Interannual fine-scale site fidelity of male ballan wrasse *Labrus bergylta* revealed by photo-identification and tagging

Gonzalo Mucientes[1,2,3] | José Irisarri[3] | David Villegas-Ríos[2,3,4]

[1]Centro de Investigacão em Biodiversidade e Recursos Genéticos, Universidade do Porto (CIBIO-InBIO), Vairão, Portugal

[2]Instituto de Investigaciones Marinas, Consejo Superior de Investigaciones Científicas (IIM-CSIC), c/Eduardo Cabello, Vigo, Galicia, Spain

[3]Ecoloxía Azul - Blue Ecology (BEC), Pontevedra, Galicia, Spain

[4]Instituto Mediterráneo de Estudios Avanzados (IMEDEA, CSIC-IUB), Universidad de las Illes Balears, c/ Miquel Marquès, Esporles, Illes Balears, Spain

Correspondence

Gonzalo Mucientes, Centro de Investigacão em Biodiversidade e Recursos Genéticos, Universidade do Porto (CIBIO-InBIO), 4485-661 Vairão, Portugal

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The site fidelity of ballan wrasse *Labrus bergylta* was studied using photo-identification and external tagging. Five male individuals were observed to defend the same small territory

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composed of a few rocks during several reproductive seasons spanning 2 to 15 years. These results provide one of the strongest indications of long-term very fine-scale site fidelity in marine fishes.

KEYWORDS

ballan wrasse, Galicia, *Labrus bergylta*, photo-identification, site fidelity, territoriality

The ballan wrasse *Labrus bergylta* Ascanius 1767 (Labridae) is a benthic fish distributed along the north-east Atlantic Ocean and Mediterranean Sea coasts (Dipper *et al*., 1977). It inhabits rocky reefs and kelp beds at depths ≤ 60 m where it mostly feeds on small invertebrates (Figueiredo *et al*., 2005). It's a long-lived wrasse (≤ 30 years) with slow growth, although demographic parameters vary between the two main morphotypes that have been described: plain and spotted (Villegas-Ríos *et al*., 2013a). As a protogynous hermaphrodite, all individuals are born females with sex change being very plastic [it occurs on average at 36 cm total length (L_T) in plain morphotypes and 47.2 cm L_T in spotted morphotypes]. Sexual dimorphism exists with males integrating the larger size and age classes (Villegas-Ríos *et al*., 2013a, 2013c).

Ballan wrasse are sedentary with home ranges averaging 0.091 km^2 (SD ± 0.031 km^2) and they display very marked diel behavioural rhythms, being more active during the day (Villegas-Ríos *et al*., 2013). During the spawning season, males defend territories, which are typically very small (ranging from 2 to 300 m^2) and consist of one or more neighbouring rocks (Sjölander *et al*., 1972; pers. obs.). Within the areas defended by the males, females clean rock surfaces by grazing on algae. Then males court with females that subsequently lay the eggs on the clean surface. After egg release and fertilisation by the male, females abandon the area and males keep patrolling the territory and provide very active parental care for the

eggs, mainly by chasing potential predators away (Sjölander *et al*., 1972; pers. obs.). However, it's unknown if males actively defend their territories after the spawning season or if they defend the same territory year after year.

Knowledge of the size, use and consistency of territories of animals is important from a conservation perspective. For instance, knowledge of home range and territory sizes is essential for the marine reserve design and spatial planning (Moffitt *et al*., 2009). This is especially relevant in the context of the conservation of hermaphrodite species, where the terminal sex may be fished selectively because it is composed of the larger individuals (Sato *et al*., 2018). Information on territory size and stability over the years is also crucial to understand reproductive strategies of marine fishes, especially in the case of species displaying a marked reproductive behaviour (*e.g*., harem-forming species), as it may be used as input to inform conservation strategies such as temporal closures that match spawning seasons (Heppell *et al*., 2006).

Territory size of individuals can be assessed using a variety of techniques, from underwater telemetry, to mark–recapture, camera trapping or individual identification (Lucas & Baras, 2000). Individual identification in fishes is commonly based on natural marks or body–facial patterns and can be an alternative to more costly methods (*e.g*., genetic) for identifying individuals in species that display variation in external characters such as body colour pattern, typical scares or marks (Buray *et al*., 2009; Dala-Corte *et al*., 2016).

Here we analysed photos and videos of ballan wrasse opportunistically recorded over 15 years to assess fine scale and long-term site fidelity in Galician waters, Spain (Table 1). One hundred-and-fifty images of ballan wrasse individuals (videos and photos) were obtained using a Sony DSC compact camera, Sony DCR MiniDV Camcorder, Sony DvCam (www.sony.com) and a Nikon D90 camera (www.nikon.com) with underwater housings. Although many of the pictures corresponded to individuals that were recorded only once, a

total of 30 photos corresponded to individuals with repeated observations and were used for this study. Images were recorded during >100 dives conducted between 1997 and 2013 at four different sites in Ría de Vigo, Galicia (NW Spain; Figure 1 and Table 1). The Ivy site consists of a shipwreck surrounded by rocky reefs and sandy bottom at depths between 12 and 20 m. This site was initially visited in 2010 and a plain male photographed and externally tagged. The rocks where that male was observed were revisited in 2012 in two different weeks during the spawning season, resulting in two new observations of the same male. The Channel site consists of an elongated rocky reef *c.* 300 m long, surrounded by sandy areas at depths between 8 and 18 m. The Channel site was initially visited in 2011 where two spotted males were photographed and one of them tagged. The site was revisited in 2011 three more times during the spawning season resulting in encounter with the same fish at the same rocks. In 2012, we returned to the same rocks and recorded the same males during two different weeks displaying reproductive behaviour, again during the spawning season. The Viños site is a shallow rocky reef around a small island surrounded by sand. It was first visited in 2011 were a male was identified displaying egg-guarding behaviour. It was tagged with an external T-bar and revisited five more times during the spawning season of that year. The same fish was observed and identified in the same rocks during three occasions in 2012 and once in 2013. The Ciegos site is a rocky area at 10–22 m depth. A spotted male displaying patrolling behaviour was initially observed and recorded from the spawning season of 1997. The place was revisited in 1998, 1999, 2000, 2005 and 2011 in several occasions, both during and outside the spawning season (Table 1) resulting in a total of eight observations of the same individual around the same rocks.

We used two methods to identify individuals from the images and, hence, be able to infer site fidelity. Spotted individuals were identified by their characteristic body marks (typically white spots and lines over a reddish background). Specifically, we selected the

region between the eye, the mouth and the operculum for our identifications as the pattern of lines and spots seemed more variable in that region (Figure 2). To validate this photo-identification method we took advantage of an external T-bar tagging programme conducted during 2010–2012 by the authors during the spawning season. One of the spotted individuals tagged during this programme was photographed in four dives in two different years, which enabled us to confirm the temporal stability of the facial marks. The pattern was considered unique for each individual at the spatial scale at which we developed the study. Plain individuals were identified based only on external tagging as we detected that direct photo-identification was not possible due to little variation and temporal instability of the head marks. Sex of all individuals was determined as males based on mating and courting behaviour. For two of the individuals (Table 1, #1 and #2) abdominal stripping resulted in sperm release, further confirming its sexual identity as a male.

Our observations re-identified five individuals at the exact same site where they had initially been recorded over time scales ranging from 2 to 12 years. In all cases, the rocks where individuals were observed spanned an area < 3 x 3 m. One of the individuals was observed at the same place in six different years in the period 1997–2011, both during and outside the spawning season. The other four individuals were observed several times in the same rocks in 2011 and 2012, with one of them being also observed in 2013. Since all these observations except two (Table 1) were conducted during the spawning season, they suggest strong inter-annual site fidelity to reproductive territories. Moreover, as observations were conducted in different weeks in 2012 and 2013 during spawning season, confirming therefore within season stability of reproductive territories. Importantly, there were no negative observations, meaning that every time that sites were visited, we observed the focal fish. Many other males in spawning behaviour were observed during the period we conducted this

study, but most of them were sighted only once, or for those sighted several times photos could not be taken, which hindered us from confirming their identity.

Our work confirms that male ballan wrasse show extreme site fidelity to a single rock or small group of rocks, especially during the spawning season; it contributes to previous findings that reported high residency and small home ranges of ballan wrasse (Villegas-Ríos *et al*., 2013b) but does so at a much finer spatial scale. Together with a similar, but invasive, study on *Lipophrys pholis* (L. 1858) (Martins *et al*., 2017), our study provides one of the strongest indications for long-term extreme very fine-scale site fidelity in marine fishes. Fine-scale site and nest fidelity is relatively common in territorial animals because familiarity with the area may increase predator avoidance, dominance status and foraging efficiency, ultimately benefiting reproductive success (López-Sepulcre & Kokko, 2005; Martins *et al*., 2017). Importantly, our results suggest that even very small marine reserves may be useful to protect male ballan wrasse. Protecting males is especially important in long-lived hermaphrodite species as males, being the largest individuals, are the main target of the fishermen. Under those scenarios, sex ratios can be skewed in favour of the females what may cause sperm limitation in the short term (Heppell *et al*., 2006; Sato *et al*., 2018) and may eventually produce evolutionary or adaptive shifts in the timing (size and age) of sex change (Hawkins & Roberts, 2004) resulting in less productive and less valuable stocks (Dulvy *et al*., 2004).

Our study suggests that individual spotted ballan wrasse can be identified based on the colour patterns of the head as tThis pattern of facial marks is constant and fixed over the years (Figure 2 and Supporting Information Video V1). As far as we are aware, this is the first time that photo-identification is applied to this species and it could provide an affordable, non-invasive and effective technique to monitor wild populations of this species across its range, particularly in conjunction with optimised pattern-recognition software and

other specific tools (Huffard *et al*., 2008). Unlike telemetry techniques, photo-identification doesn't depend on catching the individuals for tagging and can be applied to already existing photos. For instance, it can be applied to photos taken by scuba divers that typically visit the same sites regularly. Given the popularity of *L. bergylta* (specially the spotted morphotype) among underwater divers and film-makers, photo-identification appears to be a practical means to monitor individuals and populations of *L. bergylta* in the wild.

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References

Buray, N., Mourier, J., Planes, S. & Clua, E. (2009) Underwater photo-identification of sicklefin lemon sharks, *Negaprion acutidens*, at Moorea (French Polynesia). *Cybium* **33**, 21–27.

Dala-Corte, R. B., Moschetta, J. B. & Becker, F. G. (2016) Photo-Identification as a technique for recognition of individual fish: A test with the freshwater armored catfish *Rineloricaria aequalicuspis* Reis & Cardoso, 2001 (Siluriformes: Loricariidae). *Neotropical Ichthyology* **14**, 1–10. doi.org/10.1590/1982-0224-20150074

Dipper, F. A., Bridges, C. R. & Menz, A. (1977) Age, growth and feeding in the ballan wrasse *Labrus bergylta* Ascanius 1767. *Journal of Fish Biology* **11**, 105–120. doi.org/10.1111/j.1095-8649.1977.tb04103.x

Dulvy, N. K., Ellis, J. R., Goodwin, N. B., Grant, A., Reynolds, J. D. & Jennings, S. (2004) Methods of assessing extinction risk in marine fishes. *Fish and Fisheries* 255–276. doi.org/10.1111/j.1467-2679.2004.00158.x

Figueiredo, M., Morato, T., Barreiros, J. P., Afonso, P. & Santos, R. S. (2005) Feeding ecology of the white seabream, *Diplodus Sargus* and the ballan wrasse, *Labrus bergylta*, in the Azores. *Fisheries Research* **75**, 107–119. doi.org/10.1016/j.fishres.2005.04.013

Hawkins, J. P. & Roberts, C. M. (2004) Effects of artisanal fishing on Caribbean coral reefs. *Conservation Biology* **18**, 215–226. doi.org/10.1111/j.1523-1739.2004.00328.x

Heppell, S. S., Heppell, S. A., Coleman, F. C. & Koenig, C. C. (2006) Models to compare management options for a protogynous fish. *Ecological Applications* **16**, 238–249. doi.org/10.1890/04-1113

Huffard, C. L., Caldwell, R. L., DeLoach, N., Gentry, D. W., Humann, P., MacDonald, B.,

Moore, B., Ross, R., Uno, T. & Wong, S. (2008) Individually unique body color patterns in octopus (*Wunderpus photogenicus*) allow for photoidentification. *PLoS ONE* **3**, 1–5. doi.org/10.1371/journal.pone.0003732

López-Sepulcre, A. & Kokko, H. (2005) Territorial defense, territory size and population regulation. *The American Naturalist* **166**, 317–325. doi.org/10.1086/432560

Lucas, M. C. & Baras, E. (2000) Methods for studying spatial behaviour of freshwater fishes in the natural environment *Fish and Fisheries*, 1: 283-316. doi:10.1046/j.1467-2979.2000.00028.x

Martins, J., Almada, F. & Gonçalves, A. (2017) Home sweet home: evidence for nest-fidelity in the rocky intertidal fish, the shanny *Lipophrys pholis*. *Journal of Fish Biology* 156–166. doi.org/10.1111/jfb.13171

Moffitt, E. A., Botsford, L. W., Kaplan, D. M. & O'Farrell, M. R. (2009) Marine reserve networks for species that move within a home range. *Ecological Applications* **19**, 1835–1847. doi.org/10.1890/08-1101.1

Sato, T., Kobayashi, M., Kurihara, T., Takebe, T., Hirai, N., Okuzawa, K., Sawaguchi, S., Matsubara, T., Akita, Y., Ebisawa, A., *et al*. (2018) Impact of fishing losses of males on the reproductive output of the large protogynous fish, *Choerodon schoenleinii*. *Marine Ecology Progress Series* **602**, 225–235. doi.org/10.3354/meps12675

Sjölander, S., Larsson, H.-O. & Engström, J. (1972) On the reproductive behaviour of two labrid fishes, the ballan wrasse (*Labrus berggylta*) and jago´s goldsinny (*Ctenolabrus rupestris*). *Revue Comporte Animale* **6**, 43–51.

Villegas-Ríos, D., Alonso-Fernández, A., Fabeiro, M., Bañón, R. & Saborido-Rey, F. (2013a) Demographic variation between colour patterns in a temperate protogynous hermaphrodite, the ballan wrasse *Labrus bergylta*. *PLoS ONE* **8**. doi.org/10.1371/journal.pone.0071591

Villegas-Ríos, D., Alós, J., March, D., Palmer, M., Mucientes, G. & Saborido-Rey, F. (2013b) Home range and diel behavior of the ballan wrasse, *Labrus bergylta*, determined by acoustic telemetry. *Journal of Sea Research* **80**, 61–71. doi.org/10.1016/j.seares.2013.02.009

Villegas-Ríos, D., Alonso-Fernández, A., Domínguez-Petit, R. & Saborido-Rey, F. (2013c) Intraspecific variability in reproductive patterns in the temperate hermaphrodite fish, *Labrus bergylta*. *Marine and Freshwater Research* **64**, 1156–1168. doi.org/10.1071/MF12362

FIGURE 1 Map of study area north-west Spain, showing the four spawning sites were observations were made of male *Labrus bergylta* site fidelity

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FIGURE 2 Unique facial patterns used in the identification of male *Labrus bergylta* (fish ID4; Table 1) at the same spawning rock in (a) 2011 and (b) 2012. (c) A male *L. bergylta* (fish ID1) T-bar tagged in 2011 and (d) photographed at the same spawning rock in 2013.

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Figure 1.

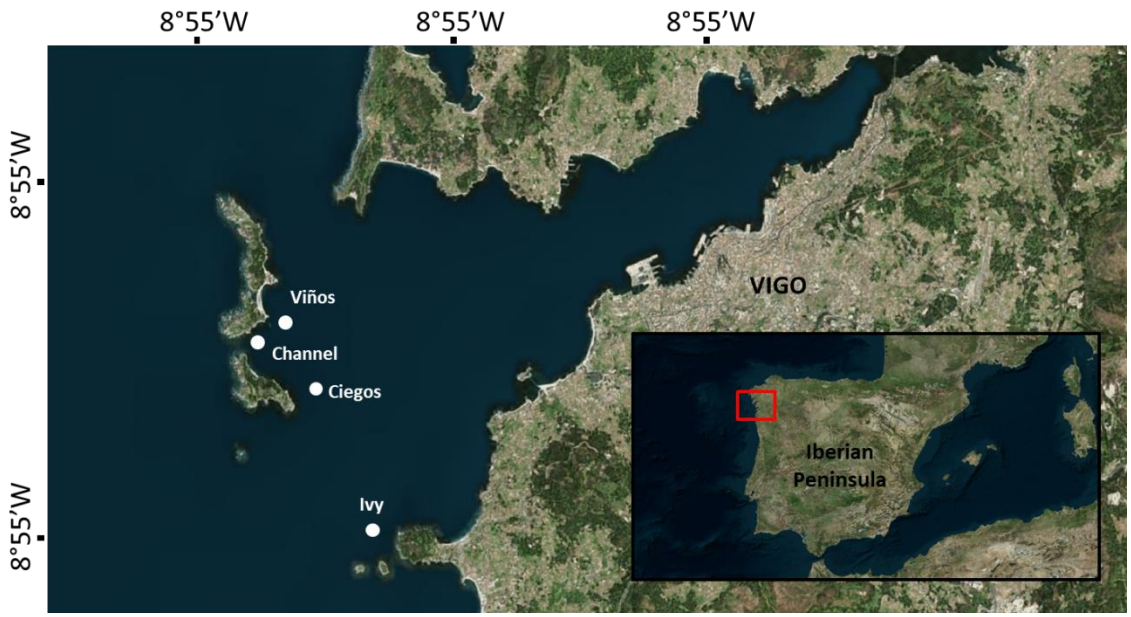

Figure 2.

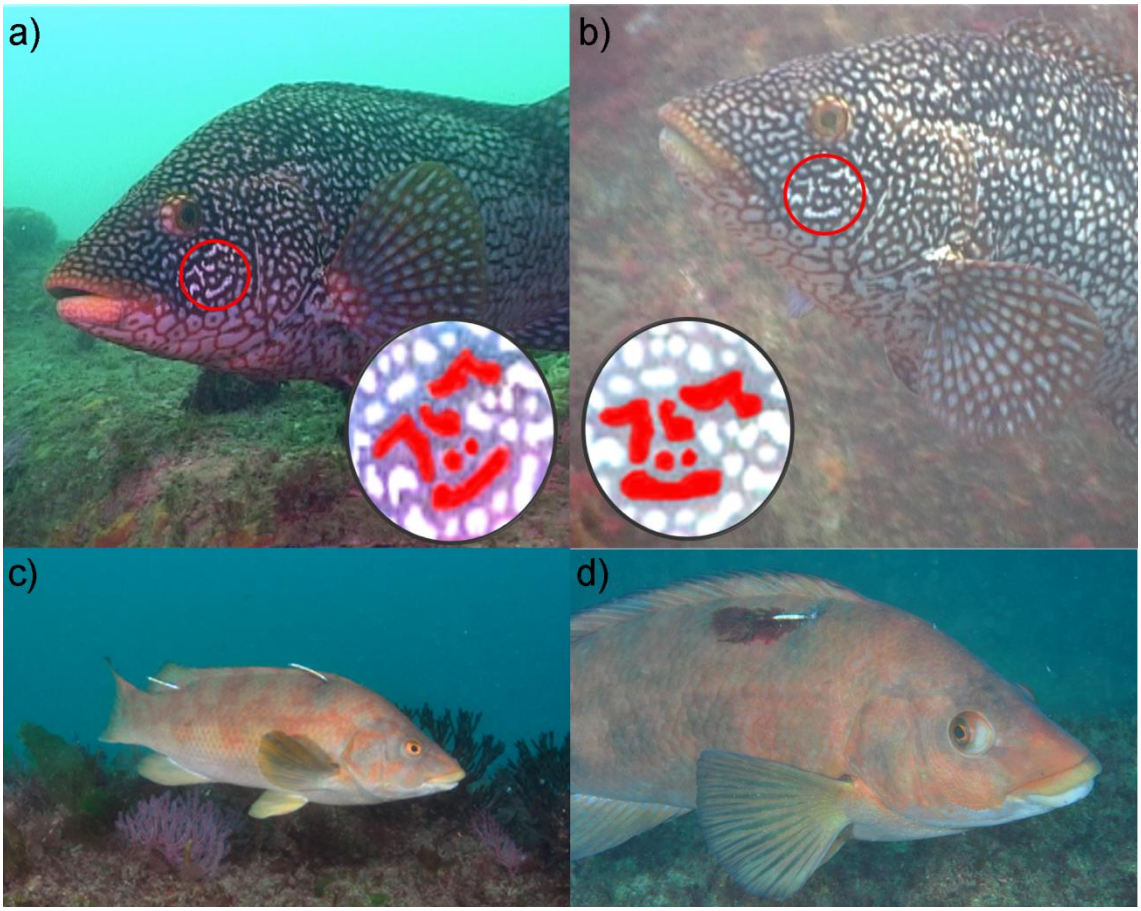

TABLE 1 List of individual *Labrus bergylta* identified at the same spawning site in the spawning season (January–April) by year and number of observations (in parentheses)

ID	Morphotype	Site	T-bar tagged	Year (number of observations)
1	Plain	Viños	Yes	2011 (5), 2012 (3), 2013 (1)
2	Plain	Ivy	Yes	2010 (1), 2012 (2)
3	Spotted	Ciegos Channel	No	1997 (1), 1998 (2), 1999 (1)*, 2000 (1)*, 2005 (2)*, 2011 (1)
4	Spotted	Channel	Yes	2011 (4), 2012 (2)
5	Spotted	Channel	No	2011 (4), 2012 (2)

ID, Individual fish identification; * Records during and outside the spawning season