Southern Inshore Fisheries Conservation Authority

Pacific Oyster (*Magallana gigas*) Monitoring Report:

Analysis of the methods and results of historic monitoring surveys In Poole Harbour and Southampton Water

Introduction

Magallana gigas, also known as Pacific oyster in the UK, is a species of bivalve native to east Asia but has since become one of the most globalised aquaculture species on the planet (Herbert *et al.,* 2016). Pacific oysters were introduced to Poole Harbour for aquaculture in 1890 following the decline of the native European flat oyster *Ostrea edulis* in the Solent. This decline was due to a combination of factors including disease and unsustainable fishing practices (Key & Davidson, 1981), mirroring historic declines in the 19th and 20th centuries across Europe (Hayer *et al.*, 2019). In contrast, Pacific oysters are a faster growing species that exhibit broader environmental tolerance (Bergström *et al.,* 2024, Renault *et al.,* 1995 and Thomas *et al.,* 2016). Additionally, *M. gigas* show resistance to *Bonamia Ostrea*, a protozoan parasite associated with the mass mortality and subsequent closure of *O. edulis* fisheries throughout Europe (Laing *et al.,* 2006). Aquaculture in Poole Harbour is primarily made up of Manila clams, blue mussels, common cockles and Pacific oysters, with Poole Harbour containing the largest *M. gigas* production area in the UK (Humphreys, 2022). The total economic activity associated with *M. gigas* aquaculture in Poole Harbour was estimated as over £2.6 million in 2018 (Syvret *et al.,* 2021).

Pacific oysters are classified as an invasive, non-native species in England and Wales. Like European flat oysters, Pacific oysters are ecosystem engineers that can create structurally complex reef systems. These reefs provide numerous ecosystem services including nitrogen cycling, carbon storage and promoting greater biodiversity (Gravestock *et al.,* 2020). However, the establishment of non-native oyster reefs have the potential to cause habitat change from soft to hard sediment altering key ecosystems with associated impacts on native species (Herbert *et al.,* 2016 & Herbert *et al.,* 2018). Furthermore, climate change-induced warmer waters are predicted to expand the range of *M. gigas* further northwards, increasing their maximum potential distribution across the UK (Jones *et al.,* 2013, King *et al.,* 2021 & Rinde *et al.,* 2016). Because of this, Pacific oysters cultivated in Poole Harbour must be triploid (Birchenough, 2020), meaning they have three sets of chromosomes instead of the usual two sets (Diploid) (Nell, 2002). Theoretically, triploid oysters are unable to reproduce and show higher growth rates than their diploid counterparts (Wadsworth *et al.,* 2019). However, triploidy in Pacific oysters can be unstable. Individual oysters have been recorded reverting to diploidy and are therefore occasionally capable of reproducing (Herbert *et al.,* 2012).

Wild Pacific oyster populations have been found across the Southern coast of England since the 1980s, prompting monitoring efforts to map the distribution of wild oysters and their impact on local ecosystems to inform future management practices (Humphreys *et al.,* 2014). Poole Harbour has been a notable monitoring area for wild Pacific oysters due to the presence of ongoing *M. gigas* aquaculture. Additionally, monitoring surveys have also taken place in nearby Southampton Water which lacks any current or historic *M. gigas* aquaculture. These monitoring reports have allowed researchers to track changes in wild *M. gigas* populations over time using comparable, traditional intertidal surveying methods such as walking beach surveys and belt transects. Despite using broadly the same surveying techniques, monitoring methodologies are not static. Different surveys contend with varying off and on-site conditions over time that create discrepancies in data. This prompts changes in future methods as surveyors try to implement recommendations from earlier studies to create more consistent and robust techniques capable of producing more precise data.

In light of this, the use of drones in surveys has been gaining traction as a more economically feasible and less manpower-intensive alternative to traditional walking surveys for shellfish surveys (Jaud *et al.,* 2019 & Radeta *et al.,* 2022). The growing importance and global distribution of Pacific oysters has led to the development and refinement of deep learning models (DLM) capable of identifying individual oysters from orthographic maps derived from aerial footage (Mata *et al,*. 2024, Sadrfaridpour *et al.,* 2021 & White *et al.,* 2022). This could enable a much broader and less manpower-intensive mapping of Pacific oysters compared to traditional methods due to the time taken to take aerial footage of an area compared to surveyors walking and visually inspecting whole areas. In addition, drones have the potential to more easily access areas with difficult terrain (Windle *et al.,* 2019). This raises the question of whether drone surveys would be suitable for monitoring Pacific oysters in Poole Harbour, and how this would compare with the methods of previous monitoring surveys.

This report aims to compare the results and methodologies of recent studies monitoring the population characteristics of wild *M. gigas* populations in Poole Harbour and Southampton.

To achieve this, this study focuses primarily on the 7 most recent monitoring surveys, with the earliest surveying Poole Harbour in 2013 (Table 1). Three studies monitored *M. gigas* populations in Southampton Water, another 3 monitored populations in Poole Harbour, and an additional study surveyed both Poole Harbour and Southampton Water sites.

When combined, these studies show the development of wild Pacific oyster aggregations across Poole Harbour and Southampton over time, with the most recent surveys providing best available evidence for current oyster densities and locations.

Table 1. Overview of previous *Magallana gigas* monitoring reports in Southampton Water and Poole Harbour including the author, the name of sampled sites, and what year the sampling was carried out. Studies highlighted in green covered Southampton Water sites, while those in orange examined Poole Harbour. Mills 2016, highlighted in blue, addressed both areas. Sites in **bold** were surveyed in all studies in that area while *italicised* sites were surveyed in some but not all. Non-characterised sites were only surveyed once.

Study	**Paper Name**	**Sample year**	**Southampton sites surveyed**	**Poole Harbour sites surveyed**
Noble 2022	The abundance and distribution of *Magallana gigas* (Thunberg, 1793) in Southampton Water and a comparison with Poole Harbour	2021-22	*Hamble, Netley, Woolston*	-
Phillips 2022	A survey of *Magallana gigas* and *Ostrea edulis* in Poole Harbour, and a comparison with Southampton Water	2021-22	-	**Hamworthy Park**, *Baiter Park/Point*, **Blue Lagoon**, Pottery Pier, *Lake Pier/Drive*
Shannon 2019	An updated assessment of the wild population structure of *Magallana gigas* (Thunberg, 1793) in Southampton Water and the Solent	2018	*Hamble, Netley, Woolston, Hill Head*, Cracknore	-
Uttley 2017	An investigation into intertidal population of the Pacific oyster, *Crassostrea gigas*, in Southampton Water, UK	2017	Test estuary, Empress Dock	-
Mills 2016	Population structure and ecology of wild *Crassostrea gigas* (Thunberg, 1793) on the south coast of England	2012-14	*Hamble, Netley, Woolston, Hill Head*	**Hamworthy Park**, *Rockley Point*, *Lake Drive*, **Blue Lagoon**, *Baiter Point*, *Morinconium Quay*, Newton, *Arne*, Whitley Lake, South Haven, *Holes Bay*, Ower, Dolphin Marina, Parkstone
Deane *et al.*, 2013	Distribution, abundance and temporal variation of the Pacific oyster, *Crassostrea gigas* in Poole Harbour	2012-13	-	*Rockley Point*, **Hamworthy Park**, *Moriconian Quay*, *Lake Drive*, *Holes Bay*, **Blue Lagoon**, Sand Banks, Cleavel Point, *Arne*
Maunder 2012	Assessing the distribution and reproductive capacity of wild *Crassostrea gigas* in Poole Harbour	2011-12	-	**Hamworthy Park** (*4), **Blue Lagoon** (*4)

Most Recent Poole Harbour and Southampton Water *M. gigas* monitoring surveys- Best Available Evidence for Pacific Oyster Location in the SIFCA District

The studies by Phillips (2022) and Noble (2022) are the most recent Pacific oyster surveys to take place in Poole Harbour and Southampton Water respectively. Both surveys were undertaken around the same period, shared data, and were written alongside each other. As both studies compared findings, they collectively form the most up to date mapping of Pacific oyster population aggregations in Poole Harbour and Southampton. Both Phillips (2022) and Noble (2022) share the aim of mapping and comparing the distribution of *M. gigas* in Poole Harbour and Southampton respectively, and to quantify changes in *M. gigas* populations over time.

Phillips and Noble 2022 used broadly the same walking survey methodology derived from earlier monitoring surveys (Table 1). The only exception was Uttley's 2017 study, which looked at offshore sites using dredge sampling, instead of the shoreline-based beach sampling used in the other studies (Table 2). Using similar intertidal sampling methods, these studies produced data that can be compared over time to create a time series.

To ensure comparability between studies over time, historic monitoring surveys have selected sites primarily based on those chosen by earlier surveys and prior knowledge of *M. gigas* locations. Hard substrate coverage was a particularly important factor as oyster larvae are dependent on hard substrate to attach and successfully metamorphose (Diedrich, 2005). Phillips and Noble's (2022) site selection was based on the sites surveyed previously by Mills 2016, that mapped Southampton and a greater proportion of Poole Harbour for *M. gigas* than any of the above studies. Of the 17 Poole Harbour sites surveyed by Mills (2016), Phillips (2022) selected 4 sites with notable rocky sediment coverage in Northern Poole Harbour, in addition to a previously unsurveyed site around Brownsea Island (Pottery Pier) (Figure 1). These sites were then classified according to oyster density using a method devised by Natural England (McKnight, 2009) and used by Mills (2016), which ranks sites from Absence to Colony status (Table 3).

Table 2 summarises oyster, and in some cases oyster predator population characteristics, measured by Poole Harbour and Southampton Water *M. gigas* monitoring reports. Although the studies had different objectives, oyster length (mm), density, and location were consistently recorded. Factors such as transect number and survey length was site-dependant and differs based on practical and site-specific factors between and within studies to account for difficulties encountered by each study (Table 6). While methodology varies between studies, they remain similar enough to compare site populations over time.

Table 2. Summary of the survey methods and data collection of seven *Magallana gigas* monitoring surveys in Poole Harbour and Southampton Water

<table>
<tr><th>Authors</th><th>Location</th><th>Years</th><th>Survey Methods</th><th>Relevant Objectives</th><th>Organisms Studied</th><th>Data Collected</th></tr>
<tr><td>Phillips</td><td>Poole Harbour</td><td rowspan="2">2021-2022</td><td rowspan="3">• Walking Beach Survey parallel to the shoreline.
• Belt transects with 1m^2 quadrats running vertically down the shoreline.</td><td>1. Establish abundance of M. gigas and O. edulis at 5 sites.
2. Determine SFD.
3. Compare species abundance across sites.
4. Update survey data.
5. Compare Poole Harbour and Southampton Water data.</td><td>M. gigas, O. edulis</td><td rowspan="3">• Length (mm),
• Abundance,
• GPS,
• Substrate type,
• Density (McKnight 2009 method)</td></tr>
<tr><td>Noble</td><td rowspan="2">Southampton</td><td>1. Map distribution and abundance at 3 sites.
2. Classify and compare densities with Shannon (2019) and Mills (2016).
3. Quantify density and compare with Poole Harbour data.
4. Examine SFD across regions.</td><td rowspan="2">M. gigas</td></tr>
<tr><td>Shannon</td><td>2018-2019</td><td>1. Map distribution and abundance at 5 sites.
2. Update site classifications.
3. Compare densities between 2014 and 2018/19.
4. Quantify max. density.
5. Compare size-frequency distributions over time and between sites.</td></tr>
</table>

Uttley		2016-2017	• Dredge Sampling in Test estuary site, • Video Transects of Empress dock wall site	1. Map oyster beds. 2. Assess SFD. 3. Determine sex ratio and reproductive traits. 4. Compare SFD and density across study sites and with Mills (2016) study.		• Length (mm), • Abundance, • GPS, • Substrate type, • Density (McKnight 2009 method), • Oyster sex ratio • Oocyte diameter (μm)
Mills	Both	2012-2014	• Walking Beach Survey parallel to the shoreline. • Belt transects with 1m^2 quadrats running vertically down the shoreline. • Oyster cementation experiment. • Crab feeding experiment.	1. Map *M. gigas* distribution and abundance. 2. Analyse size, growth, and mortality (SFD). 3. Study reproductive traits via histology. 4. Assess the impact of predation from crabs, 5. Examine the impact of low temperatures on oyster respiration and gaping	*M. gigas, Carcinus maenas* (Common shore crab)	• Length (mm), • Abundance, • GPS, • Density (McKnight 2009 method), • Oyster sex ratio • Oocyte diameter (μm), • Growth rate and Mortality estimates, • Respiration rates at different temperatures, • Proportion of oysters cemented to substrate, • Crab : Oyster Predation
Dean *et al*	Poole Harbour	2012-2013	• Walking Beach Survey parallel to the shoreline. • Belt transects with 1m^2 quadrats running vertically down the shoreline. • Settlement plat analysis. • Crab marking, release and recapture.	1. Quantify naturalised *M. gigas* abundance and relation to settlement factors. 2. Measure spatfall potential. 3. Examine oyster predation *by C. maenas,* 4. Analyse the contribution of filter feeder predation to oyster larvae mortality	*M. gigas, C. maenas,* Various sessile filter feeders	• Length (mm), • Abundance, • GPS, • Density (m^2), • Surface Type, • Spatfall Settlement, • Plate analysis, • Shore Crab, • Population Estimates,

					• Crab : Oyster Predation
Maunder	2011-2012	• Walking Beach Survey parallel to the shoreline. • Belt transects with 1m^2 quadrats running vertically down the shoreline.	*1.* Map distribution of wild M. *gigas*. *2.* Assess M. *gigas* impact on *O. edulis*. *3.* 3. Assess reproductive capacity with histology.	*M. gigas, O. edulis*	• Length (mm), • GPS, • Abundance, • Density (m^2), • Oyster sex ratio, • Oocyte diameter (μm)

Table 3. *Magallana gigas* site classification table adapted from the McKnight (2009) oyster classification method that uses oyster density to distinguish between populations of different sites.

Site Type	Colour Classification	Live *M. gigas* per m^2	Site Definition
Absent		0	No oysters present.
Solitary Site		1	A single oyster observed. No others present within a 10m range.
Solitary Zone		1	More than 1 solitary oyster observed within a site (site boundary determined by tide line, physical barriers, e.g., sea defences or a change in substrate type). I.e., there is >10m between oysters.
Cluster Site		2-10	A group of oysters, where individuals are within a 10m range of any neighbour but density <10 oysters per m^2.
Cluster Zone		2-10	2 or more clusters within a site i.e., most oysters have <10m between them, however there may be areas of uncolonized substrate resulting in larger gaps. Density < 10 oysters per m^2.
Colony		>10	All oysters within the site have <10m distance between them, with areas of settlement that exceeded 10 oysters m^2.

Current understanding of the 5 most recently sampled sites in Poole Harbour

Following a review of the results and methodologies of the seven most recent monitoring studies in Poole Harbour and Southampton Water, this summary presents the latest status of *M. gigas* populations in Poole Harbour, based on the best available evidence from five key Poole Harbour sites: Hamworthy Park, Baiter Park, Blue Lagoon, Pottery Pier and Lake Drive/Pier (Figure 1). These findings are contextualised with the results of earlier survey data, creating a timeline of the development of *M. gigas* population characteristics in Poole Harbour from 2011 – 2022.

Figure 1. Map of Poole Harbour developed by Phillips 2022 using Arc GIS Pro to visualise 5 sites surveyed for *M. gigas* monitoring. Each pin represents the following sites: green = Lake Pier, purple = Hamworthy Park, orange = Pottery Pier, yellow = Baiter Park, and blue = Blue Lagoon.

Hamworthy Park & Baiter Park

The most recent surveys (Phillip, 2022) found that Hamworthy Park and Baiter Park had similar oyster densities and were both designated as Cluster Sites (Table 3). The density designations of both sites were updated since 2014 from Solitary Zones to Cluster Sites, reflecting an increase in *M. gigas* density over time.

The sites exhibited similar peaks in percentage frequency for the 45-49mm size class, with a growth rate indicating that these populations likely originate from the same year (Fey et al., 2010). A larger age class (91-120mm) was recorded during 2011–2012; however, very few oysters from this class were detected the following year (Table 4). These findings suggest that both sites demonstrate highly variable recruitment, with successful recruitment presumably occurring only in 2006 and 2012 (Deane *et al*., 2013). Furthermore, very few individuals from the 2006 cohort were detected in 2012–2013, indicating a low survivability rate.

Hamworthy Park and Baiter Park are both southern-oriented sites that share characteristics. Both sites contain pebbly substrate in addition to sandier portions dominated by macroalgae, and both sites are impacted by wave action. This offers an explanation to the relatively low densities when compared to Blue Lagoon and Pottery Pier as both sites show a pattern of low *M. gigas* abundance and variable size distributions.

Lake Drive/Pier

The Lake Drive/Pier site was characterised by comparably muddier sandy substrate with smatterings of small boulders on the western portion of the site. Despite sharing some similar substrate characteristics with Hamworthy Park and Baiter Park, Lake Pier is the only one of the 5 sites surveyed by Phillips (2022) that was redesignated to a lower density classification, from a Solitary Zone in 2012-14, to a Solitary Site in 2021-2022.

This site has consistently shown low abundances (3-4 observations) and densities (<1 oyster per m^2) compared to other sampled Poole Harbour sites (Table 4). Furthermore, the few oysters found appear to decline in size category over time, painting a pattern of low recruitment and low survivability between 2012-2022.

Like Hamworthy Park and Baiter Park, Lake Pier is also exposed to southerly winds and high wave action. However, anthropogenic disturbance from bait digging and vessel launches is present at this site, reducing oyster survivability and solid sediment availability (Mills, 2016 & Phillips, 2022). The primary reason for the low abundance of oysters is likely the lack of suitable sediment. Oysters were mainly found growing on wooden groynes and pier beams, indicating that while they can settle in the area, their growth is limited by the availability of hard sediment.

Blue Lagoon and Pottery Pier

Blue Lagoon and Pottery Pier accounted for 89.4% of *M. gigas* observations from the 5 sites in 2022. Blue Lagoon and Pottery Pier stand out as the only two sites designated as Cluster Zones. Phillip (2022) highlighted both sites had areas with densities greater than 10 *M. gigas* per m^2, which are densities expected in a colony. In contrast, none of the other surveyed sites had a density greater than 1 oyster per m^2.

Blue Lagoon had the greatest *M. gigas* density (7.64 per m^2), size range (71-256mm), and percentage SFD peak (~160mm) of all the sites surveyed by Phillips (2022). Of the 17 Poole Harbour sites surveyed by Mills (2016) in 2012-14, Blue Lagoon was the only site with sufficiently high abundance and densities to analyse SFD. These findings are present in all previous Poole Harbour surveys that mark Blue Lagoon as a site with uniquely large aggregations among the other Poole Harbour sites (Table 4).

Pottery pier is the site with the closest proximity to *M. gigas* aquaculture beds. As 2022 was the first time this site has been surveyed, it is unclear to what extent the *M. gigas* population has changed over time. However, Pottery Pier had a higher percentage size frequency (>100m) than Hamworthy Park and Baiter Park suggesting higher survivability. Furthermore, the percentage SFD show two distinct peaks (50-54mm & >100m) suggesting that the site has high levels of adult survival compared to other Poole Harbour sites and ongoing recruitment. However, average densities in Blue Lagoon appear to have declined between 2012 – 2022, with Blue Lagoon redesignated from a Colony classification to a Cluster Zone with some Colony characteristics. The combination of a decline in abundance and increasing average size cohort suggest that recruitment success is variable.

Higher densities and survivability in both sites in the context of Poole Harbour are likely due to a combination of factors including a lack of disturbance from bait digging, the presence of suitable substrate for larvae settlement, and in the case of Blue Lagoon, protection from severe tidal forces (Mills, 2016). Despite the lack of earlier data for Pottery Pier, this site can be compared to contemporary surveys in Southampton Water sites.

Table 4. Overview of *Magallana gigas* densities, abundance, and most frequent size class of 5 Poole Harbour sites surveyed by Phillips 2022. The data is collated from the following 4 studies that undertook surveys at different years. 2021-2022 = Phillips (2022), 2012-2014 = Mills (2016), 2012-2013 = Deane *et al*., (2013), 2011-2012 = Maunder (2012). The following cell colouration designates site oyster density classification according to the method designed by McKnight 2009 where this information has been available from the relevant studies (Table3): Solitary Site , Solitary Zone , Cluster Site , Cluster Zone, Colony.

***Average M. gigas* densities (m^2) across the entire site**					
Survey sampling period	Blue Lagoon	Hamworthy Park	Lake Drive / Pier	Baiter Park	Pottery Pier
2021 – 2022	7.64	1.3	0.43	1.5	3.54
2012 – 2014	> 10	NA	NA	NA	NA
2012 – 2013	3.01	< 0.01	< 0.01	NA	NA
2011 – 2012	2.28	NA	NA	NA	NA
Most frequent *M. gigas* size / length class (mm) & number of abundance peaks (*)					
Survey sampling period	Blue Lagoon	Hamworthy Park	Lake Drive / Pier	Baiter Park	Pottery Pier
2021 – 2022	~160	45-49	60-69	45-49	50-54 (2)
2012 – 2014	145-160 (3)	85-90	90-95	NA	NA
2012 – 2013	130-139	NA	NA	NA	NA
2011 - 2012	120-129	91-120	NA	NA	NA
Number of *M. gigas* observations					
Survey sampling period	Blue Lagoon	Hamworthy Park	Lake Drive / Pier	Baiter Park	Pottery Pier
2021 – 2022	275	24	3	23	145
2012 – 2014	610	6	4	3	NA
2012 – 2013	541	6	4	NA	NA
2011 - 2012	150 - 175	25	NA	NA	NA

Please note that site some site classifications differed in individual surveys. Both Pottery Pier and Blue Lagoon were given a Colony designation in 2021-22 based on their >10m^2 maximum densities. The results in table 4 instead reflect average site densities, reclassifying Pottery Pier and Blue Lagoon as Cluster Zones.

<u>Comparing *M. gigas* populations between Poole Harbour and Southampton</u>

The most recent surveys show that Southampton Water has a statistically higher abundance of pacific oysters than Poole Harbour despite the absence of *M. gigas* aquaculture in the area (0.43 – 7.64 m^2 vs 6.44 – 11.38m^2). This is reflected by the designation of the Netley and Woolston sites Southampton Water sites sampled in 2021 as Colonies. Furthermore, Noble (2022) classified the remaining Hamble site as both a Cluster Zone with Colony characteristics. In comparison, only

Blue Lagoon and Pottery Pier were designated as Cluster Zones in Poole Harbour, with the remaining sites were designated as solitary and cluster sites.

Southampton Water sites show consistently more even density distributions between sites than Poole Harbour sites (Table 4 & 5). This is to the extent that the Pacific oyster colony in Blue Lagoon has a more similar density and distribution to the Southampton Water sites than other Poole Harbour sites (Mills, 2016). However, the Southampton Water monitoring surveys took place far closer to each other compared to the Poole Harbour surveys, with 4 Southampton monitoring surveys having taken place between the two most recent Poole Harbour surveys (Table 1).

Southampton sites consistently show a greater Pacific oyster distribution over larger areas, with multiple age classes. For example, 5 notable age classes were recorded in the Woolston site in 2022 (Table 5). In contrast, Poole Harbour shows sparsely distributed, highly variable zones containing limited oyster size ranges. However, these size ranges reach greater maximum lengths than those observed in Southampton Water (~160mm vs 40-49mm).

These observations portray a trend where Pacific oysters in Southampton Water sites have a greater abundance and more even density distribution, higher recruitment success but lower survivability. Meanwhile, *M. gigas* in Poole Harbour show higher survivability, but patchier distribution, lower abundance and slower more variable recruitment.

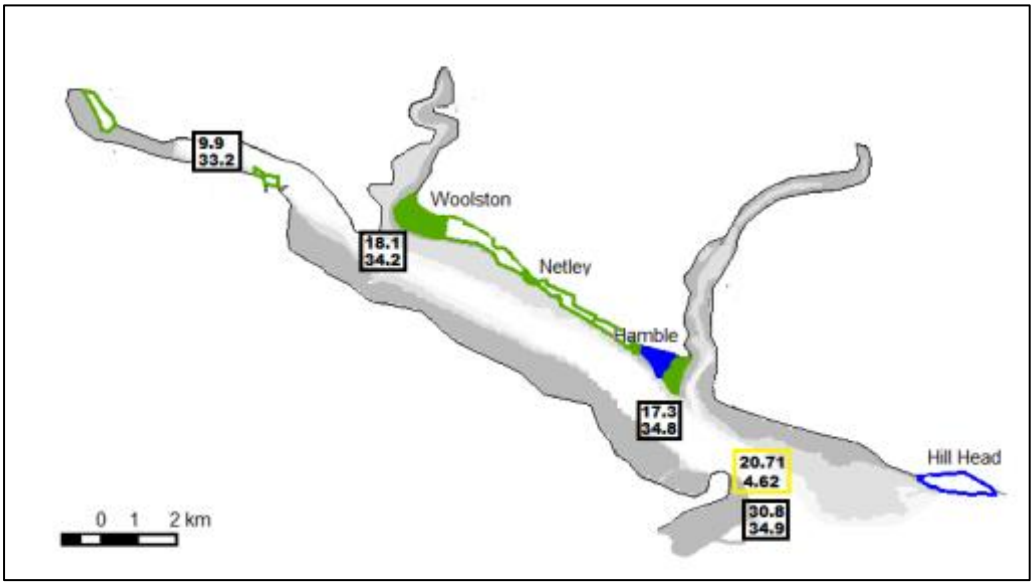

Figure 2. Map of Southampton Water highlighting 4 sites: Hamble, Netley, Woolston, and Hill Head, surveyed by Mills (2016) for Pacific oysters. Adapted from Mills 2016. The four sites are represented by filled in areas (Green for Woolston & Netley, blue for Hamble and Hill head), with additional areas with a green outline and no fill representing walk-over surveys where *M. gigas* abundance wasn't quantified.

Table 5. Overview of *Magallana gigas* densities, abundance, and most frequent size classes of 3 Southampton Water sites surveyed by Noble 2022, and the additional Hill Head site surveyed previously by Mills 2014 & Shannon 2019. The data is collated from the following 3 studies that undertook surveys in different years. 2021-2022 = Noble (2022), 2018 = Shannon (2019), 2012-2014 = Mills (2016). The following cell colouration designates site oyster density classification according to the method designed by McKnight 2009 (Table 3) where this information is provided in relevant studies: Solitary Site , Cluster Zone , Colony.

***Average M. gigas* densities (m^2) across the entire site**				
Survey sampling period	Hamble	Netley	Woolston	Hill Head
2021 – 2022	6.44	11.38	10.76	NA
2018	3.73	15.03	4.98	NA
2012-14	NA	NA	NA	NA
Most frequent *M. gigas* size / length class (mm) & number of abundance peaks (*)				
Survey sampling period	Hamble	Netley	Woolston	Hill head
2021 – 2022	40-49	40-49 (2)	40-49 (2)	NA
2018	71-75	61-65	66-70	81-85
2012 – 2014	75-84 (3)	60-64 (3)	80-84 (5)	85 -89 (2)
Number of *M. gigas* observations				
Survey sampling period	Hamble	Netley	Woolston	Hill Head
2021 – 2022	NA	NA	NA	NA
2018	488	1075	333	456
2012 – 2014	145 / 294-130	114 /309–399-423	181	53/ 105-110

Please note that site some site classifications differed in individual surveys. Woolston was given a Colony designation in 2018, whilst Hamble was given a Colony designation in 2021-22 and 2018 based on their >10m² maximum densities. The results in table 5 instead reflect average site densities, reclassifying Hamble and Woolston as Cluster Zones.

Limitations

The surveys conducted to date have identified limitations in the data collection methods, including limitations due to health and safety considerations, access to sites when sampling using intertidal methods, evidence gaps in environmental parameters and limited abilities to assess size frequency when densities were low. These limitations help explain the differences in beach survey methodologies for factors such as transect number, length, number of repeats etc. This site-by-site variance has been identified as a repeating source of data discrepancies that can result in oyster underestimations through limiting the surveyable area (Phillips, 2022).

Future Monitoring Methods

Current UK shore-based surveying methods rely on surveyors conducting surveys to observe and record individual oysters. However, drones are increasingly gaining attention as an alternative surveying method (Mata *et al.,* 2024 & White *et al.,* 2022). While traditional arial survey methods have been effective in surveying large areas in a short space of time, surveys are usually restricted to large marine animals such whales due to the low resolution of footage captured at altitude. In contrast, multi-rotor drones offer a more cost-effective, less labour-intensive aerial survey method that can collect footage at significantly lower altitudes and generating higher quality footage (English *et al.,* 2024).

Drone use has been trialled for Pacific oyster monitoring (Mata *et al.,* 2024) and Southern IFCA have worked with Devon & Severn IFCA to trail intertidal mussel bed mapping using the Southern IFCA DJI Matrice 300 RTK drone. The use of this technology for this type of intertidal surveying offers a potential opportunity for future monitoring in Poole Harbour and Southampton Water, however, there remain a number of limitations which would need to be further explored before such a methodology could be successfully implemented, these include for example cost, the legal requirements around drone use and the complexity of associated analysis software.

Summary

The most recent survey data from Poole Harbour indicates that there has been an increase over an approximate 10-year period in two of the five sites which have been surveyed in multiple years. However, in looking at the relative densities represented by the McKnight (2009) classifications of oyster density (Table 3), the increases have not resulted in areas being classed as more than a Cluster Site, demonstrating still relatively low densities per m^2 (1.3 and 1.5 per m^2). For one site, there is a higher density of Pacific oysters (3.54 per m^2, Pottery Pier), however there is no data available to indicate whether this represents a change from a previous status. There has also been an observed decline in one area (Lake Drive/Pier), with a corresponding lower classification zone applied in the most recent surveys (representing 0.43 per m^2). The Blue Lagoon site consistently represents the highest densities in Poole harbour, however the classification has declined from a Colony designation to a Cluster Zone as average densities have not increased and in the most recent survey, are lower (7.64 per m^2) than documented in studies from 2012-2014 (>10 per m^2).

Looking at these results in comparison with Southampton Water where there are demonstrated to be generally greater densities of Pacific oyster more consistently across the area with no associated aquaculture activity, the most recent survey results from Poole Harbour do not indicate that the aquaculture activity in Poole Harbour is causing large increases in the presence of wild Pacific oysters. There is also no indication that the presence of wild Pacific oysters in Poole Harbour is resulting in large scale habitat change or the formation of reefs.

It is accepted that there are limitations to intertidal survey methodologies which mean that the full geographic area of a particular site cannot be sampled within the scope of a single study, however having repeatable sites surveyed within Poole Harbour helps support the general patterns in populations which are being seen. On the basis of this study of existing data, additional monitoring is likely to be beneficial within the next cycle of lease bed allocation (2025-2030) to maintain the timeseries dataset, at the time at which a new round of monitoring is determined to be appropriate, the potential for future monitoring methods such as the use of drones can be explored more fully.

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