A review of wrasse ecology and fisheries interactions

1. Background:

The cleaning behaviour of wrasse has enabled the control of sea lice on farmed Atlantic salmon. Biological control of lice infestations in salmon is a preferred alternative to the use of chemicals. The use of wrasse in salmon aquaculture was first identified and experimented in laboratory trials and in situ by Bjordal in 1988. The commercial fishery for live wrasse started in Norway in 1988, in Scotland one year later, and in England and Ireland in 1990 (Darwall *et al.* 1992). The ratio recommended for commercial farms is 1 wrasse to 20 salmon, or 5% (Skiftesvik *et al.* 2013). Skiftesvik *et al.* (2013) found intensively cultured ballan wrasse were as efficient as wild wrasse at removing lice. Although there is an increasing supply of cultured wrasse from hatcheries, there is still a reliance on wild caught wrasse to help fulfil the demand in salmon aquaculture and now species are being sourced from outside the local areas. Within the Devon and Severn IFCA district a new fishery for wrasse began in 2015 with vessels operating out of Plymouth. There has also been interest in a fishery starting in Torbay.

2. Wrasse biology and ecology:

There are five common species of wrasse found within the Devon and Severn IFCA district; cuckoo (*Labrus mixtus*), ballan (*Labrus bergylta*), goldsinny (*Ctenolabrus rupestris*), corkwing (*Symphodus melops*) and rock cook (*Centrolabrus exoletus*). They live among rocky and seaweed covered areas inshore and seagrass beds. Their diet mainly consists of molluscs and crustaceans. Their wider distribution ranges from the Mediterranean, Atlantic, English Channel, North Sea and West Baltic (Campbell, 2004).

The five species of wrasse have relatively different life history strategies. The two larger species, ballan and cuckoo are protogynous hermaphrodites, which means they are born female and some change their sex to male later in life. Sexual inversion depends on the proportion of the sexes in local populations and most populations tend to have more females than males (Naylor, 2005). In ballan wrasse, a male guards a harem of females (Darwall *et al.* 1992). Apart from goldsinny which have planktonic eggs, wrasse have sticky benthic eggs deposited in nests guarded by the males (Darwall *et al.* 1992). In goldsinny and corkwing wrasse, non-territorial, but mature ‘sneaker’ males which mimic the female phenotype steal fertilisation of eggs in territorial male’s nests (Darwall *et al*. 1992).

See Table 1 for summary of life history characteristics of all five wrasse species. Annex 1 shows the identifying features of the wrasse species.

Table 1 - 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)	Females & males 6-9	Females 2, males 6-9	Females 2	Females 2	Females 2-3
Size at maturity (cm)	Females 16-18, males 28	Females 16, males 24	?	9.5	10
Sex change	Yes	Yes	?/No	No	No
Accessory males	No	No	?	Yes	Yes
Territorial	Yes	Yes	Yes	Yes	Yes
Spawning season (Atlantic)	April - August	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 stations, 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

<u>Ballan wrasse – *Labrus bergylta*</u>

Habitat: Lives among rocky reefs, kelp forests and other seaweeds in coastal waters of all conditions of exposure (Gibson, 2001) down to about 20m (Campbell, 2004) to 30m (Irving, 1998). Villegas-Rios *et al.* (2013b) found ballan wrasse to have high site fidelity with small home ranges (0.091km^2) from acoustic telemetry in Galicia, Northwest Spain. Morel *et al.* (2013) also used acoustic telemetry to determine ballan wrasse movements in Portelet Bay, Jersey and they were found to be year round residents of the site and detections were most frequently by the receivers closest to their capture location indicating high site fidelity.

Diet: They feed on tube worms, crustaceans (crabs and barnacles) and molluscs (Gibson, 2001; Bagengal, 1985). Analysis of gut content from ballan wrasse from the Isle of Man by Dipper *et al.* (1977) found the dominant food items to be decapod crustaceans, followed by isopods and molluscs, then ophiuroids, amphipods, barnacles, algae and bryozoans. Deady and Fives (1995) found the diet of ballan wrasse in Ireland and Dinard, France, comprised mostly of decopods and bivalves. Ballan wrasse stomach contents from the Azores contained, in order of importance, decapods, echinoderms (sea urchins) and gastropods (Figueiredo *et al*. 2005). Algae, bivalves, worms and other invertebrates were also preyed upon but at lesser extent. Predation of decapods and bivalves decreased and predation of echinoderms and gastropods increased with increasing fish size, showing as they grew, they changed from soft towards harder prey items in this study area (Figueiredo *et al*. 2005).

Biology: They breed in early summer, building nests in rock crevices. They start life as a female, changing to male after several years. Eggs are laid in nests of seaweed which are built into rock crevices, guarded by the male (Gibson, 2001). Males guard a harem of females (Darwall *et al.* 1992). They take 6 years or more to become sexually mature and some males and females may reach 29 and 25 years old, respectively (Dipper *et al.* 1977). There is no obvious colour to distinguish sex (Naylor, 2005). Juvenile ballan wrasse found in the intertidal are bright green (Naylor, 2005).

Two distinct colour patterns (morphotypes) have been reported: spotted and plain. They coexist in sympatry and are not related to sexual dimorphism. These two types have different life history strategies, in growth and maturation (Villegas-Rios *et al.* 2013a), which raises the question of whether they represent one or two different taxonomic species. Alamada *et al.* (2016) found analyses of mitochondrial and nuclear markers revealed no genetic differences between the morphotypes in wrasse samples from Norway, North Spain, Portugal and the Azores. However, Quintela *et al.* (2016) used microsatellite markers for a genetic analysis of plain and spotted wrasse in Galicia (northwest Spain) and concluded there was significant genetic heterogeneity within the species, which appears to be highly associated with the two forms, but not completely explained by them.

Cuckoo wrasse – *Labrus mixtus*

Habitat: They live among rocky reefs from 10m downwards (Campbell, 2004; Irving, 1998) and hide in rock crevices during winter (Naylor, 2005).

Diet: The cuckoo wrasse eats invertebrates such as crustaceans and molluscs and small fish (Gibson, 2001). Matić-Skoko *et al.* (2013) analysed the gut contents of cuckoo wrasse from near Croatia and their diet was primarily based on crustaceans and gastropods, but also small fishes, polychaetes, bivalves, echinoderms and bryozoans.

Biology: Born females (Irving, 1998), some change from female to male after exceeding a certain size or between 7-13 years of age (Irving, 1998) and/ or depending on the proportion of the sexes in local populations (Naylor, 2005). They lay eggs in nests of seaweed on the seabed, defended by males (Gibson, 2001). Most populations have more females than males (Naylor, 2005). Males and females differ in colouration.

Rock cook – *Centrolabrus exoletus*

Habitat: Lives among rocks, kelp, seaweeds and seagrass beds in shallow water (Campbell, 2004; Gibson, 2001).

Diet: The gut contents of rock cook from the west coast of Scotland in males were dominated by mussels, small crustaceans and polychaete worms, and in females were small crustaceans, gastropods and mussels (Sayer *et al.* 1996). Groups of rock cook have been seen to follow ballan wrasse and feed from the disturbance made by the ballan wrasse (Naylor, 2005).

Biology: Rock cook is the least studied of all British wrasse. Females spawn in late spring (Dipper, 1987). There is no evidence of sex change in rock cook (Dipper, 1987) and it is difficult to distinguish between sexes.

Goldsinny – *Ctenolabrus rupestris*

Habitat: Found on rocky shores among seaweed, also on quite exposed subtidal reefs (Gibson, 2001) down to about 30m (Campbell, 2004) to 50m (Gibson, 2001; Irving, 1998). Sayer *et al.* (1993) found that habitat preference in goldsinny was related to the presence of rock crevices with two or more entrances. Macroalage coverage, depth and current speed did not affect their distribution (Sayer *et al.* 1993). Territories of goldsinny in Sweden did not change and were between 0.7m² and 2m², with a mean of 1.4m² and foraging predominantly occurred within them (Hillden, 1981).

Diet: Its diet is believed to consist mainly of small invertebrates; crustaceans, molluscs, polychaetes and bryozoans (Gibson, 2001; Bagengal, 1985). The gut contents of corkwing from the west coast of Scotland included hydrozoans, molluscs (gastropods and bivalves), crustaceans (e.g. cirripedoa, amphipods, copepods, decapods and isopods), and polychaetes (Sayer *et al.* 1995). Foraging was scarcely observed during the spawning season (Hillden, 1981).

Biology: Goldsinny rarely leave their territories and females stay in the vicinity of the territory of the male they spawn with (Hillden, 1981). Territorial males patrol their boundary and if disturbed by a conspecific they act aggressively. During the mating season, which is the end of May to the end of June in Sweden, the male and female dart into the water column where they spawn and the fertilised eggs develop in the plankton (Kay, 2009; Gibson, 2001; Hillden, 1981). In two thirds of the spawnings witnessed by Hillden (1981) 'sneaker' males joined in unnoticed. There is no evidence of sex change (Irving, 1998) and there is no obvious difference between females and males although Hillden (1981) recorded males to have red spots on their flanks. See Hillden (1981) for more in depth detail on goldsinny behaviour.

<u>Corkwing – *Crenilabrus melops*</u>

Habitat: Inshore rocky coasts, among seagrass or rocks and seaweeds in rock pools and shallow water (Kay, 2009; Campbell, 2004) to depths of up to 30m (Gibson, 2001; Irving, 1998; Bagenal, 1985). Nesting male corkwing are thought to have territories greater than $15m^2$ (Costello *et al.* 1995) and travel up to 50m away from their nest site to collect certain algae types (Potts, 1985).

Diet: Food consists of various small invertebrates (Gibson, 2001); barnacles, tube worms, small crustaceans, snails and bivalves (Bagenal, 1985). The gut contents of corkwing from the west coast of Scotland were dominated by gastropods and other taxa of importance were amphipods, ostracods, bivalves and polychaete worms (Sayer *et al*. 1996). Other species included hydrozoans and crustaceans i.e. cirripeds, copepods, decapods, and isopods (Sayer *et al.* 1996). Deady and Fives (1995b) found the diet of corkwing wrasse in Ireland and Dinard, France, comprised mostly of bivalves, gastropods, amphipods and isopods.

Biology: There is no evidence of sex change in corkwing (Irving, 1998). Males make nests in spring (Irving 1998) and early summer (Naylor, 2005) in which eggs are laid by the female (Bagenal, 1985). Occasionally 'sneaker' males resembling females, fertilise eggs guarded by larger male (Gibson, 2001). Potts (1995) found nests made in Wembury consisted of up to 16 species of algae, with *Corallina officinalis* and *Gigartina stellate* being preferentially selected. The nest locations were in sheltered crevices and the amount of algae insulated eggs from temperature fluctuations (Potts, 1985). The male guards it vigorously and after mating with one or more females, males tend fertilised eggs. Depending on water temperature, the eggs hatch 11-16 days after spawning (Potts, 1974). Colouration varies; females with eggs can be seen with blue egg laying papilla visible near anal fin, males generally more colourful, especially during breeding season (Naylor, 2005).

Wrasse activity has been found to be temperature-correlated and seasonal (Costello *et al.* 1995). They are diurnal species and are known to wedge themselves in crevices at night. Goldsinny were found to be more active during dawn and dusk, which is thought to be related to feeding (Costello *et al.* 1995). During winter, it was believed they escaped the cold retiring to deeper water offshore (Prichard and Linsell, 1986) however it has since been found that wrasse 'hibernate' in rock crevices during winter. Morel *et al.* (2013) found clear diel and seasonal patterns in ballan wrasse, with activity higher during daytime and during spring and summer. Additionally, ballan wrasse showed evidence of tidal rhythms, there were higher detection rates during lunar phases associated with spring tides than neaps and new moons than full moons (and even less for first and last quarters) (Morel *et al.* 2013).

Skiftesvik *et al*. (2015) analysed experimental catch data from 1997-1999 and looked at the distribution and habitat preferences of the five species of wrasse in a Norwegian fjord. Corkwing wrasse was always the most abundant species, ranging from 52 to 68%. Goldsinny and rock cook were the second most abundant (up to 30%) and ballan and cuckoo wrasse represented <2% of the catches. The four most abundant wrasse species occupied different areas. Rock cook was caught at the most exposed stations; ballan and goldsinny wrasse were mostly found in shallow stations (intermediate wave exposure, sandy bottom with large stones along the edges). Finally, corkwing were more abundant in the sheltered area. Cuckoo wrasse were present at every station and did not show any specific clustering. Skiftesvik *et al.* (2015) found there was little variation over the three years, but high variation over short distances, with differences in species composition over distances of just a few metres. Individuals were segregated according to species and body size. The smaller fish of each species (<11cm) were always located in more sheltered areas, while the larger fish were found in more exposed areas. Species segregation was thought to be related to food availability according to wave exposure (Skiftesvik *et al.* 2015).

3. <u>Wrasse fishery - Norway:</u>

Four species of wrasse are utilised in Norway; goldinny, corkwing, rock cook and juvenile ballan wrasse. Goldsinny and corkwing are the most abundant species in Norway (Skiftesvik, 2014). Effective chemicals decreased the used of wrasse in salmon aquaculture from 1998 to 2005, until there was found to be some resistance to the chemicals in 2007 and 2008 (Skiftesvik, 2014). Then demand increased and the estimated use of wrasse exceeded 10 million fish in 2010. The estimated use of wrasse in 2012 surpassed 14 million fish (Skiftesvik, 2015). The local fisheries are insufficient in meeting the demand for salmon production and wrasse have been transported from the south and south eastern coasts (where there are no fish farms) of Norway and Sweden to the Northern parts since the early 1990s (Skiftesvik, 2014).

Before 2008, fishermen mainly used fyke nets but now specifically designed pots are used by the majority of fishermen on the western coast, whereas fyke nets are still used on the south coast (Skiftesvik, 2014). The Directorate of Fisheries in Norway introduced management measures for the wrasse fishery from 2011 and two measures set are minimum length and when the fishery should be opened (Hassen, 2014). The minimum length for all species since 2011 is 11cm. The minimum size limit for corkwing wrasse was raised from 11 to 12cm in 2015 (Halvorsen *et al.* 2016b). The measures are supposed to protect wrasse populations by securing that some wrasse are able to spawn before they are exposed to the fishery (Hassen, 2014). However, even though the official minimum length is 11 cm, there are other functional minimum sizes (FML) set by the fish farms, as salmon of different sizes need specific sizes of wrasse for efficient delousing. The FML for corkwing wrasse and ballan wrasse is 14cm, and 11cm for goldsinny wrasse (Hassen, 2014).

The use of wrasse in salmon and rainbow trout production has been reported to the Norwegian Directorate of Fisheries since the 1990's, although catches were deemed underreported before 2006 (Skiftesvik, 2014). In 2010, catches of wrasse appeared to be more reliable in terms of numbers and species composition. Skiftesvik *et al.* (2014) looked at the use of wrasse in the Hardangerfjord area. The estimated number of wrasse used on salmon and rainbow trout farms varied from 86,000 to 241,000 in the period 2002-2006, but has since increased to 1.1 million individuals in 2009 and 2010, in line with the significant increases in mean annual biomass of salmon and rainbow trout. Corkwing was the most important species and constituted to almost 52% in biomass and 56% in number. Ballan wrasse made up 34% in biomass but only 14% by number due to its larger size. The annual catches of wrasse are thought to be higher than the numbers reported due to the unknown level of mortality from discarding or wounded and dead fish during fishing operations (Skiftesvik *et al.* 2014).

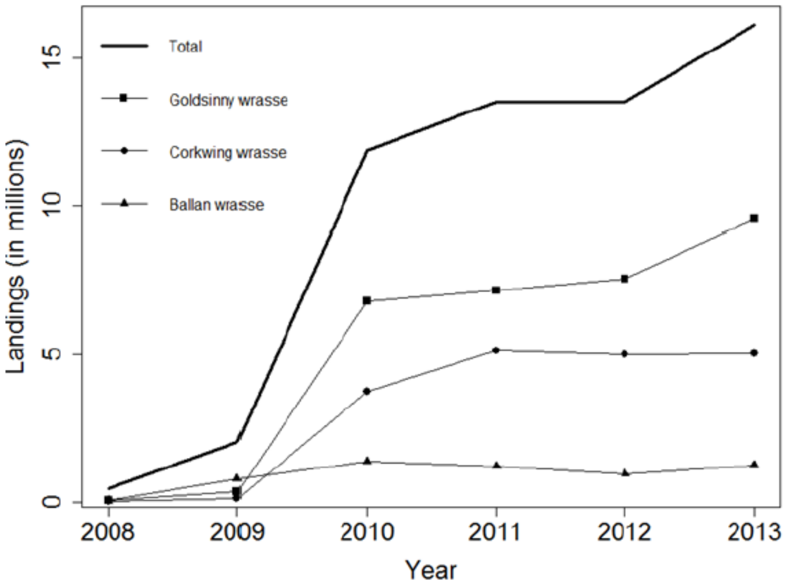

Figure 1 – Total landings (individuals; in millions) from 2008-2013 in the Norwegian wrasse fishery. The landings for each of the target species (goldsinny, corkwing and ballan) are shown individually (Directorate of Fisheries, landings statistics). Taken from Hanssen (2014).

Halvorsen *et al.* (2016b) looked at sexual size dimorphism (SSD) in corkwing wrasse in eight populations in Norway. They found mature nesting males had larger body sizes than females and sneaker males, and the size difference was significantly larger in the four northernmost populations. Contrasting life history traits in two of the populations (a southern and a northern), they found that the larger SSD in the north was because of nesting males delaying maturation and growing faster relative to females and sneaker males. Mature northern nesting males also had smaller gonads at smaller sizes relative to their southern counterparts, indicating a trade-off between reproduction and somatic growth in males. Halvorsen *et al.* (2016b) found applying the current minimum legal size limit for commercial fishing in Norway (12 cm) would have failed to protect any mature nesting males in five out of the eight populations. Moreover, the findings of more male-biased SSD and female-biased sex ratios in the northern populations imply that there is larger potential for sex-selective harvesting in these populations.

Skiftesvik *et al.* (2015) looked at wrasse distribution prior to the commercialisation of the fishery and at one of the sites which was used in Halvorsen *et al.* (2016b) nested males constituted 34-39% of the spawning population which is substantially higher than what Halvorsen *et al.* (2016b) found in the same area (11-15%). Halvorsen *et al.* (2016b) noted that as a conservation measure, fishing was prohibited until 11th July 2016 and if the main spawning season occurred before this, it may allow some nesting males and females to breed at least once before being harvested.

Gjøsæter (2002) conducted analysis of catch data from 1994 to 1998 for goldsinny from pots along the Norwegian Skagerrak coast. There was a reduction in the frequency of low catches over the years and one explanation was the fisherman become more experienced with potting for wrasse over time. Gjøsæter (2002) suggests that with the increasing proportion of pots over time, with large catches of fish, the fishery did not have any serious adverse effects on the stock within the time period assessed. However, it was noted that the proportion of large fish (above 10cm) would soon be overexploited.

4. Wrasse Fishery – Ireland:

Darwall *et al.* (1992) looked at the life history strategies of wrasse and the impact of a new wrasse fishery for goldsinny and corkwing in Mulroy Bay and Lettercallow Bay, Ireland. They found that overall catch per unit effort (CPUE) increased from May to August, reflecting seasonal sea temperature change but in the second year of sampling the CPUE decreased in July 1991 and Darwall *et al.* (1992) noted it may reflect overfishing. Catches of corkwing were male biased and males were generally larger than females. Additionally, there was a reduction in males greater than 13cm long in June and July 1991 suggesting the fishery may have depleted numbers of large males.

Deady *et al.* (1993) also looked at the impact of the first two years of a wrasse fishery for goldsinny and corkwing in Lettercallow Bay. They found the overall mean CPUE of the two species was significantly lower in the second year (1992) and there was a lower percentage frequency of larger wrasse evident within the five month fishing period in 1992. Deady *et al.* (1993) stated that this study demonstrates that overexploitation of wrasse stocks within a confined area (such as Lettercallow Bay) could occur in a relatively short time span.

5. Devon and Severn IFCA District fishery:

The fishery is thought to have begun in Plymouth around March 2015 and Devon and Severn IFCA were informed of the fishery by Cornwall IFCA in September 2016. There are three vessels in D&S IFCA District which fish for wrasse between March to November. The parlour pots used are deigned to catch wrasse (Figure 2), which are lightweight (3.7kg) and fitted with wrasse escape gaps. They measure 72Lx40Wx28H. The IFCA has been informed that a salmon farming company has approached several Brixham vessels in October 2016, to commence fishing for wrasse in 2017.

Figure 2 - Parlour pot for wrasse used by the fishermen ©D.Cresswell

A. Vessel 1
   - 7.7m
   - 120 pots
   - 8 strings of varying length, up to 30 pots in a string
   - Working 3 or 4 strings south of the breakwater and the rest all along the shore down to the Mew Stone
   - 200-300 fish a day (50 per sting is good)
B. Vessel 2
   - 5.4m
   - ~200 pots
   - Prospecting around a few places and hauls his pots twice a day
   - 400-500 fish a day
C. Vessel 3
   - Fishes on mostly on the Cornish side

Fish are stored in cages/bongos off the harbour and have a 99% survival rate. Every week to ten days when there are at least 6,000 fish in the store cages, a lorry collects the fish transports them to a salmon farming company in Scotland. They are all getting £1.30 a fish and up to £2.50 for ballan wrasse. The salmon farm company is looking at sourcing around 100,000 fish a year from the south west, i.e. Dorset, Devon and Cornwall (Cornwall IFCA 2016, pers. comms.). An advert was posted on the ‘Find a Fishing Boat’ in September 2016 asking for fishermen to catch wild wrasse to supply the salmon farm company (see Annex 2). It is believed that a fishery for wrasse will begin out of Brixham in 2017, with three/ four fishermen known to be interested in starting.

6. Possible implications of the fishery:

Special Areas of Conservation (SAC) and Marine Conservation Zones (MCZ):

The areas in Plymouth targeted for wrasse (see Section 5) are within the Plymouth Sound and Estuaries SAC. Table 2 shows the relevant features and conservation objectives for the site. The typical species have not yet been identified (Natural England, 2015). The five species of wrasse are considered iconic species found in rocky reefs and therefore may be put forward as typical species. Potential pressures from the fishing activity on the features need to be assessed under a Habitat Regulation Assessment (HRA). Removal of target species (i.e. wrasse) has been identified as one of the pressures needing further consideration. The HRA deciphers if the fishing activity will adversely affect the sub-features assessed and if the conservation objectives can be met.

Table 2 – Relevant conservation objectives for Plymouth Sound and Estuaries SAC (Natural England, 2015)

Feature(s) and sub-feature(s)	Conservation objective	Attribute	Target
Estuaries (1130): intertidal and subtidal seagrass beds Reefs (1170): intertidal, infralittoral and circalittoral rock	The structure and function (including typical species) of qualifying natural habitats.	Structure: presence and abundance of typical species.	Maintain or restore the abundance of listed typical species, to enable each of them to be a viable component of the habitat.

Torbay is designated as an SAC and features which may interact with the wrasse fishery are infralittoral rock, circalittoral rock and subtidal stony reef. Additionally, Torbay is designated as a MCZ and features which may interact with the fishery are subtidal mud and seagrass beds.

Pots/ fish traps:

The impact of the pots on the habitat and by-catch of other species will also need to be addressed. The selectivity of pots results in low by-catch of non-target species, which are released back into the sea. By-catch recorded in wrasse pots has been conger eels, shrimp, crabs, whelks, dragonets, pogge/scorpion fish, goby and starfish (Cornwall IFCA 2016, pers. comms.). Damaged or injured wrasse are not retained.

Benthic communities are thought to be relatively unaffected by static gear such as potting due to the footprint of the gear and the small area of the seabed in direct contact (Eno *et al.*

2001). Studies by Coleman *et al.* (2013) and Eno *et al.* (2001), both found epifaunal assemblages suffered little impact from pots and traps and could be considered generally insensitive to commercial potting. No literature on the specific impacts of pots on seagrass beds could be found (Walmsley *et al*. 2015). Walmsley *et al.* (2015) reviewed existing evidence and on-going studies to provide conclusions of whether potting could compromise the achievement of conservation objectives. The review concluded there was low to no sensitivity/impact on reef features from potting, and the wrasse pots used are lightweight and therefore may have less of an impact.

Wrasse ecology and habitat interactions:

Wrasse are adapted for grazing hard animal growths on seaweeds and rocks, and eating shelled animals (crustaceans and molluscs) (Costello, 1991). The removal of a significant amount of wrasse populations could potentially impact their surrounding habitat. There could be a shift in community structure through loss of grazing small invertebrates. For instance, a negative impact may potentially be seen in kelp forests through an increase of epifaunal growth and/ or epifaunal grazing, as wrasse prey upon isopods, gastropods, amphipods and bryozoans (Norderhaug *et al.* 2005).

Studies have been carried out in New Zealand exploring the relationship of wrasse predating on small invertebrate grazers living on brown seaweeds. Pérez-Matus and Shima (2010) used mesocosms to look at the interaction with the two Labridae, *Notolabrus celidotus* and *N. fucicola* and found they exerted positive indirect effects on the giant kelp, *Macrocystis pyrifera,* via the consumption or behavioural modification of amphipods. Newcombe and Taylor (2010) also used *N. celidotus* in mesocosms but containing three species of brown seaweed. They found predation on epifaunal species reduced epifaunal grazing on the seaweeds. In mesocosms without fish, seaweed biomass was reduced (with increased damage). Additionally, in mesocosms with reduced epifaunal densities, seaweeds were larger but more heavily fouled than seaweeds with uncontrolled epifaunal densities (Newcombe and Taylor, 2010). These experimental results were not consistent with findings from field survey sites with varying fish density.

Figueiredo *et al.* (2005) looked at the diet of ballan wrasse in relation to the predation of sea urchins in the Azores. Ballan wrasse were found to be important predators of sea urchins, and larger fish accounted for most of the predation on sea urchins. They concluded that a reduction in the abundance and mean size of fishes could result in a trophic cascade, with the proliferation of sea urchins, through a decrease in predation (Figueiredo *et al.* 2005).

Algae forms part of the diet of all five wrasse species, but corkwing wrasse also utilise multiple algae species to make complex nests (Potts, 1985). Corkwing wrasse are highly selective of which species are used in the formation of the nests.

Wrasse diet consists of a large amount of crustaceans, and particularly decapods, which for ballan and cuckoo wrasse, makes up a significant amount of their diet (Matic-Skoko *et al*. 2013; Figueiredo *et al*. 2005; Deady and Fives, 1995; Dipper *et al.* 1977). Wrasse are found in seagrass beds and may use this habitat for feeding. Shore crabs, *Carcinus maenas* are known to inhabit seagrass beds, by burrowing under the seagrass rhizomes (Collins *et al.* 2010). These burrows can undermine the edges of seagrass beds which, in some areas, are already subjected to impacts from moorings and anchors (Collins *et al.* 2010). The importance of wrasse predation on decapods in seagrass beds is unknown. Vanderkift *et al.* (2007) looked at the density of wrasse species occupying seagrass beds with varying distance from rocky reefs and the level of predation on crabs in Jurien Bay and Marmion Lagoon, lower west coast of Australia. The abundances of wrasses varied significantly among distances, they were more abundant at 0m, than at 30m and >300m, indicating that overall abundance of wrasses declined rapidly within a short distance from the reef edge. The level of predation on crabs was not influenced by proximity to reef (Vanderklift *et al.* 2007).

Additionally, a reduction in cleaning behaviour from the removal of wrasse could have significant implications for parasite populations on other species of fish. Symbiotic cleaning behaviour has been recorded for the five species of wrasse, although not necessarily for both sexes or for all life stages (Costello, 1991). Wrasse cleaning behaviour seems to be instinctive, as wrasse that had never been exposed to salmon before were cleaning within minutes (Bjordal, 1988). Their signature swimming manner, which allows them to swim in any direction, may be recognised by host fish (Costello, 1991).

Naylor (2005) noted rock cooks and goldsinny act as cleaner fish on the larger wrasse (i.e. Ballan wrasse) and will remove parasites from their flanks, sometimes in small groups. Certain locations, such as the boilers on a shallow-water wreck, act as ‘cleaning stations’ where this behaviour can regularly be observed (Naylor, 2005). Hilldan (1983) observed ballan wrasse enter goldsinny territory and adopt an invitation posture, before being cleaned by the resident goldsinny in Sweden. Hilldan (1983) found goldsinny were a facultative cleaner (diet not dependent on cleaning). Galeote and Otero (1998) found rock cook does not establish clear cleaning stations in Tarifa (Gibraltar Strait area) and they were facultative cleaners. Henriques and Almada (1997) watched rock cook, goldsinny and corkwing wrasse cleaning behaviour at Arrabida, west coast of Portugal. Only rock cook was observed to clean and mostly cleaning corkwing and ballan wrasse. Rock cook were found to be a facultative cleaner, with only 7% of observed feeding acts from cleaning.

Costello (1991) summarised the evidence of cleaning behaviour by wrasse in northern Europe. Corking, goldsinny and rock cook were observed (majority in aquariums) to clean ballan wrasse, plaice, black bream, mackerel, salmon, halibut, anglerfish and grey mullet (Costello, 1991). Henriques *et al.* (1997) observed rock cook cleaning mullet, an ocean sunfish, six species of wrasse and four species of sea bream in Portugal. Observations of cleaning activity in the wild are difficult and attempts often disturb the activity (Hilldan, 1983).

The importance of wrasse as prey for predators is not known. However, wrasse are identified as prey for commercial species such as gadoids (Halvorsen *et al*. 2016a). They are known to be an important food source for marine birds such as shags and cormorants (Steven, 1933) and have been identified as prey for marine mammals such as the grey seal (Gosch *et al.* 2014).

<u>Wrasse biology:</u>
The minimum size for use in salmon cages is 10cm so the removal of larger (>10cm) fish can alter population structures (Darwall *et al.* 1992). For goldsinny and corkwing, while the population may be ensured (<10cm fish are returned), the average size and age at first maturity would be expected to decrease (Darwall *et al.* 1992). For larger species, such as the ballan and cuckoo wrasse, their size at sexual maturity is higher than 10cm. The industry requires certain sizes of the different species related to their efficiency in cleaning, which are currently between 12 cm to 22 cm for most species. One farm has a different functional slot size for Cuckoo wrasse as this species has an elongated snout and tends to be slimmer. This is 15 cm to 22 cm. Another salmon farm company requires only Ballan wrasse. Larger (>22cm) fish may become too aggressive in cages (Cornwall IFCA 2016, pers. comms.) and can become a threat to the salmon.

The fishery could alter social structures through the removal of large males and subsequently change the sex ratios. Nesting corkwing males had higher vulnerability to being captured in a baited pot fishery (Halvorsen *et al*. 2016c). The need for wrasse in salmon production coincides with the spawning season of wrasse (Skiftesvik *et al*. 2015). Wrasse are highly territorial, occupying small spatial areas (Villegas-Rios *et al.* 2013b) with some species having dominance hierarchies and the removal of nest guarding males may reduce egg survival (Darwall *et al.* 1992). There is an unknown impact to species with sneaker males; either decrease in numbers due to the removal of social inhibition for dominant status or increase in numbers through increased spawning success (Darwall *et al.* 1992).

In ballan wrasse, there are spotted and plain morphotypes (see Section 2). Spotted individuals are under stronger selective pressure from fisheries because they attain larger mean sizes, and as a result have lower reproductive output, and unbalanced sex ratios due to male-biased overexploitation may occur since the ballan wrasse is a protogynous hermaphrodite (Almada *et al.* 2016; Villegas-Rios *et al.* 2013a). As a precautionary measure, Almada *et al.* (2016) suggested plain and spotted should be considered two independent management units.

Additionally, it is likely that local populations are genetically isolated and removal would affect stock structure (Skiftesvik *et al.* 2014). Recorded home ranges of wrasse have been 91m² for ballan (Villegas-Rios *et al.* 2013b), territories of up to 2m² for goldsinny (Hillden, 1981) and >15m² for corkwing (Costello *et al.* 1995) but they do travel up to 50m away from their nest site (Potts, 1985). Wrasse's territorial behaviour and production of benthic eggs can suggest limited dispersal from nesting areas (D'Arcy *et al.* 2013). It has been shown that populations of goldsinny wrasse (Sundt and Jorstad, 1998) and corkwing wrasse (Knutsen *et al.* 2013) are genetically differentiated along the Norwegian coast, and between Atlantic and Scandinavian populations in ballan wrasse (D'Arcy *et al.* 2013) and corkwing (Robalo *et al.* 2011). A relatively long planktonic larval stage, 37-49 days in ballan (Ottesen *et al.* 2012) but only 25 days in corkwing and goldsinny (Darwall *et al.* 1992) may contribute to lowering genetic differentiation between adjacent areas (D'Arcy *et al.* 2013). Water currents can vary in inshore waters and may be responsible for larval transportation along the coast (D'Arcy *et al.* 2013). However, Gonzalez *et al.* (2016) found habitat fragmentation from a long stretch of sand (26km) along the Norwegian coast is the cause of genetic differentiation between western and southern populations of corking. If wrasse populations are spatially fine structured, local populations experiencing high fishing intensity might be overfished.

If wrasse were able to return to Plymouth once they had reached a size that is no longer suitable for use in salmon cages then there is a risk of them carrying diseases/ invasive species. Although to date no information about the transport of pathogens through import has been reported (Skiftesvik *et al.* 2014).

<u>Other factors:</u>
Wrasse are considered an iconic species of rocky reefs and due to their inquisitive behaviour and colouration, a popular species by recreational divers. Additionally, they are a sought after species in recreational angling in the south west. Consequently, wrasse are valued in other marine sectors.

Wrasse stocks and their biology in the UK are poorly understood and whilst there has been some limited research in the past, currently no stock assessment exists. In the past wrasse have been treated as a single species by the fishery, however, they exhibit different life history strategies, requiring different management and monitoring measures (Skiftesvik *et al*. 2015). The impact of the new wrasse fishery in the District is largely unknown, and the need to collect data on the effort and the potential impacts is recognised.

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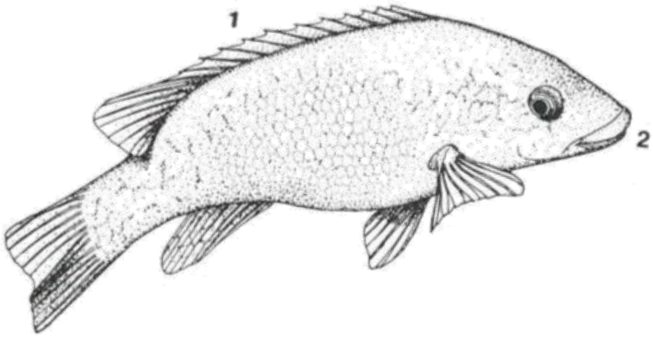
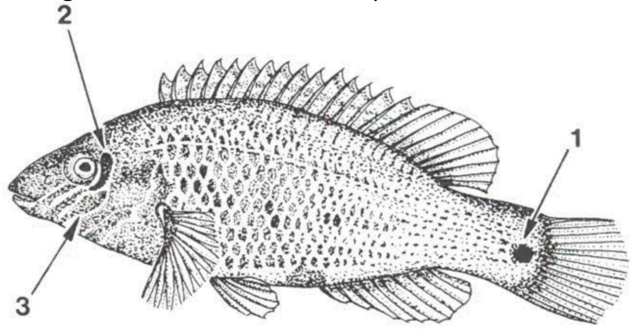
Annex 1 – Wrasse ID Guide (Photos from Dipper, 1987)

Ballan wrasse *Labrus bergylta*



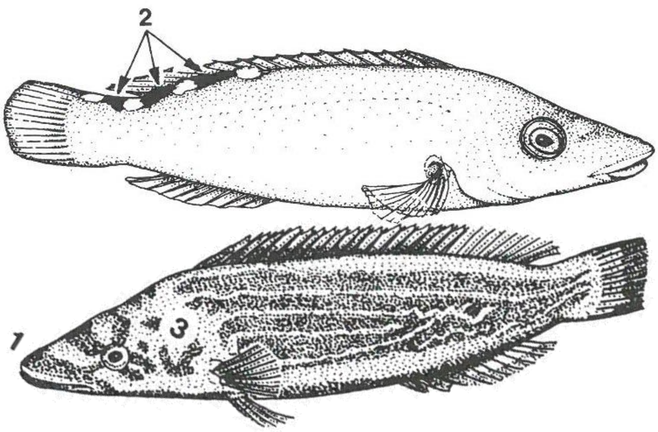
1. Single, long dorsal fin.
2. Thick lips
3. Large size
4. Two morphotypes: spotted and plain
5. Juveniles bright green
6. No obvious difference between sexes

Corkwing wrasse *Crenilabrus melops*



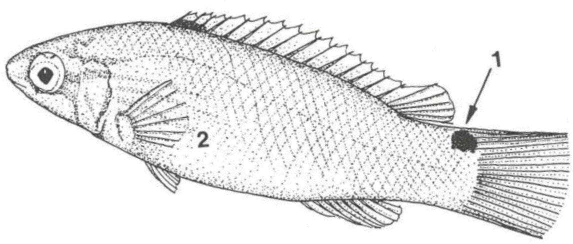
1. Black spot in middle of tail stalk
2. Comma-shaped spot behind eye
3. Lines on head and gill covers. Females brown and pale blue, males bright green or blue
4. Females (and 'sneaker' males) can be seen with blue egg laying papilla near anal fin during breading season
5. Males generally more colourful, especially during breeding season

Cuckoo wrasse *Labrus mixtus*



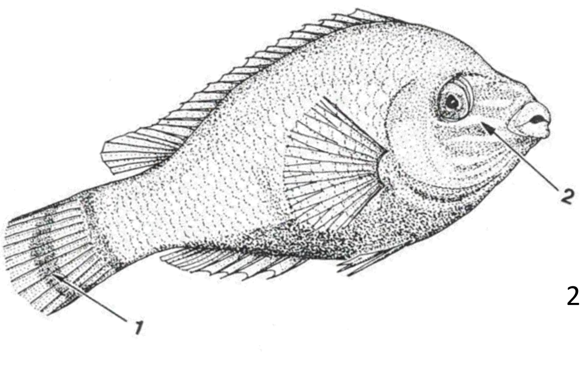
1. Pointed head
2. Females with 3 black blotches on back
3. Males with blue head and lines

Goldsinny *Ctenolabrus rupestris*



1. Black spot on top side of tail stalk
2. Golden colour
3. No obvious difference between sexes, although red spots on flanks recorded in breeding males

Rock cook *Centrolabrus exoletus*



1. Dark bar across tail fin
2. Blue lines on head
3. No obvious difference between sexes

Annex 2 - Advert in Find a Fishing Boat:

Wanted:
Wrasse wanted all species!!
Location:
Portland
Description:
Fishermen we are expanding our efforts!!!

NMC are looking for more fishermen to aid our wild wrasse collections. We have had a great success, fine tuning our methods to produce the best quality oflive fish for our clients. Ideally we are looking for guys who are experienced wrasse fishermen with pots. We are in partnership with Marine Harvest and have been contracted to collect all species of wrasse for the coming years.

NMC specialise in the consultation, collection, quarantine, farming and transport of marine animals. We are currently the UK's number one lumpfish producer and supply high quality quarantined wrasse and lumpfish to Marine Harvest. We also supply many of the attraction aquariums and universities through out Europe with an array of live marine species.

7 years ago we setup a wild wrasse collection program working with a number of fishermen up and down the coast. The aim was to setup a sustainable management program working with local fisheries SIFCA, Natural England, Fish health inspectorate and the MMO. Since, we have developed our systems to produce the best quality fish on the market with the lowest mortality the wrasse industry has seen to date. We have also provided the 3 wrasse/ lumpfish hatcheries with brood stock over the years.

The main issue with have seen in the past was fishermen, holding the fish to long on the quayside with no treatments. This resulted in an average mortality of 30-40% from collection to the farms. NMC introduced a staging post and now have that mortality down to around 5%.

This is what we offer.

Wrasse prices vary according to quality from £1-£1.50 each

Ballan wrasse prices have fluctuated this year with other companies, although this is the rate we pay, we will always take all the other species!!

We have a fishing / quayside management plan we like all our guys to follow, as its tried and tested and reduces mortality massively.

We ask our fishermen to collect wrasse at a minimum size of 12cm-22cm. This is very strict!!

The fish are held for no longer than a week prior to pick up this is also very strict!!. holding fish for longer than a week creates major health issues and mortality!!! plus it helps the fishermen get the best money for their fish

We ask for a minimal order of 2000 fish and collect the fish with our transport system from you guys, usually within 7 days!!

Fish are transported back to NMC where they held in our 50m2 land based quarantine facility. Our facility can hold up to 18000 wrasse at one time.

Fish are cared for by our marine biologists on site. Fish cleaned of parasites and fed daily. Once deemed healthy the fish are transported to our partners Marine Harvest. This is a tried and tested method.

We work with the governing bodies and Marine Harvest cage farmers directly

If this may be of interest please contact us at NMC

amy@nativemarinecentre.com mike@nativemarinecentre.com