



Dispersal of larval and juvenile seabream: Implications for Mediterranean marine protected areas



Antonio Di Franco^{a,b,*}, Antonio Calò^c, Antonio Pennetta^d, Giuseppe De Benedetto^d, Serge Planes^e, Paolo Guidetti^{a,b}

^a Université Nice Sophia Antipolis, Faculté des Sciences, EA 4228 ECOMERS, Nice, France

^b CoNISMa (Consorzio Nazionale Interuniversitario per le Scienze del Mare), Rome, Italy

^c Departamento de Ecología e Hidrología, Universidad de Murcia, Murcia, Spain

^d Laboratorio di Spettrometria di massa analitica ed isotopica, Dipartimento di Beni Culturali, University of Salento, Lecce, Italy

^e USR 3278 CNRS-EPHE, Laboratoire d'excellence 'CORAIL', Centre de Recherches Insulaires et Observatoire de l'Environnement, Université de Perpignan, 66860, Perpignan Cedex, France

ARTICLE INFO

Article history:

Received 22 May 2015

Received in revised form 20 October 2015

Accepted 24 October 2015

Available online 4 November 2015

Keywords:

Dispersal

Juvenile

Otolith

Propagule

Two banded seabream

Marine protected areas

ABSTRACT

In the marine context, information about dispersal is essential for the design of networks of marine protected areas (MPAs). Generally, most of the dispersal of demersal fishes is thought to be driven by the transport of eggs and larvae in currents, with the potential contribution of dispersal in later life stages relatively minimal. Using otolith chemistry analyses, we estimate dispersal patterns across a spatial scale of approximately 180 km at both propagule (i.e. eggs and larvae) and juvenile (i.e. between settlement and recruitment) stages of a Mediterranean coastal fishery species, the two-banded seabream *Diplodus vulgaris*. We detected three major natal sources of propagules replenishing local populations in the entire study area, suggesting that propagule dispersal distance extends to at least 90 km. For the juvenile stage, we detected dispersal of up to 165 km. Our work highlights the surprising and significant role of dispersal during the juvenile life stages as an important mechanism connecting populations. Such new insights are crucial for creating effective management strategies (e.g. MPAs and MPA networks) and to gain support from policymakers and stakeholders, highlighting that MPA benefits can extend well beyond MPA borders, and not only via dispersal of eggs and larvae, but also through movement by juveniles.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Dispersal, defined as the movement of individuals away from their “source” (Nathan et al., 2003), determines the spatial scale at which local populations are ecologically connected to each other. Dispersal is widely considered a major determinant of the: 1) distribution and local abundance of species; 2) dynamics of spatially structured metapopulations (and of community structure) and 3) extent to which populations and assemblages of species are able to respond to perturbations (Clobert et al., 2001).

In the marine context, the development of spatial management using marine protected areas (MPAs) in the 90s, and later the concept of MPA networks, has identified dispersal and connectivity as key factors in designing effective networks (Planes et al., 2009; Gaines et al., 2010; Almany et al., 2013). The overall framework driving MPA design is that the size of MPAs should be set to allow for 1) effective protection of populations of target species inside MPA borders, 2) both self-replenishment

and export of propagules (i.e. pelagic eggs and larvae) and 3) spillover of some juveniles, subadults and adults beyond boundaries (Harrison et al., 2012; Di Lorenzo et al., 2014). Knowledge about dispersal and movement patterns is, therefore, of paramount importance in designing effective MPAs and MPA networks (Green et al., 2014).

In a network of MPAs, each individual MPA should be adequately connected to the others via dispersal to support the persistence and the recovery of local populations from disturbance (Planes et al., 2009; Gaines et al., 2010). If MPAs are isolated from one another and not connected by dispersal between them, MPAs are more vulnerable to local extinctions because of local perturbations, since they cannot be replenished by immigration from elsewhere (Gaines et al., 2010).

The management-oriented need for information on dispersal was recently recognized even at policy level, as highlighted by the implementation of the California Marine Life Protection Act in the USA (Anadón et al., 2013) and by the ‘Marine Strategy Framework Directive’ (MSFD; 2008/56/EC) in the EU, where the creation of coherent and effective networks of MPAs is considered a key tool to reach conservation targets in the marine environment (Anadón et al., 2013).

Despite the variety of approaches currently used to tackle this issue, tracking the movements of marine fauna and quantifying dispersal

* Corresponding author at: Université Nice Sophia Antipolis, Faculté des Sciences, EA 4228 ECOMERS, Nice, France.

E-mail address: dify@libero.it (A. Di Franco).

patterns is, however, a complex task due to the difficulty in following individuals throughout their entire life cycles (Calò et al., 2013). Many larval dispersal patterns are estimated using models (e.g. Lagrangian models) parameterized with information about species life history traits (e.g. pelagic larval duration (PLD) and spawning date (SpD)) and oceanographic data (Pujolar et al., 2013; Andreollo et al., 2013, 2015). Other approaches that have proved highly valuable in estimating fish movements and dispersal use genetics (Planes et al., 2009; Weersing and Toonen, 2009) and tagging (both natural and artificial, Thorrold et al., 2002; Di Lorenzo et al., 2014).

Among natural tags, otolith chemical signatures have proven to be a valuable approach to both tracking fish movements and modelling dispersal patterns (Elsdon et al., 2008; Gillanders, 2009; Di Franco et al., 2012a). Focusing on natural tags, otoliths (ear bones) are carbonate structures usually in the form of aragonite (even if they can be found also in form of vaterite) located in inner ear of fishes and grow by the daily accretion of calcium carbonate increments throughout the fish's entire lifetime (Campana, 1999). Otoliths, starting from their formation during the embryonic stage, incorporate chemical signatures of the water mass the fish is in during each life history stage (Green et al., 2009). Though under physiological constraints, otolith chemistry reflects the water chemistry of the surrounding environment, and once laid down, increments (that can be referenced to specific ages) remain unaltered (Campana, 1999; Elsdon et al., 2008).

The chemical information acquired locally within the otoliths can be used to derive profiles of the movement history of an individual (Campana, 1999; Green et al., 2009). Despite some limitations (see Elsdon et al., 2008 for detailed description of the method), otolith chemistry is nowadays largely accepted as a useful method for unravelling fish dispersal and connectivity patterns (Calò et al., 2013; Starrs et al., 2014, but see Berumen et al., 2010).

In order to provide crucial information for the design of a network of effective MPAs, in this study we estimate dispersal patterns at both propagule (i.e. eggs and larval stages) and juvenile stages of an ecologically and economically important Mediterranean coastal fish, the two-banded seabream *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817), using analysis of otolith chemistry. Specifically we aim to estimate the scale of dispersal at propagule stage (i.e. eggs and larvae) and to build a dispersal kernel for juvenile (i.e. post-settlement) dispersal. This enables us to assess the paradigm that dispersal at juvenile stage is negligible and that dispersal and connectivity for coastal fish equate with propagule dispersal.

2. Material and methods

2.1. Study species

The two-banded seabream (*Diplodus vulgaris*) is a demersal reef fish distributed throughout the Mediterranean and the eastern Atlantic. It usually grows to a length of about 30 cm, although it can reach a maximum length of 45 cm (Fisher et al., 1987) and exceed 30 years in age (Guidetti et al., unpublished data).

D. vulgaris, with the congeneric *D. sargus sargus*, is an economically important fish exploited both by professional and recreational fisheries (Lloret et al., 2008) and plays an ecologically relevant role in Mediterranean coastal ecosystems. Preying on sea-urchins (grazers), the two *Diplodus* species indirectly control the transition from macroalgal forests to coralline barrens (i.e. bare rocks with encrusting algae), and may therefore have strong effects on rocky-reef community structure and ecosystem function (Guidetti, 2006).

Seabream eggs, released in the water column, hatch two days after fertilization and then larvae develop in pelagic waters for more than 1 month (Di Franco et al., 2013). Larvae metamorphose and settle (a stage called 'settlement') in shallow coastal habitats (mainly small bays characterised by mixed sandy and rocky bottoms) at approximately 10 mm TL (Planes et al., 1999; Vigliola and Harmelin-Vivien, 2001).

About six months later, the juveniles (i.e. small-sized subadults, approximately 8 cm TL) join the adults (at a phase that is operatively defined recruitment) and at about 2 years of age they reach sexual maturity.

Adults are relatively sedentary, with evidence of high site fidelity and movement at the scale of few kilometers (La Mesa et al., 2013). Much less is known about dispersal during the propagule and juvenile stages, with the only information concerning the Atlantic coasts of Portugal and showing dispersal at the scale of 1 km for juveniles (Abecasis et al., 2009) and inconclusive evidence for larvae (Correia et al., 2011).

2.2. Sampling scheme

We used otolith chemistry to obtain information on: 1) natal origin and larval dispersal by analysis of the core (laid down during embryogenesis, Green et al., 2009), of post-settler otoliths; 2) "site fidelity" and juvenile dispersal (i.e. the movement between settlement and recruitment) by analysis of the post-settlement rings of otoliths (i.e. about 10 daily increments after the settlement mark, which marks the transition from pelagic larva to demersal settler, Di Franco et al., 2013) of both post-settlers and juveniles. The second issue has been very scarcely studied despite its potential relevance.

Assaying otoliths of post-settlers (i.e. transitional juveniles *sensu* Vigliola and Harmelin-Vivien, 2001) collected along a stretch of coast and identifying groups of similar origins based on elemental signatures in otolith cores provided information about the spatial extent of larval dispersal. Larval dispersal distance was estimated on the basis of the distance among different sampling sites that were replenished by a single source.

Evaluating "site fidelity" of juvenile fish between settlement and recruitment, and the distance travelled between settlement and recruitment sites, provided information about juvenile movement after settlement. A prerequisite for this kind of investigation is to assess the spatial patterns of elemental signatures in otoliths among sampling sites. The elemental composition of the portion of the otolith formed just after settlement (the portion chemically characterized by the site where the fish settled) of post-settlers was assessed for 14 sites (see Section 2.3) and used to generate a reference set of site-specific chemical fingerprints representing potential settlement sites in the study area. Post-settlement movement (i.e. the distance travelled by juveniles) between settlement and recruitment stages was inferred by comparing chemical fingerprints of the same portion of the otolith (i.e. corresponding to about 10 days after settlement) between juveniles (collected 8–10 months after settlement) and post-settlers (collected shortly after settlement) from multiple sites.

The analysis of the same portion of the otolith in both post-settlers and juveniles prevented us from any bias related to potential temporal variability in water chemistry between settlement and recruitment. In addition the choice of analysing the portion of the otolith corresponding to 10 days after settlement (based on visual identification of otolith microstructure) reduces the risk related to temporal mismatch between microstructural and microchemical processes (see Freshwater et al., 2015). No evidence of this mismatch exists for Mediterranean species and findings from sockeye salmon *Oncorhynchus nerka* highlight, in 50% of individuals examined, a lag of about 9 days with microchemical process occurring before microstructural ones. If this would be the case also in our model species, the portion of otolith that we chemically analysed would still correspond to a moment when settlers inhabited settlement sites and therefore would allow us to properly characterize settlement sites.

2.3. Sample collection and study area

Both propagule and juvenile (i.e. post-settlement to recruitment) dispersal was investigated at the scale of approximately 180 km. Post-

Download English Version:

<https://daneshyari.com/en/article/6298608>

Download Persian Version:

<https://daneshyari.com/article/6298608>

[Daneshyari.com](https://daneshyari.com)