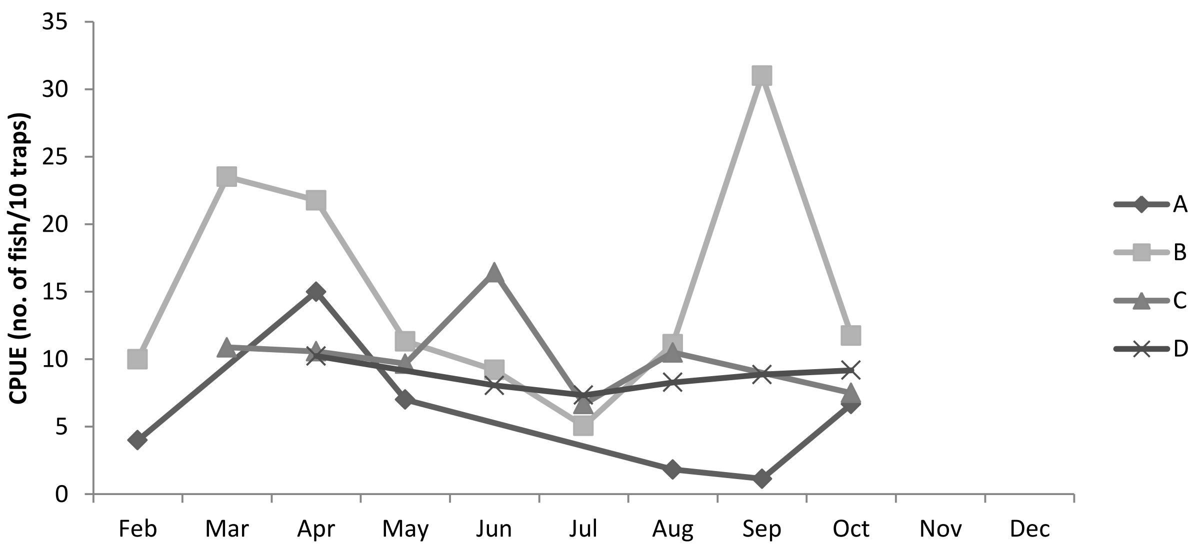


Figure 54: Monthly catch per unit effort (CPUE) (no. of fish/10 traps) of goldsinny wrasse by geographic location A-D.

Length frequency distributions varied the most in area A, however data was limited in this area making it less reliable, in the remaining three areas there was some variation in length frequency distributions (Figure 55).

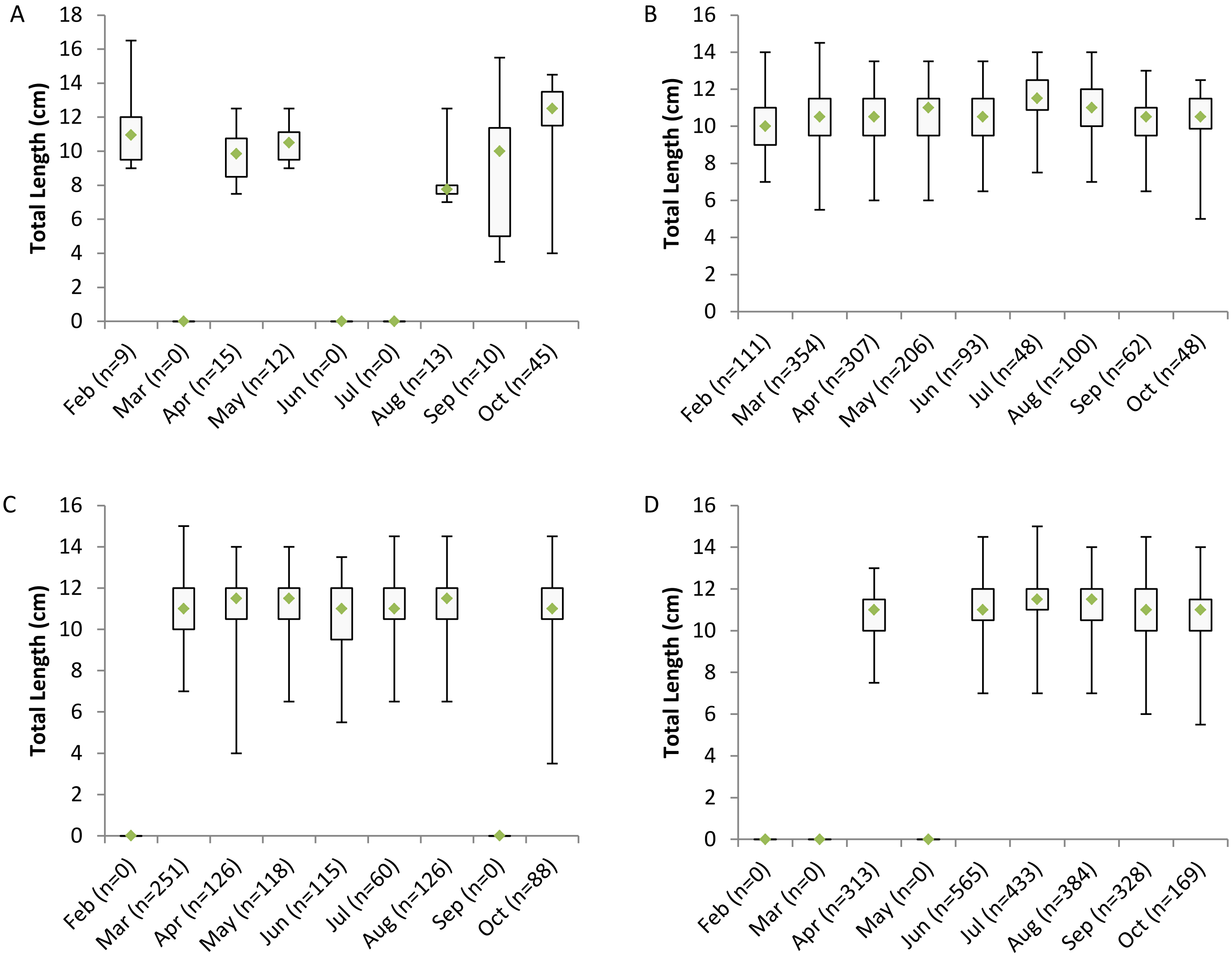


Figure 55: Total length box plots for all goldsinny wrasse sampled in the 2017 survey, grouped by month, by area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.

5.10.3 Spawning

Spawning fish were sampled from May to August (Figure 56). Area B shows a decrease in spawning in August; fish were also sampled in areas A and D during August with no spawning fish present.

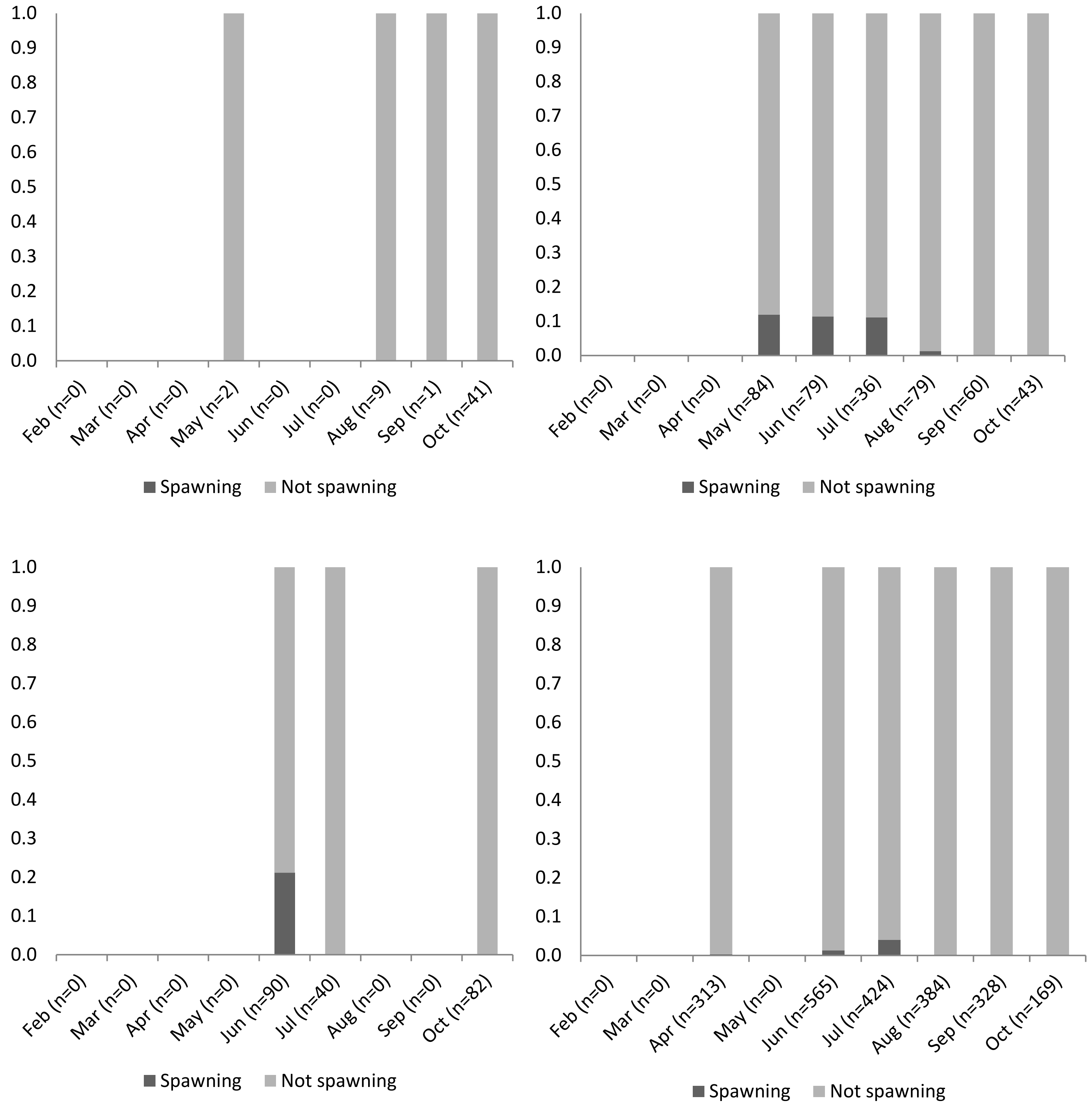
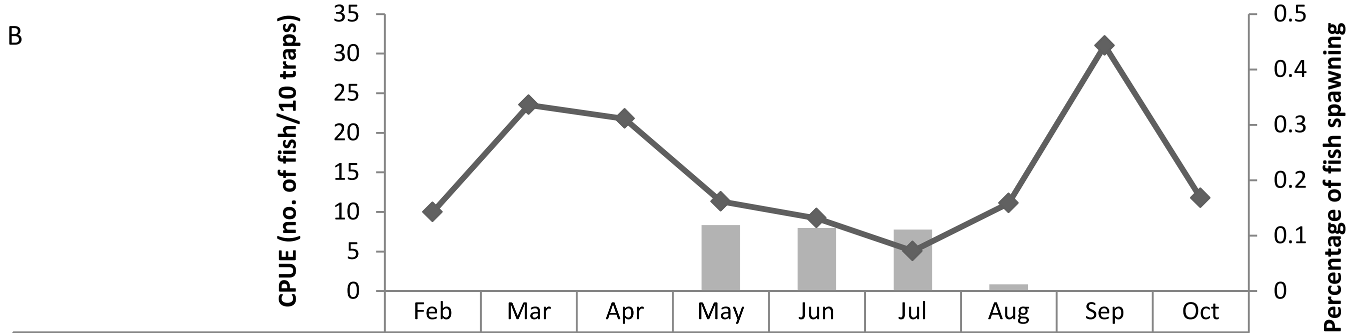


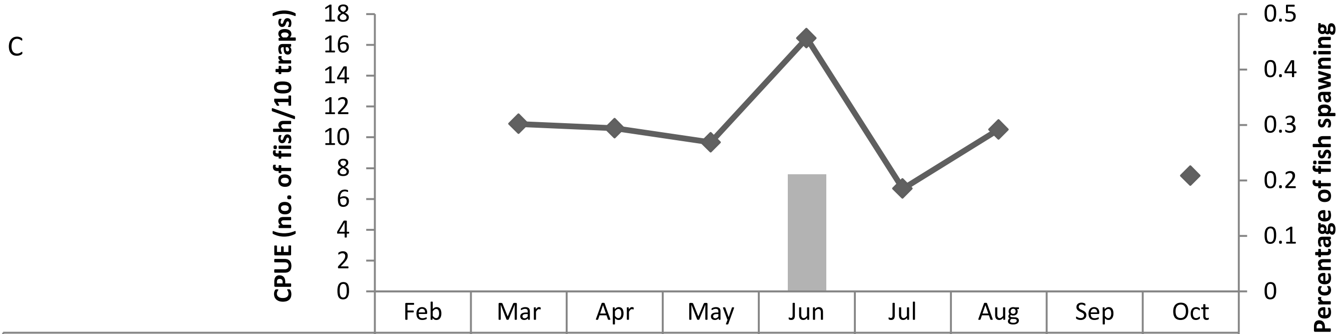
Figure 56: Proportion of spawning goldsinny wrasse to non-spawning goldsinny in areas A to D by month.

5.10.4 CPUE (no. of fish/10 traps) and spawning time

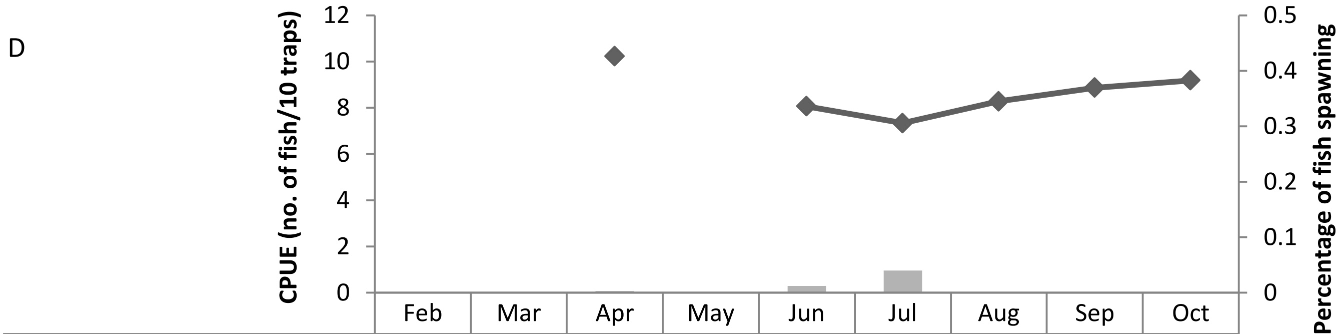
Spawning state and CPUE (no. of fish/10 traps) have been plotted together for areas where spawning fish were sampled (B, C and D). In areas B and C a drop in CPUE (no. of fish/10 traps) coincides with a peak in spawning, however the opposite is true in area C (Figure 57).



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of fish spawning				12%	11%	11%	1%	0%	0%
CPUE	10.00	23.51	21.77	11.32	9.21	5.05	11.11	31.00	11.75



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of fish spawning					21%	0%			0%
CPUE		10.87	10.58	9.67	16.43	6.67	10.50		7.50



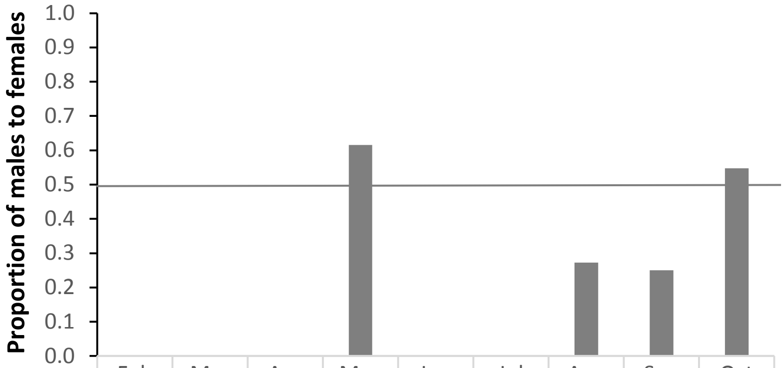
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of fish spawning			0%		1%	4%	0%	0%	0%
CPUE			10.23		8.06	7.34	8.28	8.86	9.18

Figure 57: Catch per unit effort (CPUE) (no. of fish/10 traps) plotted with percentage of goldsinny spawning for areas B, C and D. Area A has been omitted due to no spawning fish being sampled.

5.10.5 Sex Ratios

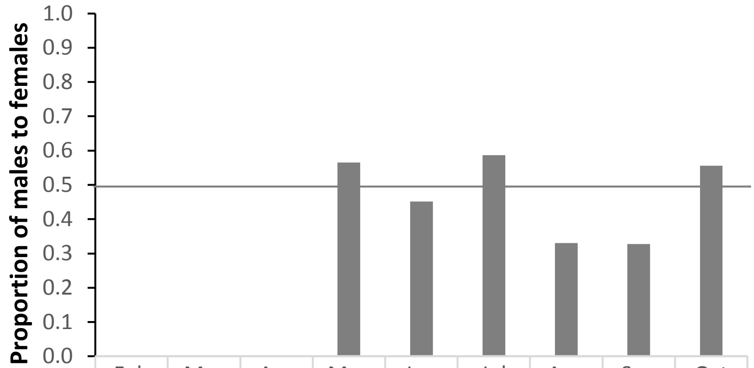
Sex ratios of goldsinny wrasse varied by month for all areas (Figure 58).

A



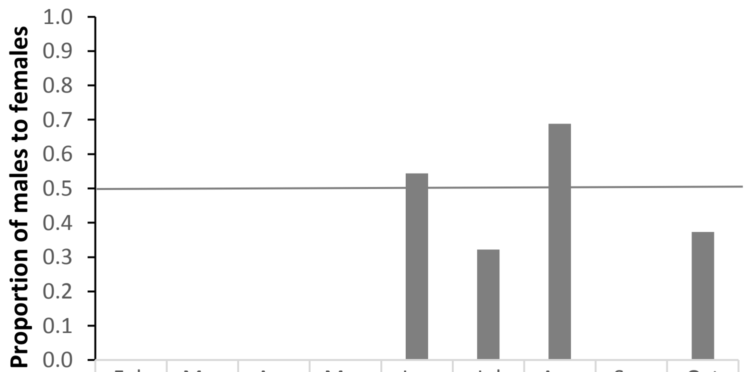
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.00	0.00	0.62	0.00	0.00	0.27	0.25	0.55
Male	0	0	0	8	0	0	3	1	23
Female	0	0	0	5	0	0	8	3	19
Unknown	8	0	15	1	0	0	2	4	4

B



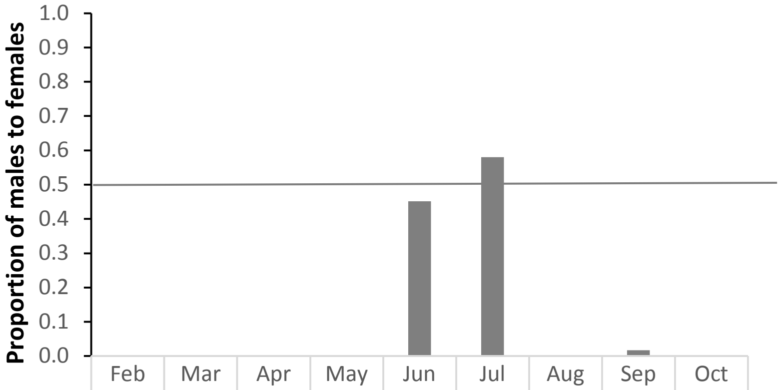
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.00	0.00	0.57	0.45	0.59	0.33	0.33	0.56
Male	0	0	0	113	42	27	32	19	25
Female	0	0	0	87	51	19	65	39	20
Unknown	111	355	307	6	0	0	3	4	2

C



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.00	0.00	0.00	0.54	0.32	0.69	0.00	0.37
Male	0	0	0	0	62	19	86	0	31
Female	0	0	0	0	52	40	39	0	52
Unknown	0	250	127	116	1	0	1	0	7

D



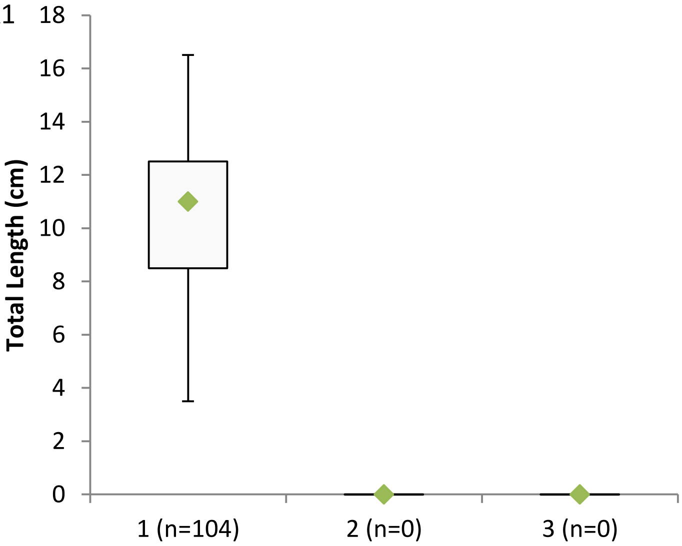
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.00	0.00	0.00	0.45	0.58	0.00	0.02	0.00
Male	0	0	0	0	185	203	0	1	0
Female	0	0	1	0	225	147	117	58	48
Unknown	0	0	312	0	155	85	267	269	121

Figure 58: Sex ratios of goldsinny wrasse by month by area A to D.

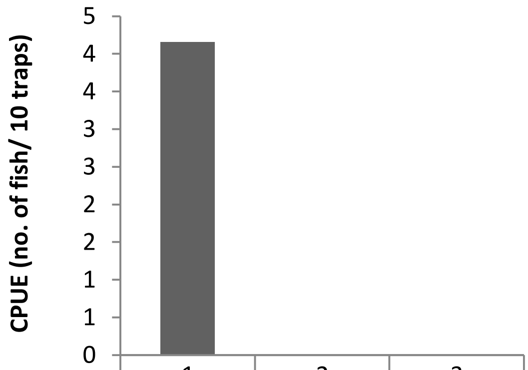
5.10.6 Charted Depth

Areas B, C and D showed an increase in CPUE in depth band 2 compared to depth band 1, with a corresponding decrease in mean average total (Figure 59, B1 to D2). In area A goldsinny were only sampled in depth band 1, none were present in the ten traps sampled in depth band 2 (Figure 59, A1 to A2).

A1

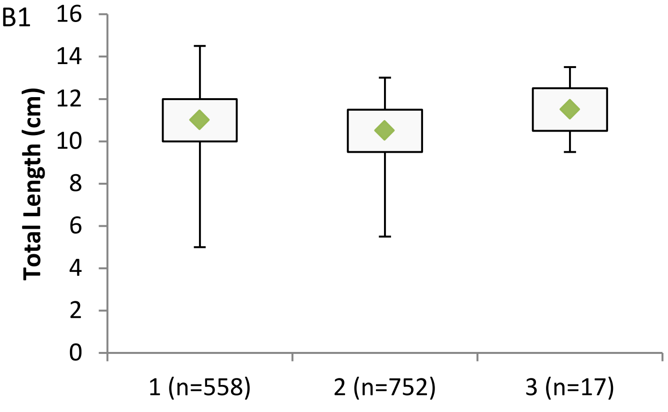


A2

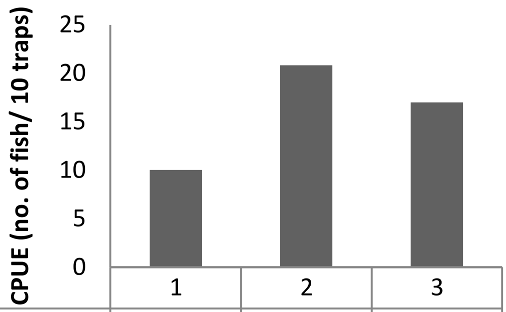


	1	2	3
CPUE (no. of fish/10 traps)	4.16	0	0
No. of traps	250	10	0
No. of goldsinny	104	0	0

B1

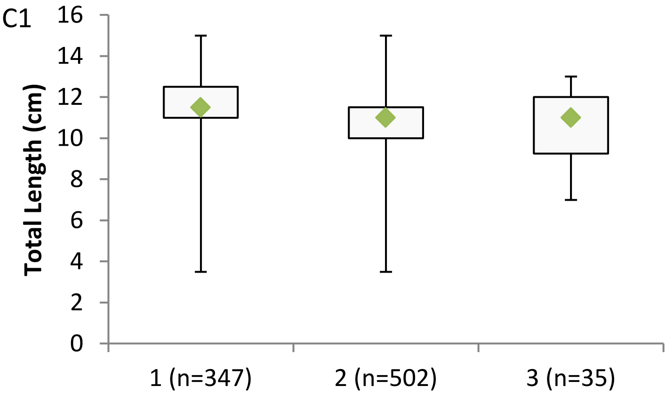


B2

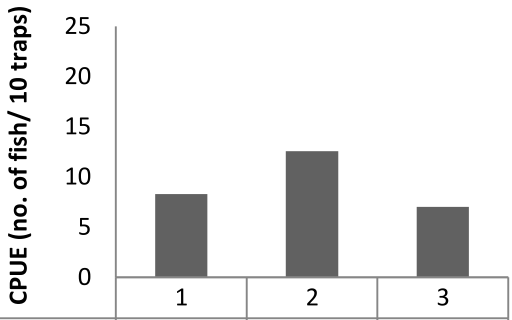


	1	2	3
CPUE (no. of fish/10 traps)	10.04	20.83	17.00
No. of traps	556	361	10
No. of goldsinny	558	752	17

C1

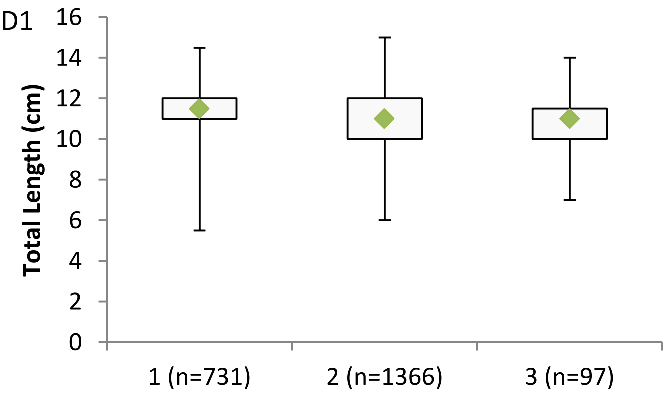


C2

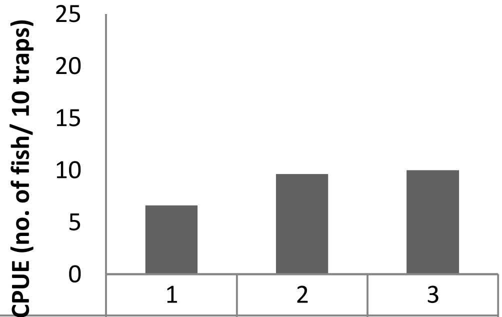


	1	2	3
CPUE (no. of fish/10 traps)	8.26	12.55	7.00
No. of traps	420	400	50
No. of goldsinny	347	502	35

D1



D2

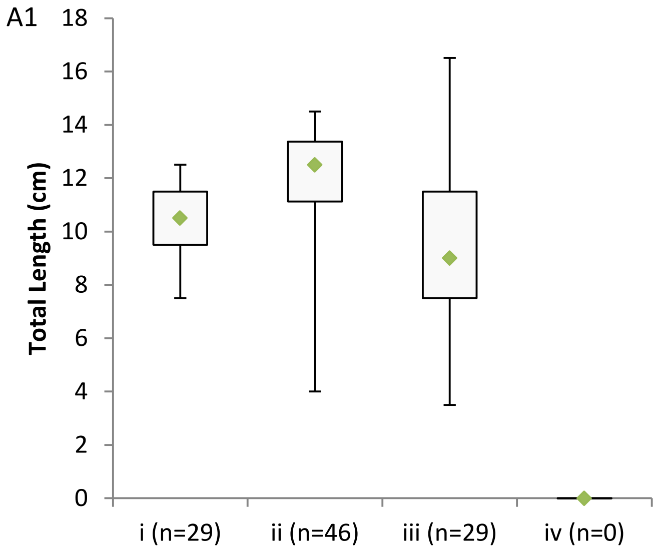


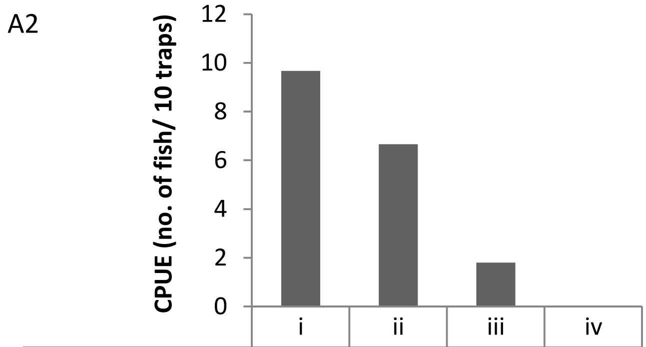
	1	2	3
CPUE (no. of fish/10 traps)	6.63	9.64	10.00
No. of traps	1103	1417	97
No. of goldsinny	731	1366	97

Figure 59: Plots A1 to A4 are box plots showing goldsinny wrasse length frequency distribution by area A to D, by depth categories 1 to 3 , points represent median, boxes represent the interquartile range and error bars represent range. Charts A2 to D2 are catch per unit effort (CPUE) (no. of fish/10 traps) of goldsinny wrasse for areas A to D by depth category 1 to 3.

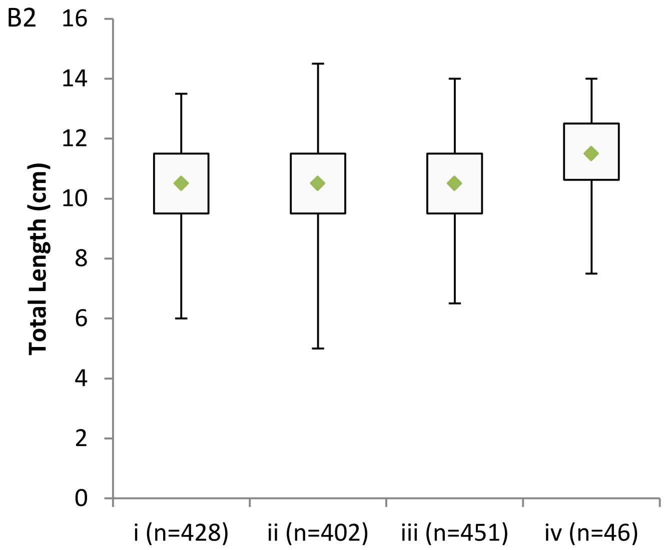
5.10.7 Tidal Range

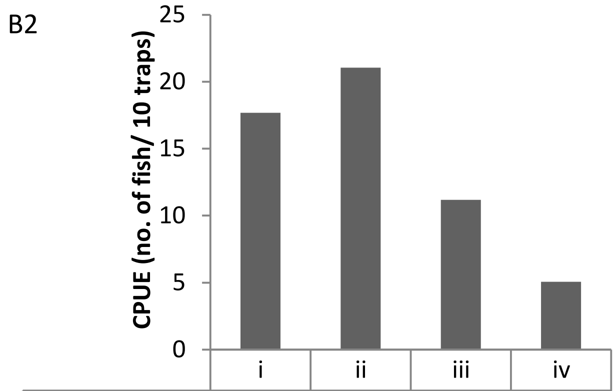
Length frequency distributions in area B, C and D no not appear to vary a great deal with changing tidal range category; however this has not been tested for significance (Figure 60, B1-D1). Tidal range category appears to have the greatest influence on CPUE (no. of fish/10 traps) in areas A and B (Figure 60, A2 to B2), there is limited data in area C and area D has the smallest fluctuations in CPUE and length frequency distributions (no. of fish/ 10 traps) (Figure 60, C1 to D2).



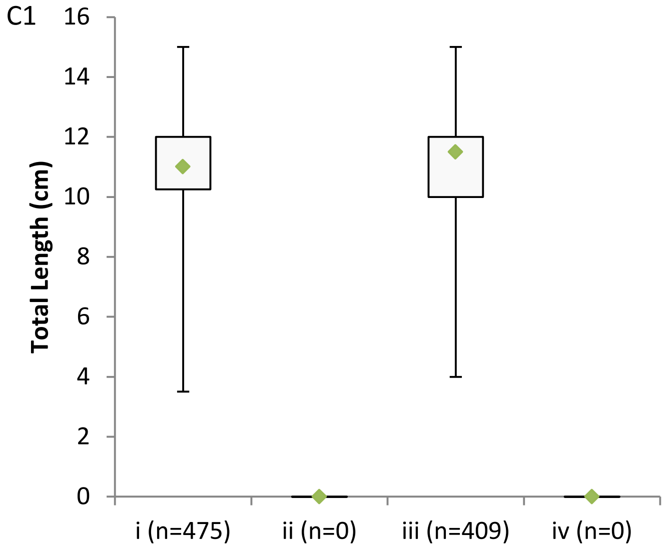


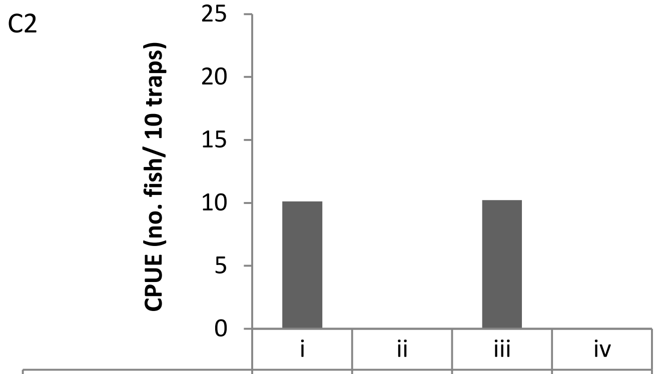
	i	ii	iii	iv
CPUE (no. of fish/10 traps)	9.67	6.67	1.80	0.00
No. of traps	30	69	161	0
No. of goldsinny	29	46	29	0



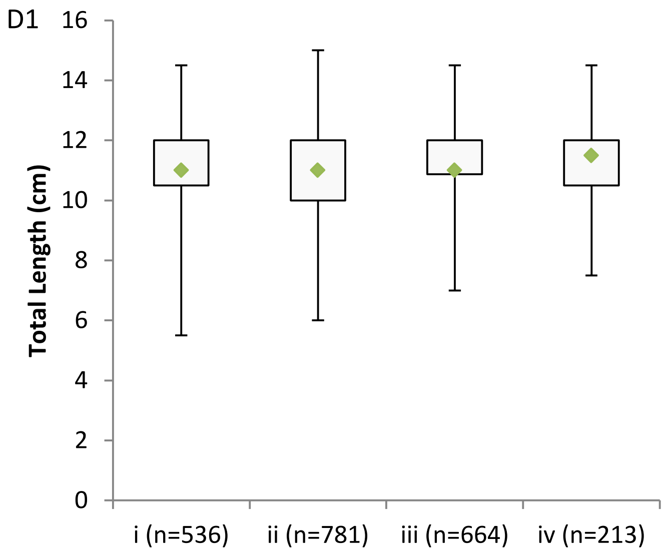


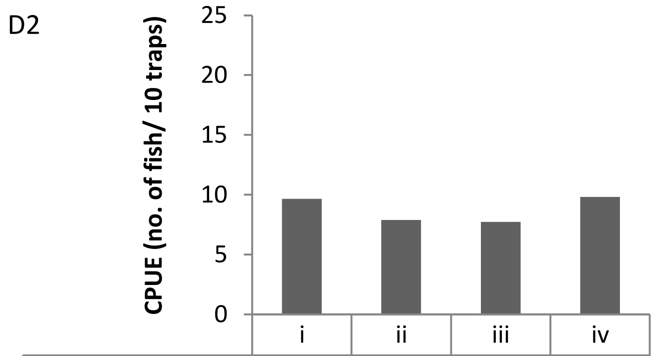
	i	ii	iii	iv
CPUE (no. of fish/10 traps)	17.69	21.05	11.19	5.05
No. of traps	242	191	403	91
No. of goldsinny	428	402	451	46





	i	ii	iii	iv
CPUE (no. of fish/10 traps)	10.11	0.00	10.23	0.00
No. of traps	470	0	400	0
No. of goldsinny	475	0	409	0



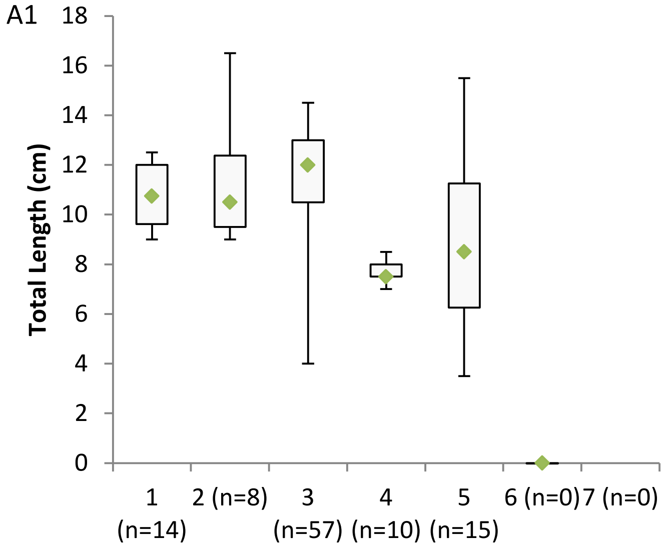


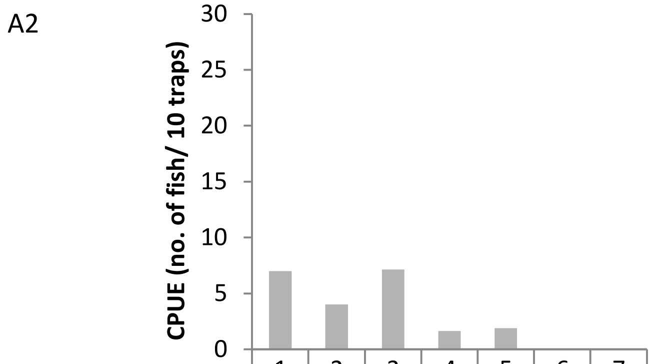
	i	ii	iii	iv
CPUE (no. of fish/10 traps)	9.68	7.90	7.75	9.82
No. of traps	554	989	857	217
No. of goldsinny	536	781	664	213

Figure 60: Plots A1 to D1 are box plots showing goldsinny wrasse length frequency distribution by area A to D, by tidal range categories I to iv, points represent median, boxes represent the interquartile range and error bars represent range. Charts A2 to D2 are catch per unit effort (CPUE) (no. of fish/10 traps) of goldsinny wrasse for areas A to D by tidal range category I to iv.

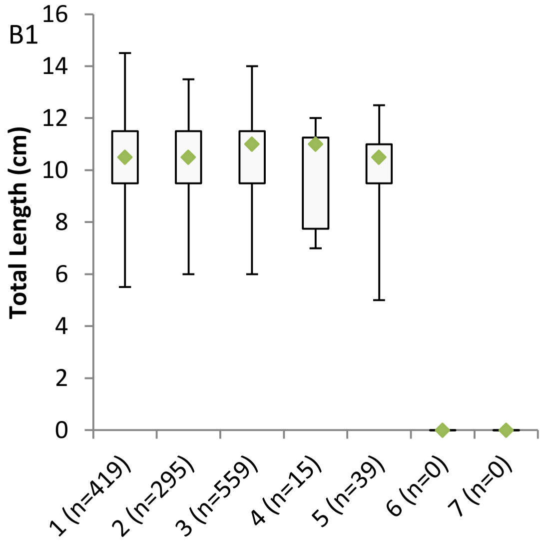
5.10.8 Nights Lie

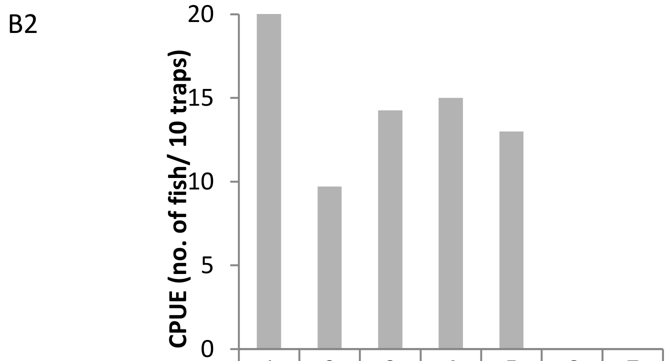
Length frequency distribution does appear to vary with nights lie, however no clear trends are apparent at this stage of analysis (Figure 61, A1 to D1).CPUE (no. of fish/10 traps) increases with nights lie for areas C and D (Figure 61, C2 and D2). This trend is not observed in areas A and B (Figure 61, A2 and B2).



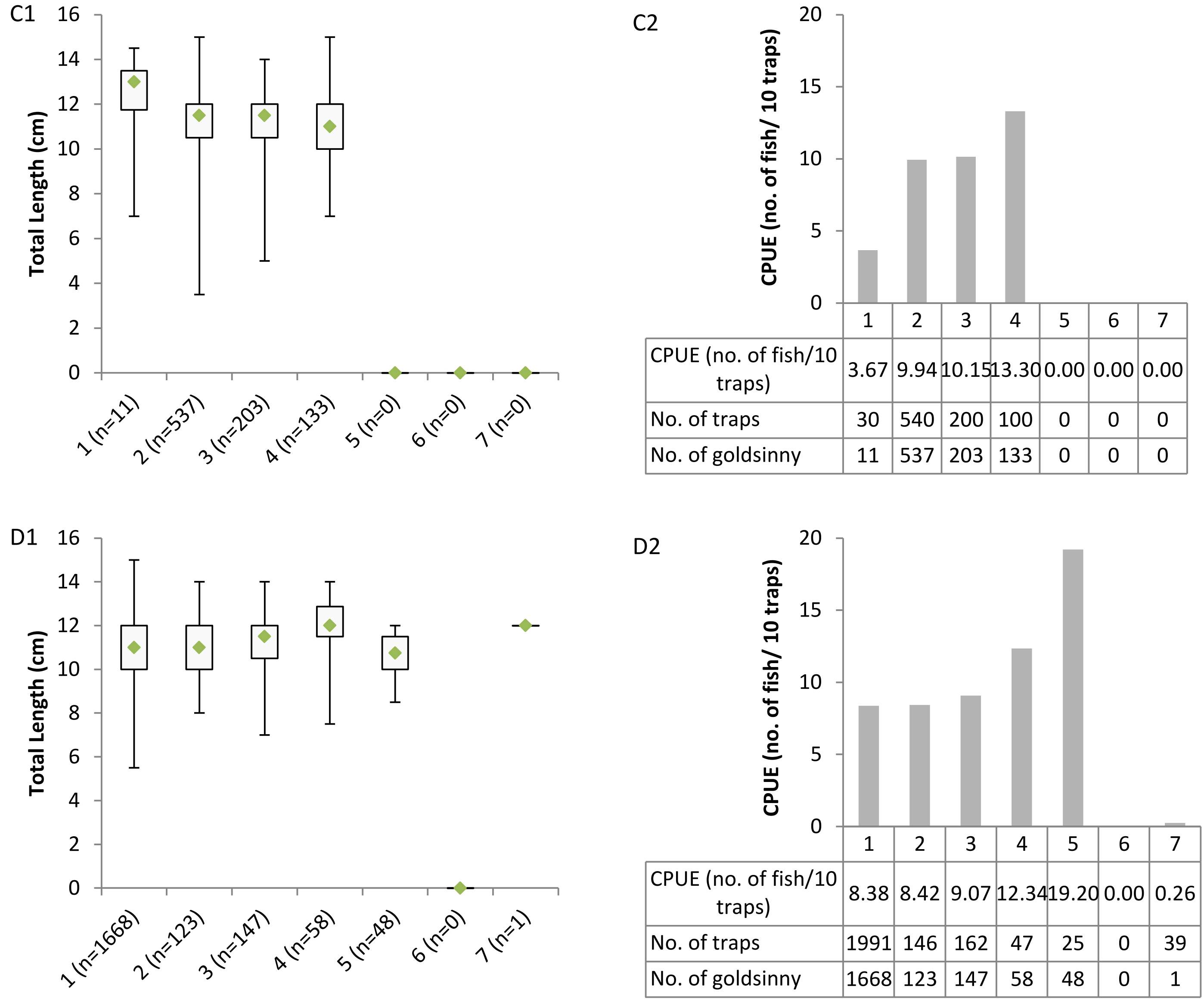


	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	7.00	4.00	7.13	1.64	1.90	0.00	0.00
No. of traps	20	20	80	61	79	0	0
No. of goldsinny	14	8	57	10	15	0	0





	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	21.9	9.70	14.2	15.0	13.0	0.00	0.00
No. of traps	191	304	392	10	30	0	0
No. of goldsinny	419	295	559	15	39	0	0



	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	3.67	9.94	10.15	13.30	0.00	0.00	0.00
No. of traps	30	540	200	100	0	0	0
No. of goldsinny	11	537	203	133	0	0	0

	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	8.38	8.42	9.07	12.34	19.20	0.00	0.26
No. of traps	1991	146	162	47	25	0	39
No. of goldsinny	1668	123	147	58	48	0	1

Figure 61: Plots A1 to D1 are box plots showing goldsinny wrasse length frequency distribution by area A to D, by nights lie, points represent median, boxes represent the interquartile range and error bars represent range. Charts A2 to D2 are catch per unit effort (CPUE) (no. of fish/10 traps) of goldsinny wrasse for areas A to D by nights lie.

5.11 Rock cook wrasse (*Centrolabrus exoletus*)

A total of 3202 rock cook were sampled by Cornwall IFCA and Devon & Severn IFCA (1709 and 1493 respectively); A (n=1), B (n=1181), C (n=508), and D (n=1512).

The mean average total length of all rock cook sampled was 10.57cm, with a minimum of 5.5cm, and maximum of 18.5cm.

5.11.1 Geographic Location

Mean average total lengths of fish sampled appear similar in categories B to D (Figure 62). Only one rock cook was sampled in area A resulting in a lower CPUE than the remaining three areas (Figure 63).

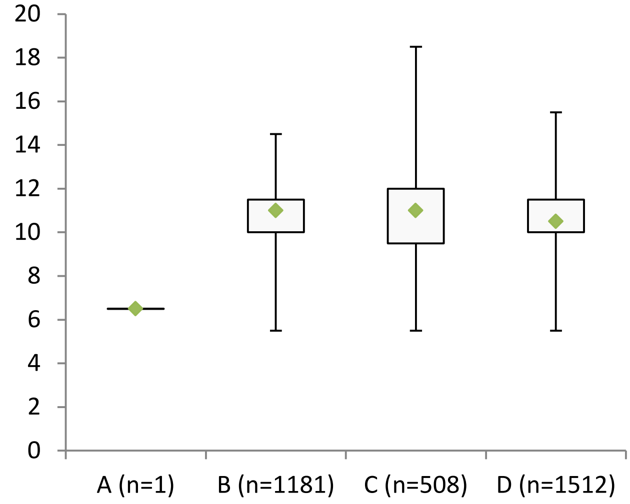
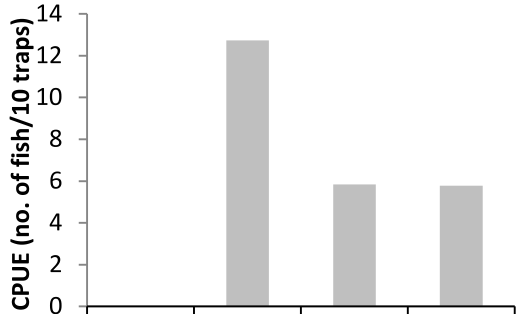


Figure 62: Total length frequency box plot for all rock cook sampled during the 2017 survey. Data is grouped by geographic area A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.



	A	B	C	D
CPUE (no. of fish/10 traps)	0.04	12.74	5.84	5.78
No. of rock cook	1	1181	508	1512
No. of traps	260	927	870	2617

Figure 63: Catch per unit effort (CPUE) (no. of fish/10 traps) for all rock cook sampled during the 2017 survey, grouped by geographic area A-D.

5.11.2 Seasonality

Area B had noticeably higher CPUE in March and April than other months, and all months in all other areas (Figure 64).

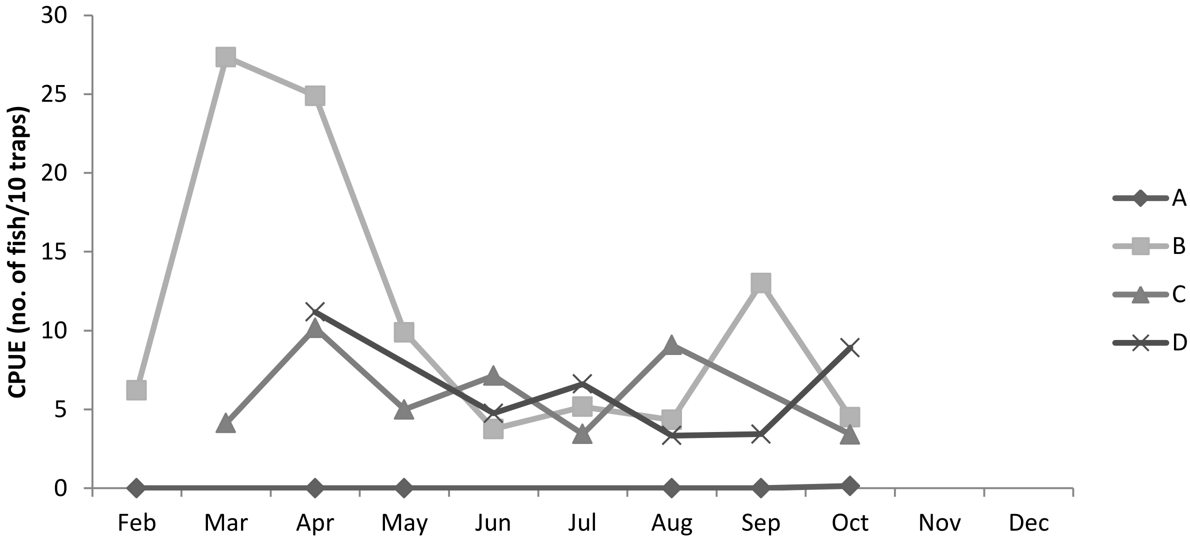


Figure 64: Monthly catch per unit effort (CPUE) (no. of fish/10 traps) of rock cook wrasse by geographic location A-D.

Length frequency varied by month in all areas (Figure 65).

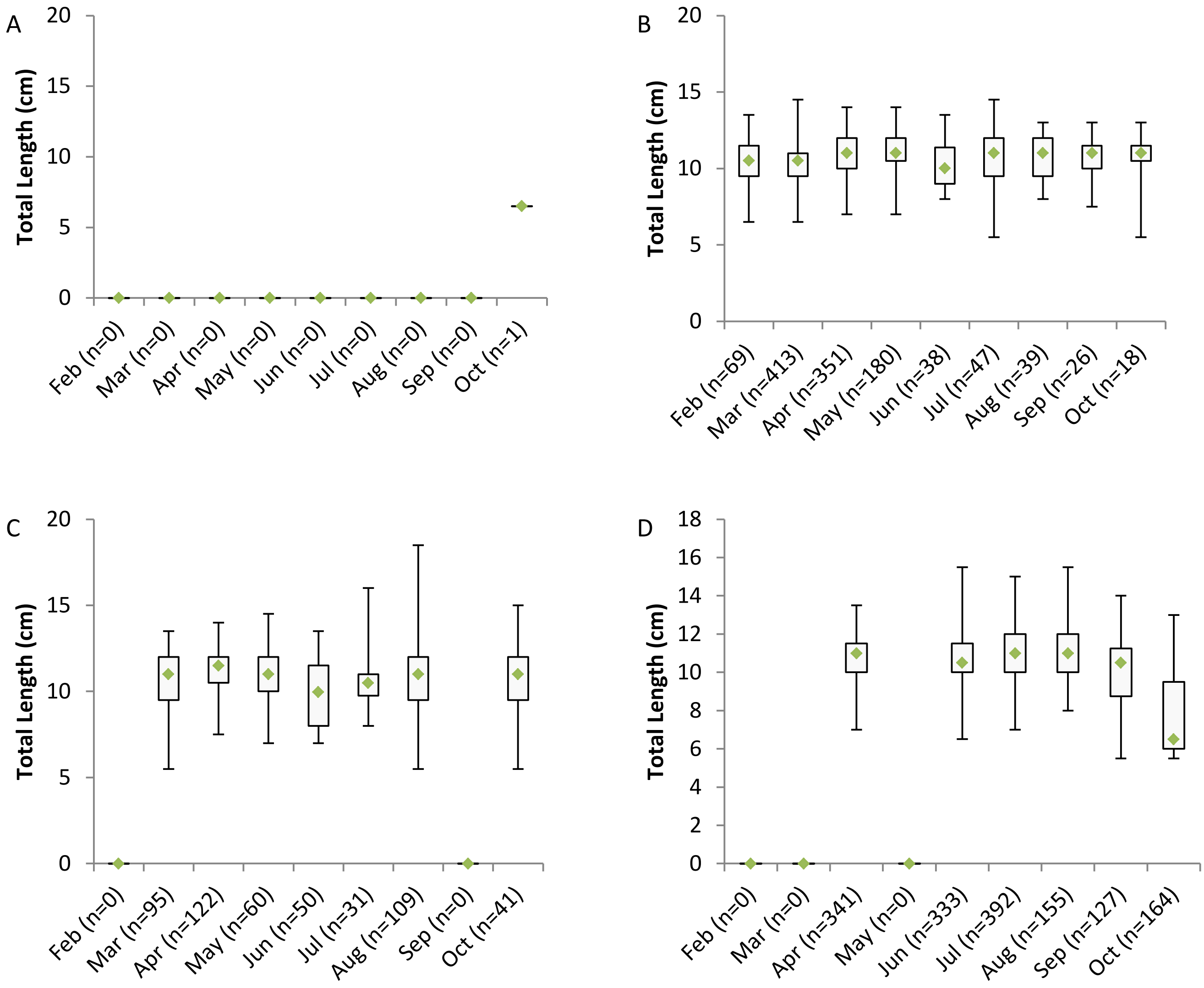


Figure 65: Total length box plots for all rock cook wrasse sampled in the 2017 survey, grouped by month, for areas A-D. Points represent median, boxes represent the inter-quartile range and error bars represent range.

5.11.3 Spawning

Spawning individuals were observed in May, June and July (in area C and D no fish were sampled in May, Figure 66). In all areas, where spawning fish were observed, there was a decrease in the proportion of spawning individuals from June to July (area B 0.29 decrease, area C 0.58 and area D 0.02 decrease).

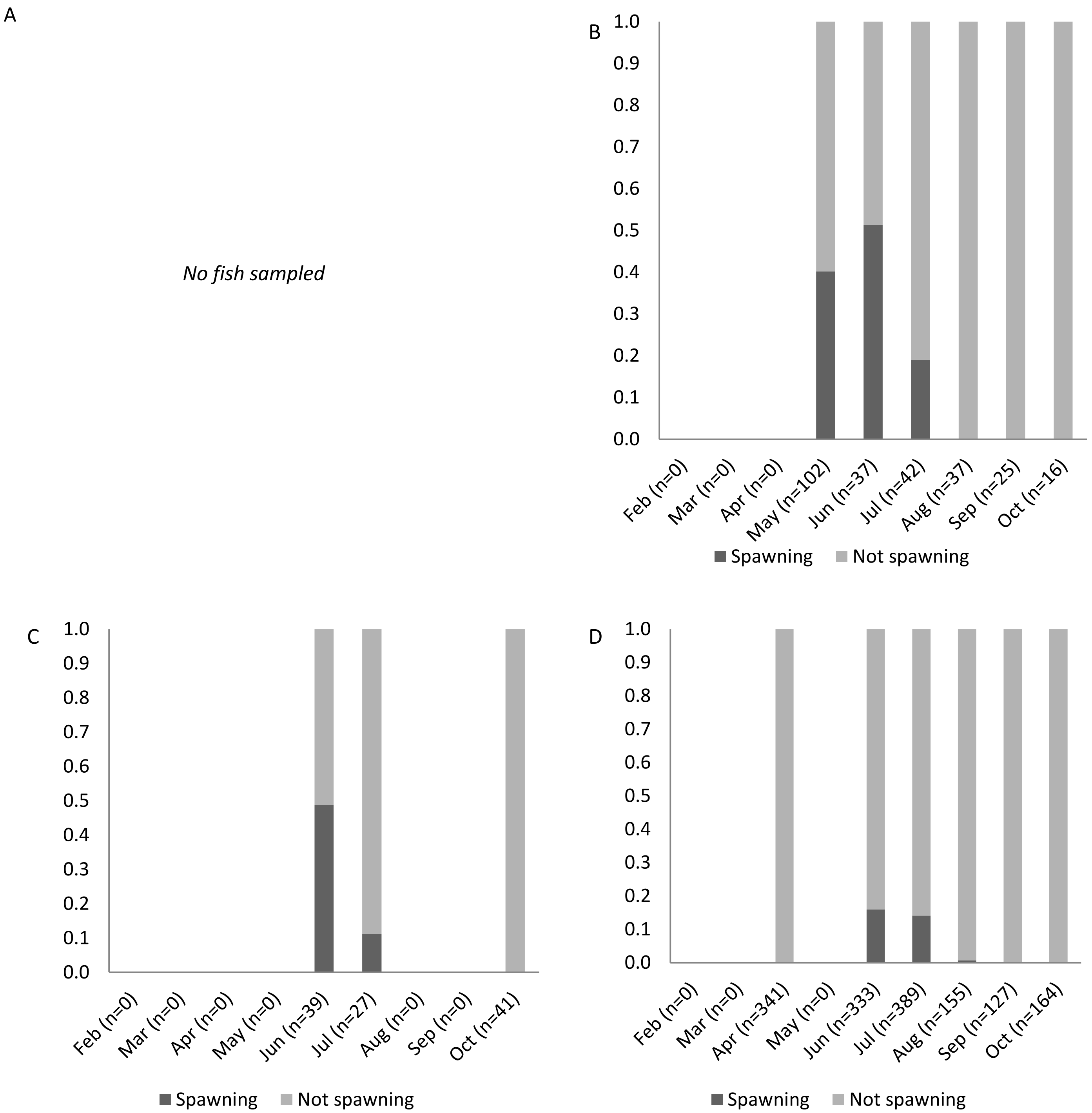
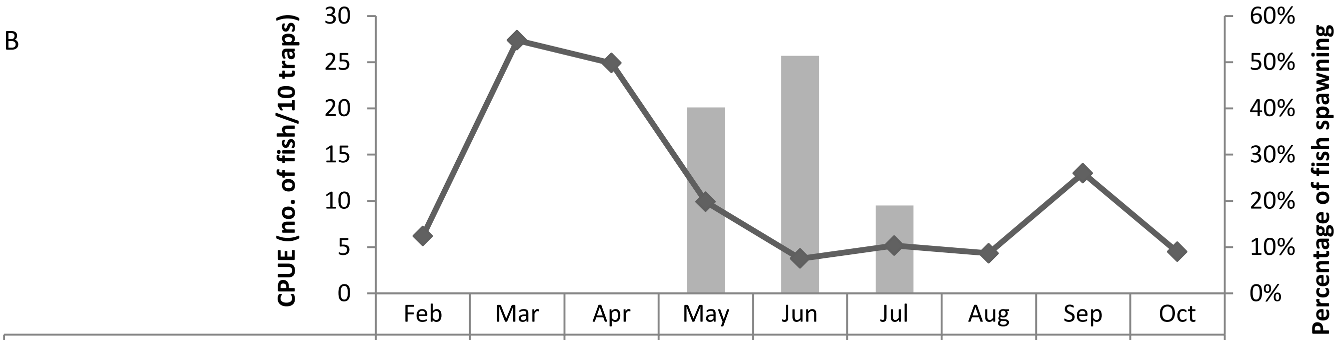


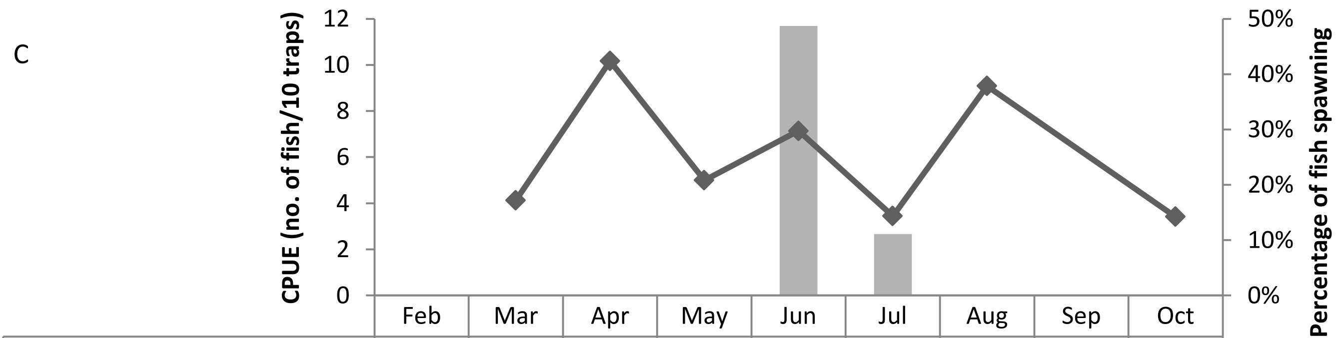
Figure 66: Proportion of spawning rock cook wrasse to non-spawning goldsinny in areas A to D by month.

5.11.4 CPUE (no. of fish/10 traps) and spawning time

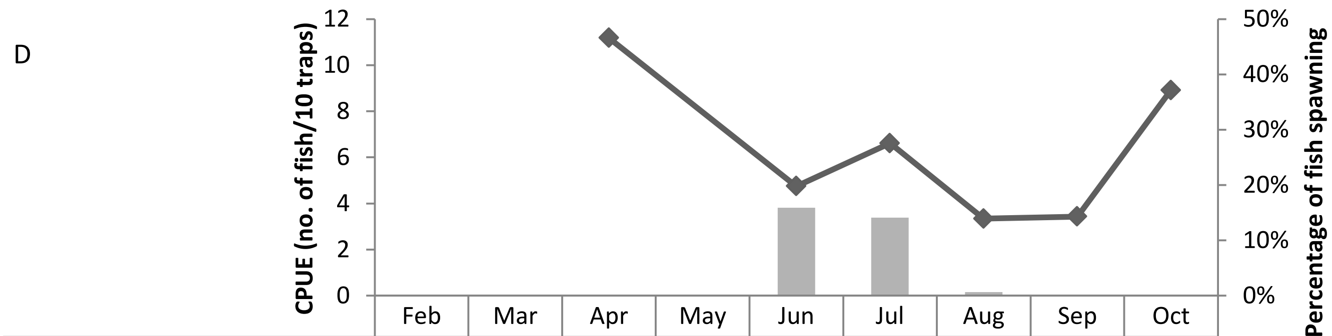
Spawning state and CPUE (no. of fish/10 traps) have been plotted together for areas where spawning fish were sampled (B, C and D). In area B there is a decrease in CPUE (no. of fish/10 traps) during the peak spawning time (Figure 67, B), however there is not such a clear pattern in areas C and D (Figure 67, C and D).



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of fish spawning	0%	0%	0%	40%	51%	19%	0%	0%	0%
CPUE	6.22	27.35	24.89	9.89	3.76	5.16	4.33	13.00	4.50



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of fish spawning	0%	0%	0%	0%	49%	11%	0%	0%	0%
CPUE		4.13	10.17	5.00	7.14	3.44	9.08		3.42



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of fish spawning	0%	0%	0%	0%	16%	14%	1%	0%	0%
CPUE			11.18		4.75	6.61	3.34	3.43	8.91

Figure 67: Catch per unit effort (CPUE) (no. of fish/10 traps) plotted with percentage of rock cook spawning for areas B, C and D. Area A has been omitted due to no spawning fish being sampled.

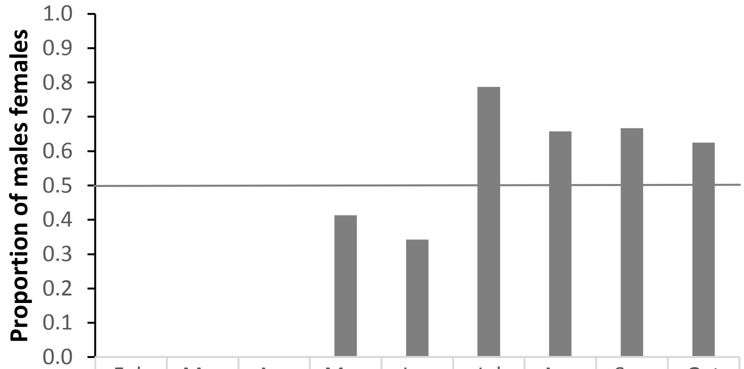
5.11.5 Sex Ratios

Proportions of males peaked in areas B and C in July (0.79, and 0.73 respectively), in area D this peak was in August (1.0, however only 16 individuals were sampled, Figure 68).

A

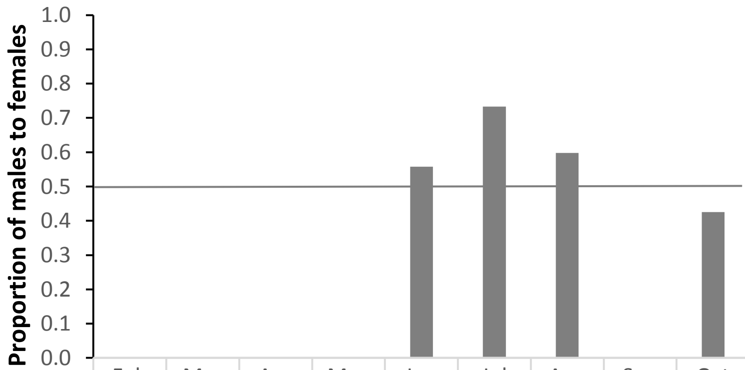
One fish sampled, sex unknown

B



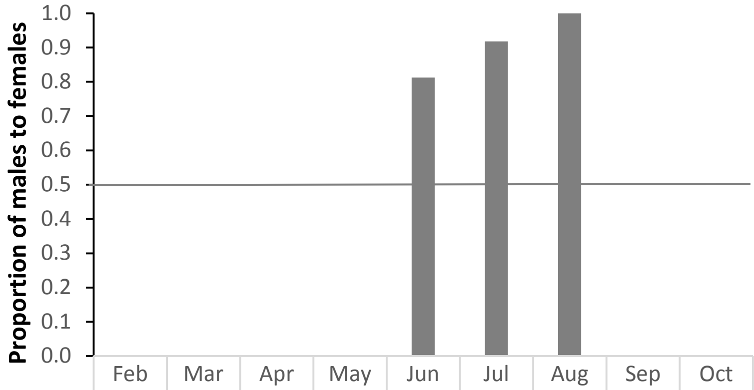
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.00	0.00	0.41	0.34	0.79	0.66	0.67	0.63
Male	0	0	0	74	13	37	25	10	10
Female	0	0	0	105	25	10	13	5	6
Unknown	69	413	351	1	0	0	1	11	2

C



	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.00	0.00	0.00	0.56	0.73	0.60	0.00	0.43
Male	0	0	0	0	24	22	58	0	17
Female	0	0	0	0	19	8	39	0	23
Unknown	0	95	122	60	7	0	12	0	1

D



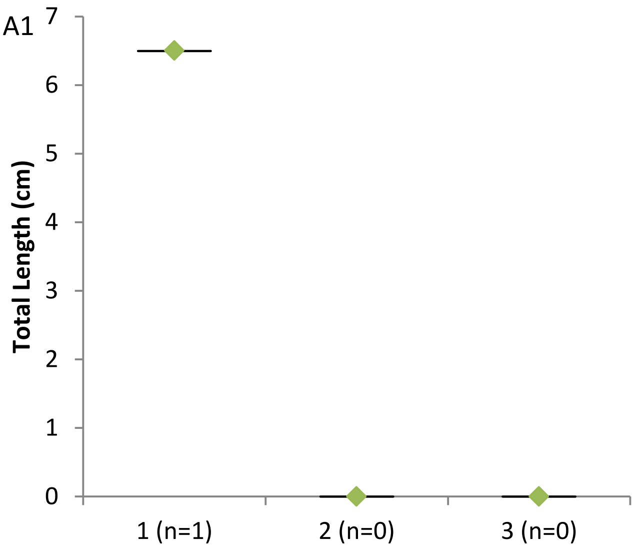
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Proportion of males	0.00	0.00	0.00	0.00	0.81	0.92	1.00	0.00	0.00
Male	0	0	0	0	108	145	16	0	0
Female	0	0	0	0	25	13	0	0	0
Unknown	0	0	341	0	200	234	139	127	164

Figure 68: Sex ratios of rock cook wrasse by month in areas A to D. Grey horizontal line indicates 50%.

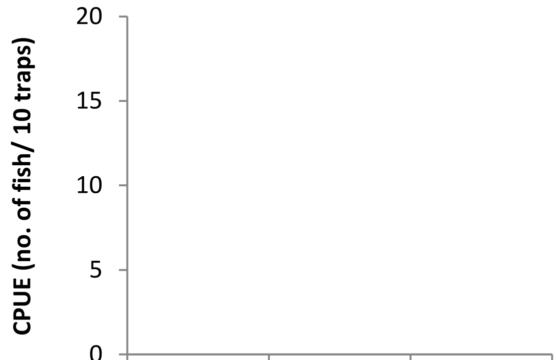
5.11.6 Charted Depth

In areas B, C and D Length frequency distributions appear to vary slightly, however this has not been tested for significance (Figure 69, B1 to D1). In area A only one rock cook was sampled (Figure 69, A1 and A2). In areas B, C and D CPUE increased from depth category 1 to 2 (Figure 69, B2 to D2), in areas B and C a decrease in CPUE followed in category 3, however in area D there was a further increase in CPUE in category 3 (in all three areas discussed sample rates were lower in depth category 3 making data less reliable).

A1

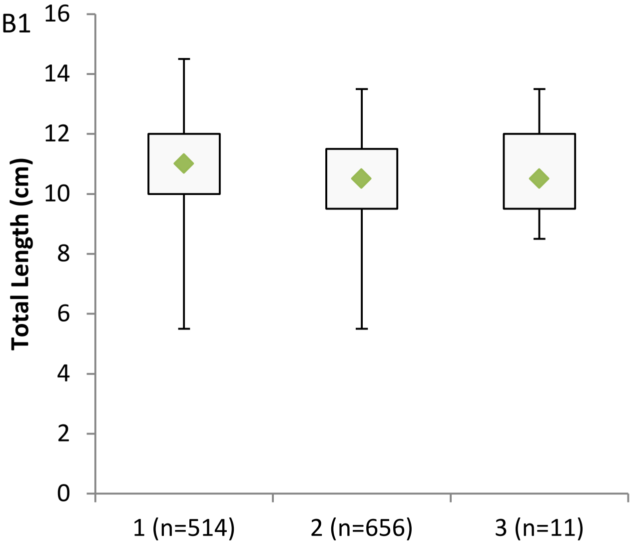


A2

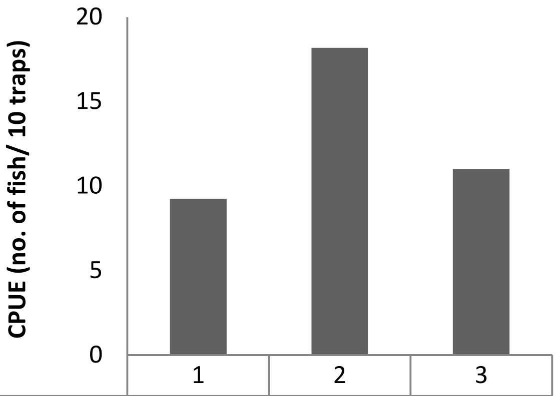


	1	2	3
CPUE (no. of fish/10 traps)	0.04	0	0
No. of traps	250	10	0
No. of rock cook	1	0	0

B1

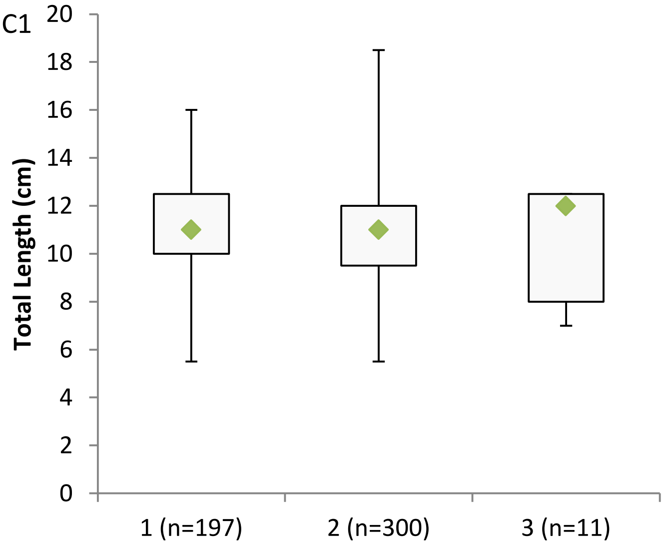


B2

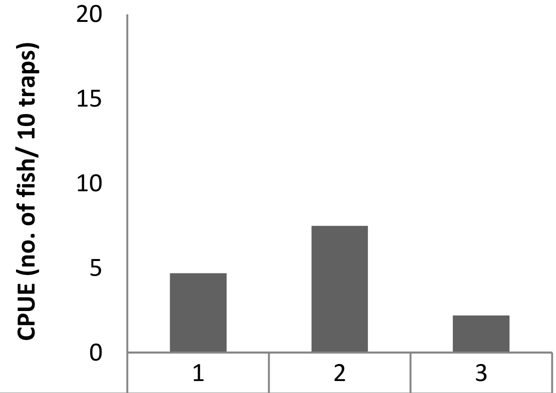


	1	2	3
CPUE (no. of fish/10 traps)	9.24	18.17	11.00
No. of traps	556	361	10
No. of rock cook	514	656	11

C1

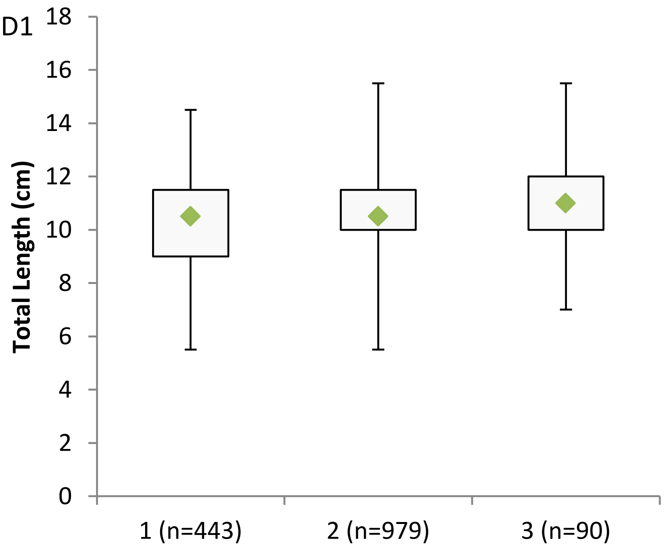


C2

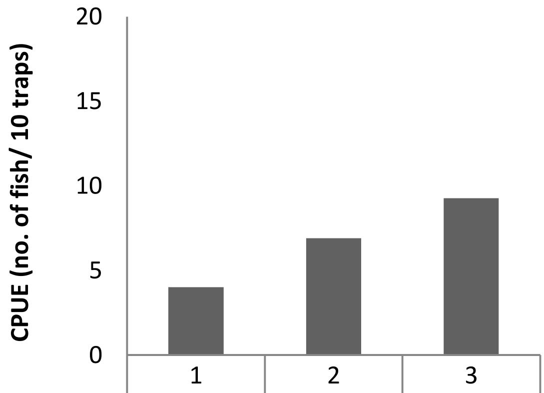


	1	2	3
CPUE (no. of fish/10 traps)	4.69	7.50	2.20
No. of traps	420	400	50
No. of rock cook	197	300	11

D1



D2



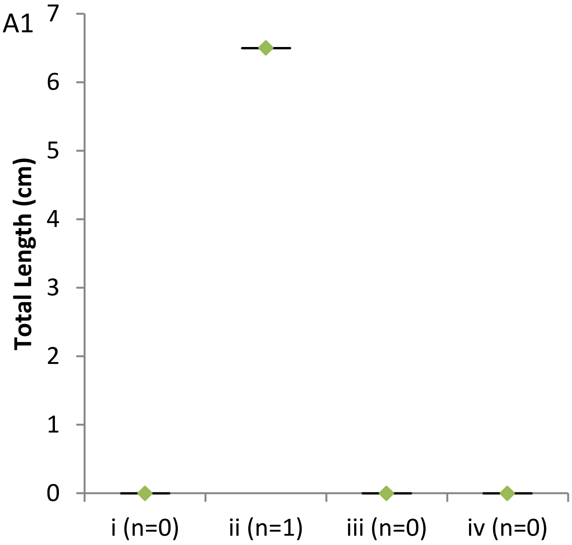
	1	2	3
CPUE (no. of fish/10 traps)	4.02	6.91	9.28
No. of traps	1103	1417	97
No. of rock cook	443	979	90

Figure 69: Plots A1 to D1 are box plots showing rock cook wrasse length frequency distribution by area A to D, by depth categories 1 to 3, points represent median, boxes represent the interquartile range and error bars represent range. Charts A2 to D2 are catch per unit effort (CPUE) (no. of fish/10 traps) of rock cook wrasse for areas A to D by depth category 1 to 3.

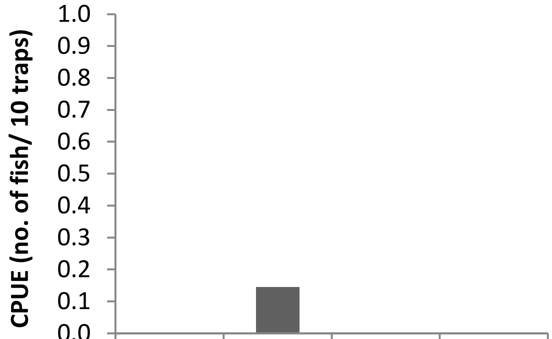
5.11.7 Tidal Range

Length frequency distributions seem to vary in area D with tidal range category (Figure 70, D1). Sampling was conducted in all four tidal range categories in areas B and D, in areas A and C data was not collected in all categories (Figure 70, A2 to D2). In area B CPUE (no. of fish/10 traps) was highest in category ii, with the lowest mean average total length also in this category (Figure 70, B1 and B2).

A1

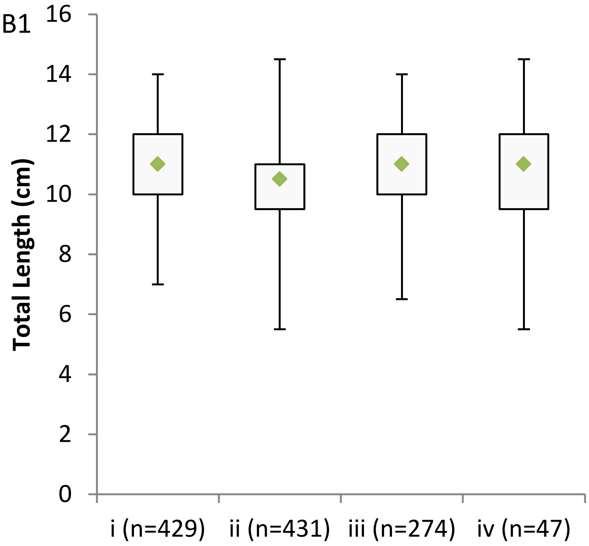


A2

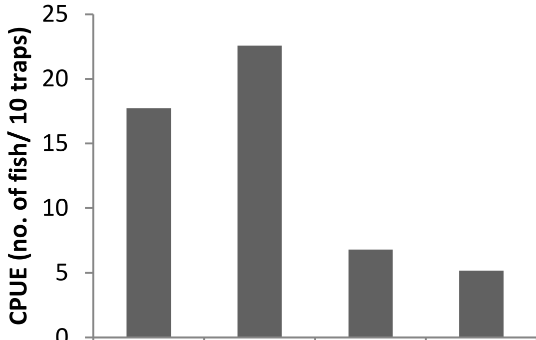


	i	ii	iii	iv
CPUE (no. of fish/10 traps)	0.00	0.14	0.00	0.00
No. of traps	30	69	161	0
No. of rock cook	0	1	0	0

B1

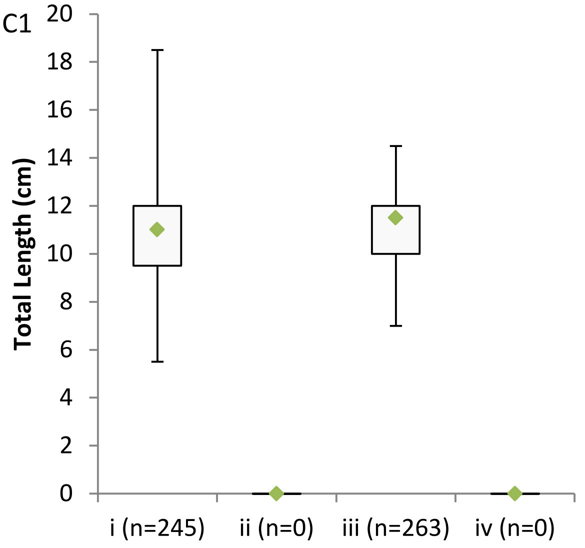


B2

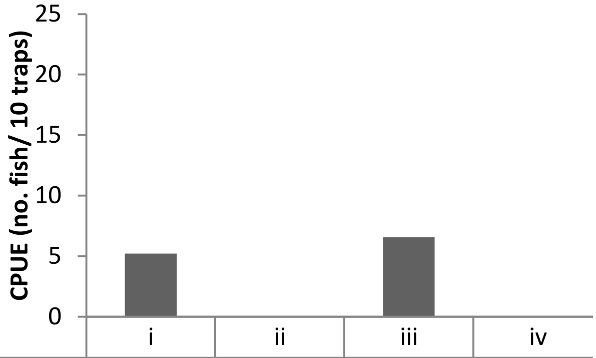


	i	ii	iii	iv
CPUE (no. of fish/10 traps)	17.73	22.57	6.80	5.16
No. of traps	242	191	403	91
No. of rock cook	429	431	274	47

C1

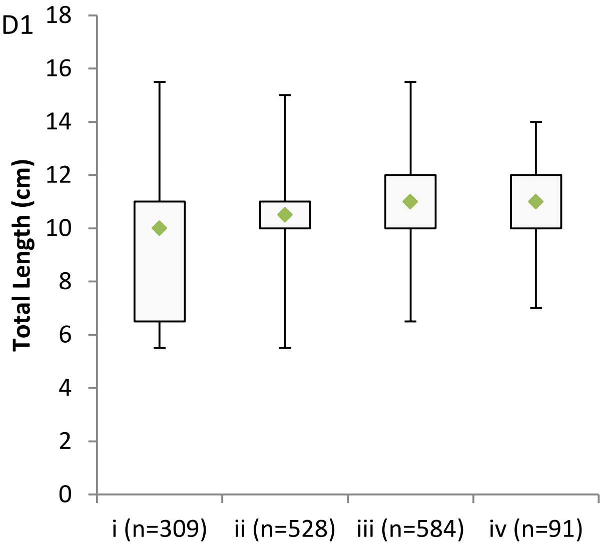


C2

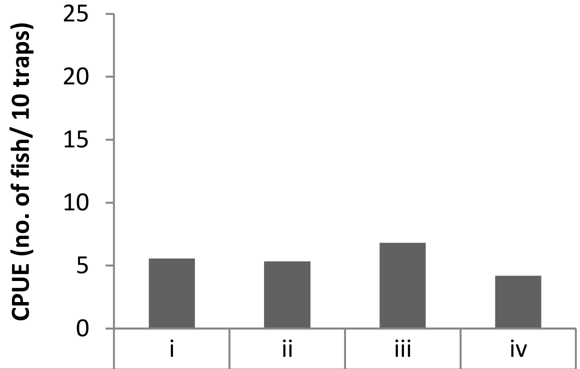


	i	ii	iii	iv
CPUE (no. of fish/10 traps)	5.21	0.00	6.58	0.00
No. of traps	470	0	400	0
No. of rock cook	245	0	263	0

D1



D2



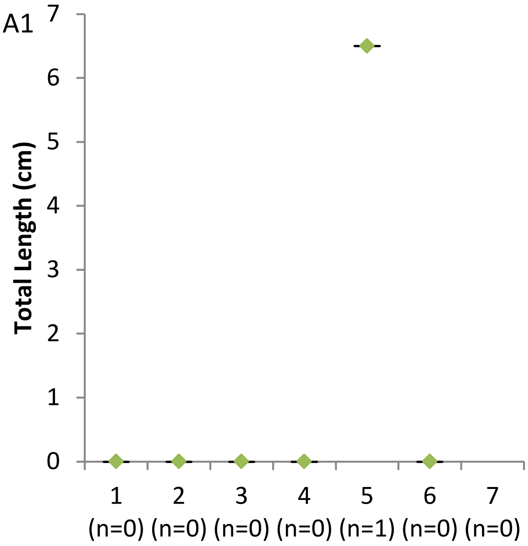
	i	ii	iii	iv
CPUE (no. of fish/10 traps)	5.58	5.34	6.81	4.19
No. of traps	554	989	857	217
No. of rock cook	309	528	584	91

Figure 70: Plots A1 to D1 are box plots showing rock cook wrasse length frequency distribution by area A to D, by tidal range categories I to iv , points represent median, boxes represent the interquartile range and error bars represent range. Charts A2 to D2 are catch per unit effort (CPUE) (no. of fish/10 traps) of rock cook wrasse for areas A to D by tidal range category I to iv.

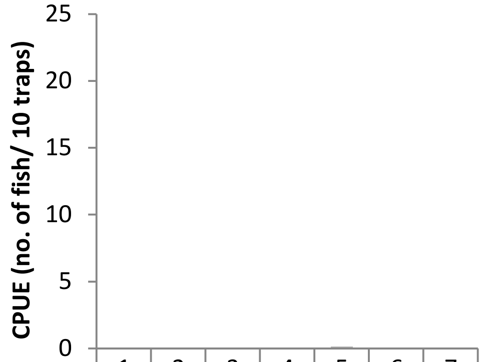
5.11.8 Nights Lie

Length frequency distributions appear to very slightly with nights lie (Figure 71, A1 to D1), and there are no apparent trends in CPUE (no. of fish/10 traps) with increasing nights lie (Figure 71, A2 to D2).

A1

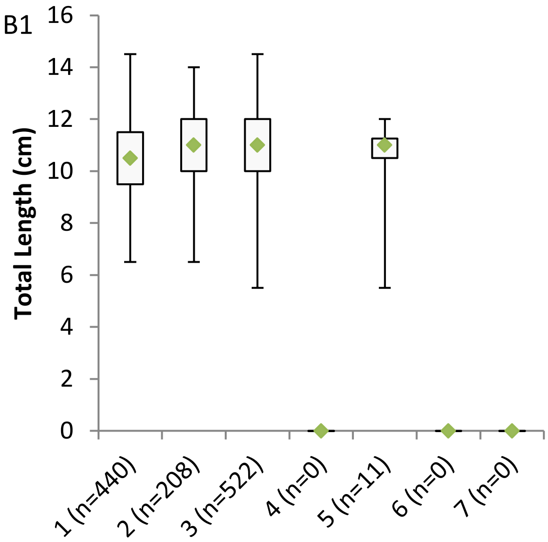


A2

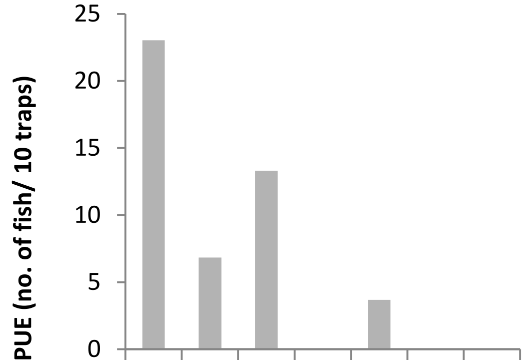


	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	0.00	0.00	0.00	0.00	0.13	0.00	0.00
No. of traps	20	20	80	61	79	0	0
No. of rock cook	0	0	0	0	1	0	0

B1

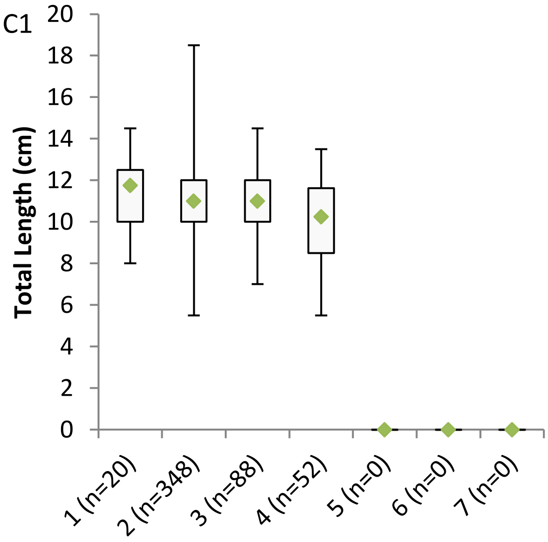


B2

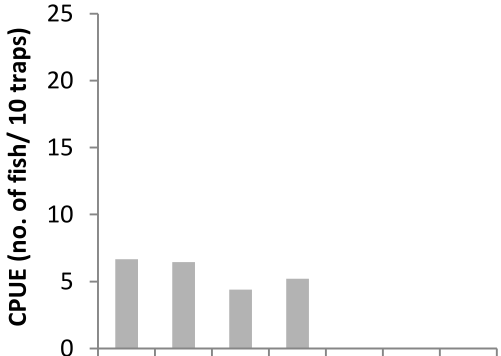


	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	23.0	6.84	13.3	0.00	3.67	0.00	0.00
No. of traps	191	304	392	10	30	0	0
No. of rock cook	440	208	522	0	11	0	0

C1

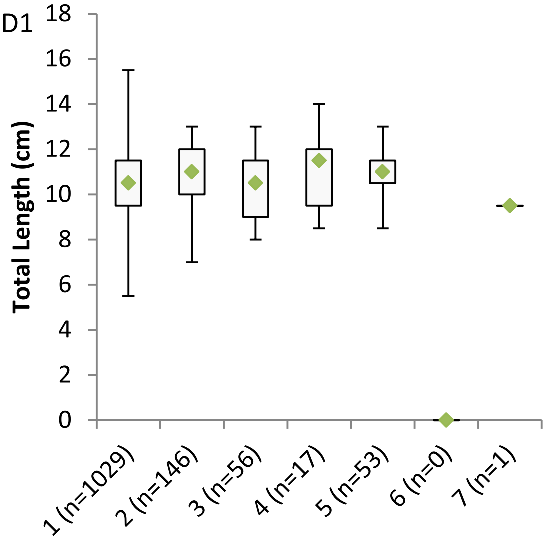


C2

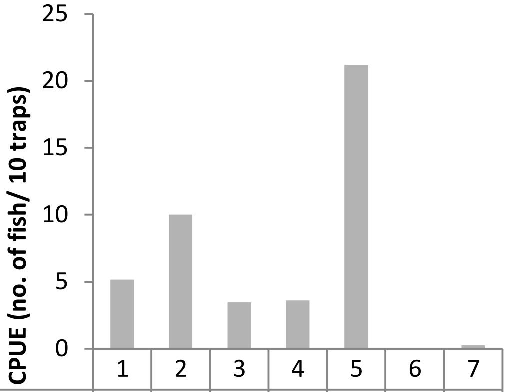


	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	6.67	6.44	4.40	5.20	0.00	0.00	0.00
No. of traps	30	540	200	100	0	0	0
No. of rock cook	20	348	88	52	0	0	0

D1



D2



	1	2	3	4	5	6	7
CPUE (no. of fish/10 traps)	5.17	10.0	3.46	3.62	21.2	0.00	0.26
No. of traps	1991	146	162	47	25	0	39
No. of rock cook	1029	146	56	17	53	0	1

Figure 71: Plots A1 to D1 are box plots showing rock cook wrasse length frequency distribution by area A to D, by nights lie, points represent median, boxes represent the interquartile range and error bars represent range. Charts A2 to D2 are catch per unit effort (CPUE) (no. of fish/10 traps) of rock cook wrasse for areas A to D by nights lie.

6 Discussion

Very little statistical analysis has been conducted to date by Cornwall IFCA; therefore the following discussion is largely based on officer's observations of apparent trends in the data set.

6.1 Effort Summary

It is clear that effort was not homogenous across the environmental variables investigated in this study. Calculating CPUE (no. of fish/10 traps) has allowed for comparisons between different variable categories, however it is clear that multiple variables are acting on all data and may be masking trends in the data.

Reflecting the current fishery effort was biased to depth categories 1 and 2, therefore less than 10m charted depth. In area A traps were set for the longest nights lie, with the majority of lies three nights or longer. In area D the most frequent nights lie for sampled traps was one night. This reflects the different fishing techniques between the different fishermen working within the Cornwall IFCA District.

In areas A, B, and C one fishing vessel works in each area, however in area D there are four vessels currently working, and catch sampling was conducted on three of these vessels. Differences in fishing practices were observed on different vessels throughout the survey, including differences in gear modifications, bait used and accuracy in setting the pots in relation to benthic features. This is likely to have an influence on catch, and therefore comparisons between geographic areas may be unreliable.

Due to the nature of the survey, following the fishery, there were very few strings in repeat locations. From literature it is clear that there can be differences in catch composition based on very small spatial scales, even just a few meters (Skiftesvik *et al*., 2014a) therefore data which could be used to observe changes in the fish populations over time were limited. Analysis of repeat strings, where strings have been sampled in repeat locations, is in progress and will be reported on, however was not completed in time for this report.

6.2 Species composition

Species composition varied significantly by geographic area. Common to all areas was the low catch rates of cuckoo wrasse (<4%), this was similar to catch composition in a Norwegian study (Skiftesvik *et al*., 2014a). The most notable difference in species composition by area was area A compared to the other three areas. The environmental conditions in this area are very different to the other areas. Area A is estuarine, and therefore has a greater potential for varying salinity, shallow water and sheltered locations. The remaining three areas are more exposed with a range of depths and benthic habitats. Corkwing dominated the catches in area A (69%), far greater than 19%, 12% and 17% in areas B, C and D respectively. This supports other studies where corkwing are most abundant in sheltered shallow sites (Skiftevik *et al*., 2014). This is discussed further in section 6.8.

Analysis by geographic location has thus far been conducted at a very coarse resolution; grouping the data into areas of approximately 10nm of coastline. Within each area a wide range of substrates, exposures and depths are encompassed which has not been addressed in this report, but have been reported to result in great differences in species composition (Skiftesvik *et al*., 2015, Rodrigues *et al.,* 2015 and Sayer *et al*., 1993). Therefore as the data is of a sufficient resolution to analyse further it is suggested that this analysis be carried out to gain a better understanding of the species habitat preferences and ecology locally.

Species composition varied significantly by month in all geographic locations. Notably in the estuarine sites the proportion of corkwing increased through the survey period with a corresponding decrease in proportion of goldsinny. The proportion of corkwing increased by 52% from May to August, and goldsinny decreased by 43.3% in the same period. It has been suggested that the ratio for goldsinny to corkwing could be used as an indicator of fishing pressure in a mixed fishery, as goldsinny may "…have a better chance of recovering/sustaining and intensive fishery", due to their 'plasticity' in access to different habitats (Skiftesvik *et al.,* 2014). The current study presents variation in species composition seasonally, even in areas where neither corkwing nor goldsinny are currently exploited commercially, therefore these ratios should be treated with caution, and only on data collected for this purpose (with repeat string locations in controlled periods) be utilised.

In all four geographic locations the proportion of ballan wrasse declined from depth category 1 to 2. In areas B and C the proportion of cuckoo wrasse increased with depth, (data were limited in areas A and D). The proportion of goldsinny increased with depth, as corkwing decreased in areas B and D, however this trend was not observed in areas A and C.

6.3 CPUE

Catch per unit effort (CPUE) is a recognised analysis tool for monitoring catch rates, and as a proxy for overall population levels (Varian *et al.*, 1996). CPUE has been calculated in this project investigating multiple variables. It is recognised that this is not an idea tool for analysis of this kind of data there are multiple factors, other than fish abundance, making the relationship between CPUE and fish abundance highly complex (Halvorsen, pers. comm), however they can provide useful information on fisheries changes, discussion points and indicate areas of future research (Maunder *et al*., 2006).

CPUE varied by area, and depth for all species to some extent, potentially reflecting habitat preferences of the different species, this has been covered in detail for each species.

Varian *et al*., (1996) found CPUE decreased with increased fishing time, i.e. the length of time that the baited traps are in the water, and hypothesised that it is possible that small fish leave the pot after feeding, or are forced out by intra-species aggression. The same study found that traps within the same string could have multiple individuals in one trap, whilst another remained empty, which may be governed by the proximity of a trap to a territory. This was noticed in the current study (CIFCA Scientific Officers, personal obs.), however not analysed in this report. This will be addressed in the student project which will be completed in spring 2018.

6.4 Length Frequency

Throughout the survey area ballan wrasse had the greatest range in total length, (6cm to 31.5cm), and goldsinny the smallest (5cm to 16.5cm). It is likely that the maximum total length for goldsinny, corkwing and rock cook (16.5cm, 31.5cm, and 18.5cm respectively) is a true representation of the maximum total length of the fish present, as all are larger than the maximum total lengths reported in Darwall *et al*., (1992); 15cm, 24cm and 15cm respectively, and Sayer *et al.,* (1996) 159mm, 212mm, and 165mm respectively.

For ballan wrasse the maximum total length is likely limited by the maximum total length of a fish which can enter the trap as the maximum total length of 31.5cm is far smaller than 60cm reported in Darwall *et al.,* (1992), and a fish of this total length would not fit within a trap. Also recorded during the survey, but not analysed, were ballan wrasse retained in parlour pots, with the maximum total length 34cm.

6.5 Spawning Season

The survey methodology allows for an indication of spawning season for 2017 across the whole current fishery within the District.

From this study spawning was observed from April to October in 2017. Goldsinny and rock cook peak spawning occurred in May, followed by corkwing peak spawning in June. In Norway, Skiftesvik *et al.,* (2015a) reported peak spawning for all three species to be June, however sampling was not carried out prior to this time, and suggested that peak spawning for corkwing may have occurred in May. Muncaster *et al.,* (2010) reported that ballan wrasse peak spawning occurred in May in the same area, approximately one month prior to peak spawning of rock cook and goldsinny. It is therefore suggested that in lieu of ballan wrasse spawning data locally it could be assumed that it occurs approximately one month prior to rock cook and goldsinny peak spawning, observed in May 2017, and so may have occurred in April locally. This period was also suggested by local fishermen who observed spawning ballan wrasse at this time.

For all species the proportions of spawning fish were lower than reported in literature (Skiftesvik *et al.,* 2015, goldsinny and rock cook: >80%, corkwing: 50%). This may be because of the different methods used, fyke nets were used rather than baited traps which may be affected by lower feeding intensities of species which are capital breeders (goldsinny and ballan) during spawning times, as suggested by Varian *et al.,* (1996); however their data did not support this. This hypothesis has been discussed further in section 6.8.

6.6 Total length at Maturity and sex ratios

Average total length at maturity, L_{50}, is generally calculated as the total length at which 50% of the population is sexually mature. Maturity was not assessed in this study; however the minimum total length of spawning fish was recorded and is an interesting metric to investigate.

Goldsinny total length at maturity is reported to be 9.5cm (Darwall *et al.,* 1992), and the smallest spawning individual sampled in this study was 9cm. Rock cook total length at maturity could not be found in literature, the smallest individual observed to be spawning was 8.5cm, the smallest of all three species. The minimum total length of spawning female corkwing was 10.5cm, similar to the reported 10cm total length at maturity in Darwall *et al*., (1992). The smallest spawning male corkwing encountered was 12.5cm, larger than the reported 10cm. It would be expected that wrasse of a total length smaller than the average total length at maturity would be encountered, as some individuals would mature at a smaller total length, therefore contributing to the calculation of average total length at maturity. It is therefore suggested that the total length at maturity for male corkwing wrasse in the Cornwall IFCA District is likely to be larger than 10cm. Halvorsen *et al.,* (2016a, and 2016b) reported the average total length at maturity of male corkwings to be between 136.6mm and 141.1mm in studies in Norway, which varied by area. This may be a more realistic total length at maturity for male corkwing wrasse, and highlights the need for further study locally into the total length at maturity for all species, especially corkwing wrasse.

Sex ratios for three species oscillated through the year, possibly reflecting different gear locations or seasonal changes in fish behaviour. There are some difficulties in identifying gender in wrasse species in the field, for example rock cook and goldsinny outside of spawning season as their sexual dimorphism is more pronounced in breeding times (CIFCA Scientific Officers, personal obs.), and juveniles of all species. This may have led to some erroneous results; however this was mitigated in that where doubt existed over the sex of an individual fish it was recorded as unknown.

6.7 Ballan wrasse (*Labrus bergylta*)

It is suggested that Area A, estuaries, is a nursery area for ballan wrasse. CPUE was far higher in area A than the other three areas, with a lower mean average total length of fish sampled (14.8cm in area A, 18.11cm, 19.07cm and 18.01cm for areas B, C and D respectively). Using 17cm as an average total length at maturity (an average of 16-17cm reported by Darwall *et al.*, 1992), 79% of the fish sampled were immature, compared to an average of 49% of fish sampled being immature in the other three areas. Currently the minimum total length dictated by the industry is 16cm, when retaining this total length range 19% of retained fish from Area A would be below 17cm, and therefore assumed to be immature and 69% of the total catch would be returned to the sea. This is a high return rate, and ideally if fishing continues in this area, measures should be taken to lower catch rates of these smaller, immature individuals to avoid stress of repeated capture and returning to the sea, with the associated increased risk of predation when swimming back to the seabed.

In Norway the highest catch rates of ballan were in July and June (Halvorsen *et al.*, 2017), in contrast in the current study June and July yielded some of the lowest CPUEs for ballan wrasse in areas D and B. During the current study no data were collected in January, November and December, however it is hypothesised that CPUE would decrease in these months when the species are reported to go into a dormant period (Muncaster *et al.*, 2010).

Spawning was only assessed in area D with one gravid female observed in June (n=357 total ballan assessed from June to October). In a study where ballan wrasse were assessed for spawning (Skiftesvik *et al.,* 2014), low numbers of spawning ballan wrasse were observed (6% on average). Spawning time and total length at maturity may be better assessed by gonad analysis for ballan wrasse. As discussed previously, based on ballan wrasse spawning one month earlier than goldsinny and rock cook (calculated from Skiftesvik *et al.*, 2016 and Muncaster *et al.*, 2010), it could be assumed that peak spawning of ballan wrasse locally may have occurred in April; however no ballan wrasse were assessed for spawning during this time.

Catch rates of ballan wrasse decreased in May and June in all areas, in area A CPUE first reduced in April, and in area D CPUE did not increase again until September. Muncaster *et al.,* (2010) suggest that post spawned female ballan wrasse enter a short resting period after ovarian atresia in June and July, which may explain low catch rates during summer months.

There was a decrease in CPUE in areas B, C and D with depth between categories 1 and 2, and a simultaneous increase in body total length, implying that there were fewer but larger fish in the deeper water. It is likely that ballan wrasse density is driven by size interaction, with larger fish having larger territories and therefore lower densities, which is being reflected in the current study.

It had been reported by fishermen that tidal range categories had influence over catch rates, especially of ballan wrasse, in area B. Therefore this hypothesis has been investigated. As suggested by the fishermen catch rates were highest for tidal range category ii, the period of time after a peak spring tide, in area B, this was also the case for area A. Area D did not show this trend and area C had no data for tidal ranges ii and iv.

Area C was the only area which showed a trend in increase of average body size and decrease in catch rates with increasing nights lie. This may be due to small fish escaping from the pots with increasing time, therefore the catch rates will decrease with the loss of fish, and the remaining fish will be of larger average body size (Varian *et al.,* 1996).

6.8 Corkwing wrasse (*Symphodus melops*)

Habitat preferences of corkwing wrasse have been reported to be sheltered areas in shallow water, less than 5m depth (Skiftesvik *et al.*, 2015, Rodrigues *et al.*, 2015 and Darwall *et al.,* 1992). This is reflected in the current studies results in that CPUE was highest in area A, and in depth band 1 for all four geographic areas.

Skiftesvik *et al.,* (2015) suggested that corkwing wrasse may change territories as they get larger as smaller fish were found in more sheltered areas than larger fish. This is reflected in the current study; in area A the mean average total length was far lower than in the remaining three areas (area A: 13.15cm, B:16.39cm, C:16.74cm, and D:15.52cm), and in these three areas the mean average length was smaller in depth category 1 than 2 (B; 1: 16.27cm, 2:16.70cm, C; 1:16.57cm, 2:16.67cm, D; 1:15.31cm, 2:16.0cm).

It may be that area A, estuaries, may act as a nursery ground for corkwing wrasse. Darwall *et al.,* (1992) reported the average total length at maturity to be 10cm, however in recent studies in Norway the L_{50} for males has ranged between 136.6mm to 141.1mm, and 87.6mm to 109.9mm for females (Halvorsen *et al.*, 2016a and 2016b). It is unknown what the average total length at maturity is locally. In this study the smallest spawning male recorded was 12.5cm and 10.5cm for females, however this is not as accurate as L_{50}; the total length at which half of the population are mature. It could be assumed that 10cm total length at maturity for females may be a suitable estimation until further research is conducted, however it is likely that the total length at maturity for males is larger than this. Using 14cm as an average (reported 136.6mm- 141.1mm, 13.89cm to the nearest 0.5cm) only 43% of the males sampled in the estuaries were mature and 98% of females. 74% of the catch was above the minimum total length for the fishery (12cm), however, using the total lengths at maturity as discusses previously, 14% of the retained catch of males would be immature, 100% of the retained females would be mature.

In all three areas where spawning was observed (B, C and D), peak spawning was in June, with some spawning corkwing wrasse still encountered in areas C and D in July, this is consistent with Skiftesvik *et al.* (2015a) in their findings of peak spawning in June in Norway.

Corkwing males have a higher catch probability in baited traps than females (Halvorsen *et al.*, 2016a), therefore sex ratios are likely to be skewed in this survey. Also, visual identification may be misleading due to type 2 males, sneaker males, which may make up to 10% of the male population (Stone, 1996), and are indistinguishable from females in the field. The proportion of males increased after spawning locally had ceased, this may be a change in behaviour after spawn. During spawning it is likely that male corkwing have a lower capture probability, as when nest guarding they have been observed to stay within 2m of their nest (Collins *et al.,* 1996). Sayer *et al.,* (1996) and Skifetesvik *et al.,* (2015) reported sex ratios of corkwing wrasse which were male biased, this is also the case, on average in area A, B, and D, however in area C the ratio was in favour of females for much of the survey.

In area A the largest total lengths were observed when tidal ranges were increasing (tidal range category i) coupled with the lowest CPUE. Smaller average total lengths and higher CPUE were observed as the tidal range was decreasing (tidal range categories ii and iii). This may indicate that in stronger tidal flow larger fish are more capable of swimming against the current and therefore interacting with a trap.

6.9 Goldsinny wrasse (*Ctenolabrus rupestris*)

CPUE was lowest in area A, consistent with Sayer *et al.,* (1993) findings that goldsinny were not always present in areas with freshwater run off, even if there was suitable habitat available (crevices and hides), which in other areas was found to be limiting factor to goldsinny density. In the current study CPUE was highest in area B, this may reflect varying goldsinny densities by area, which may be due to benthic habitat differences between the survey areas, as mentioned previously this may also be due to differences in fishermen's fishing practices.

In area B catch rates were at their lowest from May to August, this corresponds with the time when spawning was observed. This finding may suggest that goldsinny wrasse are capital breeders meaning that they having a higher food intake outside of the breeding season, and are potentially less attracted to baited traps. Catch rates were also low in February and October, which may be explained by Darwall *et al.* (1992), in that outside of the spawning season fish remain inactive and hidden in refuges. The fish may have a higher energy demands immediately pre and post spawning, followed by a period of inactivity in the winter months, as reflected in lower catch rates in February and October. A similar trend is observed in area D. Area C however appears to show a contradictory trend, the peak spawning and CPUE are both in the same month, June. This hypothesis should therefore be tested further.

In all areas spawning occurred from May to August, with a peak in June in area C, and July in area D. Norwegian studies reported a peak in June (Skifesvik *et al.*, 2015).

Sex ratios varied by area, in favour of males in area C (52%), and females in areas B and D (52 and 60% respectively). The same numbers of male and female fish were sampled in area A, therefore giving a 50:50 ratio. In other studies sex ratios varied significantly year to year (Skiftevik *et al.,* 2014), in favour of males in 1997 (56%), and females in 1998 and 1999 (53 and 51%), similarly Sayer *et al.,* (1996) reported that sex ratios varied by survey area, some infavour of males, and others females. Both results suggest that sex ratio is highly changeable in goldsinny wrasse.

CPUE was consistently higher in depth band 2 and 1 for areas B, C and D. Smaller goldsinny have been reported to be more prevalent in shallow water (<10m) (Varian *et al.,* 1996), however this did not appear to be a trend in the current study. Area B showed increase catch rates in tidal range category ii, similar to that observed in corkwing and ballan wrasse, this seems to be a local phenomenon in area B. Areas C and D show an increase in CPUE with increasing nights lie however this is not observed in areas A and B.

6.10 Rock Cook wrasse (*Centrolabrus exoletus*)

CPUE of rock cook wrasse was highest in area B, and lowest in area A where only one rock cook was sampled. Similarly, Skiftesvik *et al.,* (2015) found rock cooks to be more prevalent in exposed sample stations, as in this study area B is more exposed than the highly sheltered area A. Rock cooks are the least studied of the wrasse species encountered in this study, with little known about their habitat preferences. It is unclear why CPUE should be over twice as high in area B as it is in C and D, it may be explained by differing fishing techniques, habitat preferences or other environmental variables.

When looking at variation in rock cook CPUE seasonally, the most notable result is the high peak in CPUE in March and April in area B. This is a similar pattern to that observed in goldsinny, also in area B, where it is hypothesised that there is a peak in energy demand, and therefore catchability pre spawning, then a drop in catch rates during spawning (May to July in this study) followed by increases in CPUE, possibly due to increased energy demand, post spawn. This hypothesis would suggest that rock cooks were also capital breeders, like goldsinny, and could be investigated with further research.

Peak in spawning in all three areas where spawning fish were encountered was June. This was also the case in a recent study Norway (Skiftesvik *et al.*, 2015). No obvious trends in CPUE or length frequency distribution were observed for nights lie or tidal range categories.

6.11 Recommendations for further analysis

Due to time restrictions statistical analysis could not be carried out on all of the analysis presented in this report. This will be completed with Kruskall Wallis' analysis of variance was applied to length frequency data to assess statistical differences between environmental variable categories, and *U* tests performed where data is only sufficient for two categories to be assessed. Chi squared test for association (χ^2 test) will be carried out to determine whether CPUE (no. of fish/10 traps) was significantly different between geographic areas and environmental variable categories. If time and resources allow, multiple correspondence analysis would be an effective tool for analysing multiple variables on the response factors, as demonstrated in Skiftesvik *et al.* (2015).

Also due to time restrictions a number of potential influences on catches have not been assessed including; bottom substrate, macrofauna coverage, exposure rating, weather conditions, temperature and bait used. These are all likely to have a significant impact on the species composition, length frequency distribution and CPUE of wrasse, and would be useful to analyse to gain a deeper understanding of wrasse habitat preferences locally.

Repeated location strings analysis is ongoing, all sample strings were plotted in MapInfo and strings in repeat locations (<50m maximum distance apart) were grouped and listed with attribute data. These were then further filtered, to groups of strings with similar environmental conditions; similar tidal range and nights lie. The resultant groups/pairs of strings are being analysed, investigating the catch composition and length frequency of fish sampled.

A student is currently analysing the Cornwall IFCA dataset, primarily investigating data per trap and variations in catch across traps within the same string. This has been developed as it has been noted that within a string one trap may have many fish in it and the next may be empty (Varian *et al.*, 1996, and CIFCA Scientific Officers, personal obs.), also at certain times it would be common to find male and female corkwing wrasse in pairs. The student will also be investigating any correlations between swim bladder damage and the charted depth of a string.

6.12 Recommendations for future surveys

This survey methodology has resulted in a greater understanding of wrasse habitat preferences locally, and base line data on wrasse populations retained in traps. If a further in-depth knowledge of the local populations is required alterations to the current methodology would need to be incorporated, dependent on the outcomes required:

6.12.1 Age and length at maturity

To establish local age and length at maturity to inform minimum sizes, and baseline current populations gonad and otolith analysis would need to be conducted. There does appear to be a need for this, especially for corkwing wrasse where there is ambiguity around the total length at maturity, and it is reported that there is geographic variation in growth rates in goldsinny wrasse (Varian *et al.*, 1996).

6.12.2 Spawning time

The current study has resulted in an indication of spawning time for three wrasse species in the Cornwall IFCA District. Ballan wrasse were not assessed and their spawning time has been estimated based on differing timings observed in Norway applied to the current study. If a more precise estimation of ballan wrasse spawning is required it is suggested that gonad analysis would be a more effective tool for assessment, as other studies have found low proportions of ballan wrasse spawning when assessed by stripping (Skiftesvik *et al.*, 2014).

The proportions of spawning fish was lower for all three species of wrasse assessed in this study, then that reported in similar studies in Norway. It is suggested that this may be due to the differing fishing methods, baited traps and fyke nets. This needs to be investigated further, potentially with a trial survey with fyke nets.

6.12.3 Population size estimates

A mark and recapture study, could be conducted, similar to that employed by Skiftesvik *et al.,* (2015) to allow for estimated for population sizes locally. There are challenges in this method as results would relative to small geographic areas, and as distribution of species is not homogenous, it would be difficult to multiply up to estimate population size and MSY. This needs to be investigated further.

6.12.4 Monitoring change in the fishery

As discussed, there are limitations in the current survey in that very few variables can be controlled. It is suggested that dedicated survey sampling be conducted independently by Cornwall IFCA in repeat locations, in similar temporal conditions so as to minimise influence on data from environmental variables so that fishery induced changes to wrasse populations may be observed.

7 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.

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.

Fish Farmer. Vol 40 No 8. August 2017. Otter Ferry at 50 - Meet the Brood. Pp 26 -30.

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

Halvorsen K. Wrasse Researcher. Personal communications during 2017.

Halvorsen, K.T., Larsen, T., Sørdalen, T., Vøllestad, A., Knutsen, H., and Olsen, E.M. 2017. Impact of harvesting cleaner fish for salmonid aquaculture assessed from replicated coastal marine protected areas. Marine Biology Reseach 13 (4).

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.

Hempleman C. Cleaner fish – Scotland Overview. Presentation to the International Cleaner Fish Summit 2017.

Houston, A.I., Stephens, P.A., Boyd, I., and Mcnamara, J.M. 2017. Capital or income breeding? A theoretical model of female reproductive strategies. Behavioral Ecology 18(1):241-250.

Maunder, M.N., Sibert, J.R., Fonteneau, A., Hampton, J., Kleiber, P., and Harley, S.J. 2006. Interpreting catch per unit effort data to assess the status of individual stocks and communities. ICES Journal of Marine Science, 63: 1373-1385.

Muncaster, S., Andersson, E., Kjesbu, O.S., Taranger, G.L., Skiftesvik, A.B., and Norberg, B. 2010. The reporductive cycle of female ballan wrasse Labrus bergylate in high latitude, temperate waters. Journal of Fish Biology, 77: 494-511.

Mylor Yacht Harbour Tide Timetable, 2017. Complementary Copy.

Pike, A.W. and Wadsworth, S.L. 2000. Sea lice on Salmonids: their biology and control. Adv. Parasitol. 44 (2000), pp 233 – 337.

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.

Sayer, M.J.D., Gibson, R.N., and Atkinson, R.J.A. 1996a. Seasonal, sexual and geographical variation in the biology of goldsinny, corkwing and rock cook on the west coast of Scotland. In: Sayer, M.J.D, Treasurer, J.W., Costello, M.J., editors. Wrasse: Biology and Use in Aquaculture. Oxford: Blackwell Science, p100-118.

Sayer, M.J.D., Gibson, R.N., and Atkinson, R.J.A. 1996b. The biology of inshore goldsinny populations: can they sustain commercial exploitation? In: Sayer, M.J.D, Treasurer, J.W., Costello, M.J., editors. Wrasse: Biology and Use in Aquaculture. Oxford: Blackwell Science, p100-118.

Sinnott, R. 1999. Sea Lice – Watch out for the hidden costs. Fish Farmer 21, pp 45 – 46.

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

Skiftesvik,A.B., Blom, G., Agnalt, A., Durif, C.M.F., Browman, H.I., Bjelland, R.M., Harkestad,L.S., Farestveit,E., Paulsen,O.I., Fauske,M., Havelin,T., Johnsen,K., and Mortensen,S. 2014b. Wrasse (Labridae) as cleaner fish in salmonid aquaculture – The Hardangerfjord as a case study, Marine Biology Research, 10:3, 289-300.

Stone, J. 1996. Preliminary trials on the culture of goldsinny and corkwing wrasse. In: Sayer, M.J.D, Treasurer, J.W., Costello, M.J., editors. Wrasse: Biology and Use in Aquaculture. Oxford: Blackwell Science, p100-118.

Varian, S.J.A., Deady, S., and Fives, J.M. 1996. The effect of intensive fishing of wild wrasse populations in Lettercallow Bay, Connemara, Ireland: implications for the future management of the fishery. In: Sayer, M.J.D, Treasurer, J.W., Costello, M.J., editors. Wrasse: Biology and Use in Aquaculture. Oxford: Blackwell Science, p100-118.

Villegas-Ríos, D., Alós, J., March, D., Palmer, M., Mucientes, G., and Saborido-Rey, F. 2013. Home range and diel behaviour of the ballan wrasse*, Labrus bergylta*, determined by acoustic telemetry. Journal of Sea Research 80: 61-71.