Live Wrasse Fishery in Devon & Severn IFCA District

Data Analysis

Research Report November 2017

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Version Control History			
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Stephanie Davies	03/11/2017	Final version for D&S IFCA Byelaw and Permitting Sub-Committee Meeting on 13th November 2017.	1
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Contents

Executive Summary

Wrasse are being targeted in Plymouth Sound for use as a cleaner fish. A fully documented fishery was implemented into the permit conditions of Devon and Severn IFCA Potting Permit Byelaw, to include an intensive data collection program. This report presents the results of the data collection from the first full season of the Live Wrasse Fishery. The two main types of data presented are from landings data recorded by fishers from April to October 2017 and twenty on-board surveys carried out by IFCA Officers. On-board survey effort equated to 7.5% observer coverage of boats surveyed, or 5.5% of the entire fleet.

There was no consistent decline in Catch per Unit Effort (CPUE) or Landings per Unit Effort (LPUE). There were observed seasonal fluctuations in CPUE and LPUE and these could be attributed to spatial movements of fishers and their pots, fish behaviour or environmental changes. Continued data collection in the future is vital to determine changes in LPUE and CPUE over time and space.

Spatial fishing effort varied over time across the Plymouth Sound area. Goldsinny and rock cook represented the majority of catch for all vessels. The proportion of species varied considerably spatially and this can be attributed to species preference for exposure and depth, for example, corkwing were found in more sheltered, inshore areas. The majority of observed spawning took place between May to mid-July. The data indicated the current closed season from 1st April to 30th June covers the majority of the spawning season for goldsinny and rock cook.

The size frequency histograms illustrated the importance of Minimum (Min) and Maximum (Max) Conservation Reference Sizes (CRS) for wrasse. The Min CRS (12cm) for goldsinny and rock cook allows a significant proportion of the catch to be returned to sea and to spawn. The introduction of the Min and Max CRS (15-23cm) for ballan demonstrated an increased proportion of the catch returned to the sea from 4% to 28%, protecting both juveniles and mature adults. However, the current Min and Max CRS (12-23cm) for corkwing is allowing over 90% of the fish caught to be landed. Due to the complex life history of corkwing, and the results of the data analysis, amendments to the slot sizes would be recommended to allow a proportion of immature and mature fish to return to sea.

The results presented in this report highlight the importance of a fully documented fishery and the need to continue data collection to monitor the live-capture fishery for wrasse.

1.0 Introduction

As described in previous D&S IFCA papers, a live-capture fishery for wrasse emerged in the D&S IFCA District in 2015 and is described in detail in Davies (2016). The fishery targets a range of wrasse species using relatively light-weight pots or traps set on or close to rocky reef habitats. The fishery occurs out of Plymouth, with four boats targeting wrasse primarily in the Plymouth Sound and the surrounding coastal waters.

Following a review of wrasse ecology and management of wrasse fisheries in Norway, management measures were proposed and consulted on by D&S IFCA and were introduced via the Potting Permit Byelaw following approval by the Authority in June 2017 (Townsend and Clark 2017).

Due to the complex nature of the fishery, it was decided that an intensive data collection programme was required, in order to capture spatial and temporal trends in CPUE and detailed information on the species, size composition and spawning state (Ross 2016). This data capture was built in to the potting permit conditions, which implemented a fully documented fishery (Townsend and Clark 2017).

This paper presents the results of the data collection from the first full season of the fishery, from April to October 2017.

2.0 Methodology

Two main types of data have been collected as part of the fully documented fishery; i) landings data, recorded by the fishers and ii) on-board observer surveys, undertaken by IFCA Environment Officers. These two datasets have different strengths and weaknesses which are described below and summarised in Table 1.

2.1 Landings Data Collection

Fishers completed landings forms (Appendix 1, Figure 23), which included the total numbers of wrasse retained per day, split into ballan, cuckoo and all other wrasse species grouped. Fishers cannot sort their catch by species on-board as they are often working single-handed and need to keep fish handling and processing time to a minimum. It is important to note that where data are presented from the fishers' data, they refer to landings only (i.e. do not take into account the number of fish returned alive). Figures from the on-board observer surveys include numbers of fish caught and retained, and also those returned alive. Therefore, fishers' data are reported as landings and observer surveys are reported as catch. Landings can be calculated from the observer surveys (simply by removing data on fish which were returned) and this will be done for future between-year comparisons. However, for the purposes of this report it is interesting to consider trends in landings and catch.

Fishers also recorded which grid cells they fished in each day, but were not required to report how many fish were caught in each grid cell, as again this would be extremely disruptive to their normal fishing behaviour. The major strength of the fishers' logbook dataset is that it records every single day of fishing activity, and results in the documentation of every single retained wrasse. It also allows for data collection from boats which are too small to host an observer.

2.2 On-Board Observer Surveys

Observers recorded the start and end position (degrees decimal minutes) of each string (Appendix 1, Figure 24). Pots were hauled by the fisher and wrasse placed into a bucket with seawater. As pots were hauled at a faster rate than catch could be processed by the observer, all the catch for a string was pooled. Each wrasse was identified to species level, total length recorded and a visual check conducted to see if the fish could be sexed. Visual signs of spawning were also recorded and gentle 'stripping' (running a finger along the fish's ventral surface and applying light pressure) was attempted to see if milt or eggs were released. Fish, which were at or above/ below the Minimum (Min) and Maximum (Max) Conservation Reference Sizes (CRS), were put into large tanks or barrels which were regularly refreshed with fresh seawater. Fish which were below the Min CRS were kept in a separate bucket and returned in such a way as to minimise predation by seabirds. Those which were above the Max CRS were returned to sea straight away.

Table 1 –Difference between landing data and on-board observer surveys

	Landings data (from fishers)	***On-board observer surveys***
Data from every day of fishing effort	✓	
Fishing effort (no. pots per day) recorded	✓	✓
Daily total number of fish caught recorded	✓	✓
Daily total number of fish returned recorded		✓
Total number of fish caught per string		✓
Spatial LPUE/CPUE		✓
Species-level data recording		✓
Sizes of fish (kept and returned) recorded		✓
Spawning state of fish recorded		✓
Approximate location of fishing effort recorded (1 km^2 grid)	✓	✓
Precise location of fishing effort recorded		✓

2.3 Data Analysis

Total Landings
Total landings were calculated from the fishers' landings forms, and verified by transport documents supplied to the MMO by the fishers.

Observer Effort
The percentage of observer effort was calculated by the number of days fishing within a month, divided by the number of surveys carried out that month. One month of landings data was missing for both Vessel 3 (June) and Vessel 4 (May). An average of the number of days fishing was taken over the other months for that vessel and used in the analysis.

Catch per unit Effort
Catch per Unit Effort (CPUE) was calculated in MS Excel from the observer surveys and includes both fish above and below the MCRS (i.e. those retained and those returned).

CPUE for individual vessels was calculated as:

$$\mathbf{CPUE = C_t / E_t}$$

Where C_t is catch C, during time period t, and E_t is Effort, E measured by the number of pots hauled during time period t.

Mean CPUE for the fleet was calculated as:

$$\mathbf{Mean\ CPUE = (C_1 + C_2 + \ldots C_n)_t / (E_1 + E_2 + \ldots E_n)_t}$$

Where C_1 is the number of wrasse caught (both retained and returned) by vessel 1, C_2 is the number of wrasse caught (both retained and returned) by vessel 2 up to C_n vessels, during time period, t. E_1 is the number of pots fished by vessel 1, E_2 is the number of pots fished by vessel, up to E_n vessels during time period t.

Landings per unit Effort
Landings per Unit Effort (LPUE) was calculated in MS Excel from the fishers' landings data and includes only fish which were above the MCRS (i.e. only those that were retained).

LPUE for individual vessels was calculated as:

$$\mathbf{LPUE = L_t / E_t}$$

Mean LPUE for the fleet was calculated as:

$$\mathbf{Mean\ LPUE = (L_1 + L_2 + \ldots L_n) / (E_1 + E_2 + \ldots E_n)}$$

Where L_1 is the number of wrasse landed by vessel 1, L_2 is the number of wrasse landed by vessel 2 up to L_n vessels, during time period, t. E_1 is the number of pots fished by vessel 1, E_2 is the number of pots fished by vessel, up to E_n vessels during time period t.

Spatial and Temporal Fishing Effort
Fishing effort maps were created using MapInfo Pro v16.0. Thematic density maps were produced with equal ranges for total number of pots set.

Catch Composition
Pie charts of catch composition were made in MS Excel from the number of individuals per species.

Size Frequency
Size frequency histograms were produced in MS Excel using number of individuals per species recorded in that size range.

Spawning State
Analysis of spawning state was carried out in MS Excel. Dates were grouped into five days and data presented from both Devon and Severn IFCA and Cornwall IFCA.

3.0 Results

3.1 Total Landings

From the landings data approximately 46,497 wrasse (including ballan, goldsinny, corkwing and rock cook) have been retained from boats working in Plymouth Sound since April to the first week of October 2017. With an average weight of 0.065kg per fish this equates to 3022.3 kgs. The price per fish is £1.70 therefore the value of the fish per kilo is approximately £26.15. See Table 2 for more details of landings.

Table 2 - Landings data (number of fish) of the live wrasse fishery during 2017.

	Date		Returns			
Vessel	First entry	Last entry	Devon only	Cornwall only	Devon & Cornwall	**Total**
Vessel 1	05/04/2017	11/10/2017	1,771	7,649	2,523	**11,943**
Vessel 2	19/04/2017	29/09/2017	9,086	0	0	**9,086**
Vessel 3	01/05/2017	09/10/2017	1,043	0	11,807	**12,850**
Vessel 4	01/06/2017	06/10/2017	0	0	12,618	**12,618**
		Totals	**11,900**	**7,649**	**26,948**	**46,497**

Landings doubled between June and July, with the highest catches in August and September. Transport documents have been handed into the Marine Management Organisation (MMO) after every collection and the number of fish transported can be seen in Table 3. The discrepancies between the total number of fish landed and transported differs due to many factors, including; the landings data not being collected properly at the beginning of the year, undersized or damaged wrasse returned to sea, a small percentage of mortality and the transport data only goes up to 24th September.

Table 3 - Transport data (number of fish) of the live wrasse fishery during 2017.

Transport Date	**Vessel 1**	**Vessel 2**	**Vessel 3**	**Vessel 4**	**Total**
24/04/2017	1,134	359	1,008	-	2,501
01/05/2017	637	228	475	-	1,340
22/05/2017	236	452	431	432	1,551
01/06/2017	312	600	63	663	1,638
07/07/2017	418	841	930	905	3,094
24/07/2017	-	711	1,007	970	2,688
06/08/2017	1,970	-	1,150	1,243	4,363
17/08/2017	1,064	1,003	1,890	1,227	5,184
28/08/2017	1,135	1,030	1,229	1,884	5,278
07/09/2017	711	1,250	1,328	1,216	4,505
24/09/2017	1,347	753	1,482	2,189	5,771
Totals	**8,964**	**7,227**	**10,993**	**10,729**	**37,913**

3.2 Survey Effort

The target survey effort was two surveys a week, spread across all four vessels. Based on four boats fishing for 6 days a week this would have equated to observing about 8% of all fishing activity.

One of the four boats could not host an observer due its extremely small size, so only three boats could be surveyed as part of the fishery. Additionally, at the start of the season fishing effort was extremely sporadic with fishers experiencing a number of technical and logistical issues which prevented them from fishing. There were also challenges making the limited amount of officer time available coincide with these, sometimes sporadic, fishing activities.

Despite these challenges twenty surveys have been undertaken between April and September; six on Vessel 1, five on Vessel 2 and nine on Vessel 4 (Table 4). No surveys took place in May due to a mixture of bad weather cancelling planned surveys, along with vessels leaving and entering the fishery. However, fishing effort during this period is also thought to have been low.

This survey effort equates to approximately 7.5% observer coverage of the boats that could be included or 5.5% of the entire fleet, including the vessel that was too small to survey (Table 5).

Observer data and landings data have not been statistically compared in the analysis yet, but information from landings data agrees with observer data in terms of magnitude and species composition of catches.

Table 4 – On-board observer surveys completed during 2017

Vessel	Survey by	Date	Month
Vessel 1	D&S IFCA	08/04/17	April
Vessel 1	D&S IFCA	13/04/17	
Vessel 1	D&S IFCA	19/04/17	
Vessel 1	D&S IFCA	01/06/17	June
Vessel 4	D&S IFCA	13/06/17	
Vessel 2	D&S IFCA	13/06/17	
Vessel 2	D&S IFCA	19/06/17	
Vessel 4	D&S IFCA	27/06/17	
Vessel 1	D&S IFCA	28/06/17	
Vessel 1	CIFCA	03/07/17	July
Vessel 4	D&S IFCA	05/07/17	
Vessel 2	D&S IFCA	05/07/17	
Vessel 4	D&S IFCA	13/07/17	
Vessel 2	D&S IFCA	14/07/17	
Vessel 2	D&S IFCA	30/07/17	
Vessel 4	D&S IFCA	08/08/17	August
Vessel 4	D&S IFCA	26/08/17	
Vessel 1	D&S IFCA	31/08/17	
Vessel 4	D&S IFCA	06/09/17	September
Vessel 4	D&S IFCA	24/09/17	
Vessel 4	D&S IFCA	04/10/17	October

Table 5 – Survey effort for 2017

Vessel	No. days fished	No. surveys	Percentage observer coverage
Vessel 1	83	6	7.2%
Vessel 2	72	5	6.9%
Vessel 3	94	0	0%
Vessel 4	113	9	8.0%
All Vessels	362	20	5.5%
3 Vessels surveyed	268	20	7.5%

3.3 Catch Per Unit Effort and Landings Per Unit Effort

Both LPUE and CPUE show a similar pattern with a decline in May and June from the initial levels of LPUE (Figure 1) and CPUE (Figure 2) in April, followed by increases in LPUE and CPUE during July, August and September. A decline in both LPUE and CPUE occurs in October.

Appendix 2 shows LPUE for each individual vessel and shows that there were some gaps in the data recorded. Vessels three (Appendix 2, Figure 27) and four (Appendix 2, Figure 28) both entered the fishery later in the season and D&S IFCA did not consistently start receiving their landings data until July. For Vessel 1, although landings have been submitted for August, September and October, they have been recorded in a way that prevents inclusion in this analysis (Appendix 2, Figure 25). Despite this, similar patterns can be seen in trends in LPUE among the three vessels surveyed. Vessel 1 was the only boat to have the highest landings in April, however all vessels saw lower LPUE for May and June, then saw increasing LPUE through July, August and September before declining again in October.

Patterns in CPUE are similar to those of LPUE with lower values in the first half of the season, followed by higher levels of CPUE in July-September and a decline in October (Figure 2).

For some species, such as rock cook, CPUE remained consistent throughout the year. For others CPUE fluctuated more widely (Figure 3). Goldsinny had the highest CPUE for much of the year, with the exception of April and October, when Rock Cook had a slightly higher CPUE. Goldsinny showed a marked increase in CPUE in August and September. The CPUE for corkwing increases markedly in the latter half of the season, particularly in September. CPUE for ballan wrasse is low all season, although appears to increase slightly in September and October (Figure 3).

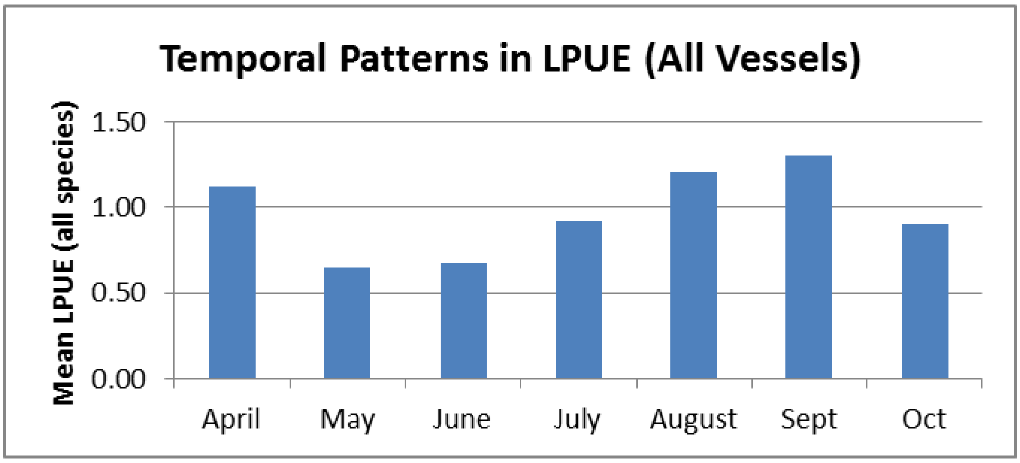

Figure 1 – Landings per Unit Effort (LPUE) for all vessels during 2017.

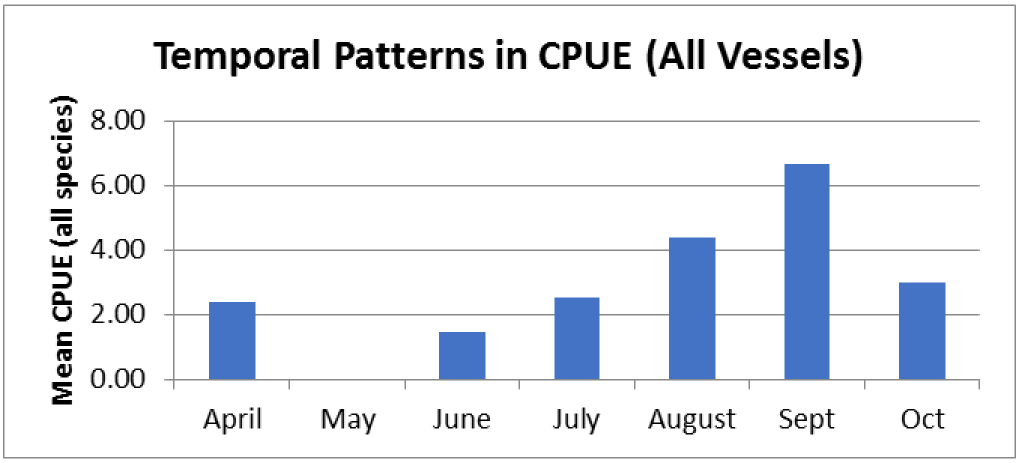

Figure 2 – Catch per Unit Effort (CPUE) for all vessels during 2017.

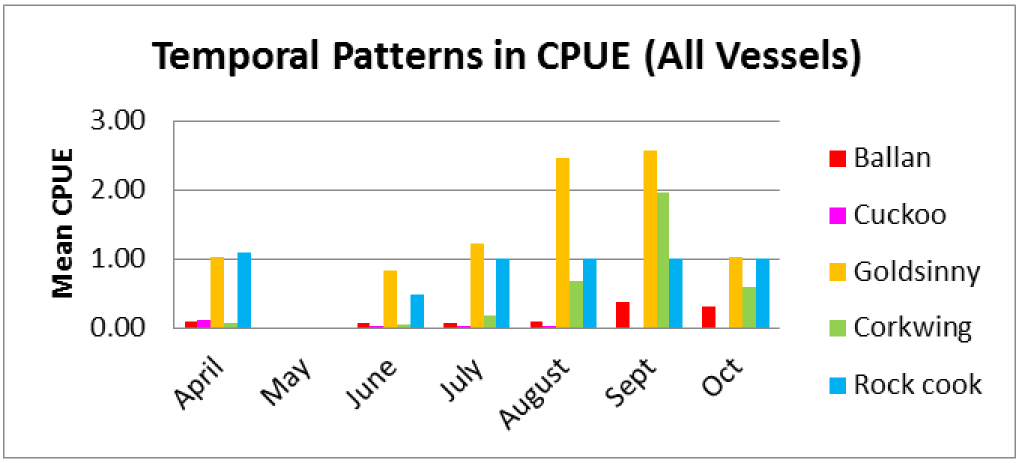

Figure 3 – Catch per Unit Effort (CPUE) for all vessels, per species during 2017.

3.4 Spatial Effort

At the start of the season all four vessels worked within D&S IFCA District, however, currently only three of these boats fish within the D&S IFCA District.

Figure 4 shows the Voluntary Closed Areas that were implemented in June 2017. The areas worked by the four vessels are shown in Figure 6 to Figure 9 and summarised in Figure 5. These figures show the total number of pots hauled within each grid square, alongside known string locations. The maps were also overlaid with the Voluntary Closed Areas to see if the vessels had been adhering to the guidance. All vessels have been working within the 10m charted depth contour.

Vessel 1 (Figure 6) started potting in the middle of the Sound, below the breakwater. In May to June the vessel gradually started moving strings solely into Cornwall IFCA District near Penlee Point and Rame Head. Since July, this is where the vessel has been potting.

Vessel 2 (Figure 7) has worked solely in D&S IFCA District. The vessel started potting from Bovisand Bay down to the Shag Stone. During the summer months some strings were moved near the Mew Stone.

Vessel 3 (Figure 8) covers the most area out of all the vessels and works around Plymouth Sound in both D&S IFCA District and Cornwall IFCA District. No on-board surveys were carried out on this vessel so exact string locations are unknown. This vessel has fished within the Voluntary Closed Areas regularly since they were implemented. However, only 20 pots were hauled in both L12 and M11 since June. Without coordinates of the strings, it is unknown if the vessel is fishing within the closed areas of M12 and K12.

Vessel 4 (Figure 9) has worked in both D&S IFCA District and Cornwall IFCA District throughout the year. The vessel started in the middle of the Sound, below the breakwater. In August strings were moved near Fort Picklecombe, Drakes Island and Mount Batten where the vessel has been fishing since. This vessel has fished within the Voluntary Closed Areas since they were implemented, however, strings are in the far corner of L11 and in the Cornish side of K12 (Figure 9). While no fishing has been recorded during on-board surveys, the landings forms have stated 200 pots were hauled in M11 during August.

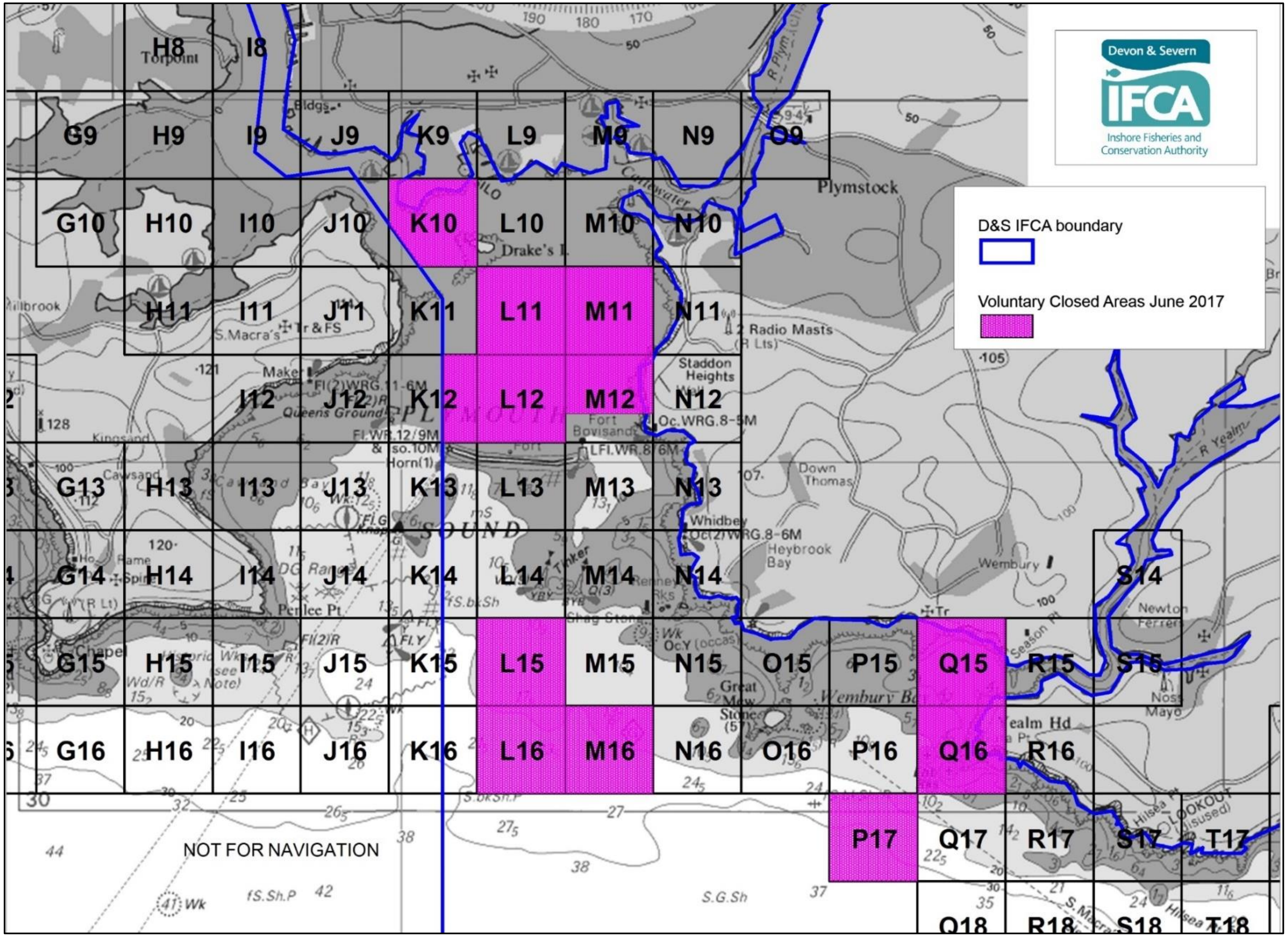

Figure 4 – Chart of Voluntary Closed Areas June 2017

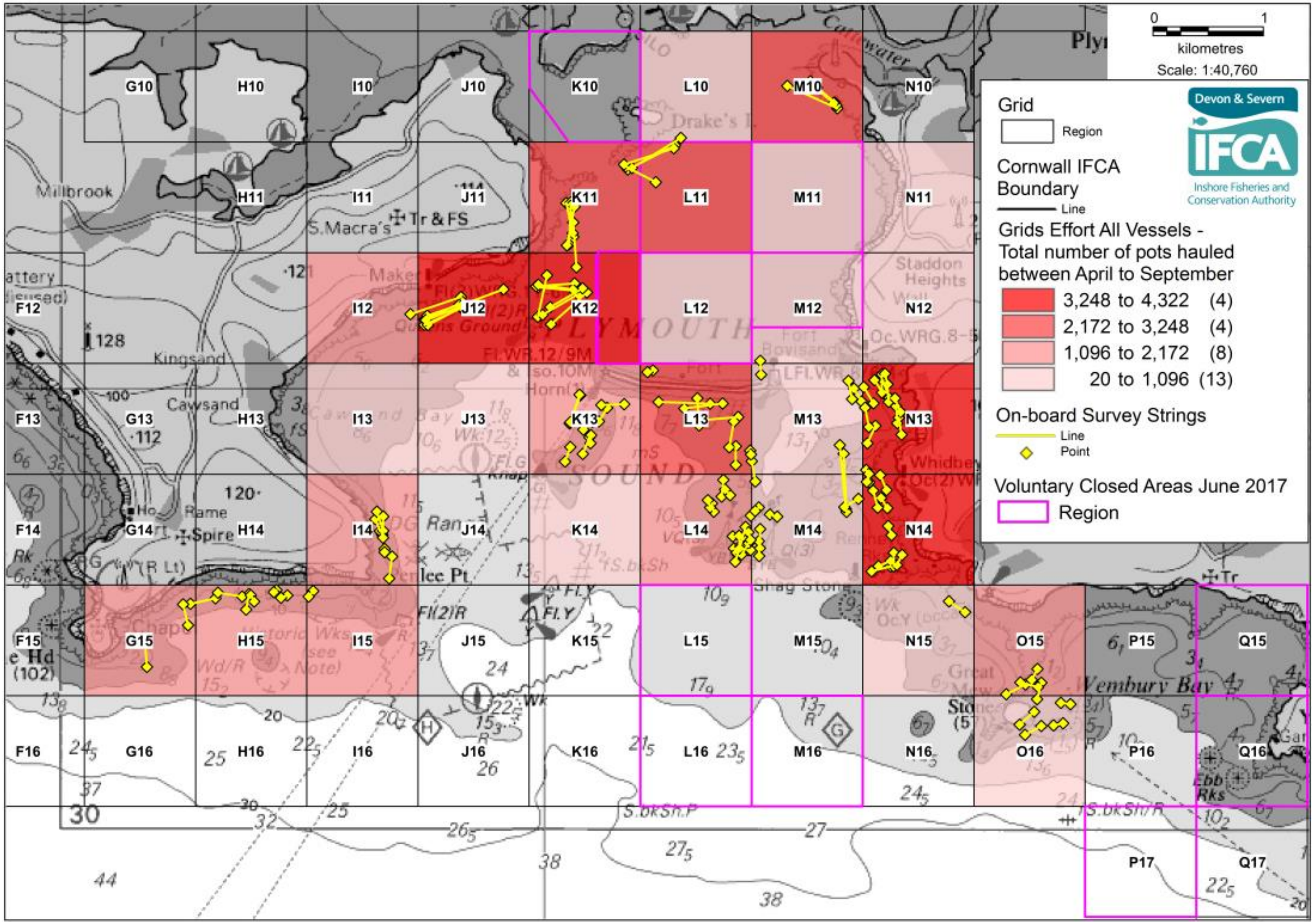

Figure 5 – Chart of Plymouth Sound showing areas worked by all vessels during 2017.

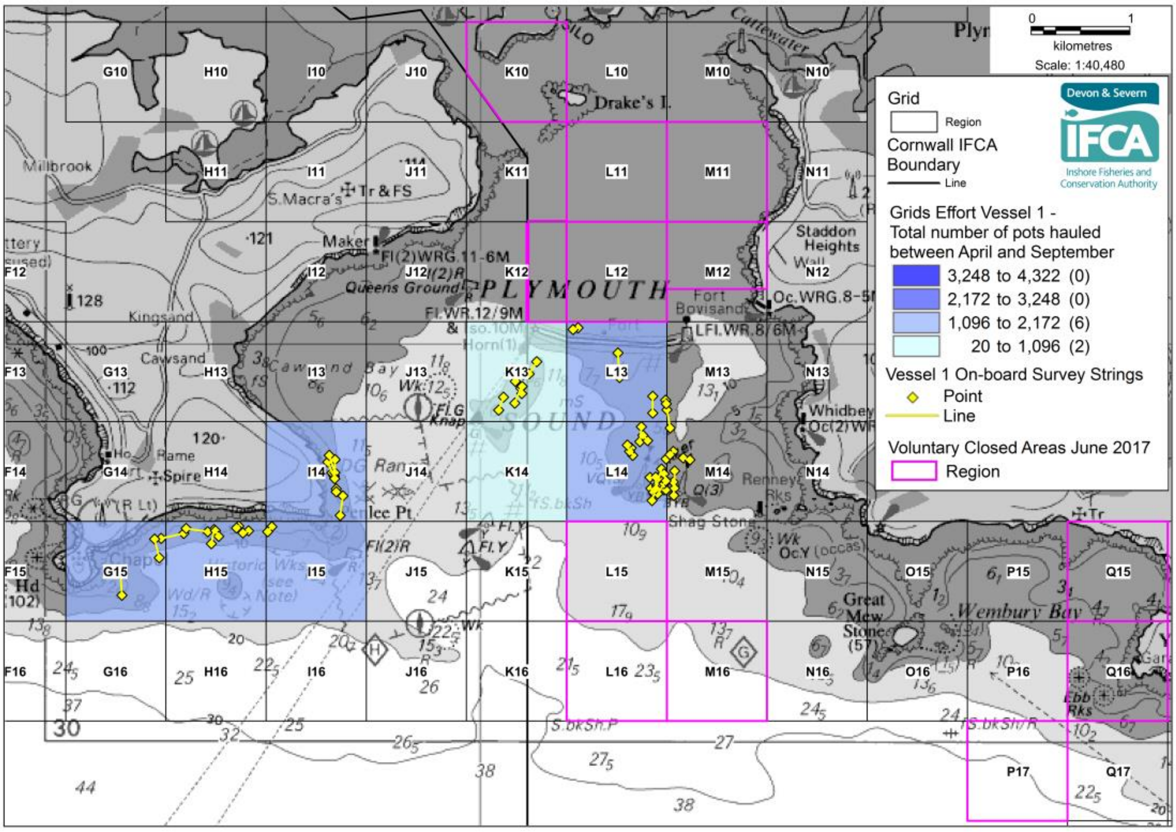

Figure 6 – Chart of Plymouth Sound showing areas worked by Vessel 1 during 2017.

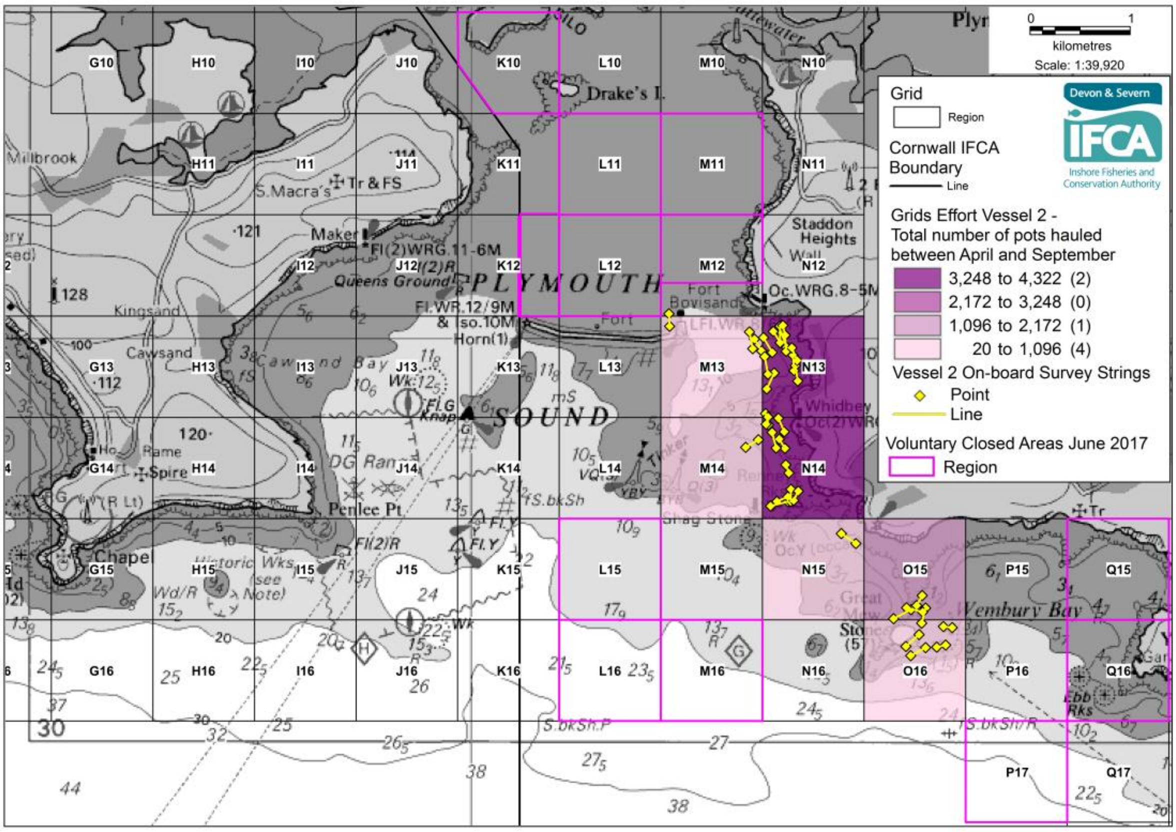

Figure 7 – Chart of Plymouth Sound showing areas worked by Vessel 2 during 2017.

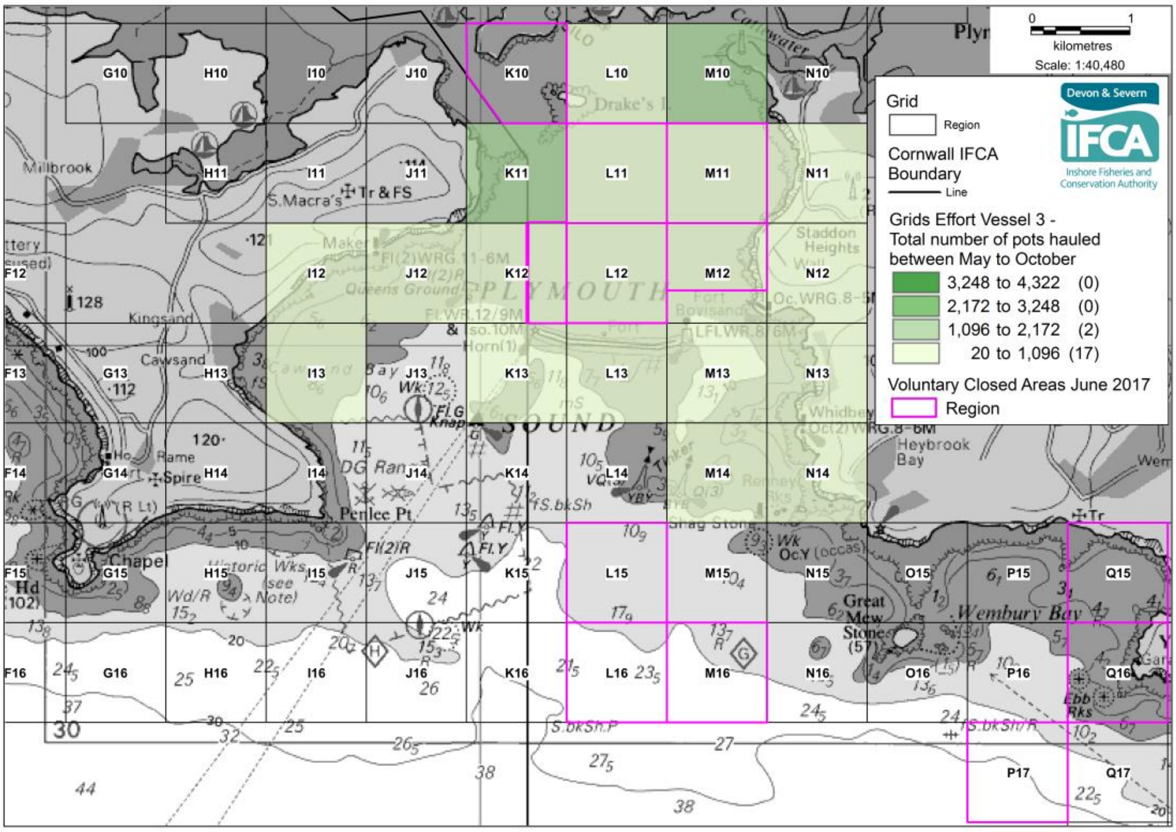

Figure 8 – Chart of Plymouth Sound showing areas worked by Vessel 3 during 2017.

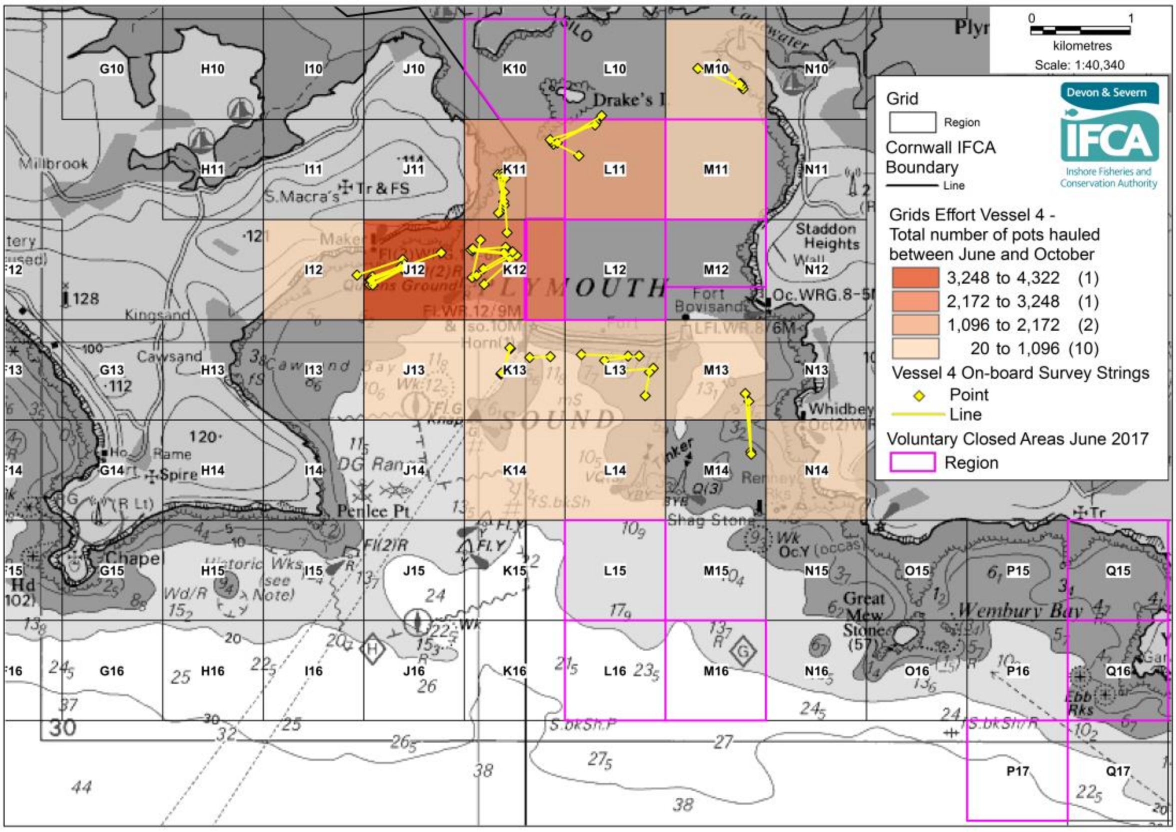

Figure 9 – Chart of Plymouth Sound showing areas worked by Vessel 4 during 2017.

3.5 Catch Composition

The catch compositions of wrasse recorded per month during the on-board surveys are shown below (Figure 10). Goldsinny and rock cook represent the largest proportion of the catches throughout the survey period. The percentage of corkwing increases over time, from 3% in April to 30% in September. Ballan also increases slightly over the survey period from 4% in April to 16% in September. Very few cuckoo wrasse were seen in catches, with the most (5%) in April. Although the catch composition varies temporally, this may be a result of vessels changing fishing effort spatially over the months. For example, the rise in corkwing over time may be attributed to Vessel 4 moving strings closer inshore, inside grids J11, K11 and K12 (Figure 9 and Figure 12).

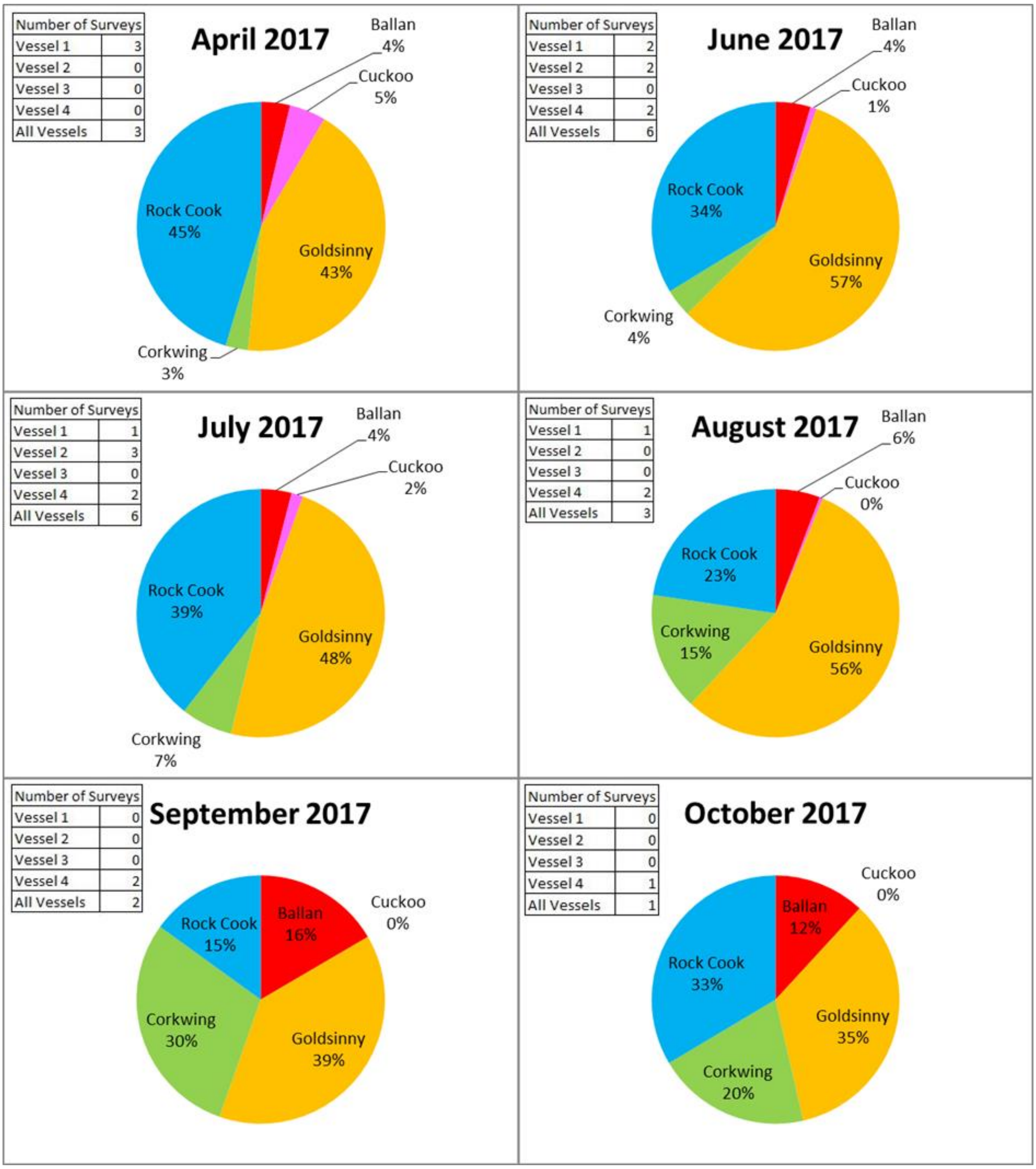

Figure 10 – Catch composition of all wrasse species per month.

The catch compositions of wrasse per vessel are shown below (Figure 11). Goldsinny is the highest proportion of catch for all three vessels, with rock cook in second place. There are subtle differences between vessels, with a higher proportion of ballan and corkwing caught by Vessel 4 compared to Vessel 1. These catch compositions per vessel relate to both the spatial effort figures (Figure 6, Figure 8 and Figure 9) and the catch compositions per grid square (Figure 12).

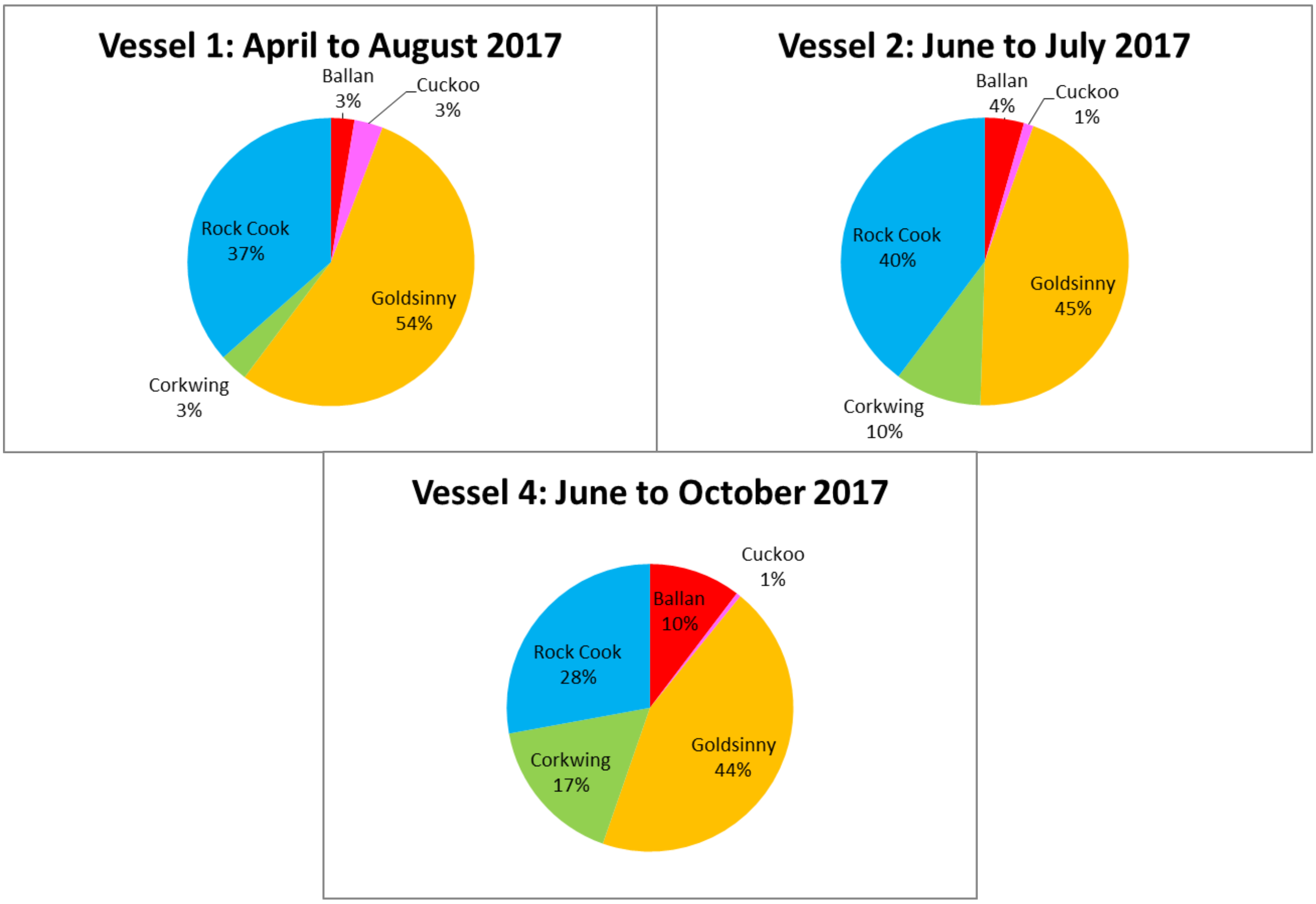

Figure 11 – Catch composition of all wrasse species per vessel

The catch compositions of wrasse per grid square can be seen in Figure 12. The catch composition varies considerably across Plymouth Sound. Goldsinny catches were highest in the south west of the chart, near Rame Head and Penlee Point. Rock cook dominated near the Mew Stone and south of the Breakwater. The proportion of corkwing is greatest in shallow coastal areas, namely, north of the breakwater and Wembury Point. Ballan percentages were also highest north of the breakwater, with very few seen in the south west of the chart. Cuckoo were rarely seen and those that were caught, were in more exposed areas; south of the breakwater and near the Mew Stone.

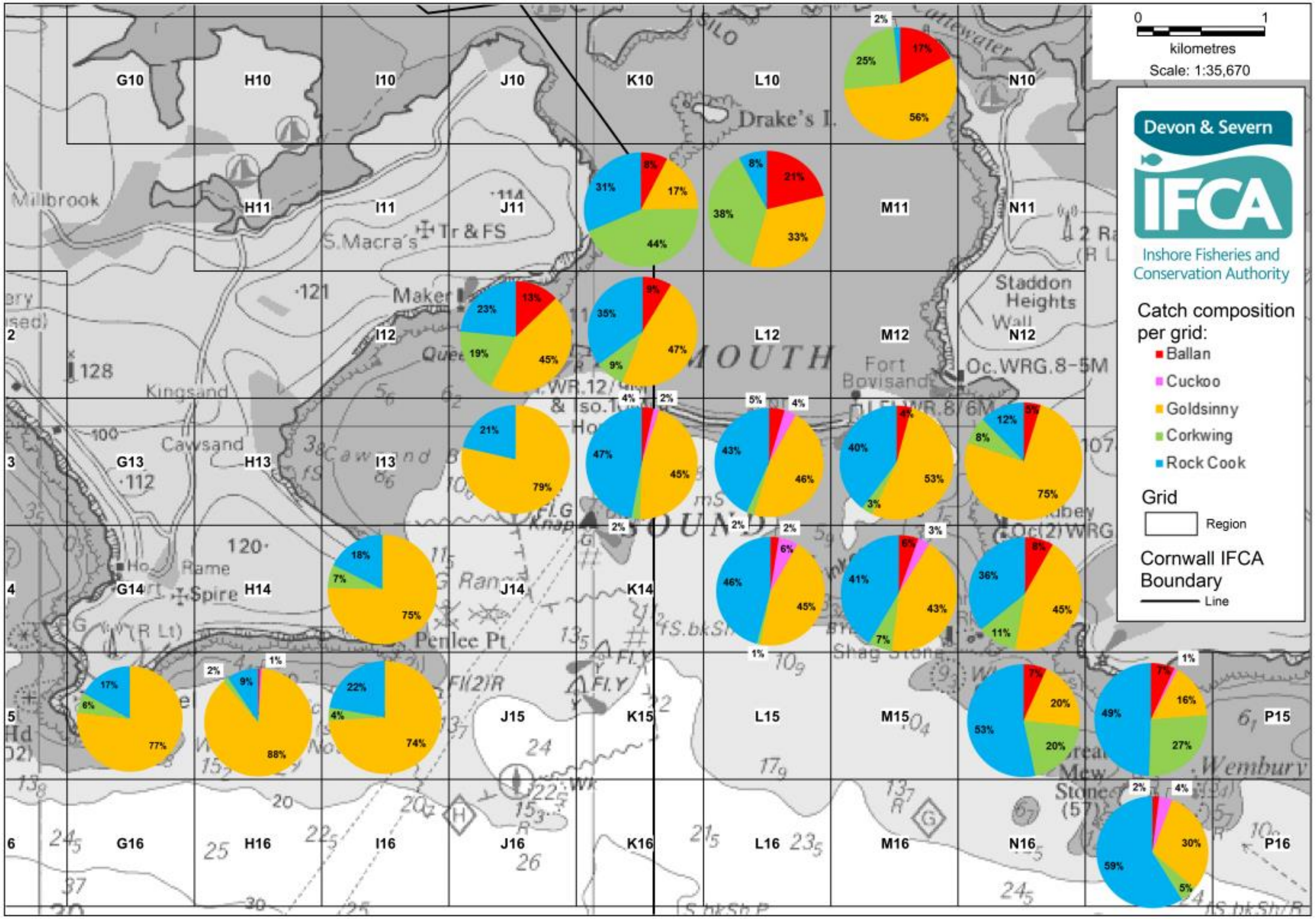

Figure 12 – Chart showing catch composition per grid in Plymouth Sound during 2017.

3.6 Size Distributions

Size-frequency histograms of all wrasse caught during the on-board surveys are shown below (Figure 13 to Figure 17). These figures show the slot size ranges for each species to demonstrate if the current Min and Max CRS are sufficient for management.

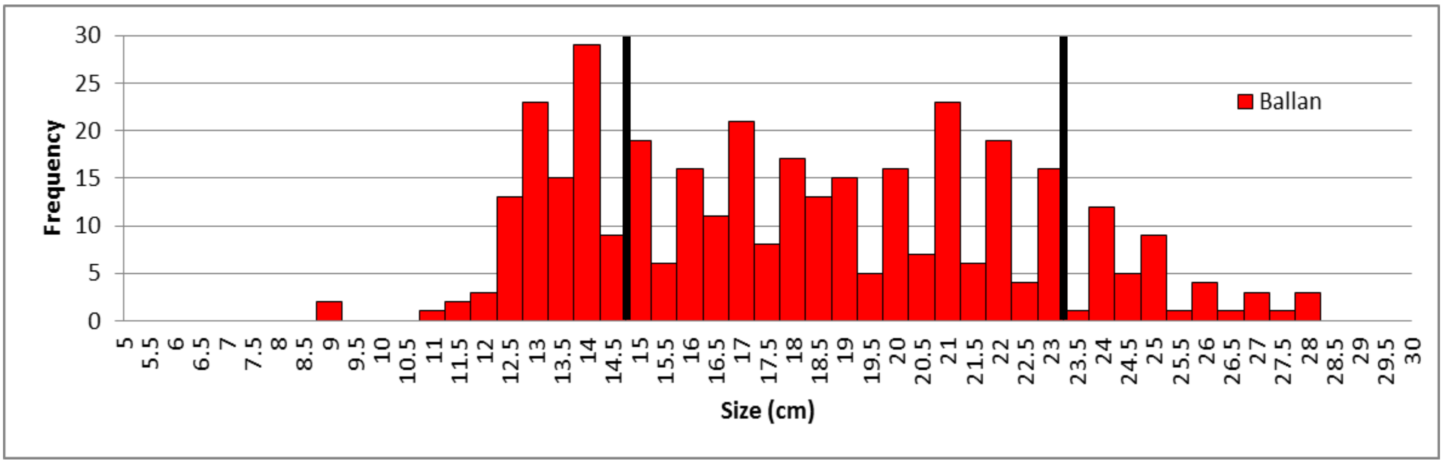

Figure 13 – Size-frequency histogram for all ballan caught (regardless of whether they were retained or returned) during surveys. Chart includes Minimum and Maximum Conservation Reference Size lines.

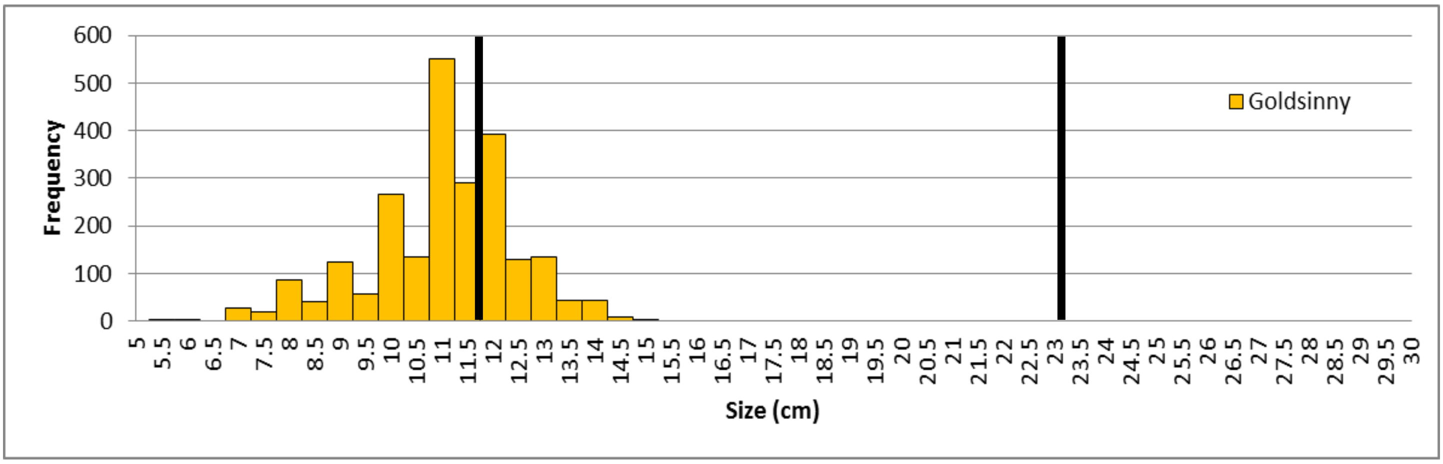

Figure 14 – Size-frequency histogram for all goldsinny caught (regardless of whether they were retained or returned) during surveys. Chart includes Minimum and Maximum Conservation Reference Size lines.

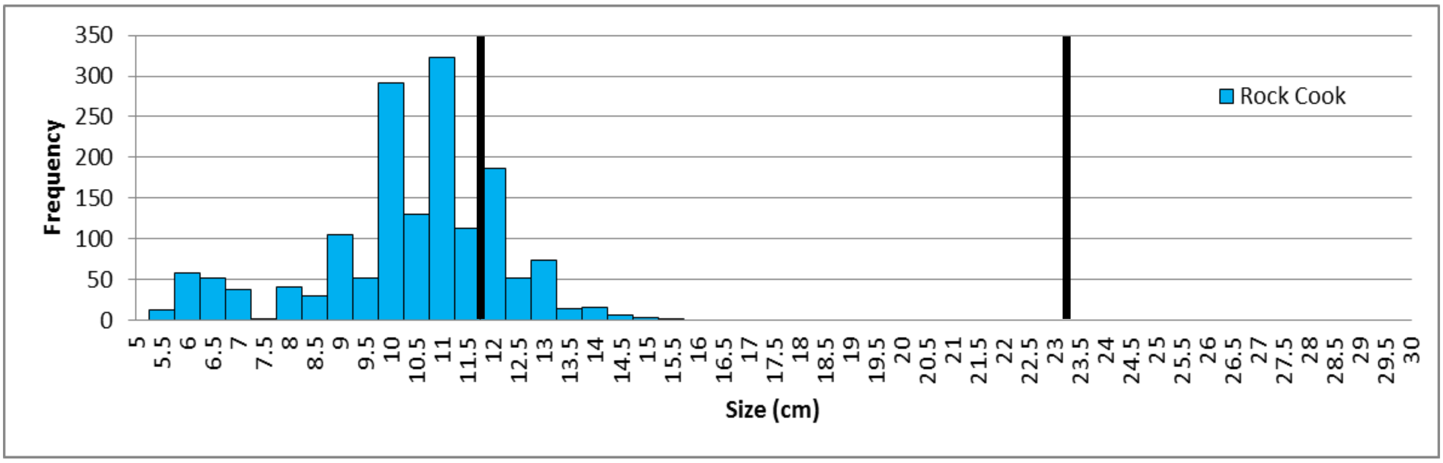

Figure 15 – Size-frequency histogram for all rock cook caught (regardless of whether they were retained or returned) during surveys. Chart includes Minimum and Maximum Conservation Reference Size lines.

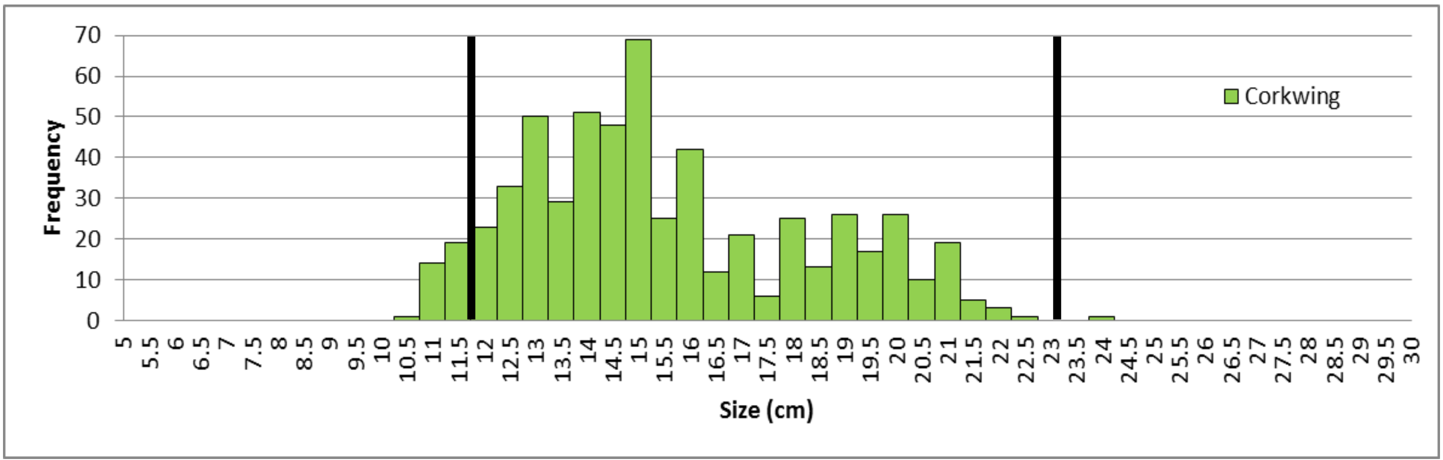

Figure 16 – Size-frequency histogram for all corkwing caught (regardless of whether they were retained or returned) during surveys. Chart includes Minimum and Maximum Conservation Reference Size lines.

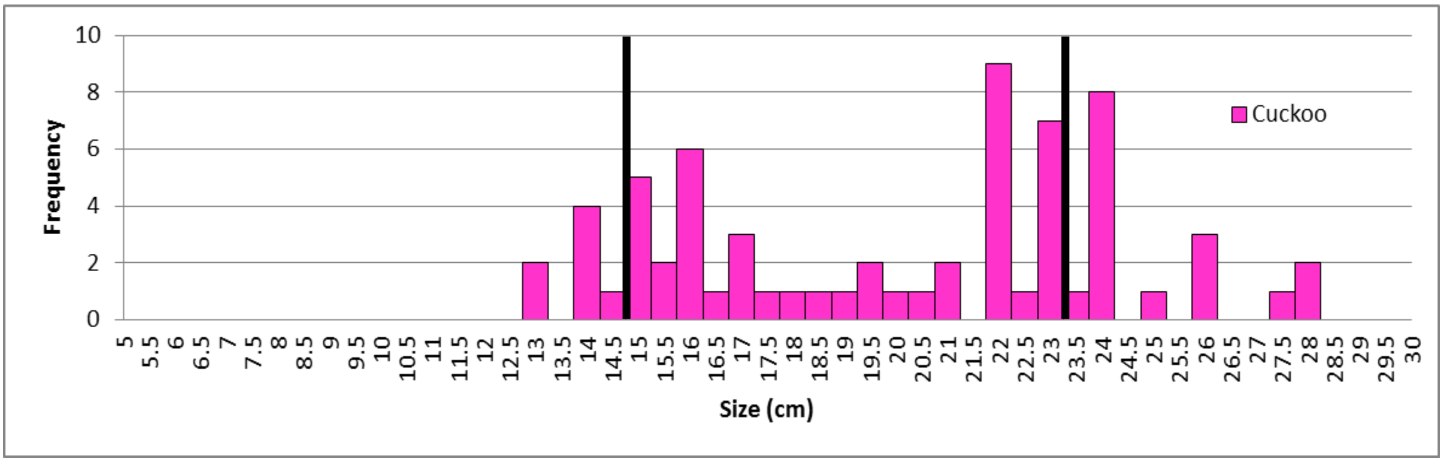

Figure 17 – Size-frequency histogram for all cuckoo caught (regardless of whether they were retained or returned) during surveys. Chart includes Minimum and Maximum Conservation Reference Size lines.

The size-frequency histogram for ballan (Figure 13) varies with numbers of individuals ranging between the minimum and maximum sizes seen, 9cm and 28cm respectively. Around 62% of the numbers of ballan seen were within the size range that can be landed. Then 27% were below Min CRS and 11% above Max CRS. The average size of ballan was 18cm (SD±4.05cm).

The size-frequency histograms for both goldsinny and rock cook (Figure 14 and Figure 15) show a large proportion of species are under the Min CRS. For goldsinny, 68% were under Min CRS and 32% were above. For rock cook, 78% were under Min CRS and 22% were above. Goldsinny size ranged from 5.5cm to 15cm and rock cook size ranged from 5.5cm to 15cm. The average size of goldsinny was 11cm (SD±1.42cm) and rock cook 10.5cm (SD±1.82cm).

The size-frequency histogram for corkwing (Figure 16) shows that the majority of corkwing (94%) seen were within the Min and Max CRS ranges. Only 5.8% were under Min CRS and 0.2% over Max CRS. The minimum and maximum sizes seen were 10.5cm and 24cm. The average size of corkwing was 15.5cm (SD±2.78cm).

The catches of cuckoo were low and the size-frequency histogram for cuckoo (Figure 17) show the minimum and maximum sizes seen were 13cm and 28cm. Of the numbers seen, 10% were below Min CRS and 24% above Max CRS. The average size of cuckoo was 20cm (SD±4.15cm).

The proportion of wrasse landed and returned to sea during the on-board surveys can be seen in Figure 18. It shows that over 90% of corkwing caught are landed. Whereas, around three quarters of rock cook and two thirds of goldsinny caught, are not retained but returned to sea. Cuckoo are not targeted by the fishery and all fish caught are returned to sea.

Figure 18 also shows that a high proportion of the ballan wrasse caught, are landed. However, this is across the whole survey period. Devon and Severn IFCA brought in permit conditions which included Min CRS of 15cm and Max CRS of 23cm in July 2017 for ballan. After the introduction of the Min and Max CRS the percentage of ballan landed was 72% and 28% returned. Whereas, before the Min and Max CRS were brought into place and in Cornwall IFCA, the proportion of ballan landed was 96% and 4% returned.

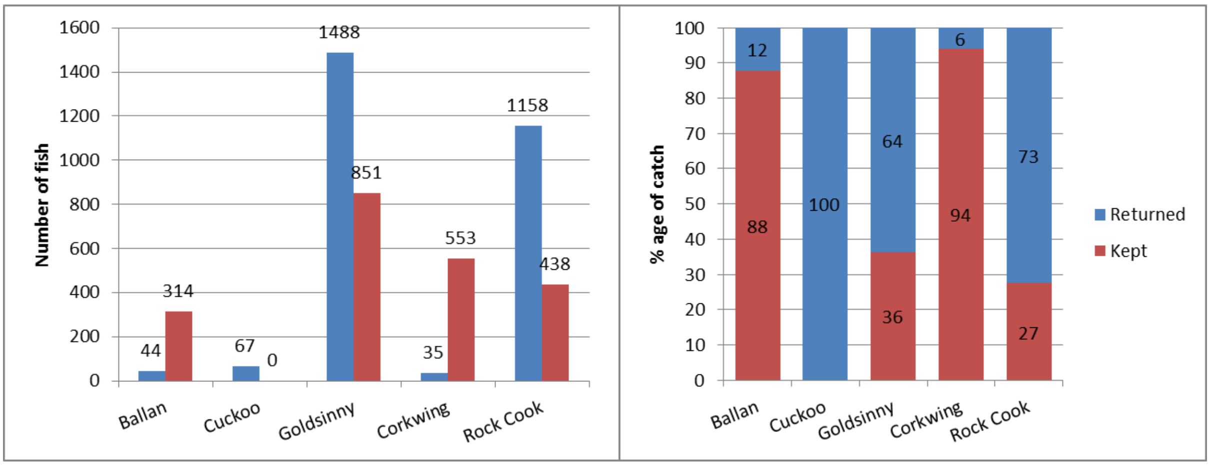

Figure 18 – The percentage of wrasse kept and returned during on-board surveys.

The size distribution of male and female corkwing can be seen in Figure 19. Unidentified sex tended to be juveniles with no distinguishing features to identify sex. Females were generally in lower abundance compared to males. There appears to be two cohorts for the male size distribution (Figure 19).

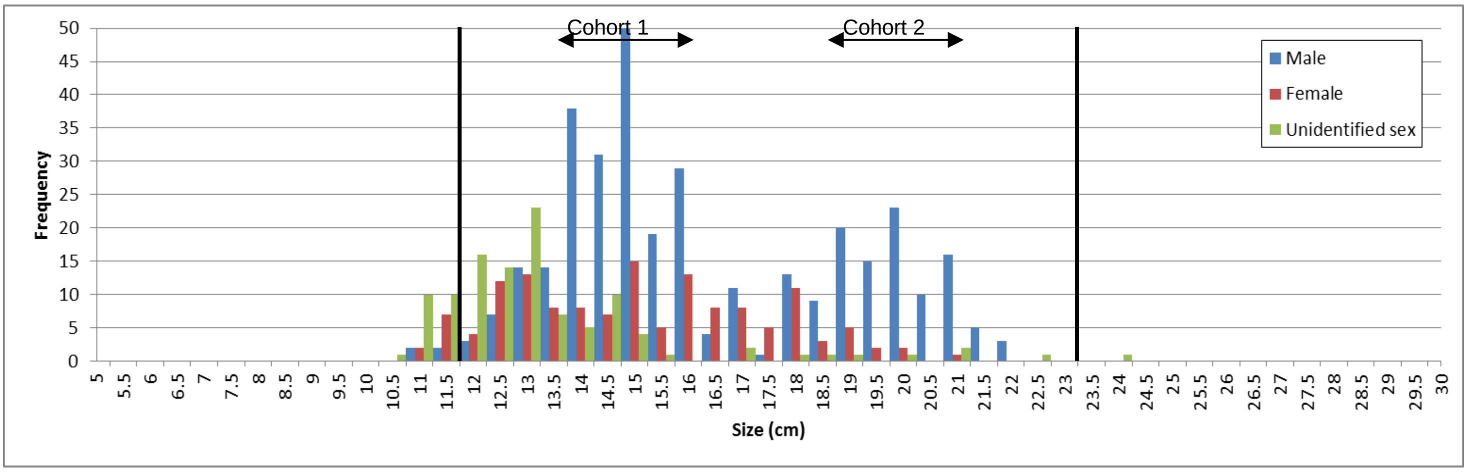

Figure 19 – Size-frequency histogram for corkwing caught by sex (regardless of whether they were retained or returned) during surveys. Chart includes Minimum and Maximum Conservation Reference Size lines.

With a significant percentage of corkwing caught landed (Figure 18), Figure 20 shows the numbers of corkwing returned under the current Min and Max CRS compared to alternative slot sizes based on size at maturity. The slot size 12-18cm increases the number of mature nesting males returned to sea, protecting the second male cohort seen in Figure 19. Whereas, the slot size 15-23cm increases the number of juveniles (unidentified sex), females and males from first cohort (Figure 19) returned. The slot size 14-18cm encompasses the second male cohort and a proportion of the juveniles, females, and males from the first cohort. The proportion retained by the fishers can be seen in Appendix 3, Figure 29.

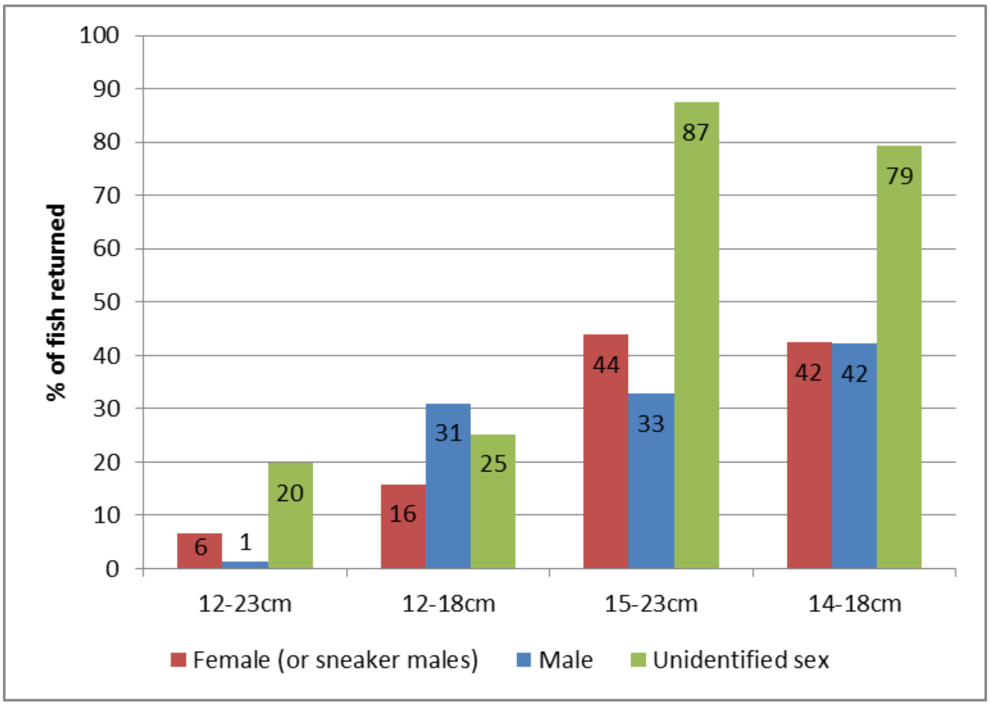

Figure 20 – The percentage of corkwing returned in current Minimum and Maximum Conservation Reference Sizes and alternative slot sizes.

3.7 Spawning State

During on-board surveys officers checked each fish for milt or eggs by stripping, and this was used as an indicator for spawning. Figure 22 shows the number of each species of wrasse observed spawning over the survey period with data included from Cornwall IFCA on-board surveys near Falmouth and Mevagissey. This figure also shows the current closed season between 1st April and 30th June. Appendix 4 (Figure 30 and Figure 31) shows the spawning data collected separately from Devon and Severn IFCA and Cornwall IFCA.

Spawning was first observed by one goldsinny in the middle of April (Figure 22). The number of fish spawning increased to 53 in May, with 10 goldsinny, two corkwing and 41 rock cook observed with milt or eggs. June and July saw the highest numbers of spawning 135 and 96 respectively, with 35 goldsinny, seven corkwing and 91 rock cook in June and 23 goldsinny, four corkwing and 69 rock cook in July. Only one ballan and one cuckoo were observed spawning over the survey period and these two individuals were both seen with eggs in June. Numbers of spawning fish dropped in the following months, with one goldsinny and one rock cook in August, one corkwing in September and two corkwing in October.

Signs of spawning were also noted, such as swollen bellies seen in female goldsinny from May through to August. During the spawning season male rock cook become an iridescent blue/ purple colour and this was also observed between May and August.

Figure 21 demonstrates the ratio of wrasse spawning to not spawning, including those not assessed. Appendix 4, Table 6 shows the actual data and calculated percentage values for Figure 21. There was a significant amount of wrasse not assessed for spawning for the first four months as stripping was not conducted during these surveys.

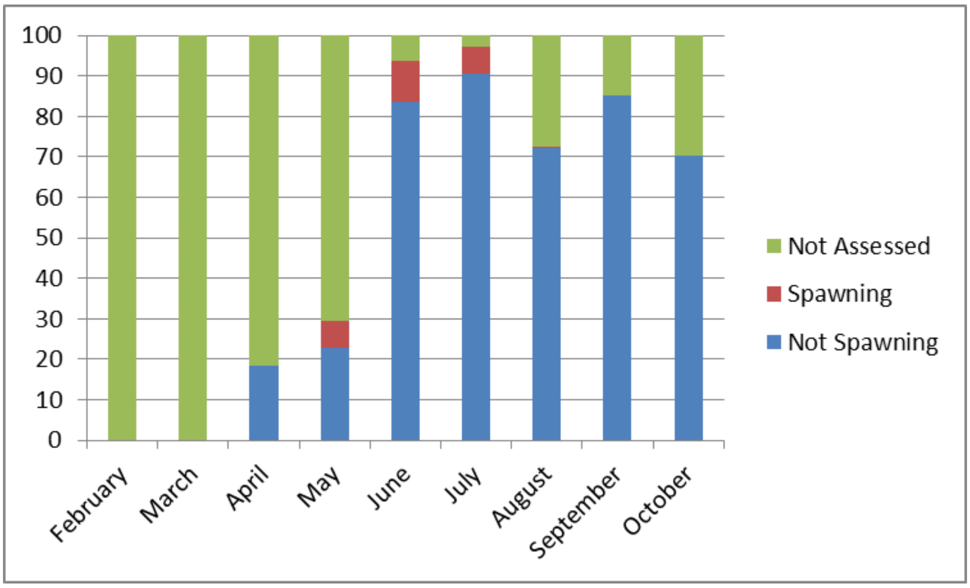

Figure 21 – Ratio of wrasse spawning to not spawning and showing those that were not assessed from D&S IFCA & CIFCA during 2017.

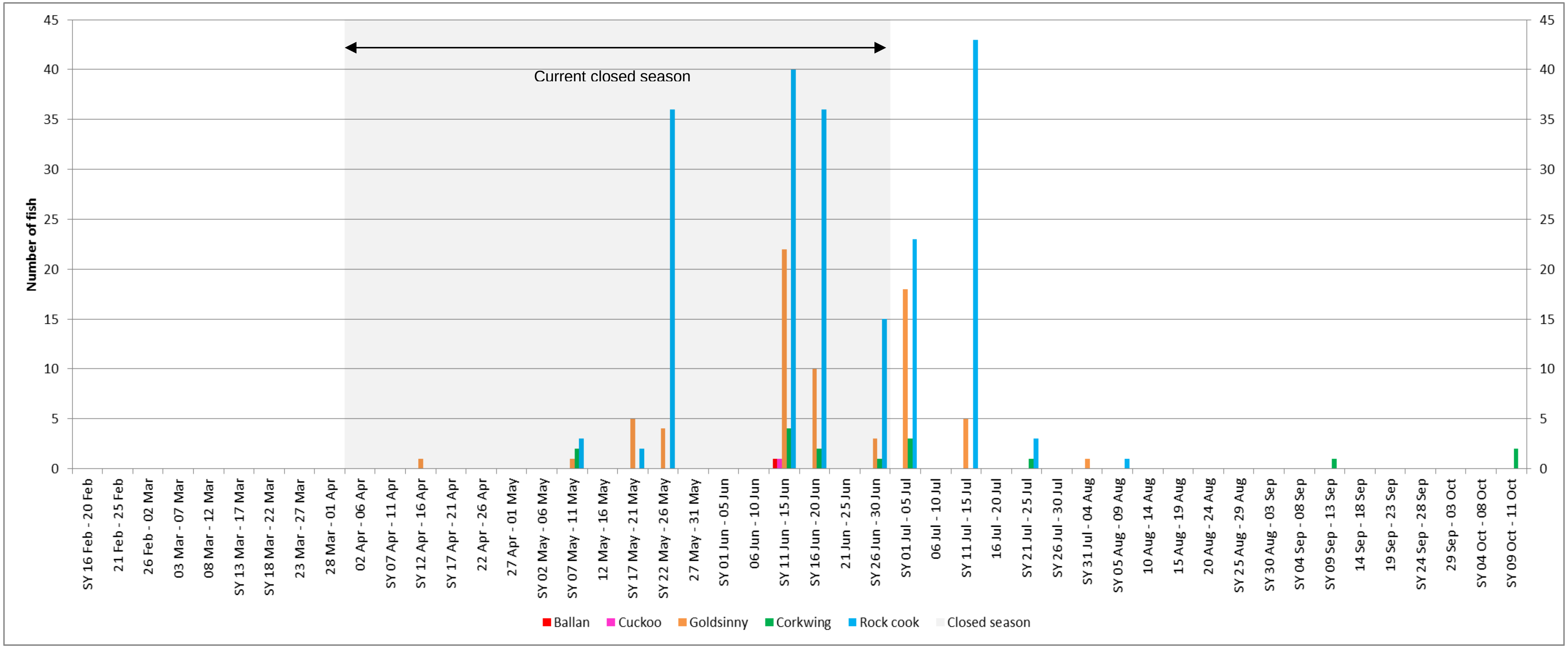

Figure 22 - Spawning state of wrasse species seen during surveys from D&S IFCA & CIFCA during 2017.

4.0 Discussion

4.1 Trends in Catches and Early Indications of Sustainability

There has been no consistent decline in CPUE or LPUE over the timeframe of the first fully documented season of the wrasse fishery. Reductions in CPUE in other wrasse fisheries which also occurred in limited geographic areas have been known to occur over a two-year time frame (Darwall *et al.* 1992, Varian et al. 1996).

Observed seasonal fluctuations in CPUE and LPUE could be due to a number of factors. Seasonal migration of wrasse into different areas could affect their local abundance and therefore CPUE and LPUE. However, many wrasse are territorial (Davies, 2016 and references therein) and have been known to be associated with an individual territory for many years (Darwall *et al*. 1992). Additionally, whilst fewer observations of wrasse in inshore environments in winter months was once attributed to their migration into deeper water (Hillden 1981) it is now thought to be due to behavioural changes where wrasse hide in crevices in reefs during the winter months (Darwall *et al.* 1992). Seasonal patterns of growth and feeding intensity in wrasse are known to be related to temperature (Darwall *et al.* 1992), which could also affect the LPUE and CPUE. For example, the males of corkwing invest in nesting and territory defence during the spawning period, resulting in a reduced LPUE/CPUE during the spawning season and an increased LPUE/CPUE after the spawning season (Skitesvik *et al.* 2015). Seasonal increases in CPUE between May and August, similar to those observed in this fishery, were noted in an Irish wrasse fishery and were attributed to increased sea temperature (Darwall *et al.* 1992).

The overall LPUE/ CPUE will be affected by a complex interaction of the ecology and behaviour of individual species, and spatial and temporal patterns of fishing effort. Catch composition varies temporally with the CPUE/ LPUE of some species remaining relatively constant over time, whilst others vary seasonally. However, catch compositions also vary spatially, which is an important consideration in the interpretation of temporal patterns of CPUE. For example, increases in corkwing CPUE could be attributed to a seasonal migration into the fished area, however closer interrogation of spatial patterns of fishing effort showed that their increased CPUE was more likely to be due to a fisher moving their effort into a more sheltered inshore area, favoured by corkwing wrasse. Similar complexities were noted in the sampling of wrasse in Norwegian fjord, where small shifts in sampling locations led to changes in species compositions which could lead to erroneous interpretation of the data if spatial and temporal patterns of fishing effort were not included in the analysis (Skitesvik *et al.* 2015).

Goldsinny were found in most fished locations, and were the dominant species in most of the grid cells. Corkwing, rock cook and ballan wrasse had more limited geographic distributions within the fished areas of Plymouth Sound. This is consistent with other studies which found goldsinny to have a wider ecological niche and to have greater ecological plasticity than corkwing, and to be found in areas of higher wave exposure (Skiftesvik *et al.* 2015). Corkwing, are a more ecologically specialist species which are limited to sheltered, shallower areas. The reproductive strategies of the two species also differ, with goldsinny producing 5 times as many eggs as corkwing wrasse. These factors can be described by selection theory as being r-selected (goldsinny) and k-selected (corkwing). R-selected species are generally more able to withstand exploitation and may recover more quickly than k-selected species (Darwall *et al.*1992, Skiftesvik *et al.* 2015). In Norwegian fisheries the ratio between corkwing and goldsinny wrasse has therefore been proposed as a relatively simple measure of the sustainability of the fishery (Skiftesvik *et al.* 2015), although in these fisheries the dominant species was corkwing, unlike in Plymouth Sound where the dominant species is the (potentially) less vulnerable goldsinny. Any such ratio would have to be spatially explicit (e.g. within a grid cell/ habitat or depth contour) as otherwise changes in the spatial distribution of fishing effort could affect the ratio, rather than true changes to the ratio between species. It is evident that careful consideration of the temporal and spatial patterns of CPUE and fishing behaviour within the context of individual species ecology are required in order to fully understand patterns of LPUE and CPUE. The current level of data collection does allow for these analyses.

An added complication is that, because the survey is fishery dependent, and the fishery only occurs in shallower water depths (generally less than 15m) the surveys only sample the portion of the stock in this depth range. Whilst many species of wrasse prefer shallower areas, most have depth ranges which far exceed the depth range of the fishery. It is possible that wrasse from deeper areas could act as a source that repopulates the shallower areas following fishing. However, given the territoriality of wrasse and possible differences in species composition between shallow and deeper areas, the likely nature of this process is unknown. Because the fishery only exists in a very limited geographic area at the present time, even if local reductions in LPUE/CPUE occurred the impact of the fishery on the population of wrasse is likely to be limited (Darwall *et al.* 1992, Hilborn and Walters 1992).

The analysis of the LPUE and CPUE data has been hugely benefited by the spatial and temporal mapping of effort and the consideration of spatial patterns of catch composition. It is vital for future interpretation of the data that this level of data collection continues in order to understand underlying causes of changes in LPUE and CPUE over time and space.

The interpretation of LPUE and CPUE data would also benefit from studies investigating pot saturation and its causes. Pot saturation can de-couple fishing effort and catch, which may lead to the misinterpretation of trends in natural abundance (Bacheler, 2013). Understanding the causes of saturation are also important as, if saturation occurs when catch is at a level which is in proportion to the true abundance for an area, then it may not decouple the CPUE-abundance relationship. D&S IFCA Officers are in the process of designing a multi-stage pot saturation experiment which includes the development of methodologies and a number of pilot and trial studies. It has not been possible to include these in the 2017 survey programme, partly because the design of the survey will benefit from the interpretation of spatial and temporal patterns of CPUE data collected in 2017. Development work continues and is planned for 2018. Initial observations on-board observer surveys suggest that saturation caused by interspecific or intraspecific aggressive behaviours are unlikely to occur as multiple wrasse of different size classes and species are often found in the same pot (S.Davies pers.comms.).

4.2 Size Distribution and Slot Limits

The size distributions of goldsinny and rock cook show a significant proportion of the catch is returned to sea. Size at maturity for goldsinny and rock cook has been recorded at 9cm for males, and 8cm for female goldsinny, and 8.5cm for female rock cook (Matland, 2015). Therefore, the current Min CRS at 12cm is allowing individuals to return and able to spawn. Future monitoring will be vital to assess if the average size of goldsinny and rock cook reduces over time. The largest goldsinny and rock cook seen were 15cm and 15.5cm respectively, way below the Max CRS. Therefore, this fishery is selecting for older, larger individuals and the average size would be expected to decrease over time (Darwall *et al.* 1992).

Cuckoo wrasse are not targeted by the fishery and returned to sea therefore cuckoo will not be discussed further in this report. Since the introduction of the Min and Max CRS for ballan (15cm and 23cm), the proportion of catch returned to sea increased from 4% to 28%. Ballan size at maturity is 16-18cm for females and 28cm for males (Darwall *et al.*1992). Ballan are hermaphrodites and start life as a female, changing to a male later in life. Therefore, the current slot limit is protecting juvenile females and mature males.

With the current slot size, the majority of corkwing caught was landed, with few individuals below or above the Min and Max CRS (12-23cm). Corkwing size at maturity is 9cm for females and 14cm for males (Matland, 2015). This implies that all mature males, females and a proportion of immature males are retained. Corkwing have a complex life history, with sexual size dimorphism meaning nesting males attain larger body sizes than females (Halvorsen *et al.* 2016a). Nesting males were found to have higher vulnerability to being captured in a baited pot fishery (Halvorsen *et al.* 2016b) which can result in fishery induced changes in sex ratios. Darwall *et al.* (1992) found there was a reduction in corkwing males greater than 13cm in the second year of the fishery, suggesting the fishery may have depleted number of large males in Mulroy Bay, Ireland. At the current state, there is a need to change the MCRS for corkwing in order to protect a proportion of the population. Figure 20 demonstrates the difference between the current Min and Max CRS compared to alternative slot sizes based on size at maturity for males and females, and the work by Halvorsen (2016). With the need to protect nesting mature males, alongside juveniles, females, sneaker males and immature nesting males, the alternative slot size of 14cm to 18cm would address these requirements. This will also contribute to 58% of males and females, and 21% unidentified sex still able to be landed by fishers (Appendix 3, Figure 29).

4.3 Spawning Season

The majority of observed spawning took place between May to mid-July. Corkwing and goldsinny are batch spawners (Darwall *et al.* 1992) meaning they only spawn periodically. This may explain the difficulties in detection during surveys, for example, female goldsinny were observed to have swollen bellies but did not release eggs and few spawning corkwing were recorded. Matland (2015) found the peak spawning period for corkwing and goldsinny in Norway was end of May to mid-June. Another study found corking spawning period was May to July (Halvorsen *et al.* (2016b), peaking in June (Skiftesvik *et al.* 2015). Rock cook were observed spawning throughout May to August, with no peak period found in Norway (Matland, 2015).

Ballan exhibit synchronous spawning meaning all individuals spawn in unison (Darwall *et al.* 1992) which may explain for the lack of ballan spawning observed. Muncaster *et al.* (2010) found the spawning period for ballan was from April to July from the west coast of Norway but from January to April for females in Galicia, Spain (Villegas-Rios *et al.* 2013).

The current closed season is from 1st April to 30th June. The data presented indicates that the closed season in place covers the majority of the spawning period for goldsinny and rock cook. However, for ballan, corkwing and cuckoo there is limited data to determine if the closed season is appropriate.

4.4 Implementation of a Fully Documented Fishery

Fisheries observer effort ranges widely. Extremely high-risk operations such as the Indian Ocean tuna purse seine fishery, which has high levels of marine mammal bycatch, are required to have 100% observer coverage (e.g. Indian Ocean Tuna Commission 2017), but more commonly observer programmes aim for a coverage of between 2 and 7%. The level of on-board observer effort achieved in this study is therefore comparable with observer programmes elsewhere despite difficulties when organising the on-board surveys because of changing logistics, officer availability and workload. Patterns of LPUE and CPUE seem to be relatively consistent, and ecological patterns such as size frequencies and geographic distribution of catch compositions recorded in the observer surveys agree with those found elsewhere in the literature, suggesting coverage is sufficient to collect meaningful data and help inform management.

Consistency of the submission of landings data has improved since the introduction of permit conditions within the Potting Permit Byelaw, making the fully documented fishery a legal requirement for wrasse fishers. Some issues still exist, for example, landings are required weekly from fishers and while this was adhered to, it often required repeated requests by IFCA Officers. Additionally, some forms were filled out incorrectly and meant the data could not be used for analysis. Vessel one still completes landing forms even though it is not fishing within D&S IFCA District. Officers were allowed on board the vessels when requested.

4.5 Voluntary Closed Areas

The Voluntary Closed Areas were implemented at the end of June 2017 and since then two vessels have been recorded not adhering to them. Officers have been in touch with the fishers and asked for them not to fish within the closed areas. Wrasse hold territories and have small home ranges (Davies, 2016 and references therein) and Halvorsen *et al.* (2017) has highlighted the importance of small Marine Protected Areas (MPAs) for maintaining natural population sizes and size structure.

5.0 Conclusions and Officer Comments

1. The on-board observer programme has been very successful and has allowed for the collection of an important dataset allowing analysis of the fishery. This should continue and should aim for coverage of 10% with a baseline of 5%.
2. The observer data and logbook data are crucial for understanding the causes of overall changes in CPUE and LPUE. Data collection must continue.
3. Further research and consideration into the ratios of R selected species (those that may be able to withstand exploitation and recover more quickly e.g. goldsinny) and K selected species (more likely to be impacted by exploitation. corkwing) may allow for the development for relatively simple measures for sustainability of the fishery in a spatially explicit area.
4. The current Min CRS and Max CRS for corkwing means that the majority of corkwing caught are retained and few are returned to sea. Changes to the corkwing MCRS are suggested. The fishery data analysis has included possible changes to the slot sizes and how these would influence the catches and protect more of the population. A slot size of 14-18cm would protect the largest proportion of size ranges, including juveniles, females and large mature males.
5. The majority of observed spawning took place between May to mid-July, the current closed season from 1st April to 30th June protects the majority of the spawning period for goldsinny and rock cook. A possible suggestion could be to shift the closed season to further protect more of the spawning fish.
6. Whilst several of the fishermen are fully adhering to the voluntary closed areas further co-operation from fishers is required to have full compliance. Because the vessels are small open boats the fishers often approximate their position. There is the opportunity to put small GPS units on the boats which could be used to monitor their spatial activity.

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7.0 Appendix 1 – Survey forms

Live Wrasse Pot Fishery			Data Collection by Fishermen			Devon & Severn IFCA		
Date:		Port:	Date:		Port:	Date:		Port:
Vessel:		PLN:	Vessel:		PLN:	Vessel:		PLN:
Grid number	Total no. pots	No. strings fished	Grid number	Total no. pots	No. strings fished	Grid number	Total no. pots	No. strings fished
Daily Totals: No. fish retained			Daily Totals: No. fish retained			Daily Totals: No. fish retained		
Ballan			Ballan			Ballan		
Cuckoo			Cuckoo			Cuckoo		
Corkwing, Goldsinny, Rock Cook			Corkwing, Goldsinny, Rock Cook			Corkwing, Goldsinny, Rock Cook		
The information you supply is covered by the Data Protection Act 1998. The data are processed by the D&S IFCA in accordance with the Data Protection principles contained within the Act. The information you provide will be used by the Authority for fisheries management purposes and anonymised data may be shared with other interested parties.								

Figure 23 - Landings forms filled in daily by fishers and submitted to the IFCA weekly

Live Wrasse Pot Fishery - On-Board Surveys							
Vessel:			PLN:		Port:	Survey Officer:	
Date:		Weather:		Soak time:	Tide HW time/Ht:	Bait Used:	
String no.	Start time:		Start Depth (m)	End Time:		End Depth (m)	Pot no.
	Start lat	Start long		End lat	End long		
Wrasse Species Ballan/Cuckoo/Corkwing/ Rock Cook/Goldsinny (B/C/CW/R/G)			Sex M/F	Size (cm)	Fate Kept/Returned/ Dead (K/R/D)	Maturity Milt/Eggs M/E	Other notes

Figure 24 - On-board observer survey forms

8.0 Appendix 2 – LPUE per vessel

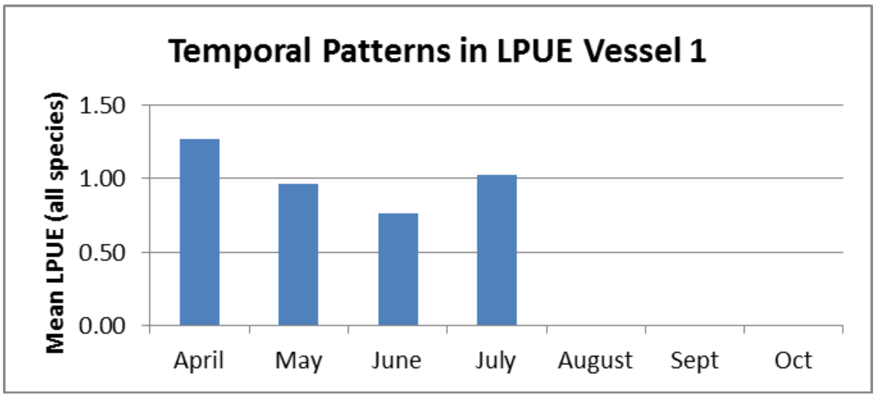

Figure 25 - Landings per Unit Effort (LPUE) for Vessel 1 during 2017.

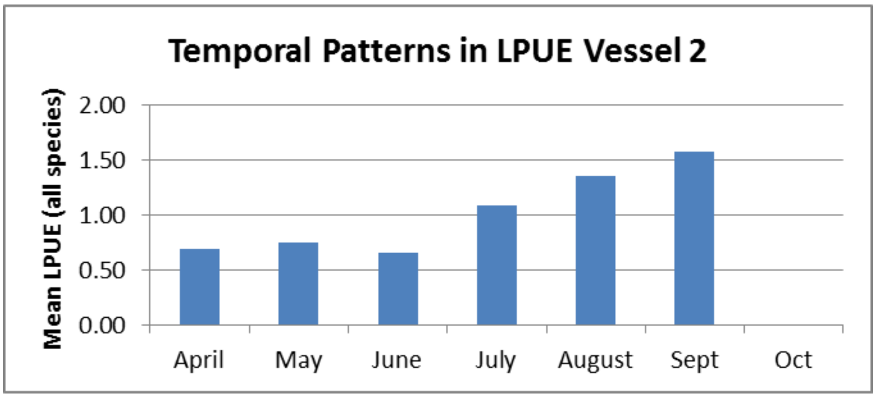

Figure 26 - Landings per Unit Effort (LPUE) for Vessel 2 during 2017.

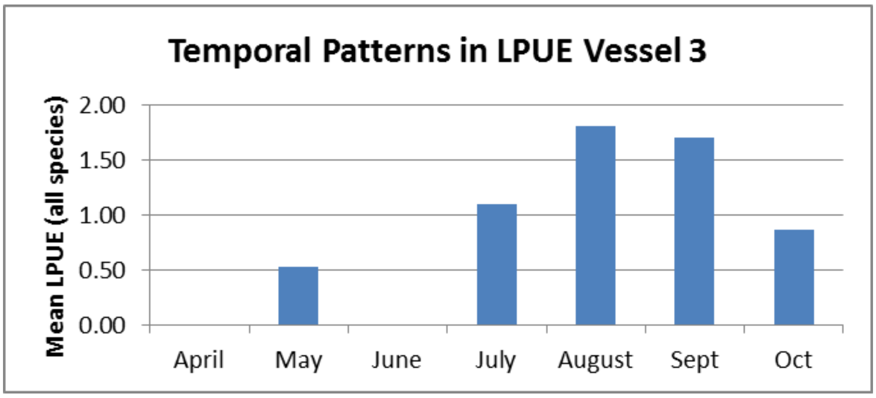

Figure 27 - Landings per Unit Effort (LPUE) for Vessel 3 during 2017.

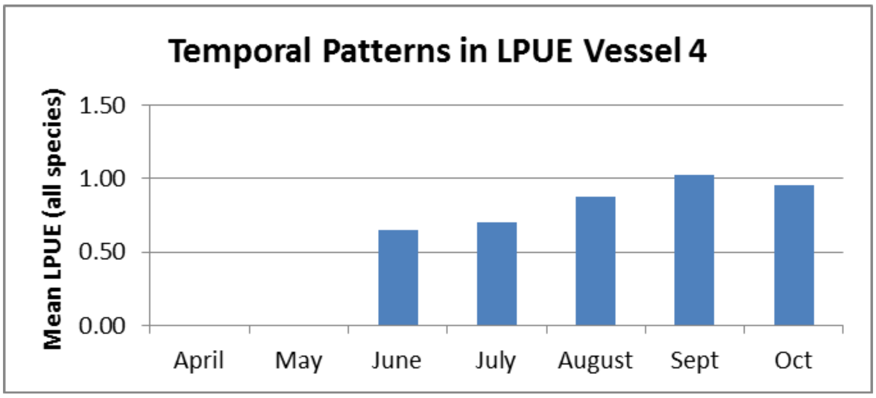

Figure 28 - Landings per Unit Effort (LPUE) for Vessel 4 during 2017.

9.0 Appendix 3 – Corkwing Minimum and Maximum Conservation Reference Sizes

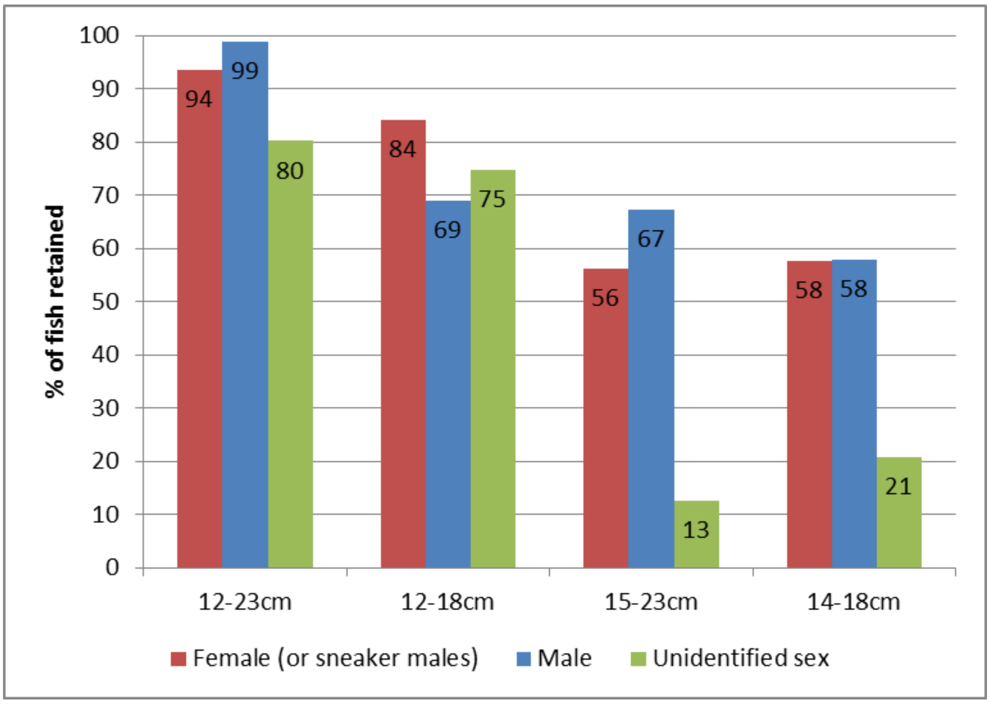

Figure 29 – The percentage of corkwing retained in current Minimum and Maximum Conservation Reference Sizes and alternative slot sizes.

10.0 Appendix 4 – Spawning data

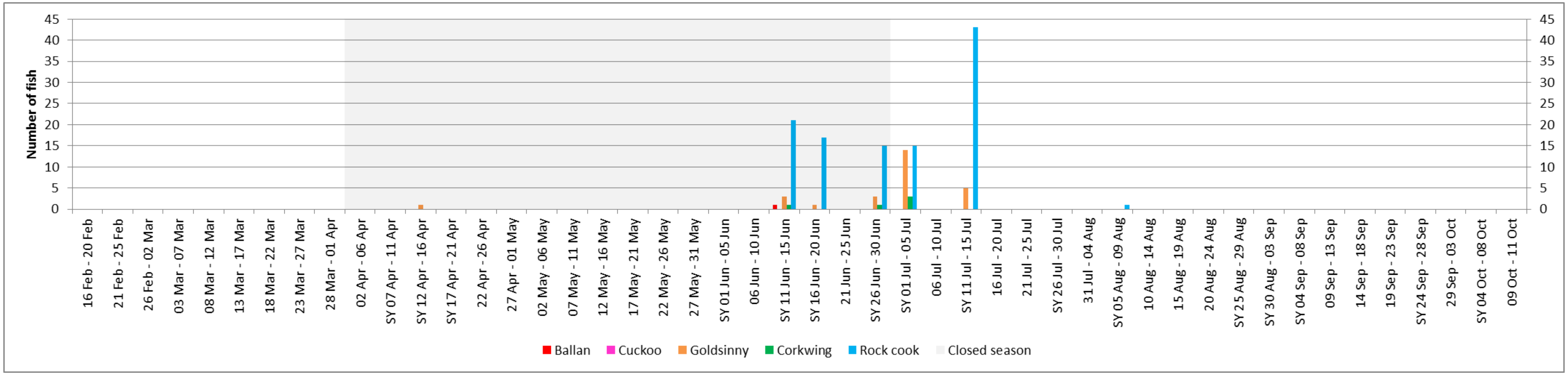

Figure 30 - Spawning state of wrasse species seen during surveys from Plymouth Sound only during 2017.

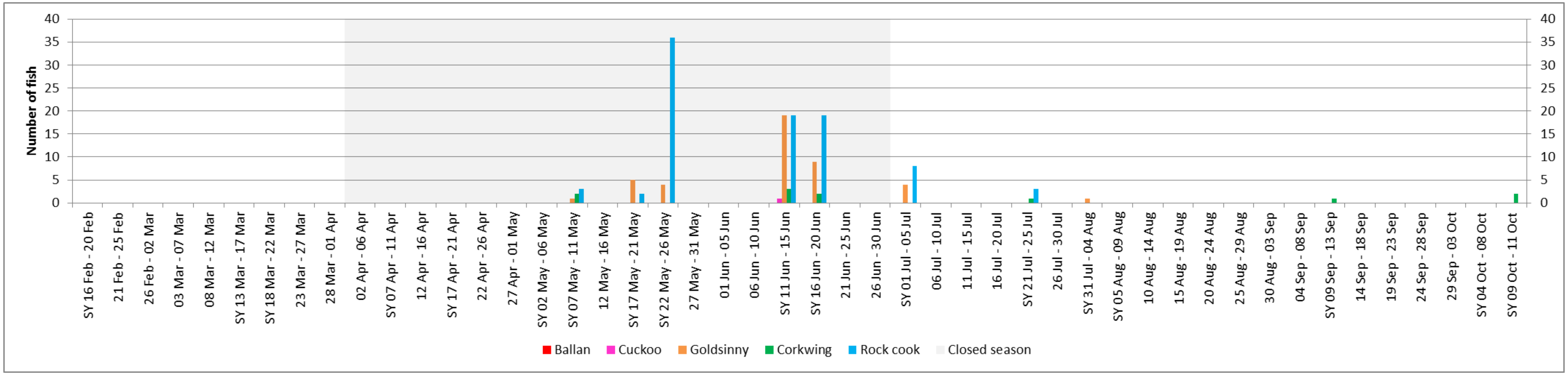

Figure 31 - Spawning state of wrasse species seen during surveys from Cornwall IFCA (Mevagissey & Falmouth) only during 2017.

Table 6 – Break down of ratio of wrasse spawning to not spawning and including those that were not assessed from D&S IFCA and CIFCA during 2017.

Month	Total no. fish caught	Total Spawning	Total Not Spawning	Not Assessed	Percentage Spawning	Percentage Not Spawning	Percentage Not Assessed
February	360	0	0	360	0	0	100
March	1672	0	0	1672	0	0	100
April	1727	1	316	1410	0.1	18.3	81.6
May	795	53	181	561	6.7	22.8	70.6
June	1345	135	1125	85	10.0	83.6	6.3
July	1469	96	1330	43	6.5	90.5	2.9
August	1982	2	1434	546	0.1	72.4	27.5
September	1675	1	1427	247	0.1	85.2	14.7
October	1856	2	1303	551	0.1	70.2	29.7

11.0 Appendix 5 - Summary of life history characteristics.

Table 7 - Summary of life history characteristics of all five common wrasse species, adapted from Darwall *et al.* (1992). "?" indicates unknown.

Characteristics	Ballan wrasse (*Labrus bergylta*)	Cuckoo wrasse (*Labrus mixtus*)	Rock cook (*Centrolabrus exoletus*)	Goldsinny (*Ctenolabrus rupestris*)	Corkwing (*Symphodus melops*)
Size range (cm)	Typical size 30-40cm (Campbell, 2004; Irving, 1998; Dipper, 1987). Grows to over 50cm (Naylor, 2005; Bagengal, 1985). Up to 60 (Gibson, 2001; Darwall *et al.* 1992; Dipper, 1987).	Grows to 35cm (Campbell, 2004; Gibson, 2001; Darwall *et al.* 1992; Dipper, 1987; Bagengal, 1985) and females generally smaller (Naylor, 2005; Irving, 1998).	Usually grows to 12cm (Dipper, 1987), but some reach 15cm (Naylor, 2005; Campbell, 2004; Darwall *et al.* 1992; Bagengal, 1985; Dipper, 1987).	Usually 12cm, some reach 18cm (Gibson, 2001; Irving, 1998; Dipper, 1987). Up to 15cm (Kay, 2009; Campbell, 2004; Darwall *et al.* 1992). Up to 20cm (Naylor, 2005).	Usually 15cm, some reach up to 25cm (Kay, 2009; Naylor, 2005; Campbell, 2004; Gibson, 2001; Irving, 1998; Darwall *et al.* 1992; Dipper, 1987). Rarely grows above 18cm (Bagenal, 1985).
Maximum age (years)	29 (Dipper *et al.* 1977)	17	9 (Treasurer, 2005)	16 (Treasurer, 2005)	9
Age at maturity (years)	F & M 6-9	F 2, M 6-9	F 2. M 2 (Matland, 2015)	F 2. M 3 (Matland, 2015)	F 2-3. M 1-3 (Matland, 2015)
Size at maturity (cm)	F 16-18, M 28	F 16, M 24	F 8.5, M 9 (Matland, 2015)	9.5. F 8, M 9 (Matland, 2015)	10. F 9, M 14 (Matland, 2015)
Sex change	Yes	Yes	?/No	No	No
Accessory males	No	No	?	Yes	Yes
Territorial	Yes	Yes	Yes	Yes	Yes
Spawning season (Atlantic)	April – August. Peaking in June (Dipper *et al.* 1977).	May - July	May - August	April - September	April - September
Spawning place	Nest (gravel & rock)	Nest (gravel)	?	Mid-water	Nest (algae)
Fecundity (1000 eggs yr^{-1})	150	?	?	20	50
Egg type	Benthic	Benthic	Benthic	Planktonic	Benthic
Nest building by	Female	Male and female	?	N/A	Male
Parental care	Male	Male	?	None	Male
Key habitat	Juveniles found in the intertidal and rock pools, adults found in sublittoral rocky areas (Dipper *et al.* 1977), reef and kelp forests.	Sublittoral rocky reefs (Naylor, 2005; Dipper, 1987).	Rocky reefs and seaweed (Naylor, 2005; Dipper, 1987). Often found in seagrass beds (Dipper, 1987).	Rocky reefs and boulder slopes, with holes, caves and crevices for refuge (Sayer *et al.* 1993). Distribution unaffected by macroalgal cover (Sayer *et al.* 1993).	Common in the intertidal and rock pools, with dense seaweed. Subtidal rocky areas with dense seaweed. Often found in seagrass beds (Dipper, 1987).
Depth (m)	Depth range from 5m to at least 30m (Ager, 2008; Dipper, 1987). Juveniles can be in <5m.	Depth range from 2-200m, but mainly between 20-80m (Gregory, 2003).	Depths of 3-25m (Galeote *et al.* 1998; Dipper, 1987).	Occasionally found <10m, mostly juveniles (Sayer *et al.* 1993). Prefer deeper water between about 10 to 50m (Campbell, 2004; Gibson, 2001; Irving, 1998; Sayer *et al.* 1993; Dipper, 1987).	More commonly found at depths <5m (Darwall *et al.* 1992; Costello, 1991), although they can occur to depths of 30m (Gibson, 2001; Irving, 1998; Bagenal, 1985) or up to 50m (Skewes, 2008).
Exposure	All conditions of exposure (Gibson, 2001). Mostly found in intermediate wave exposure stations (Skiftesvik *et al.* 2015).	No specific exposure level, found at all stations (Skiftesvik *et al.* 2015).	Relatively more abundant at more exposed stations, Smaller fish (<11cm) occurred mainly in sheltered areas (Skiftesvik *et al.* 2015).	Mostly found in intermediate wave exposure, smaller fish (<11cm) occurred mainly in sheltered areas (Skiftesvik *et al.* 2015). Distribution unaffected by current speed (Sayer *et al.* 1993).	More abundant in sheltered area (Skiftesvik *et al.* 2015). Nests found in sheltered north facing crevices (Potts, 1985).
Main diet type	Crustacea and Mollusca	Crustacea and Mollusca	Crustacea and Mollusca	Crustacea and Mollusca	Crustacea and Mollusca
Growth rate	5cm/year	3.5cm/year	3cm/year	3cm/year	4cm/year