BLUE MARINE FOUNDATION

Solent Oyster Restoration Project

Management Plan

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Executive Summary

The Blue Marine Foundation is working with a number of partner organisations on a long-term project to restore the native oyster beds of the Solent and enable the development of a sustainable oyster fishery. The marine environment of the Solent is subject to a number of interlinked environmental problems including overfishing, habitat loss, water pollution, invasive species and disease. Overfishing of oysters in the past has drastically reduced the amount of oyster bed habitat in the Solent. The long-term reduction in oyster bed coverage may also have contributed to water quality issues through a reduction in overall filtration capacity of oysters. A decline of the oyster population could also have knock-on socio-ecological effects, by reducing the habitat available for fin-fish stocks and their prey, and therefore affecting catches for both commercial and recreational fishers.

Oyster restoration is a high priority at the national, European and global level. The decline of the UK's native oyster population by 50% over 25 years was instrumental in its classification as a priority species in the UK's Biodiversity Action Plan. Native oysters have been identified as one of the most threatened species that requires conservation action at the national level. This national action plan is part of the UK's contribution to meeting global biodiversity targets set by the UN Convention on Biological Diversity. Globally, an estimated 85% of oyster beds and reef habitats have been lost.

A key consequence of the oyster population loss in the Solent has been a reduction in the marine ecosystem structure and function, and the provision of ecosystem services by this keystone species. Oyster beds provide a wide range of ecosystem services, particularly those categorised as *provisioning* as a food source, *supporting* broader processes such as nutrient cycling and biodiversity, and *cultural*, as part of our natural heritage. As active filter-feeders oysters remove suspended material from the water column leading to clearer and cleaner water. A single native oyster can filter up to 200 litres of water a day whilst a one hectare oyster bed may remove and deposit over 7.5 tonnes of suspended sediment per year. Large-scale removal of oysters can lead to increased nutrient levels, stronger algal blooms and increased risk of anoxic conditions, as reported for Chesapeake Bay on the U.S. Atlantic coast.

As a food resource, oysters have been harvested in Europe since Roman times or earlier. An oyster fishery has been operating in the Solent for centuries. Between 1972 and 2006 the Solent supported Europe's largest self-sustaining native oyster fishery. In 1978, 450 vessels were involved in oyster fishing between Weymouth and Chichester and at least 700 fishermen relied on oysters for a substantial part of their income.

However, since this peak in production the oyster population has declined with a sharp drop reported in 2007 as a result of poor recruitment. In 2013, the marine authorities were forced to close the Solent oyster fishery to protect the remaining stock.

A study commissioned by BLUE in 2014 reported that it is biologically possible to restore the native oyster population of the Solent. From extensive consultations, BLUE believes that an oyster restoration project is will make a major contribution to national and global conservation priorities for this species. Furthermore, the project has great potential to engage public support around a shared overall vision for sustainable fisheries and conservation in the Solent which is currently lacking. The

native oyster can trigger debate on the management of inshore fisheries, stakeholder and public engagement, pollution control and protected areas.

Employing valuable knowledge and experience gained from its project in Lyme Bay, BLUE formed a coalition of stakeholders, including fishermen, marine and local authorities, scientists and conservationists to establish the Solent Oyster Restoration Project. To date, seed-funding from Marks & Spencer, MDL Marinas and The Roddick Foundation has allowed BLUE to form a working group which has researched the main issues and possible solutions, assessed potential restoration activities and site locations and developed this five year management plan. The project has the overall goal to:

Restore the status of the native oyster (Ostrea edulis) in Solent waters so that a healthy, self-sustaining oyster population is present that will support the development of a viable and sustainable oyster fishery and improve the provision of other ecosystem services.

A series of objectives has been designed to achieve this long-term ambition with the prime objective being to increase the spatial coverage of healthy oyster beds across the Solent. The next stages of the project will implement the oyster reseeding programme using a number of different techniques, commission the necessary environmental studies and assessments, establish a scientific monitoring programme and start planning an extensive communications programme for the project and the native oyster through awareness-raising events and activities such an annual oyster festival.

The restoration and reseeding programme is challenging. However, we believe that the following initiatives when combined will stand a high chance of success: we will be laying an unprecedented volume of seed oysters; we will be using a varied mix of wild, innovative mariculture and ranched methodologies and; we will protect the broodstock against fishing and other disturbance. This combination of volume, variety of technique and protection will give us the best chance of ensuring resilience against issues that have beset other repopulation initiatives.

Successful oyster restoration is a numbers game: the Working Group intends to source **ten million** juvenile native oysters from a UK hatchery to grow to maturity using a variety of wild- and culture-based techniques, to help repopulate the Solent with oysters. Thousands of mature brood oysters will also be translocated into 'sanctuary' sites protected from any fishing activity to enhance natural spawning and spat distribution into the Solent. The Working Group, in conjunction with Land Rover Ben Ainslie Racing, MDL Marinas and Portsmouth University, has also initiated an innovative native oyster breeding programme which involves suspending brood stock oysters in cages beneath mooring pontoons in seven marinas. This programme will be extended to other marinas across the Solent over the next five years.

The regeneration of the Solent's oyster population offers multiple benefits for the environment, fishermen and other stakeholders, helping to create more sustainable livelihoods and improving the economy in the local area. This project will also develop greater awareness of the importance of the Solent as a natural marine and coastal system in providing a range of ecosystem services to local people. The intrinsic value of this project is in the establishment of an integrated process to ensure the long-term recovery of not only the native oyster but of the entire Solent marine ecosystem.

Acknowledgements

BLUE would like to thank Marks & Spencer, MDL Marinas, The Roddick Foundation, Selfridges and The Alice Ellen Cooper Dean Charitable Foundation for their initial financial support that has allowed BLUE to form a working group to research the main issues and possible solutions, and assess potential restoration activities and site locations which have all contributed to this management plan. We would like to thank our partners Southern IFCA, Land Rover Ben Ainslie Racing, and Portsmouth University and for the technical advice and guidance of the members of the Working Group.

Abbreviations

BAP	Biodiversity Action Plan
BLUE	Blue Marine Foundation
BWD	Bathing Water Directive
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
DEFRA	Department for Environment, Food and Rural Affairs
EMFF	European Maritime Fisheries Fund
EMS	European Marine Site
FLAG	Fishery Local Action Group
iVMS	Inshore Vessel Monitoring System
IFCA	Inshore Fisheries Conservation Authorities
LR BAR	Land Rover Ben Ainslie Racing
MMO	Marine Management Organisation
MSFD	Marine Strategy Framework Directive
RFID	Radio Frequency Identification
SAC	Special Area of Conservation
SPA	Special Protection Areas
SWQA	Solent Water Quality Association
WFD	Water Framework Directive

Introduction and Background

Project Background

Using the valuable lessons learned from previous work in Lyme Bay on collaborative management and restoration of inshore waters in Southern England, Blue Marine Foundation (BLUE) is working with a number of partner organisations on an ambitious, long-term project to restore the native oyster (*Ostrea edulis*) beds of the Solent and enable the development of a sustainable oyster fishery.

The marine environment of the Solent is subject to a range of serious and interlinked environmental problems including water pollution, invasive species, disease, habitat loss and overfishing. Poor water quality is causing the closure of some shellfish fisheries due to inadequate waste water infrastructure. Overfishing of oysters in the past has drastically reduced the amount of oyster bed habitat in the Solent leading to the closure of the oyster fishery in 2013. The replacement and smothering of oyster beds by slipper limpets (a non-native, invasive species) further limits the amount of space available for the settlement of oyster spat.

A long-term reduction in oyster bed coverage in both estuarine harbours and the main Solent channel is also likely to have contributed to water quality issues through a reduction in overall filtration capacity of oysters through their ability to filter and clean large volumes of water. The decline of the oyster population also has knock-on socio-ecological effects, by reducing the habitat available for fin-fish stocks and their prey, impacting both commercial and recreational fishers. Water pollution is affecting two of the world's most iconic game fish rivers, the Test and the Itchen which flow into the Solent and support important stocks of migratory fish such as salmon and sea trout. Furthermore, the Solent is a key nursery area for seabass which have been considerably overfished across their distribution range in the Channel and require careful management.

BLUE's first step for the Solent was to commission a research and feasibility study published in early 2014 to identify the reasons for the collapse of the oyster population and fishery and the possibility of bringing about its restoration (Gravestock et al., 2014)[1]. During the next 18 months BLUE gathered intelligence in the area and conducted a series of meetings with the fishermen and other stakeholders to fully understand all the issues and views. In June 2014 BLUE established a stakeholder Working Group consisting of a range of stakeholders, regulatory bodies and concerned organisations including fishermen, fish merchants, the Southern and Sussex Inshore Fisheries Conservation Authorities (IFCAs), the Marine Management Organisation (MMO), Natural England, Hampshire and Isle of Wight Wildlife Trust, the Environment Agency, Public Health Authorities, Portsmouth and Southampton Universities and the Solent Forum. Out of the main stakeholder group emerged a smaller technical working group responsible for planning, creating and implementing a comprehensive management plan for the restoration of the native oyster and associated ecosystem improvements.

The Solent Oyster Restoration Project takes inspiration from other large restoration projects such as the Billion Oyster Project in the United States, a coalition aiming to re-seed a billion live oysters in the New York Harbour area by 2030 and create 100 acres of self-sustaining oyster reef. Similarly, the native oyster is a keystone species in the Solent with the potential to transform the status of the

[1] Gravestock, V., James, F., and Goulden, M. 2014. Solent Native Oyster (*Ostrea* edulis) Restoration: Literature Review and Feasibility Study. MacAlister, Elliott & Partners.

marine environment if oyster beds are restored and the key stressors for oysters minimised and managed. It is desirable to restore its prodigious filtration capacity, as well as the potential for a valuable edible harvest of sustainably sourced oysters.

The previously mentioned feasibility study commissioned by BLUE (Gravestock et al., 2014) suggests that a portfolio of viable techniques exist for oyster restoration. BLUE and the Solent Working Group believe the time is ripe for a project to restore the largest population of native oysters in Europe. Such a project is bound to teach many lessons that can be applied to other water bodies with a history of human influence and neglect.

Oyster biology, ecology and status

The native oyster (*Ostrea edulis*) is a bivalve mollusc that grows in excess of 110mm in length and lives in depths of up to 80 metres. The species is widely distributed around the British Isles and Norwegian, North and Mediterranean Seas as well as off the Atlantic coast of Morocco. The main stocks in the UK are found in the west coast of Scotland, the south-east and Thames estuary, the River Fal, Lough Foyle and the Solent (Jackson, 2007)[2].

The species is associated with productive estuarine and shallow coastal water habitats and lives on firm bottoms of mud, rocks, muddy sand, muddy gravel with shells and hard silt. Suitable habitats in the form of 'cultch' (broken shells and other hard substrata) have been created in areas where the species is exploited (Jackson, 2007).

Native oysters have a life span of five to ten years but may reach in excess of 15 years of age. They reach maturity at age three years and reproduce from June to September. Larvae can disperse as far as ten kilometres and the larval stage lasts from 11-30 days. Oysters are protandrous alternating hermaphrodites – they start off as males producing sperm then switch to females producing eggs, before switching back to male and back again several times (Jackson, 2007).

Native oysters feed by pumping water through a filter in the gill chamber, removing suspended organic particles. An important food source is thought to include particulate matter which has been re-suspended from the bottom material through tidal currents and storms (Grant et al., 1990)[3]. The growth rate of oysters living in sheltered sites is faster than in exposed locations. This is thought to be attributed to the seston volume (volume of organisms and non-living matter floating in the water column) rather than flow speed or food availability (Valero, 2006)[4].

The introduced slipper limpet (*Crepidula fornicata*) is a direct competitor with the native oyster. They compete for space and food and can occur in very high densities. However, oysters are able to settle on slipper limpet shells which are known to be a suitable settlement substrate. Native oysters are predated on by a variety of species including starfish and mollusc species such as the sting winkle

[2] Jackson, A. 2007. *Ostrea edulis* Native oyster. In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitive Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: http://www.marlin.ac.uk/species/detail/1146

[3] Grant, J., Enright, C.T. & Griswold, A., 1990. Resuspension and growth of *Ostrea edulis*: a field experiment. *Maine Biology*, 104, 51-59.

[4] Valero, J., 2006. *Ostrea edulis* Growth and mortality depending on hydrodynamic parameters and food availability. *Department of Marine Ecology, Gøteborg University*, Strømstad, Sweden. pp. 47.

(*Ocenebra erinacea),* common whelk (*Buccinum undatum)* and the American oyster drill *(Urosalpinx cinerea*) with the latter feeding mainly on oyster spat (Jackson, 2007).

The native oyster population of the UK declined by 50% over 25 years, which was instrumental in its classification as a priority species in the UK's Biodiversity Action Plan (BAP) (UKBAP, 1999)[5]. This means that it has been identified as one of the most threatened species that requires conservation action at the national level. Recommended actions under this BAP include the protection of remaining oyster beds from mobile fishing gear and commercial exploitation; the maintenance of the existing geographical distribution within UK inshore waters; increasing the abundance of the oyster within UK inshore waters; monitoring of populations at existing locations and prevention of deterioration to the habitat of the species through competent authorities (JNCC, 2010)[6]. The native oyster has also been included on the OSPAR[7] list of threatened and/or declining species and habitats since 2003, with recommendations for improving its conservation status provided for the regional level (OPSAR Commission, 2009)[8].

Globally, some 85 per cent of oyster reefs and beds have been lost, with a corresponding loss in the multiple ecosystem services provided by these keystone species (Beck et al., 2011)[9].

Solent Oyster and Fishery history

Oyster beds have been exploited in the Solent since Roman times (Günther, 1897)[10] and were an important fishery in the Middle Ages with records of managed beds across the region (Tubbs, 1999)[11]. Although the Solent oyster population has fluctuated in the past, there has been a long-term decrease since the 19th century, mainly caused by overfishing of oyster beds through the introduction of dredging in the mid-19th century. Oyster beds were quickly denuded through dredging in the following decades, so much so that all managed beds in the Solent were sustained by imported oysters as natural beds were nearly exhausted (Woods, 1877)[12]. Oysters were imported from Spain and North America, which also introduced invasive species that are oyster predators or competitors including the slipper limpet. The Solent oyster industry collapsed in the 1920s as most of the remaining oyster population was killed by disease[13] that was associated with high laying densities in managed beds (Tubbs, 1999). After some recovery in the 1950s the population was devastated again by the harsh

[5] UKBAP 1999. Tranche 2 Action plans. Maritime species and Habitats. [Online] http://jncc.defra.gov.uk/PDF/UKBAP_Tranche2-ActionPlans-Vol5-1999.pdf

[6] JNCC, 2010. *Ostrea edulis.* UK priority species pages – Version 2.

[7] The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention")

[8] OSPAR Commission, 2009. Background document for *Ostrea edulis* and *Ostrea edulis* beds. 22 pp. ISBN 978-1-906840-68-6. Publication Number: 428/2009

[9] Beck et al., 2011. Oyster Reefs at Risk and recommendations for conservation, restoration and management. *Bioscience*

[10] Günther, R. (1897). `The oyster culture of the ancient Romans'. Journal of the Marine Biological Association of the United Kingdom 4, 360-365.

[11] Tubbs, C. (1999). The ecology, conservation and history of the Solent. Packard Publishing Limited, Chichester. 184 p.

[12] Woods, W. (1877). Letters on oyster fisheries: the causes of scarcity; the remedies; etc. Talbot collection of British pamphlets. Edward Bumpus, Holborn Bars. 43 p. London.

[13] Retrospectively identified as the flagellate protozoan *Hexamita*

winter of 1962-63 which included a large proportion of those in Beaulieu Estuary and Newtown Harbour (Kamphausen, 2012)[14].

Restocking of the Beaulieu beds in the late 1960s with imported oysters from Northern Europe along with those that survived into 1963 led to a remarkable recovery of oyster populations with consecutive years of successful spatfall throughout the Solent in the 1970s (Kamphausen, 2012). The recovery continued throughout the Solent into the early 1980s despite heavy fishing and led to the Solent becoming the largest self-sustaining native oyster fishery in Europe between 1972 and 2006 (Tubbs, 1999, Gravestock et al., 2014). The oyster fishery peaked at the end of the 1970s with, in 1978, 450 vessels involved in oyster fishing between Weymouth and Chichester and at least 700 fishermen relying on oysters for a substantial part of their income (Key & Davidson, 1981)[15]. Catches were highest in the 1979-1980 season at 840 tonnes or 15 million oysters (Key & Davidson, 1981). However, oyster beds in the Beaulieu estuary were cleared in 1986 as a control measure against the disease bonamiosis (Kamphausen, 2012).

Since the early 1980s, the Solent oyster population has been in decline with a particularly steep drop reported in 2007. The decline over the last 25 years is thought to be partly caused by a previous lack of suitable regulatory tools and resources so that the fishery was not properly managed which allowed fishing to continue at an unsustainable level. From the 1970s onwards, oysters were taken from the Solent and re-laid in other parts of Britain and Europe for growing-on to marketable size. Stocks were depleted by overfishing with catches also under-reported which hindered effective management of the fishery. Historically, the population was enhanced by larval supply from managed oyster beds in the estuaries and harbours but this has not been the case in recent years (Gravestock et al., 2014)[16].

Finally, in 2013, the Southern IFCA reported that the annual harvest had dropped from 200 to 20 tonnes over five years and subsequently severely restricted the fishery. That restriction included the complete closure of the wider Solent to oyster fishing but opening of the fishery in Portsmouth and Langstone Harbours for four weeks per year in 2013-2014, and two weeks per year for the 2014-2015 and 2015-2016 seasons.

Stressors

Ostrea edulis populations are highly susceptible to population fluctuations caused by their sporadic recruitment, as well as overexploitation, predation, disease, and changes in their local environment (Kamphausen, 2012). There is a variety of theories on the reason for the recent decline of the native oyster in the Solent. No single cause was attributed to the population decline - it is more likely to be a combination of factors, some of which are discussed below.

It is thought that the decline began after multiple failures in recruitment which suggested that there had been a disturbance in the reproductive processes of the population (Gravestock et al., 2014). An issue that may be faced by the population in relation to reproduction is a skewed sex ratio (a ratio of

[14] Kamphausen, L.M. 2012. The reproductive processes of a wild population of the European flat oyster *Ostrea edulis* in the Solent, UK.

[15] Key, D. & Davidson, P.E. 1981. A Review of Development of the Solent Oyster Fishery, 1971-80. Laboratory Leaflet, No. 52. Lowestoft. 40 pp.

[16] Gravestock et al., 2014. Solent native oyster (*Ostrea edulis*) restoration – Literature review & feasibility study.

6:1, male to female was found in one study (Kamphausen, 2012)) which, if the case, would reduce the reproductive potential of the population. There is also a lack of suitable spat settlement substrate leading to insufficient numbers of spat overcoming mortality factors.

All of these problems have been exacerbated by other factors such as overfishing in the region as mature individuals who are able to reproduce were continuously removed while no new individuals were added to the population. The native oyster is particularly vulnerable to overfishing as the species is relatively long-lived and characterised by sporadic reproduction (Laing et al., 2005)[17]. Habitat loss and degradation, also brought about by the effects of channel dredging, resulted in a loss of broodstock and available space for future recruitment. Habitat loss has occurred due to the proliferation of slipper limpets (*Crepidula fornicata*) which has smothered large areas of oyster beds in the estuaries. Populations have also been threatened by the increase in numbers of the European oyster drill (*Ocenebra erinacea)* (a predator of the oyster) and the parasite *Bonamia ostreae* in the Solent which cause an increase in mortality of oysters (Gravestock et al., 2014).

Another key stressor in the Solent is the quality of the water. The Solent consists of a large coastal water body which is fed by several estuaries and harbours all of which contribute to failing chemical status and eutrophication in the main water body as assessed under the Water Framework Directive. The main Solent water body was assessed to have moderate ecological status in 2013 but has failed for chemical status in several years. Hygiene classifications have also been carried out for the native oyster populations in several areas in the Solent and the majority have been classified as a long-term B. This classification means that post-harvest, oysters must be re-laid or purified by cooking by an approved method. The microbiological standard is:

'*live bivalve molluscs from these areas must not exceed the limits of a five-tube, three dilution MPN test of 4,600 E. coli 100g FIL in more than 10% of samples. No sample may exceed an upper limit of 46,000 E. coli 100g FIL.'*

These classifications and other water quality issues will have implications for any oysters harvested from the fishery later in the process as well as being a potential stressor to the populations.

The Need for Oyster and Ecosystem Restoration

Locally, the Solent oyster collapse has been significant in both economic and environmental terms. It has challenged the economic viability of an inshore fishing fleet of 140 registered vessels and fishermen have either left the industry or diversified into other fisheries such as the new fishery for self-seeded manila clams. Consequently, dredging and digging for these clams in the intertidal is damaging the habitat where the clams are found. Whilst some of this clam fishing is legal some is also illegal, unregulated fishing, and poaching, in areas closed to shellfish fisheries due to microbiological contamination, often as a result of poor water quality.

[17] Laing, I., Walker, P. & Areal, F. 2005. A feasibility study of native oyster (*Ostrea edulis*) stock regeneration in the United Kingdom. CARD Project FC1016 Native Oyster Stock Regeneration – A Review of Biological Technical and Economic Feasibility. CEFAS. 97 pp.

The Solent contains important habitats such as seagrass beds that are critical feeding grounds for birds for which the Solent has been protected under national and European law. Dredging and fishing is prohibited in seagrass beds across the Solent.

The loss of oysters has had an impact on fisheries and on the ecosystem in general. A key consequence of the oyster's collapse has been a reduction in the Solent's ecosystem structure and function, and the provision of ecosystem services by this keystone species. Oyster beds provide a wide range of ecosystem services, particularly those categorised as *provisioning* as a food source, *supporting* broader processes such as nutrient cycling, and *cultural*, as part of our natural heritage (Kamphausen, 2012). Oyster beds contribute significantly to inshore shallow biodiversity by increasing habitat complexity and providing a hard structure for settlement of marine life. These beds are also a cryptic habitat that provides protection and nursery grounds for juvenile fish and other species. As active filter-feeders, oysters remove organic material from the water column such as phytoplankton, bacteria and particulate detritus. Oysters provide a rich food source for marine animals living on or in the seabed through the production of waste materials, increasing the turnover of nutrients and organic carbon which increases the overall productivity of the ecosystem (Dame, 1996)[18]. Filtering large volumes of water also reduces water turbidity and allows greater light penetration which in turn increases primary production. Removal of oyster beds can lead to increased nutrient levels, stronger algal blooms and increased risk of anoxic conditions as occurred in Chesapeake Bay after the decline of oyster reefs (Dame, 1996).

The Solent has a series of estuaries with serious water quality issues. The harbours and estuaries at Langstone, Chichester, Portsmouth, Pagham, Medina, Newtown, Eastern Yar and Hamble are considered by the Environment Agency to be either eutrophic or at risk of eutrophication (when a water body becomes enriched with nutrients such as nitrate and phosphate). This can cause algal blooms in the water which disrupt normal ecosystem function and promote the growth of benthic algae which can smother seabed habitats.

Investigations by the Environment Agency have resulted in the designation of Langstone, Chichester, Portsmouth, Pagham, Medina, Newtown, Eastern Yar and Hamble estuaries as sensitive areas or polluted waters under the Urban Waste Water Treatment Directive and/or Nitrates Directive. Following these designations, Southern Water is upgrading sewage treatment works to reduce nutrient inputs and the agricultural sector is being targeted with nitrate vulnerable zones. However, the Solent Water Quality Association estimates it will take decades before the levels of nutrients reduce sufficiently for the amount of seaweed to reduce visibly. The restoration of the oyster population in the Solent, along with these other measures, could help to improve water quality in these areas.

There is growing interest in oyster restoration internationally, particularly in America where restoration projects are being carried out across the country. A number of approaches have been taken by these initiatives including the formation of artificial reefs, the establishment of broodstock sanctuaries and community involvement in oyster husbandry (Brumbaugh et al., 2006)[19]. The 'Billion

[18] Dame, R., 1996. Ecology of Marine Bivalves: An Ecosystem Approach. CRC Press, New York. 272 p.

[19] Brumbaugh, R.D., Beck, M.W., Coen, L.D., Craigh, I. and Hicks, P. 2006. A practitioners' guide to the design and monitoring of shellfish restoration projects: an ecosystem services approach. The Nature Conservancy, Arlington, VA., MRD Educational Report No. 22. 28pp

Oyster Project' has been running in New York harbour for six years. During this period, students have successfully restored over eleven million oysters (where the population was previously functionally extinct[20]) through the use of oyster cages, nurseries and hatcheries as well as reef reconstruction. As in the Solent, along with the restoration of the oyster population, a key aim of the project is restoring the local marine ecosystem's natural mechanisms for maintaining itself and so cleaning the waters where the oysters reside[21]. Another project has been underway since 2014 in Chesapeake Bay and its tributaries where there was historically a very valuable fishery but the current population is estimated to be as low as 1% of historic levels[22]. The project involves the creation of oyster reefs and the use of hatcheries to grow-on spat[23].

In Europe, there have been some limited attempts at oyster restoration in Scotland, Wales and Germany. The first restoration efforts in the UK were made in October 2004 when the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), commissioned by the Department for Environment, Food and Rural Affairs (DEFRA) and Seafish, undertook a feasibility study on native oyster restoration in the UK (Laing *et al*., 2005, Laing *et al*., 2006)[24]. A number of groups in different locations around the UK have considered the feasibility and attempted the restoration of native oyster populations. This has been done in South Wales (Woolmer *et al*., 2011)[25], Shetland (Shelmerdine & Leslie, 2009)[26], Strangford Lough in Northern Ireland (Kennedy & Roberts, 1999[27]; Roberts et al., 2005[28]) and the Solent (Key & Davidson, 1981)[29] and Chichester Harbour (Vause, 2010[30]; Eagling, 2012[31]) on the south coast. Further details of these restoration programmes are summarised in the commissioned MEP report (Gravestock et al., 2014).

To date, there have been trials in Chichester harbour, but restoration techniques have yet to be applied along the 30-mile long waterway that is the Solent. This plan is part of Britain's contribution to meeting targets set by the United Nations Convention on Biological Diversity.

Recovery of the population is dependent on improved larval recruitment. Recruitment tends to be sporadic and dependent on local environmental conditions including summer sea water temperature,

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[20] Billion oyster project – about: http://www.billionoysterproject.org/about/

[21] http://www.billionoysterproject.org/about/

[22] http://www.cbf.org/about-cbf/offices-operations/oyster-restoration-centers

[23] http://chesapeakebay.noaa.gov/oysters/technical-aspects-of-oyster-restoration

[24] Laing, I., Walker, P. & Areal, F. 2006. Return of the native – is European oyster (*Ostrea edulis*) stock restoration in the UK feasible? *Aquatic Living Resources*, **19**, 283-287.

[25] Woolmer, A.P., Syvret, M. & Fitzgerald, A. 2011. Restoration of Native Oyster, *Ostrea edulis*, in South Wales: Options and Approaches. CCW Contract Science Report No: 960, 93 pp.

[26] Shelmerdine, R. L. & Leslie, B. 2009. Restocking of the native oyster, *Ostrea edulis*, in Shetland: habitat identification study. Scottish Natural Heritage Commissioned Report No. 396.

[27] Kennedy, R.J. & Roberts D. 1999. A Survey of the Current Status of the Flat Oyster *Ostrea edulis.* In Strangford Lough, Northern Ireland, with a view to the Restoration of its Oyster Beds. *Biology and Environment: Proceedings of the Royal Irish Academy*. **99B**, 79–88.

[28] Roberts, D., Smyth, D. & Browne. L. 2005. Native oyster (*Ostrea edulis*) fishery enhancement in Strangford Lough, Northern Ireland. *Shellfish News*, **20**, 5-6.

[29] Key, D. & Davidson, P.E. 1981. A Review of Development of the Solent Oyster Fishery, 1971-80. Laboratory Leaflet, No. 52. Lowestoft. 40 pp.

[30] Vause, B., 2010. Chichester harbour oyster initiative. Shellfish News, 30, 5-6

[31] Eagling, L., 2012. Reproductive success of the re-laid Native Oyster *Ostrea edulis* in Chichester harbour. Master's Thesis. University of Southampton, UK. 63 pp.

predation intensity and hydrographic conditions. As well as unfavourable environmental conditions, recovery could also be restricted by the dominance of other species such as the slipper limpet that came about following the loss of the oyster population (Jackson, 2007).

The Solent

The Solent is a strait of water separating the Isle of Wight from the south mainland coast of England. The Solent estuarine system consists of a number of separate estuaries and harbours including Southampton water, the West Solent, the East Solent and Spithead, Portsmouth, Langstone and Chichester Harbour. Within the Solent a mixed fishery targets a number of different commercial species throughout the year. There are 140 commercial vessels registered to berths in the Solent. The Solent harbours are important nursery areas for seabass and support threatened runs of migratory salmon and sea trout on their way to and from spawning grounds on the rivers Test, Itchen, Meon, Hamble and the New Forest streams. Eels also migrate from these rivers to spawn at sea. The Solent is important to recreational anglers who fish from the shore and from private and chartered boats.

Habitats found in the Solent include mudflats, sandflats, grazing marsh, saltmarsh, vegetated shingle, sea cliffs, rocky shores, lagoons and various types of seabed. They include examples lost from other areas of the south coast. Its mudflats are rich in invertebrates and are therefore important feeding grounds for waterfowl and waders. Oyster beds support a complex trophic structure and high levels of biodiversity, thus highlighting another reason to restore them (Grabowski and Peterson, 2007)[32].

There are two Special Areas of Conservation (SACs) in the Solent: the Solent and Isle of Wight Lagoons and The Solent Maritime. Both of these sites were selected as SACs due to special habitats that are contained within them. The Solent and Isle of Wight Lagoons' habitat consists of 'coastal lagoons' priority habitat which does not interact with the oyster fishery. In the Solent Maritime, the three priority habitats are estuaries, spartina swards (*Spartinion maritimae*), and Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*). There are also three Special Protection Areas (SPAs) that are protected for birds and their supporting habitats located in the Solent area. These are the Solent and Southampton Water SPA, Portsmouth Harbour SPA and Chichester and Langstone Harbours SPA. These three SPAs and the Solent Maritime SAC form the Solent European Marine Sites (EMS).

[32] Grabowski, J. H. and Peterson, C.H. 2007. Restoring oyster reefs to recover ecosystem services. In: Ecosystem Engineers: Plants to Protists. doi:10.1016/S1875-306X(07)80017-7

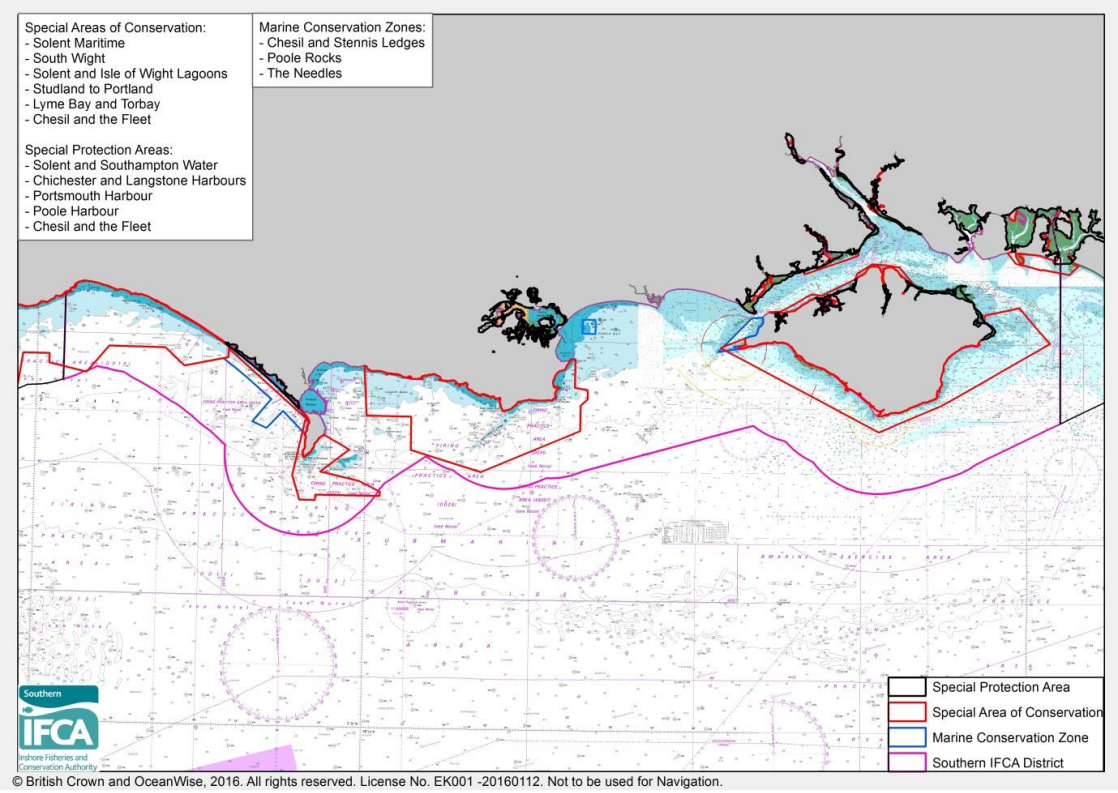

Figure 1: Map of the Solent indicating the location of designated European Marine Sites

BLUE and its experience in Lyme Bay

BLUE came into existence as a result of the award-winning film, *The End of the Line*, based on the book of the same name. Both the film and the book advocate responsible fishing and the creation of large-scale marine protected areas. BLUE was established to bring about the creation of marine reserves, marine protected areas and private sector solutions in the sea to make fisheries more sustainable.

BLUE has been working in Lyme Bay on the Devon/Dorset coast since 2011 to improve fisheries' management. Here, BLUE helped to strengthen an existing marine protected area that was being overfished with pots after mobile gears were banned. BLUE helped to bring together a range of stakeholders including fishermen, regulators and conservationists to form a working group. Together this working group set up a model that helped to restore the fishery to a sustainable level. Actions taken under the model included agreeing on a code of conduct for fishing in the bay; the development of a fully documented fisheries scheme; and the development of infrastructure (including chiller units) to ensure fish caught are of high quality to bring in high prices to the fishermen.

BLUE intends to roll out the collaborative model established in Lyme Bay in the Solent to improve its fisheries, in particular for the native oyster over the long-term. The feasibility study (Gravestock et al., 2014) indicates that it is biologically possible to restore the native oyster population of the Solent. From extensive consultations, BLUE believes that an oyster project is not only worthwhile in itself but that it has the best potential to engage public support around a shared overall vision for fisheries and conservation in the Solent which is currently lacking. The oyster is the starting point in a conversation that can include the management of fisheries, enforcement, pollution control and protected areas.

Goals, Objectives, and Activities

The primary long-term goal of the Solent Oyster Restoration Project is to:

Restore the status of the native oyster (Ostrea edulis) in Solent waters so that a healthy, self-sustaining oyster population is present that will support the development of a viable and sustainable oyster fishery and improve the provision of other ecosystem services.

Management Objectives

Objective 1

Restore native oysters through wild and mariculture re-seeding of the Solent's waters with a significant volume of juvenile oysters using active management methodologies.

Objective 2

Protect wild and re-seeded mature breeding oysters in 'sanctuary sites' where they will be able to reproduce undisturbed in order to sustain long-term replenishment of the native oyster stock.

Objective 3

Improve the ability of the native oyster to provide a suite of ecosystem services for the Solent.

Objective 4

Develop awareness of the oysters, their importance and the wider marine environment, and develop support for the project through community engagement and education.

To achieve the above objectives and restore the native oyster population of the Solent a suite of activities is planned over the next five years. These include, but are not limited to:

- Site feasibility assessments to identify the locations for a range of oyster-focussed activities
- Designation of oyster broodstock, re-seeding and culture sites
- Oyster bed restoration including harrowing of historical beds dominated by slipper limpets
- Assessment of the feasibility of invasive species mitigation measures
- Sourcing, re-laying and growing of juvenile oysters
- Re-seeding of hatchery-reared juvenile oysters at sites across the Solent
- Community engagement and education

These activities are incorporated into the draft five year timeline for the project (Annex 3) along with other potential areas of work (see next section). It should be stressed that oyster restoration is a long-term process which is highly likely to take more than five years to achieve (Laing et al., 2006). Restoring the oyster fishery will only be feasible when there is sufficient recovery of the native oyster population along with effective management to ensure that any future fishing is well-documented and

sustainable. By injecting unparalleled numbers of oysters into the Solent (over ten million), we believe that the restoration programme stands an unprecedented chance of success.

Anticipated Outcomes

Outcome 1

Increased and protected coverage of healthy oyster beds in the Solent up to and beyond 2020.

Outcome 2

Supported restoration of oysters in the Solent to enable sustainable local harvesting of oysters in certain carefully selected zones beyond 2020 through a variety of wild seeding and mariculture methodologies.

Outcome 3

Increased proportion of locally-sourced, sustainably reared or caught oysters in local and regional markets beyond 2020 from certain zones.

Outcome 4

Raised public and stakeholder awareness of the importance of oysters for the health of shallow inshore marine waters of the Solent.

Oyster Restoration - Activities

Figure 2: The native or flat oyster (*Ostrea edulis*)

The native oyster restoration programme will take a multi-faceted approach with a number of linked activities occurring across the Solent. There are five main site types for different activities with some overlap between them. A key outcome will be increased and protected biomass of oyster broodstock present in Solent waters. This will be achieved by a combination of oyster translocation to designated **broodstock sites** and oyster culture in protected estuaries. Locally- or UK-sourced wild oysters will be re-laid at set densities at subtidal sites located within harbours and estuaries (Broodstock 1) and also in the main Solent channel (Broodstock 2). All the broodstock sites will be protected from fishing to ensure that oysters are left undisturbed.

Broodstock sites in the Solent channel will be located in areas where the use of towed fishing gear is not possible (rocky areas or around man-made structures). These areas were selected through discussions with local oyster fishermen. Translocated oysters will also be housed in specially designed cages attached to pontoons in marinas across the Solent region (subject to the success of initial trials). The anticipated increase in the number of oyster larvae in the Solent will lead to enhanced recruitment of spat on both seabed sites and in spatting ponds. The spat collected in spatting ponds by the Beaulieu and Newtown rivers will be grown-on in pontoon cages and at sites within the two river systems (**oyster culture sites**). These two rivers are privately owned without public access which will prevent poaching. After one to two years the reared oysters will be transferred to selected broodstock or active management sites across the Solent.

In addition, the feasibility of using hatchery reared native oysters is also being assessed. Seasalter Shellfish Ltd., a hatchery based in Whitstable, Kent, would rear oysters that would be used both to re-seed Solent oyster beds and to provide juvenile oysters for on-growing in pontoon cages and ranching systems. This offers the potential to deposit ten million juvenile oysters (50 mm shell height) into the Solent marine environment, substantially enhancing the existing oyster population.

Through the restoration of oyster habitat throughout the Solent, the project will support the long-term development of a sustainable oyster fishery in certain carefully selected zones. Due to a decline in the Solent oyster fishery over the past two years, Southern IFCA have restricted oyster dredging in the Solent to a two week season in Langstone and Portsmouth Harbours. Every year, management of these areas is reviewed so measures and fishing seasons are likely to vary. During the 2015 oyster season in November, a total of ten vessels dredged for oysters, mostly within Portsmouth Harbour. As the occurrence of oysters has declined in the Solent many of the subtidal oyster beds have now become overrun with slipper limpets (*Crepidula fornicata*). The potential to restore the oyster fishery will be assessed by a process of active management of selected sites known as **oyster bed restoration sites**. Associated project activities to reduce the impacts of invasive species on oyster populations are outlined in Annex 1.

Existing information on current patterns, larval dispersal and spat settlement will be used in addition to information on historic oyster bed sites to select site locations that are prone to high spatfall. If recruitment is poor and spat mortality high, the oyster populations on these sites could be enhanced by translocating juvenile oysters that have been grown-on from spat either at the cultures sites or from the hatchery reared stock. If oyster recruitment and on-growing is successful these sites may be opened to fishing by local vessels involved in the project with the long-term aim of establishing a sustainable well-managed oyster fishery that opens specific areas for fishing on a rotational basis for set time periods.

In addition to **oyster bed restoration sites**, a second related activity will be to conduct a trial of an **oyster ranching** system specifically designed for the project. Plans are being developed that will use buoyed lines with cages or rafts, both on the sea surface and at set depths, to grow-on oysters for harvest by local fishermen. This offers the potential to provide a sustainable, locally-sourced oyster supply whilst also providing an alternative non-destructive form of oyster-based livelihood for local fishermen. Additional, alternative (less destructive) oyster harvesting methods, including hand picking in the intertidal or subtidal zones (by diving), more sustainable dredge designs and use of grabs or tongs, will also be investigated.

Developing a range of activities to restore oyster numbers to the Solent minimises risk to the overall project and identifies best-practice activities that can be further developed across the Solent.

The final site type is **oyster sanctuaries**. These are naturally occurring oyster populations within subtidal habitats where all forms of fishing are prohibited by local or European regulations for protected areas including the Southern IFCA seagrass beds byelaw and European Marine Site Legislation. Monitoring at these sites will detect any change in undisturbed oyster beds in shallow depths over the timeframe of the project.

Broodstock, and potentially juvenile oysters, will also be housed in cages suspended from pontoons in marinas across the Solent. MDL Marinas has a significant presence in the Solent with seven marinas berthing nearly 2,000 vessels of all sizes, mainly used for recreational purposes. MDL generously funded the initial feasibility study which formed the foundation for this project's development and has agreed to install specially designed oyster cages in their marinas, attached to pontoons. Brood oysters in these cages will increase larvae and spat levels in the area complementing the other restoration activities. MDL provided the pontoon for the Land Rover Ben Ainslie Racing (LR BAR) HQ in Portsmouth Harbour and in association with LR BAR's sustainability team agreed to use this pontoon

to trial the installation of four cages. BLUE, Portsmouth University, LR BAR and MDL introduced broodstock into the cages in January 2016 and the progress of these oysters will be closely monitored by researchers from Portsmouth University. This early trial will inform effective expansion of the scheme into the MDL marinas and collect information on important elements such as stocking density, fouling and mortality, which will be key to success when the scheme is rolled out to other marinas. Interest has also been expressed from other owners of marinas and yacht clubs in the area who would welcome oyster cages on their pontoon systems.

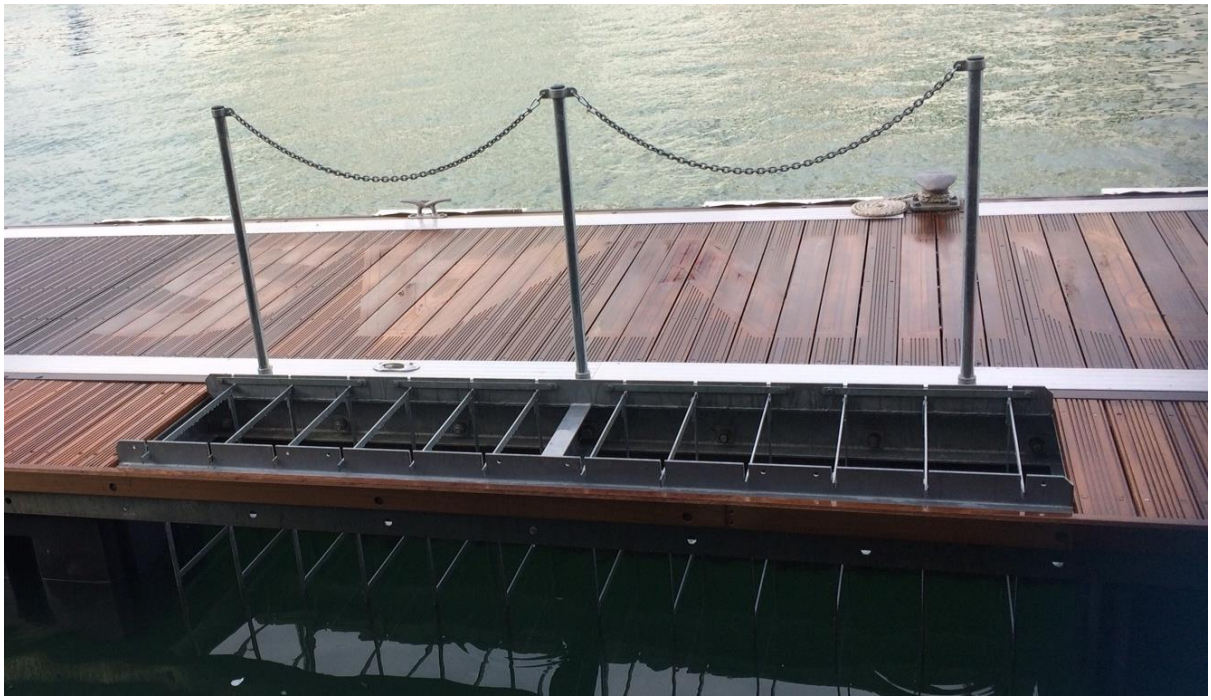

Figure 3: One of the Land Rover Ben Ainslie Racing pontoons with installed oyster cages

Table 1: A Summary of the types of Sites within the Solent Oyster Restoration Project

Site Name	Definition	Purpose / Function	Notes
Broodstock	Area of the seabed where oysters are re-laid at set (low) densities and left undisturbed (not fished) to act as broodstock for larval release	Increase the biomass of oyster broodstock to enhance larval abundance and spat settlement across the Solent	These include sites in harbours / estuaries (Broodstock 1) and in the main channel where dredging is not possible (Broodstock 2)
Oyster Culture	Site where the culture and on-growing of oysters (spat or adults) occurs using a variety of techniques.	Collection and grow-on oyster spat and disease resistant adults for relaying into broodstock and oyster bed restoration sites	Includes cages on pontoons in marinas and sites in privately owned rivers. Also act as important broodstock
Oyster Bed Restoration	Area of seabed on historical oyster beds that is (actively) managed to increase the settlement and establishment of oysters for fishing	Provide areas of seabed for monitoring of natural spatfall, oyster reseeding and experimental fishing of oysters	Management practices can include harrowing, slipper limpet reduction and techniques to reduce other invasive species impacts (if applicable e.g. tingle)
Oyster Ranching	Line-based systems of rafts or cages in sheltered open water	Provide an alternative non-destructive means of producing and harvesting Solent oysters for local fishermen	Trial run. Link to marketing of sustainably reared Solent oysters if logistically feasible. This depends on take-up by fishermen
Oyster Sanctuaries	Area of shallow seabed in undisturbed habitat with naturally occurring oyster populations	To show, through monitoring, the status of natural oyster beds over the length of the project	Seagrass beds protected from fishing with mobile gear by an IFCA byelaw

Site Selection and Location

Proposed sites for project activities are listed in Table 2. At this stage the general location of each site type (except for sanctuary sites) has been identified through initial discussions with Southern IFCA and local fishermen. The exact position and spatial coverage of each site will be decided in the first half of 2016 after further discussion within the Working Group and feedback from stakeholders and local specialists. Selection of sanctuary sites will require an assessment of existing and proposed protected areas in the Solent to identify their location in a range of habitats with suitable existing oyster populations.

Table 2: Proposed Project Sites (working draft)

Site Type	Site Name	Location	Notes
Culture	Newtown Beaulieu	Newtown River Beaulieu River	Spatting ponds present
Broodstock 1	Langstone Harbour 1	Near Langstone Harbour Board office	To be agreed with Langstone Harbour Board
	Langstone Harbour 2	Near Portsmouth University Langstone campus	
	Langstone Harbour 3	Broom Channel	
	Portsmouth Harbour 1	Spider Lake	To be agreed with QHM Portsmouth
	Portsmouth Harbour 2	Tipner Lake	
	Portsmouth Harbour 3	Fareham Creek	
Broodstock 2	Hill-Head to Stokes Bay	tbd*	Only general location (large areas) identified
	Hamble - Lee-on-Solent	tbd	
	Lymington - Hurst Castle	tbd	
	Portsmouth Harbour Entrance (Hamilton Bank)	tbd	
	Ryde Roads	tbd	
	Bracklesham Bed	tbd	
Sanctuary	Sanctuary 1	tbd	Locations to be decided in protected areas in a range of suitable habitats. Requires further assessment to identify suitable sites
	Sanctuary 2	tbd	
	Sanctuary 3	tbd	
	Sanctuary 4	tbd	
	Sanctuary 5	tbd	
	Sanctuary 6	tbd	
Active Management	Hamble mouth west	tbd	Only general location (large areas) identified.
		tbd	
	Peel Wreck	tbd	
	Spit Bank to Spit Sand Fort	tbd	
	Calshot wreck	tbd	
	Lee-on-Solent	tbd	

*: tbd = to be determined

Proposed Additional Activities

A number of other proposed activities have linkages with the main theme:

1. Water quality improvement
2. Invasive species management
3. Sustainable oyster marketing

Details of each of these potential activities can be found in Annex 1.

Environmental and Fisheries Monitoring

Monitoring of sites and activities, oyster status and environmental conditions is a key element of the Solent Oyster Restoration Project. The draft monitoring programme is summarised below (Table 3). Existing environmental and fisheries monitoring initiatives in the Solent managed by Southern IFCA, the Solent Forum (which also act as secretariat for the Solent European Marine Sites) and other organisations will be utilised where possible to collect some of the required information.

Table 3: Draft Monitoring Programme for the Solent Oyster Restoration Project

Target	Variable	Sites	Frequency
Oysters:			
Larvae	Abundance	Multiple across Solent	Annually
Spat	Settlement density	Spatting ponds, Managed sites, Sanctuaries	Annually
	Survival		Monthly
	Condition		Monthly
Juveniles	Density Survival	Managed sites, culture, cages	Quarterly
Broodstock	Density	Cages, Broodstock sites, Culture	Before and after relaying, then annually
	Survival		Bi-annually
	Condition		Bi-annually
Water	Temperature	Multiple across Solent – including different sites (broodstock, managed, sanctuary, culture)	Monthly
	Salinity		
Productivity	Chlorophyll a		
Particulates	Suspended solids		
Pests:			
Slipper limpet	Abundance	Managed sites	Before and after harrowing and then annually
Tingle	Abundance	Broodstock , culture and managed sites	Various
Disease:			
Bonamia	Presence / absence	All project sites	Annually

The draft monitoring programme will be finalised in the second quarter of 2016 in collaboration with project and monitoring partners. Discussions with Portsmouth, Southampton and Bournemouth Universities will be held followed by a workshop to agree the finer detail of the monitoring programme including responsibilities for data collection and initial analysis.

Statutory Fisheries Monitoring

Monitoring of the fisheries in the Solent area is conducted by the Southern IFCA and the MMO. These two regulators monitor fishing taking place in the region to ensure that local, national and European legislation is abided by. This can include making inspections on fishing vessels to check on the gears being used, retention of fish or fishing more than is allowed under a quota.

Environmental Education and Awareness

It is important to connect the general public with the environment and increase awareness of its importance and issues faced. This will be achieved through the establishment of an Environmental Education and Awareness Programme to run alongside the oyster restoration activities.

- The Solent Working Group will set up a series of information boards around the Solent. These boards will supplement other public educational initiatives that could potentially be developed such as an oyster hatchery and exhibition centre.
- BLUE is keen to ensure that this project is as public facing as possible. This will be achieved by including elements of citizen science such as recruiting volunteers to help with oyster cage monitoring and maintenance and oyster monitoring in intertidal seagrass beds. This activity could also be included in a schools' engagement programme.
- A series of public meetings will inform the local public and interested parties about the project and its progress over the five years. In addition, the Working Group may consider establishing a schools' education and awareness programme as BLUE has successfully done in Lyme Bay. This could involve fishermen and other members of the Working Group visiting local schools to educate pupils about marine conservation and its importance. The use of underwater videos, fishing equipment and other props will engage the public.
- Exchange visits for fishermen are also planned over the length of the project. These visits will enable local oyster fishermen to meet with other oyster fishers or ranchers in Europe to exchange information and knowledge on fishing and culture practices with the potential to introduce new techniques to the Solent which have been successful in these other areas. Using a variety of restoration techniques, in particular those that have been found to be successful elsewhere, will give the highest chance of success in restoring the oyster beds.

Project Management and Expenditure

The project will be managed on a day-to-day basis by BLUE staff in close collaboration with the Southern IFCA. BLUE senior management and technical staff will be responsible for daily project management with expert advice and support provided by other project partners, consultants and from academia.

Project costs have been estimated for the next five years (2016 – 2020) and are presented in Annex 2. The current total project cost of the Solent Oyster Restoration Project is estimated at £1,436,500. This includes the costs of implementing the various work packages as well as day-to-day management and administration costs. The timing of activities is depicted in the five year timeline for the project (Annex 3). The main achievements and milestones for the project for each year are provided in Annex 4. Of these, the key milestones are summarised below:

Year	Milestone
2016	• Main oyster restoration sites identified and designated • First annual translocation of oysters onto broodstock sites • Cost-benefit analysis of potential broodstock mortality completed • Oyster monitoring programme finalised and underway • Start culture of 10 million oysters in Seasalter hatchery • 1st round of community engagement meetings held • 1st fisher exchange visit undertaken • Oyster cages for MDL marinas built • At least two non-MDL marinas join the project to house oyster cages (repeat annually)
2017	• Strategic Environmental Assessment completed • Slipper limpet fishery feasibility study completed • First harrowing of oyster beds on fishing sites • 1st annual Oyster Festival held • (Campaign for coastal water quality improvement started) • 10 million juvenile oysters transferred to the Solent for reseeding and on-growing (Q4) • Broodstock and possibly juvenile oysters transferred to cages in MDL marinas
2018	• 2nd fisher exchange visit completed • (Measures to improve clam fishery management implemented) • 2nd socioeconomic monitoring of local stakeholders undertaken • (Oyster visitor centre opened) • Oyster ranching trial initiated
2019	(Annual milestones as mentioned – work programmes ongoing)
2020	• 3rd and final fisher exchange visit completed • Oyster ranching trial completed • Socioeconomic monitoring of local stakeholders undertaken • Project presentation event held, potentially in new oyster visitor centre • 5th and final round of community engagement meetings undertaken
2021	• Final Project Report (s) produced • Final Project presentation event

Please note that the points in brackets are for proposed additional project activities (Annex 1). Although the timeframe for the project is five years, it is envisaged that the final report and presentation of results and achievements will be completed shortly after the five year programme in order that any data collected in the second half of 2020 can be analysed and fully incorporated.

Project Legacy

The project's main legacy will be the restoration of the native oyster in the Solent so that a self-sustaining population is established that can improve the provision of a range of ecosystem services provided by oysters and oyster beds. Linked closely to this is the provision of sufficient suitable substrata for the recruitment and subsequent survival of oyster spat. As oyster restoration is a long-term endeavour predicted to take decades (Laing et al., 2005) it is likely to take longer than the timeframe of this project to fully restore the native oyster to the Solent. The current project is considered as the first stage of a long-term process to fully restore native oysters to the Solent and improve the health of its marine and coastal environment. Once the oyster population is sufficiently restored then the appropriate authorities can consider re-opening the oyster fishery. Other ecosystem services provided by oysters and the habitat they create will also increase as the oyster re-establishes itself to eventually become, once again, a key species and generator of extensive habitat in shallow inshore waters of the Solent.

The main outcomes from the current five year programme are anticipated to be:

- Designation of oyster broodstock sites closed to fishing
- Increased biomass of broodstock oysters permanently protected from fishing
- Increased number and biomass of oysters in the Solent
- Increased spatial coverage of oyster beds in the Solent
- Increased oyster larval abundance and spat settlement
- At least 20 marinas across the Solent with permanent oyster cage systems Increased public and stakeholder awareness of the importance of native oysters as part of a healthy inshore marine environment

Other potential outcomes that can be achieved working with project partners but highly dependent on funding and resources include:

- Improved clam fishery management
- Development of a harvesting system to enable the production of locally-sourced sustainably reared oysters by the end of the current timeframe (2020) or soon afterwards (before 2025).
- Successfully run campaign to highlight / improve water quality

A long-term (15-20 years) desired outcome from this work is a well-managed self-sustaining oyster fishery that is supported by the majority of fishermen in the Solent with a corresponding decrease in the level of illegal fishing for oysters.

Achieving this partly depends on IFCAs having sufficient resources to enforce fisheries regulations but also on local support and buy-in from fishermen and other maritime stakeholders to help self-monitor Solent waters. Another potential outcome is the creation of a Fisheries Local Action Group (FLAG). FLAGs are community groups tasked with developing locally applicable strategies to promote sustainable activities through diversification and adding value in the fisheries sector. FLAGS are the main route to accessing EU Axis 4 funds (from the European Maritime Fisheries Fund (EMFF)) that will

help with further fisheries and conservation projects going forward. These FLAGs are considered to be key organisations for the delivery of the 2020 Common Fisheries Policy goals, particularly regionalisation and continued support is proposed through the EMFF.

This project can make a significant contribution to restoring the native oyster in the inshore waters of the UK and therefore help to meet a number of the government's strategic objectives within the UK Post-2010 Biodiversity Framework.

The proposed restoration programme differs fundamentally from any previous initiatives to enhance oyster stocks in the Solent in that the volume of brood and juvenile oysters to be introduced is significant. Allied to this, an unprecedented percentage of the broodstock will be fully protected from any fishing activity (located in unfishable or legally protected areas and in managed cages) and will therefore perpetuate the sustainable rejuvenation of the oyster beds.

Over the long-term restoring the native oyster will provide multiple socio-ecological benefits to the Solent region and help to rebuild the natural capital of this keystone species and ecosystem engineer.

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Annexes

Annex 1: Proposed Additional Activities

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Annex 4: Main achievements and milestones

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Annex 1: Proposed Additional Activities

- **Water Quality Improvement**

There are significant issues with water quality within the Solent's inshore waters and estuaries. These issues have come about as a result of a number of factors including: population growth, large and small industrial enterprises, the water industry, urban infrastructure, agriculture, horticulture, transport, discharges from abandoned mines and pollution incidents.

An increase in storm events in recent years has led to enhanced sewage discharges into rivers flowing into the Solent due to poor infrastructure (Clark pers. comm.)[33]. These discharges have contributed to issues related to increased bacterial loads leading to oyster beds being downgraded which can deem them unsuitable for human consumption. In addition to sewage discharges, there are also other factors that impact the water quality. Dredging operations are a key factor as they can increase sedimentation rates and increase sediment in suspension as well as impacting the levels of dissolved oxygen, potential chemical and microbiological contaminants and nutrient concentrations in the water. Run-off from agricultural land and its effect on water quality in estuaries and the Solent will take many years to put right, but the working group will support measures and Directives intended to reduce chemical usage on the land and more sympathetic farming methods.

Defra has overall responsibility for water policy in England while the Environment Agency is the principal regulator. The project working group will therefore work with the Environment Agency to address these issues, particularly further upstream from the main body of the Solent.

The return of the native oyster population would help to improve the water quality of the Solent, but the volume of sewage discharge must decrease in order to ensure that oysters from this fishery (when viable again) are safe for human consumption. The project will help draw attention to water quality issues in the Solent. The Solent Working Group will use the oyster project to engage in debate with stakeholders responsible for and affected by water quality in the area.

- **Invasive Species Management**

One key invasive species that strongly impacts the native oyster and is likely to slow the population's recovery is the slipper limpet (*Crepidula fornicata*), a native to North America (the population is distributed from Canada down to the Caribbean). The species is thought to have been first introduced to the UK into Essex in the 1880s and into the Solent in the 1930s (Barnes et al., 1973)[34]. By the 1970s, it was thought to be the most abundant benthic seabed species in the area, covering large areas of seabed which were previously oyster beds. These limpets are able to lay down thick cohesive mud

[33] Robert Clark, Southern Inshore Fishery and Conservation Authority (IFCA), personal communication. In Gravestock et al., 2014.

[34] Barnes, R.S.K., J. Couglan and J. Holmes. – 1973. A preliminary survey of the macroscopic bottom fauna of the Solent, with particular reference to *Crepidula fornicata* and *Ostrea edulis*. Proc. Malac. Soc. London, 40: 253-275.

which alters the seabed and is anoxic. This mud can smother cultch which limits native oyster settlement opportunities.

Objective 5 of the project aims to reduce the impact of invasive species on oyster populations. Slipper limpets will be tackled by reducing their spatial coverage in specific areas through harrowing, which will also increase the availability of suitable substratum for oyster recruitment.

A range of options will be considered for dealing with slipper limpets. A practical approach would involve an initial intense harrowing exercise prior to the oyster spawning season (which occurs from May to August / September) in the first year of the project to break up the slipper limpet beds leaving broken shells which are a suitable 'natural' material for oyster spat settlement. Harrowing specific slipper limpet dominated areas could therefore increase the availability of suitable hard substrata for oyster recruitment.

Another option would involve fishermen dredging in areas that are known to have high densities of slipper limpets, crushing the limpets on board then returning the broken shells to the sea, again providing good settlement substrate for oyster spat. It is envisaged that natural oyster recruitment onto these prepared beds will occur assuming that there is sufficient oyster larvae and spatfall (i.e. broodstock). These options may require a Habitat Regulations Assessment (HRA) to be carried out.

- **Sustainable Oyster Marketing**

In Lyme Bay, BLUE established a Lyme Bay Reserve Seafood brand which is used to promote and sell sustainable, traceable seafood caught in Lyme Bay. BLUE aims to implement a similar model in the Solent to support the marketing and selling of sustainable native oysters once the fishery has recovered. Additionally, as part of a marketing strategy to promote the project and the seafood brand, an annual oyster festival will be created to promote the achievements of the project and the importance of the native oyster.

Annex 2: Budget

ACTIVITY	2016	2017	2018	2019	2020	TOTAL
Main Project Activities						
SCIENCE, MONITORING AND ANALYSIS						
Strategic Environmental Assessment (SEA)	35,000	35,000				70,000
Cost-benefit Analysis	15,000					15,000
Environmental & Fishery Monitoring	25,000	25,000	25,000	25,000	25,000	125,000
Socio-Economic & ecosystem services analysis		20,000		15,000		35,000
OYSTER RESTORATION						
Site Feasibility Assessment	15,000					15,000
10 million hatchery reared oysters for re-seeding and on-growing	100,000	100,000	50,000			250,000
Broodstock collection and relaying on seabed sites	10,000	10,000	10,000	10,000	10,000	50,000
Broodstock housed in pontoon / cage systems (not MDL)		10,000	10,000	10,000	10,000	40,000
Spat collection - spatting ponds / nets	15,000	15,000	15,000	15,000	15,000	75,000
Oyster bed restoration (harrowing /slipper limpet reduction)	5,000	5,000	5,000	5,000	5,000	25,000
Workshops	5,000		5,000			10,000
OYSTER FISHERY / RANCHING						
Oyster Ranching Trial - raft/cage systems			20,000	20,000		40,000
COMMUNITY SUPPORT AND ATTRACTIONS						
Exhibitions & education programme	5,000	10,000	5,000	5,000	5,000	30,000
Oyster Festival			5,000	5,000	5,000	15,000
COMMUNICATIONS						
Site Brand, Logo and website development	3,000	1,500	1,500	1,500	1,500	9,000
Interpretation boards		15,000				15,000
Website & social media management	3,500	3,000	3,000	3,000	3,000	15,500
Exchange visits		2,500		2,500		5,000

ACTIVITY	2016	2017	2018	2019	2020	TOTAL
PROJECT MANAGEMENT						
BLUE project management team	60,000	60,000	60,000	60,000	60,000	300,000
PHD project coordinator & Project consultants	25,000	25,000	25,000	25,000	10,000	50,000
Office contribution	9,000	9,000	9,000	9,000	9,000	45,000
Travel & subsistence	15,000	15,000	15,000	15,000	15,000	75,000
Meetings & communications	15,000	15,000	15,000	15,000	15,000	75,000
Sub-total for Main project activities	**360,500**	**376,000**	**278,500**	**241,000**	**188,500**	**1,444,500**
Proposed Additional Activities						
FISHERIES						
Sport fishery codes		2,000				2,000
Migratory species protection		2,000	2,000	2,000		6,000
Slipper limpet fishery feasibility study		5,000				5,000
WATER QUALITY						
Negotiations, lobbying, initiatives		4,000	4,000	4,000	2,000	14,000
Workshops (Env. Health, agriculture)		5,000	5,000			10,000
Sub total – additional activities		**18,000**	**11,000**	**6,000**	**2,000**	**37,000**
TOTAL	**360,500**	**394,000**	**289,500**	**247,000**	**190,500**	**1,481,500**

Annex 3: Project Timeline

	2015		2016				2017				2018				2019				2020				NOTES
Quarter:	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
PROJECT DEVELOPMENT / MANAGEMENT																							
Agree MOU and ToR																							
Management plan development																							
Establish Blue Oyster Network																							Information sharing network
European Marine Sites Regulations changes (end of 2016)																							Identify potential areas of overlap and adjust plan accordingly
OYSTER RESTORATION																							
- Traditional fishing knowledge																							Collect from fishermen to feed into three work streams Immediately below
- Site Feasibility Assessment																							Selecting sites for broodstock, harrowing and re-seeding
- Designation of oyster sites for multiple activities																							Sites – broodstock, active management, reseeding and sanctuary
- Oyster translocation to broodstock sites (locally sourced)																							Sites permanently protected from mobile gear. Tie in with proposed or existing MPAs
- Hatchery rearing of 10 million oysters																							Seasalter Hatchery, Kent
- Oyster re-seeding																							Using hatchery reared oysters
- Spat collection																							From nets or spatting ponds (trial)
- Oyster cages (LRBAR & MDL)																							broodstock / juvenile on-growing

- Oyster cages (other marinas)																							broodstock / juvenile on-growing
- Oyster bed restoration – harrowing and slipper limpet reduction																							harrowing provided by fishermen Start before initial reseeding and repeat annually on some sites
- Oyster ranching																							Trial of raft / cage system to grow and harvest oysters
SCIENCE, MONITORING & ANALYSIS																							
Strategic Environmental Assessment (SEA)																							Check whether there have been recent SEA's completed that can be used.
Cost-benefit Analysis																							To estimate the financial implications of potential broodstock mortality (MEP 2014)
Environmental Monitoring																							Habitats, Water quality, Oysters. Include ecosystem services indicators. Incorporate citizen science surveys if possible
Socioeconomic assessment																							Includes ecosystem services indicators
COMMUNITY ENGAGEMENT																							
Education and Awareness:																							
- Community Engagement / Update																							Initial meetings plus regular follow-up to keep people informed of progress
- Interpretation Boards																							
Oyster Hatchery and Visitor Centre																							
Fisher Exchange Visits																							2016: Solent fishers to visit other sites; 2020: Other fishers to visit Solent project

Events / Exhibitions / Seafood Festivals																							Local (e.g. Cowes Week) and National (e.g. London)
Oyster Festival (various locations)																							Hold the festival in different locations each year around the Solent
ADDITIONAL ACTIVITIES																							
Slipper limpet fishery feasibility study (desk top)																							Whether a slipper limpet fishery can be developed in the Solent?
Tingle / Boring sponge research and monitoring																							Field monitoring and lab-based research on pest abundance and spat predation levels
Clam Fishery management																							
- Identify main issues and potential management measures																							
- Implement measures for pilot site																							
Oyster Marketing / Promotion																							Local responsibly sourced oysters
Lobbying / Campaigning																							
Water Quality Improvement																							
- Background Research																							
- Campaign Development																							
- Campaign Launch																							

Annex 4: Main achievements and milestones

LIST OF ACTIVITIES AND MILESTONES TO BE ACHIEVED FOR EACH YEAR

Timing of achievements is based on the current working draft of the project timeline

YEAR	MILESTONE / ACHIEVEMENT	Funding Required*
2015	• Project MOU and TOR drawn up, and agreed • First draft of the Management Plan completed • Traditional Fishing Knowledge collected from oyster fishermen • Oyster Site Feasibility Assessment undertaken • First oyster cages installed on MDL / BAR marina pontoons	N/A
2016	• Management Plan completed • Main oyster restoration sites identified and designated (broodstock, fishing, sanctuary, culture) • First annual translocation of oysters onto broodstock sites • Start Strategic Environmental Assessment • Complete Cost-benefit analysis of potential broodstock mortality • Start culture of 10 million oysters in Seasalter hatchery • Oyster cages for MDL marinas built At least two non-MDL marinas join the project to house oyster cages (repeat annually) • Finalise oyster monitoring programme and undertake 1st annual monitoring • Undertake 1st round of community engagement meetings • Complete 1st fisher exchange visit • Attend at least one seafood festival • Develop and finalise marketing campaign for locally-sourced sustainable oysters • (Develop and finalise campaign for water quality improvement) • Finalise plans for oyster hatchery / visitor centre • Assess success of each work programme and adapt accordingly • Produce 1st annual project report • Produce at least 2 regular project update newsletters • At least 2 updates for website per year	£345,500
2017	• Complete Strategic Environmental Assessment • Complete oyster site and environmental monitoring for Year 2 • First harrowing of historical oyster beds at active management sites • 10 million juvenile oysters transferred to the Solent for reseeding and on-growing • Broodstock (and possibly juvenile) oysters transferred to cages in MDL marinas • Install oyster cages in at least two new marinas • (Complete slipper limpet fishery feasibility study) • (Main local issues with clam fisheries identified and recommendations to improve clam fishery management are provided)	£386,500

	• Attend at least one seafood festival / event • Undertake 2nd round of community engagement meetings • (Start campaign for coastal water quality improvement) • Assess success of each work programme and adapt accordingly • Produce 2nd annual project report • Produce at least 2 regular project update newsletters • At least 2 updates for website per year	
2018	• Complete oyster site and environmental monitoring for Year 3 • Third annual harrowing of oyster fishing sites • Install oyster cages in at least two new marinas • Complete 2nd fisher exchange visit • (Continue implementation of measures for seabass conservation) • (Complete oyster pest predator research study) • (Implement agreed measures to improve clam fishery management) • (Launch marketing campaign for locally-sourced sustainable oysters) • Oyster ranching trial initiated • Attend at least one seafood festival / event • (Start building / setting up the oyster visitor centre) • Undertake 3rd round of community engagement meetings • Hold First Annual Oyster Festival • (Continue campaign for coastal water quality improvement) • Assess success of each work programme and adapt accordingly • Produce 3rd annual project report • Produce at least 2 regular project update newsletters • At least 2 updates for website per year	£277,000
2019	• Complete oyster site and environmental monitoring for Year 4 • Fourth annual harrowing of oyster fishing sites • Install oyster cages in at least two new marinas • (Continue implementation of measures for seabass conservation) • (Continue implementation of measures to improve clam fishery management) • Attend at least one seafood festival / event • Complete building / setting up the oyster visitor centre • Undertake 4th round of community engagement meetings • Hold annual Oyster Festival • (Continue campaign for coastal water quality improvement) • (Continue marketing campaign for locally-sourced sustainable oysters) • Assess success of each work programme and adapt accordingly • Produce 4th annual project report • Produce at least 2 regular project update newsletters • At least 2 updates for website per year	£234,500
2020	• Complete oyster site and environmental monitoring for Year 5 • Oyster ranching trial completed • Fifth annual harrowing of oyster fishing sites • Install oyster cages in at least two new marinas • Complete 3rd and final fisher exchange visit • Complete socioeconomic monitoring of local stakeholders	£193,000

	• (Continue implementation of measures for seabass conservation) • (Continue implementation of measures to improve clam fishery management) • Attend at least one seafood festival / event • Hold project presentation event (in new oyster visitor centre) • Undertake 5th round of community engagement meetings (in new centre?) • Hold annual Oyster Festival • (Continue campaign for coastal water quality improvement) • (Continue marketing campaign for locally-sourced sustainable oysters) • Produce 5th annual project report • Assess overall success of each work programme • Produce at least 2 regular project update newsletters • At least 2 updates for website per year • Produce project exit strategy
2021	• Produce Final Project Report (s) • Final project presentation event or workshop

Notes: Text in brackets refers to additional project activities.

Funding Totals are for both core and additional activities

Annex 5: Maps

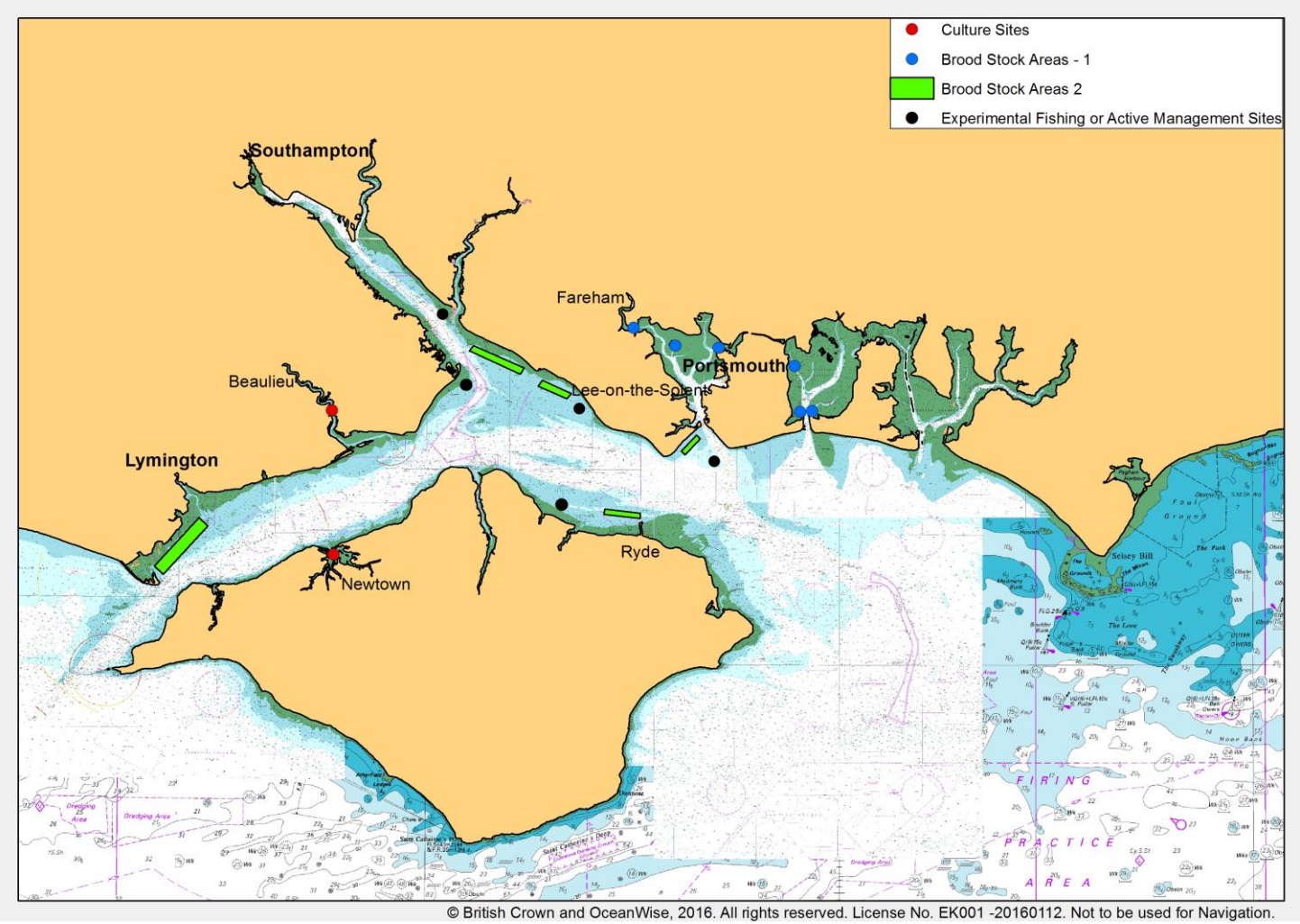

Figure 4: Map showing the location of culture, brood stock and experimental fishing/active management sites

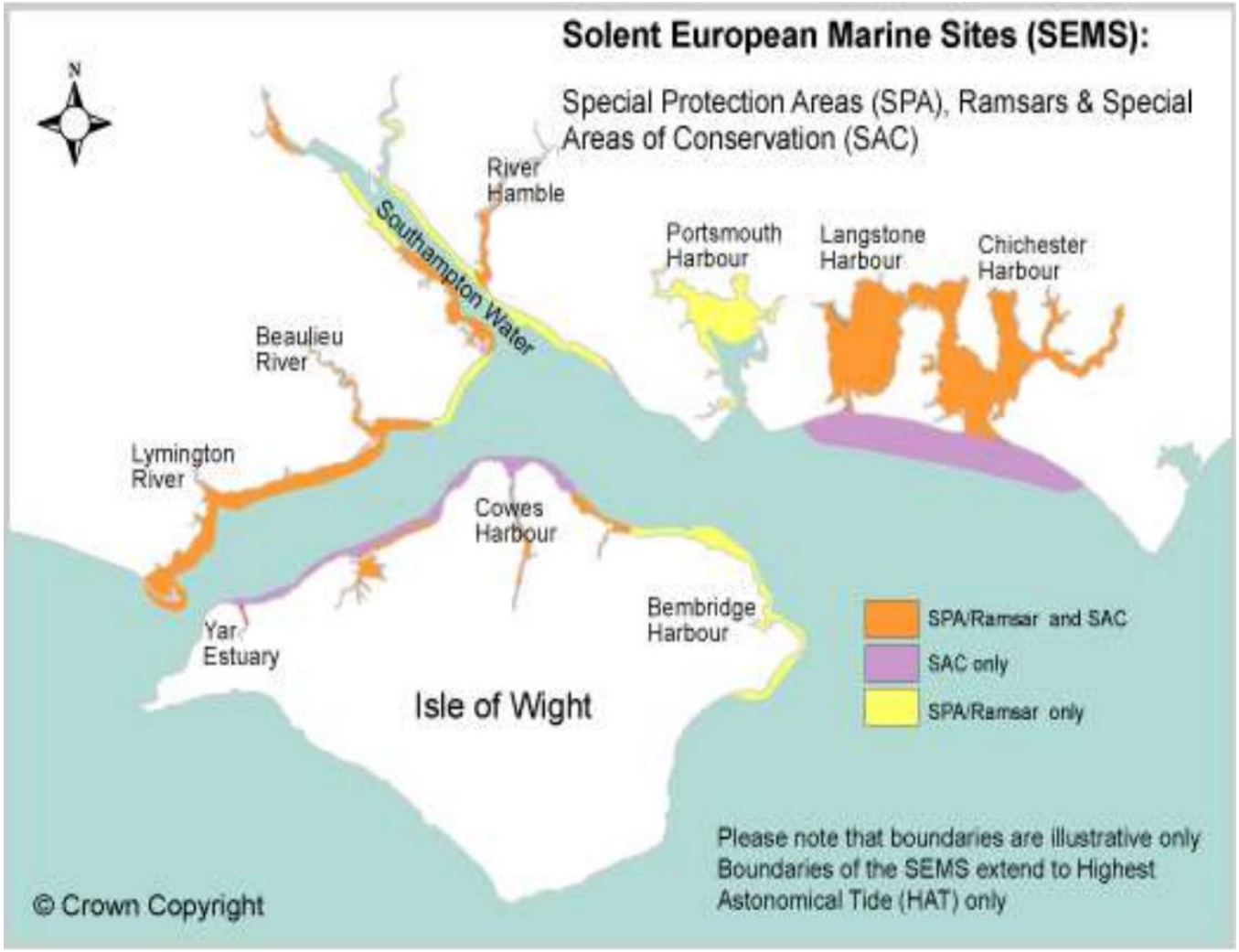

Figure 5: Map of the Solent showing European Marine Sites. Source: Southern IFCA, 2012[35]

[35] Southern IFCA, 2012. Research and Evidence Plan. Available: https://secure.toolkitfiles.co.uk/clients/25364/sitedata/files/ResearchandEvidencePlan.pdf

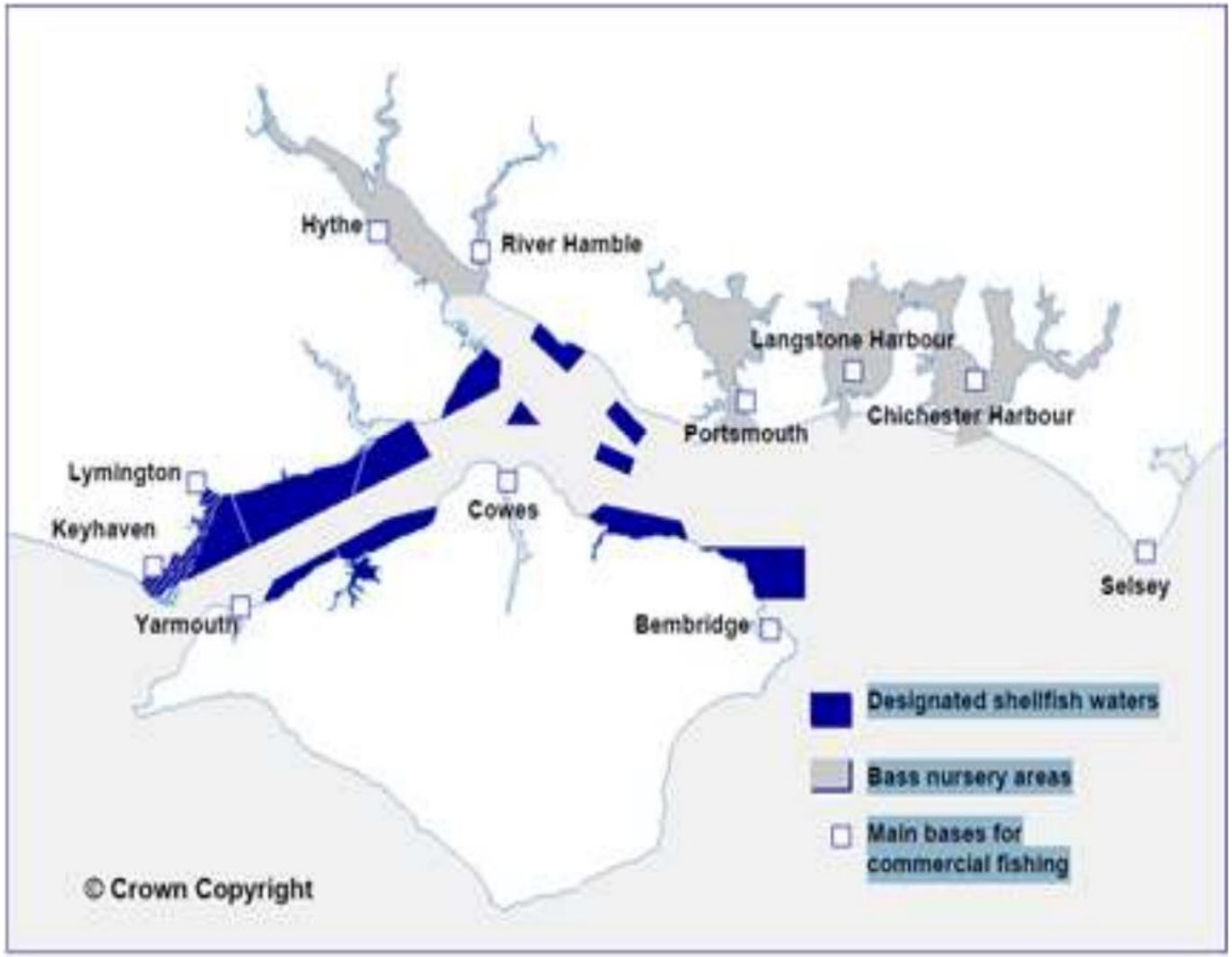

Figure 6: **Map of the Solent showing the designated shellfish waters, bass nursery areas and key bases for commercial fishing. Source: Southern IFCA, 2012**

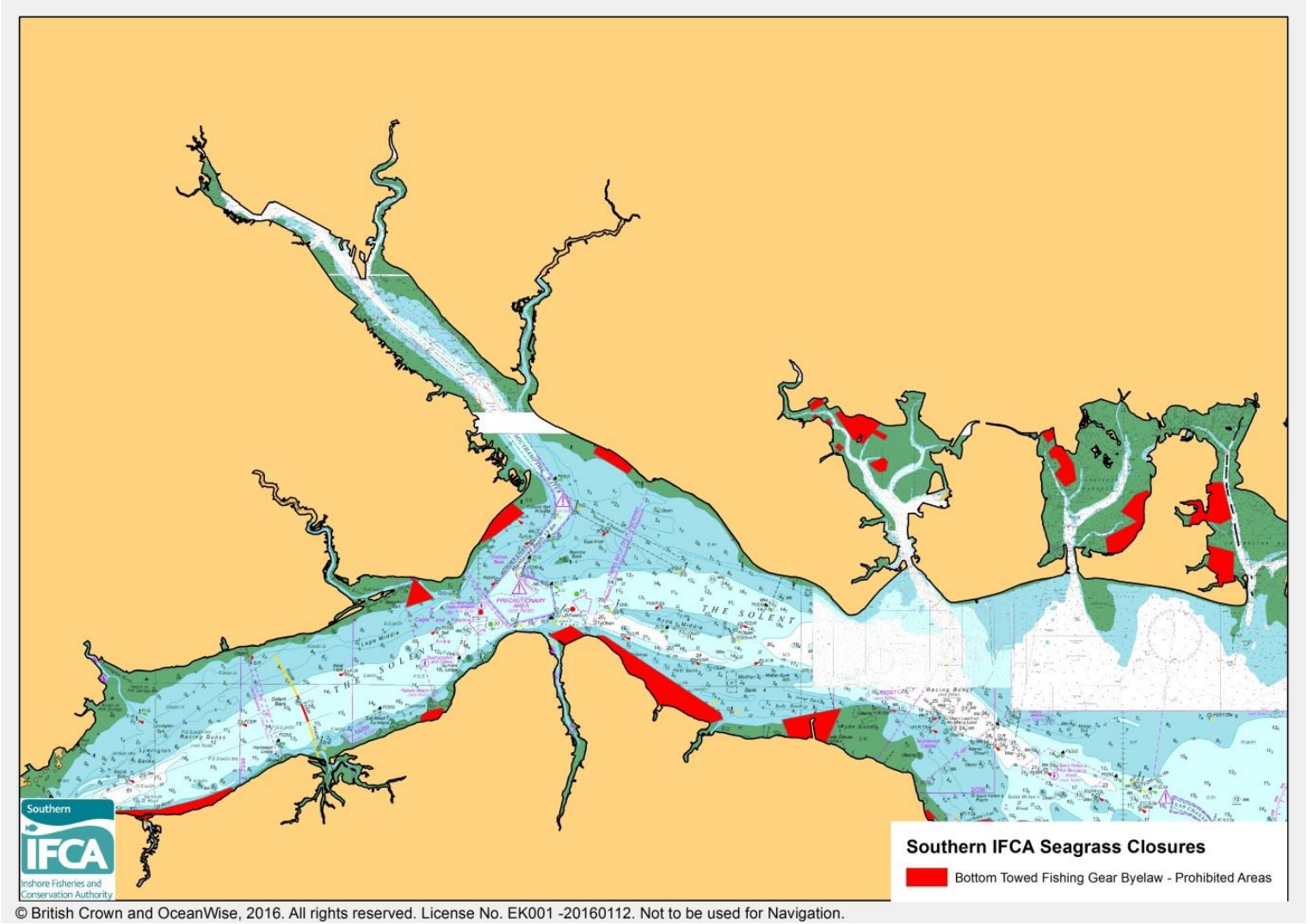

Figure 7: Map showing the location of seagrass closures in the Solent area

Annex 6: Partners

Marks & Spencer

MDL Marinas Ltd

The Roddick Foundation

Land Rover Ben Ainslie Racing

Southern IFCA

Sussex IFCA

Portsmouth University

Southampton University

CEFAS

Marine Management Organisation

The Environment Agency

Portsmouth City Council

Solent Protection Society

Hampshire & IOW Wildlife Trust