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The world is their oyster: Differences in epibiota on sympatric populations of native *Ostrea edulis* and non-native *Crassostrea gigas* (*Magallana gigas*) oysters

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A B S T R A C T

In this study we aimed to assess the relative effects of native *Ostrea edulis* and non-native *Crassostrea gigas* and their associated epibiotic biodiversity. We recorded epibiont location on the shell as well as the upper or lower valve. Epibiont species richness was significantly lower on *C. gigas*. The epibiota communities differed significantly between the two oyster species. The continued spread of *C. gigas* may potentially impact the epibiont biodiversity associated with oyster species in Strangford Lough. Management strategies should prevent sustained population expansion and associated changes in colonisation habitat.

1. Introduction

Oysters have long been recognised as ecologically important within both the intertidal and subtidal environments (Korringa 1951; Yonge 1960). They are not only an economically important fishery resource but also provide a suite of ecosystem services that benefit the health and wellbeing of their surrounding environments (Cranfield et al. 2003). Oysters are renowned for their ecosystem services such as; water column filtration, sediment stabilisation and benthic pelagic coupling and as such can be considered ecosystem engineers (Rodney and Payneter, 2006; Thurstan et al. 2013; Smyth et al. 2018). Their intrinsic value to the marine environment was highlighted during a Cost Benefit Analysis (CBA) into the feasibility of a proposed European oyster restoration initiative. The CBA revealed that the non-marketable consequential environmental improvements of *O. edulis* restoration (e.g. biodiversity, environmental services) would provide habitat managers with significantly greater monetary value than that of a commercial fishery (Laing et al. 2006).

A key aspect of the environmental contribution of the oyster is via the shell through the provision of a rich calcium carbonate substrate (Gosling 2003). The shell provides a favourable hard surface for the settlement of numerous bentho-pelagic larvae such as algae, barnacles and tube-building polychaetes (Wells 1961; Gutierréz et al., 2003; Smyth and Roberts 2010). The gregarious nature of oyster settlement also has the potential to increase habitat heterogeneity, particularly when reefs are formed, many of which have been shown to support substantial commercial fisheries (Summerhayes et al. 2009; Grandcourt 2012). However the effects of over-exploitation and pollution have led to the decimation of many wild oyster stocks (Thurstan et al. 2013; Smyth et al. 2016). Consequently oyster aquaculture has increased considerably over the last 50 years in order to meet consumer demand (Laing et al. 2006; Sawusdee et al. 2015). The European oyster *O. edulis* can still command a high market price although, low brood stock numbers and its susceptibility to disease have meant alternative species have been used to meet industry demands (Laing et al. 2006).

The Pacific oyster *Magallana gigas* formerly *Crassostrea gigas* was initially considered an ideal replacement for many struggling native oyster fisheries due to its fast growth rates and resilience to disease (Kerckhof et al. 2007). Its success as a culture species led to its translocation to over 60 countries outside of its native range and at one point it accounted for > 80% of global oyster culture (Ayers 1991; Kong et al. 2015). When *C. gigas* was initially introduced into northwest Europe in the late 1960s, it was believed that the species would not reproduce successfully under the environmental conditions (Steele and Mulchay, 1999). However, as a result of climatic changes and the environmental conditioning of aquaculture stock, the species spread from culture sites (Cognie et al. 2006; Cardoso et al. 2007; Troost 2010; Wrange et al. 2010).

The spread of non-native species in this way can greatly alter the function and structure of native communities and ecosystems

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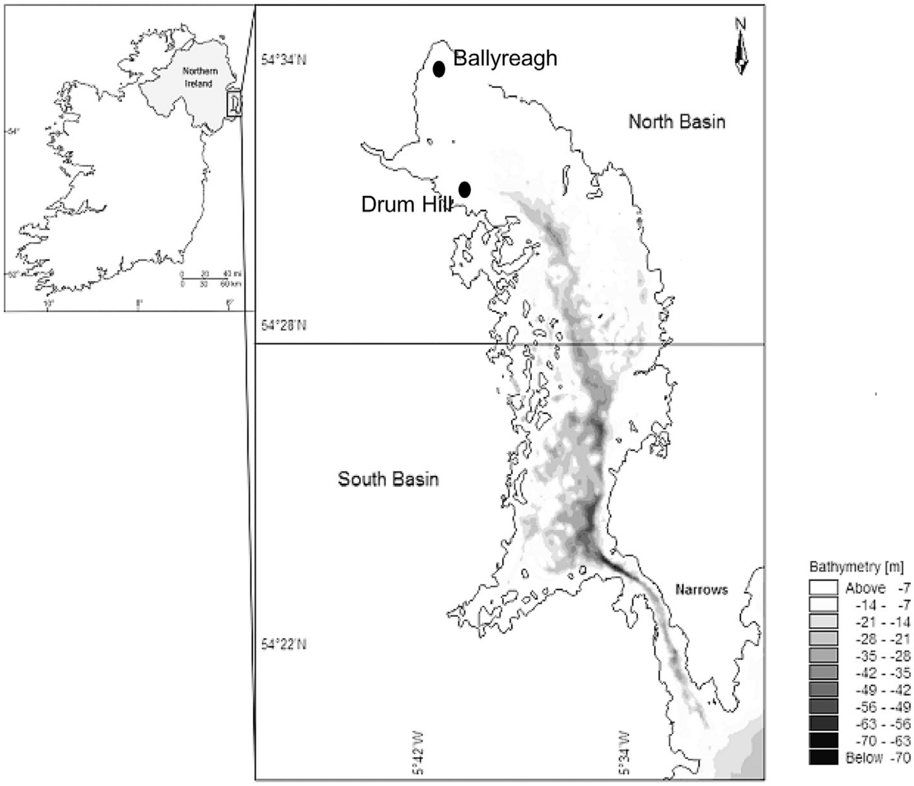

Fig. 1. Strangford Lough Northern Ireland with associated bathymetry and relevant oyster sites.

(Occhipinti-Ambrogi and Savini 2003; Walles et al. 2015). As assemblages of non-native species become established they can lead to changes in the physical habitat and resource availability. These can have wide reaching effects particularly as interactions will be experienced throughout the associated trophic chain leading to numerous individual and group biotic interspecies interactions (Thomas et al. 2016).

In conjunction with being an excellent aquaculture species *C. gigas* is also a successful marine invader (Troost 2010). It is highly fecund, fast growing and relatively disease resistant equipped with these traits it's an adept competitor with many indigenous species for space and food (Dankers et al. 2006). Its spread in coastal regions of the Northeast Atlantic represents a particular cause for concern as it is in direct competition for resources in the mid-intertidal with *Mytilus edulis* which is of significant commercial value to countries in the region (Gollasch and Nehring 2006; Brandt et al. 2008; Eschweiler and Christensen 2011). It is currently competing with tentative recovering assemblages of *O. edulis* on the lower-intertidal zone of Strangford Lough Northern Ireland (Guy and Roberts 2010). A similar scenario is also taking place along the Pacific coast of North America where *Ostrea lurida* assemblages have been settled on by *C. gigas.* As a result the North American native oysters have experienced depressed survival rates of > 45% and reductions in growth of > 20% (Trimble et al. 2009). In the Oosterschelde estuary in the Wadden Sea *C. gigas* has been forming large assemblages which have transformed intertidal mudflats important to bird life into oyster reefs (Wolff and Reise, 2002; Stelios et al. 2014). Dramatic changes in habitat of this type can herald shifts in nutrient cycling, food web dynamics and biodiversity (Jackson et al. 2001; Reise et al. 2017). In the Wadden Sea shifts from mussel beds to *C. gigas* reefs have been extensive and rapid resulting in extensive changes to benthic epifaunal communities (Kochmann et al. 2008; Stelios et al. 2014).

At Strangford Lough Northern Ireland, records of commercial harvesting of the native oyster *O. edulis* date back to the 17th Century (Kennedy and Roberts 1999; Smyth et al. 2009). However, as a result of overfishing *O. edulis* populations collapsed in the 1900s, after which the species was no longer commercially viable. The feasibility of reinstating a commercial oyster fishery within Strangford Lough was examined by Parsons (1974) and Briggs (1978) through a series of growth trials using *C. gigas.* As a result of their success, several intertidal commercial *C. gigas* farms were established (Kennedy and Roberts 1999). Approximately twenty years after the first *C.gigas* sites had been established the oyster was recorded outside of its licensed sites (Smyth et al. 2009). Subsequent surveys have identified feral populations throughout the northern basin of the lough (Smyth et al. 2018). However, settlement density and growth appears to be slow as the Allee effect may be limiting population expansion and the temperature regime of the region is not optimal (Guy and Roberts 2010). Nevertheless the discovery of *C. gigas* is of particular concern as the region is a designated Special Area of Conservation (SAC) under the 2009/147/EC Habitats Directive on the conservation of wild birds (Smyth et al. 2018). The mudflats in the northern basin are of particular importance as they accommodate the over-wintering of > 50% of the international population of Brent geese (*Branta bernicla hrota*) (Mathers et al. 2000). Any habitat change to these mudflats could affect the feeding behaviour of the Lough's internationally important wintering birds (Tinkler et al. 2009). Furthermore, *C. gigas* has the potential to negatively impact the recovery of *O. edulis* within the Lough. A species which has received considerable interest lately from NGO's, habitat managers and commercial fisheries and has been recognised within both the UK Biodiversity Action Plan and the OSPAR convention as a species which warrants conservation and expansion (Kennedy and Roberts 1999; Smyth et al. 2018).

Investigations into the effects of invasive species often occur after the non-native has become established and little can be done to prevent its further colonisation or mitigate its impacts (Giraldes et al. 2015). In this classic "closing the gate after the horse has bolted" scenario the emphasis is on reporting the changes which have occurred as a result of the invasive, rather than predicting what changes may occur should the species become well established. The high water retention which typifies the northern basin of Strangford and influences the ecosystems (Kregting et al. 2016) in the region has meant that both oyster species