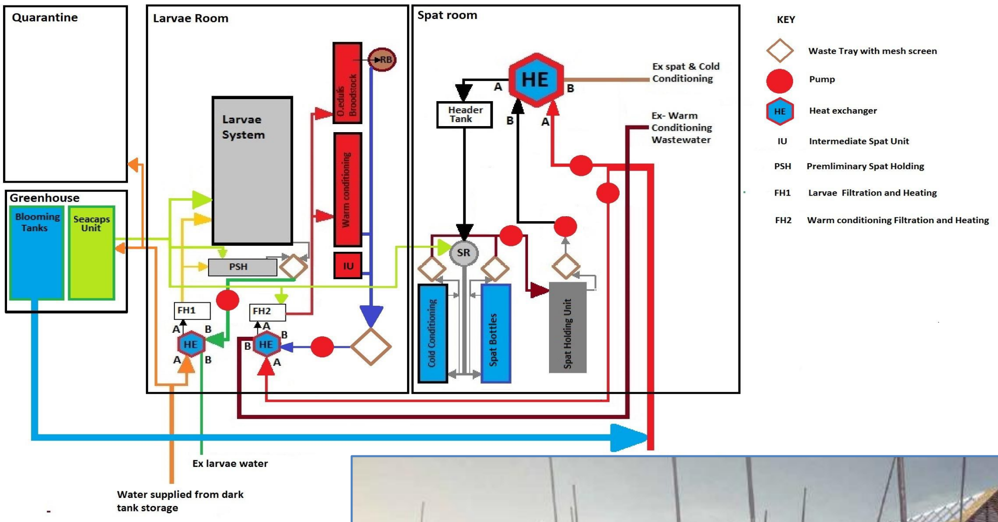

Closing the Circle Report II: Development of a Generic Shellfish Hatchery Design

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FOR: MUMBLES OYSTER COMPANY LTD.

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AUTHORS: MARTIN SYVRET[1]; JOHN BAYES [2]; DR JACK JAMES[3]; DR ANDREW WOOLMER[4]

1. **Aquafish Solutions Limited, Carthouse, Whitnage, Tiverton, Devon EX16 7DU**
   E-mail: martin@aquafishsolutions.com

2. **Seasalter Shellfish (Whitstable) Limited, The Old Roman Oyster Beds, Reculver, Herne Bay, Kent CT6 6SX**
   E-mail: seasalter@globalnet.co.uk

3. **Pontus Aqua, Unit 20/21, Hirwaun Ind. Est., Hirwaun, RCT, CF44 9UP**
   E-mail: jmj@pontusaqua.com

4. **Salacia-Marine, 14 Rectory Road, Llangwm, Pembrokeshire SA624JA**
   E-mail: andy@salacia-marine.co.uk

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PROJECT TEAM, ACKNOWLEDGEMENTS AND AUTHORSHIP

Project Team: Listed in alphabetical order of surname;

John Bayes – Seasalter Shellfish (Whitstable) Ltd.

Jack James – Pontus Aqua

Martin Syvret – Aquafish Solutions Ltd.

Andrew Woolmer – Salacia-Marine

Authorship and Contributions*: Listed in order of citation on preceding page using PCI (percentage-contribution–indicated) approach to author sequencing. Where section contributions are numerically equal then Authors are placed in alphabetical order by surname. No differentiation is made between primary or contributory authorship;

Martin Syvret -	Primary Author of Section(s)	1 and 3
	Contributory Author to Section(s)	2 and 4
Jack James -	Primary Author of Section(s)	-
	Contributory Author to Section(s)	1 and 2
John Bayes -	Primary Author of Section(s)	2
Andrew Woolmer -	Primary Author of Section(s)	4
	Contributory Author to Section(s)	-

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SECTION 1 – DEVELOPMENT OF A GENERIC HATCHERY DESIGN IN ASSOCIATION WITH SPATTING PONDS

1.1 Introduction

At present, there is only a limited capacity for the supply of biosecure hatchery produced bivalve shellfish seed to the UK aquaculture sector. The need for a national seed strategy for shellfish has been highlighted recently in work by Hambrey and Evans (Ref: 2016) where a call was made for a new hatchery facility to work with existing commercial hatcheries to fill the current demand gap and to help develop production techniques for new shellfish species for the future. In discussions with Seasalter Shellfish (Whitstable) Ltd., John Bayes (pers. comm.) described the need for a national modern facility to help support the shellfish cultivation sector along the lines of that previously offered by the Cefas Conwy Laboratory.

Native oyster (*Ostrea edulis*) restoration is central to the biodiversity aims of Tidal Lagoon Swansea Bay. TLSB have committed to building a hatchery with spatting ponds to support a programme of reintroduction of native oysters to Swansea Bay and elsewhere. There are wider commercial and ecological drivers supporting the drive to produce large quantities of low cost biosecure seed for species such as the native oyster (*Ostrea edulis*), a Biodiversity Action Plan species which also has a high market value and demand. Previous studies (Ref: Syvret *et al*., 2008) have highlighted the potential role that spatting ponds may play in helping to produce native oyster seed that could contribute to developing this sector whilst providing positive marine environmental benefits, a win-win scenario that has been described as 'Restoration Aquaculture' (Andy Woolmer, pers. comm.).

Whilst this report references TLSBs native oyster aims throughout, the generic hatchery design considerations and process that it describes are equally as relevant to hatchery design and seed production of other bivalve shellfish species, as well as a for multi-species bivalve seed facility.

1.2 Overview of Current Study

This Authors of the current study, under funding from the Strategic Investment Programme of the Sea Fish Industry Authority, have been working with Tidal Lagoon Swansea Bay (TLSB) to scope out the potential for aquaculture development within the proposed tidal lagoon in Swansea Bay.

In addition to the co-location potential of aquaculture and marine renewable energy generation, TLSB have also given a commitment under a Section 106 agreement (Town and Country Planning Act 1990 (as amended)) to provide the following:

- Western Landfall Facility; incorporating a hatchery and laboratory.
- Spatting Ponds; structures for hatching oyster larvae and spat inside the proposed lagoon.
- Ecological Enhancement Measures; a programme to encourage reintroduction of the native oyster to Swansea Bay.

1.2.1 Scoping Study

Initial investigations towards the development of a shellfish hatchery at the proposed tidal lagoon in Swansea Bay have also formed part of the work programme of the current study. The potential for the tidal lagoon site to be used a multi-species shellfish hatchery was first reviewed by Syvret (Ref: 2015) in a report entitled 'Local Oyster Hatchery Feasibility Study. Report for the Mumbles Oyster Company Ltd. and Swansea FLAG'. The 2015 Feasibility Study also provided a comprehensive review of differing hatchery options and microalgae production techniques that might be considered for a number of sites in Wales.

Earlier work within the current study contained in a Scoping Study (Ref: Bayes and Syvret, 2016) has highlighted that rather than a Western Landfall Facility, a better location for a shellfish hatchery at the proposed tidal lagoon may be on the eastern landworks where seawater abstraction is likely to be more practical and better and more integrated use can be made of the proposed spatting ponds. These findings have been taken on-board by TLSB and the latest designs for the proposed lagoon now include a separate 'National Aquacentre' towards the east of the proposed lagoon.

1.2.2 Generic Hatchery System Design

The current study also seeks to provide a framework for development of a national hatchery facility and presents an initial Generic Hatchery System Design based upon a Seasalter (Whitstable) Template that could be considered for development at a suitable site where defined infrastructure and services are available.

In addition to the Generic Hatchery Design the current study considers the role that spatting ponds could play in association with a hatchery in producing large numbers of biosecure, and potentially low cost, shellfish seed for on-growing or for purely restoration purposes.

The following section, Section 1.3, summarises the design process that was adopted in the current study for development of a Generic Hatchery System Design

1.3 Stages of Development of a System

As a starting point, it is important to understand the stages in the development of a system in terms of what the client and the design engineer will need to do or provide to get a project running along smoothly. Pontus Aqua work with one system engineer, who we know well, although it should be noted that other companies and consultants may work differently. However, this approach has proved successful in several the installation and commissioning of related systems, from research scale Recirculating Aquaculture Systems (RAS) to commercial scale production systems.

Note: each stage is dependent upon the previous stage, and therefore they cannot be undertaken in parallel.

The current study seeks to develop a system design that incorporates the main aspects of Stage 1 – Project Details as they might apply to a Generic Hatchery System Design using the Seasalter (Whitstable) system as a template.

1.3.1 Stage 1 – Project Details

Carried out by the client and/or consultant(s).

Comprising:

- Collection and collation of all pertinent information relating to the requirements of the project. Note: Scoping Study provides this information for the current study.
- Identification of important systems within the project (e.g. nursery, on-growing, microalgae cultivation etc.).
- Determine expectations of the operating parameters of the system (e.g. species, water parameters, etc.).
- Identifying peripheral equipment required (sorters/graders, feeding systems, etc.)
- Site requirements are determined (e.g. access to water, municipal services, power, communications, etc.). This is included as an "Infrastructure and Services" section in the current report.

The current study has been designed to provide the main details required for this stage and essentially has these points as its deliverables, the end point being a set of guidelines allowing the subsequent stages to be undertaken. The subsequent stages therefore constitute the next follow-on stages for development of a shellfish hatchery e.g. once the go ahead is given at TLSB.

This information obtained and collated during Stage 1 would normally be provided to the engineer on their Project Enquiry Sheet (see Appendix 1). In this case, the Generic Shellfish Hatchery Design will provide the basis of the required information plus useful supplementary information.

1.3.2 Stage 2 – Site Selection

Carried out by the client and/or consultant(s).

A suitable site is selected for development fitting as many of the site requirements as possible identified in Stage 1.

1.3.3 Stage 3 – Conceptual Design

Carried out by the system engineer/designer.

As much information as possible is supplied to the engineer to allow him to design the system within the constraints of the site chosen. This information is that gathered during Stages 1 and 2. This stage cannot be carried out before Stage 1 and 2 are complete.

The output of this stage of development is a Conceptual Design (CD), consisting of the following:

1. 3D designs for the systems(s).
2. Planned production schedules.
3. A Bill of Quantities (BoQ) which will outline what equipment will be needed.
4. An Electrical Bill of Quantities (EBoQ) which will outline the power usage of the system.
5. A budgeting price for the full construction and commissioning of the system(s).

The overall cost of this stage will be a relatively low cost compared to the total build cost, typically around £10,000 to £12,000 paid directly to the engineer (depending on the scale of the project and the amount of information available to him at the outset).

There is scope at this stage to make alterations and adjustments to better suit the production plans, requirements and site constraints. Assuming the contents of the CD are satisfactory, the price is acceptable for the project as a whole, and the client is happy to proceed, then the project will proceed to Stage 4.

1.3.4 Stage 4 – Build and Commission

Carried out by the system engineer/designer and selected contractors.

Full design and build. This stage consists of:

- Final designs drawn up and approved.
- Equipment purchased and delivered to site.
- All site works carried out.
- All building works carried out.
- Systems commissioned.

This stage will involve securing and spending the full build cost as determined at Stage 3.

1.4 Tidal Lagoon Swansea Bay - Case Study

Tidal Lagoon Swansea Bay (TLSB) plans to build the world's first, man-made, energy-generating lagoon, delivering 320MW capacity of generation for 14 hours every day. As a pioneer of this generation approach TLSB state that they will develop scalable approaches and technologies that can be applied in subsequent tidal lagoon power developments.

The 9.5 km Lagoon wall starting at the eastern side of the River Tawe and enclosing an 11.5km^2 area of water around to the eastern extent of the new university campus will be constructed of rock faced bunds up to 20 m high (see Figure 1). The visible height of the seawalls above the water level measured at the highest point will be approximately 4 m at high tide (MHWS) and 12.5 m at low tide (MLWS). This sheltered body of water will remain subject to tides which will force water in and out through the turbines over the 14 hour generation cycle.

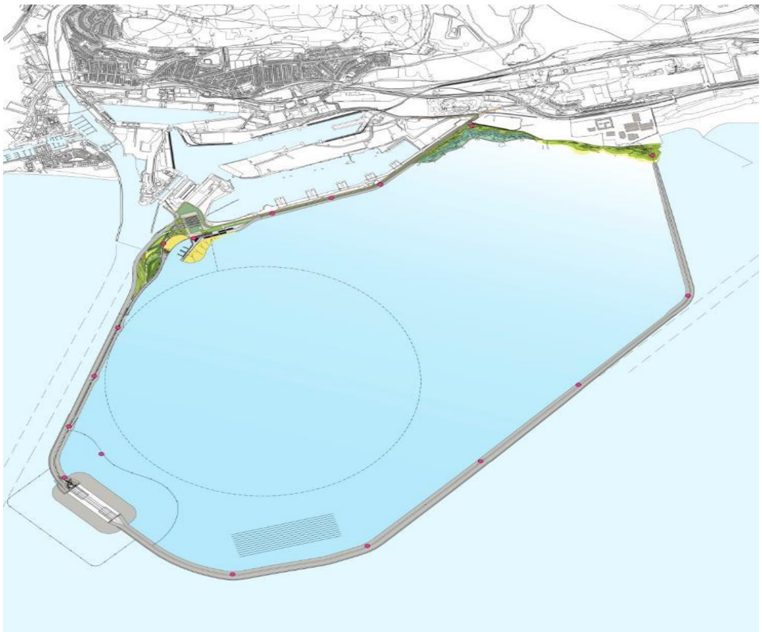


Figure 1. Plan overview of Tidal Lagoon Swansea development

(Note: Minor revisions to the design have been undertaken since this schematic was produced. Source: Tidal Lagoon Swansea Bay)

Section 1.4 gives an overview and update of the hatchery and ancillary facility options that were first presented by Syvret (Ref: 2015) in a report entitled '*Local Oyster Hatchery Feasibility Study*. Report for the Mumbles Oyster Company Ltd. and Swansea FLAG'.

1.4.1 Native Oyster Restoration

The proposed TLSB development involves a range of community benefit initiatives, including the provision of local medium and long-term employment beyond the construction phase. These initiatives include recreation and watersports facilities, support for arts and culture funding, the development of skills training and educational programmes and pertinent to this study, mariculture and native oyster restocking programmes. TLSB aims to develop a hatchery and spatting ponds to enable this.

The native oyster forms a design inspiration for the TLSB offshore visitor centre proposed for the lagoon wall. The concept of the visitor centre comprises a series of overlapping, sculpted oyster shells.

1.4.2 Site and Buildings

TLSB have, as part of their development plans, commissioned a design for a native oyster/shellfish hatchery from Faulkner Browns the designers responsible for the 2012 Olympic White Water Centre. The building design has been inspired by traditional fishing warehouses and boat houses that would have been common at the time of the native oyster fishery (see Figure 2).

The proposed 4,000m^2 building would house a watersports centre which includes operational and maintenance facilities, boat storage and wet changing areas and a gateway facility. The 750 m^2 hatchery includes plans for an algal photobioreactor greenhouse facility, laboratory facilities and shellfish culture tanks arranged over two storeys. The hatchery has been envisaged to house a fully serviced aquaculture system that can support the development and hatchery of oysters.

Microalgae production is envisaged through the use of a photobioreactor which is enhanced by a glass envelope system to generate greenhouse conditions for optimised algae growth with a bio fence-type network for algae cultivation. The greenhouse structure has been designed to harness solar power, generating clean, low-energy nutrient supply to the adjacent hatchery.

Figure 2. Visualisation of the planned watersports centre and hatchery building.

Note the bioreactor unit second right (Source: TLSB)

Planning consent has been received for the hatchery through a Development Consent Order (DCO). In addition to the proposed hatchery, TLSB included in the construction of the lagoon walls the provision for seven spatting ponds for the production of seed oysters. The construction of the lagoon itself has recently received planning consent from the Department of Energy & Climate Change.

1.4.3 Site Options

Discussions with TLSB developers in 2015 highlighted that whilst detailed plans have been drawn up for a hatchery as part of the DCO, they will look to work with local businesses to help in the development of sustainable mariculture activities (Dr. Jeanette Reis, pers. comm.).

TLSB have confirmed that at present, the intention is to facilitate small scale commercial development - potentially with a focus on research and development, or provision of seed stock. They state that it is important that the mariculture activities do not adversely impact on other lagoon amenities e.g. tourism, recreation, conservation. Consequently, the scale of commercial mariculture activities will need to reflect that (Dr. Jeanette Reis, pers. comm.). This parallels the approach of the Mumbles Oyster Company who have trialled restoration aquaculture techniques on their site in Swansea Bay. Their aim is to develop economically viable, low impact and long-term sustainable subtidal native oyster ranching that will both deliver seafood production and address native oyster conservation issues through restoration with minimal impact on other sea users.

There are a range of possible options for this site which could incorporate the wider native oyster restoration and mariculture development aims. Given the scope and potential for the site the main considerations were:

- Size, position and provision of buildings/infrastructure such as spatting ponds
- Potential for commercial mariculture at the lagoon site
- Access to potential nursery areas
- Opportunities for collaboration and R&D

1.4.3.1 Spatting Ponds

Tidal Lagoon Swansea Bay's plans to incorporate spatting ponds into the design and construction of the eastern wall of the lagoon may well represent the best short to medium-term option for producing spat-on-shell seed (see Section 4 for a detailed review).

The short-term ability to produce spat-on-shell would benefit local aquaculture businesses and also enable native oyster restoration initiatives to proceed. There is a growing interest in native oyster restoration beyond Swansea Bay with a series of regional projects in the UK and Europe either in development or just beginning. These initiatives are constrained by biosecure oyster seed supply and spat-on-shell is particularly suited for spreading directly on the seabed in restoration work.

It would be possible to utilise the naturally occurring productivity in seawater in the ponds to produce batches of spat-on-shell prior to the establishment of a hatchery. In the medium term, as a hatchery became operational, remote setting techniques settling hatchery produced eyed larvae onto shell cultch would enable production to increase.

1.4.3.2 Commercial-scale Hatchery

A potential medium-term option could well be the development of a commercial-scale hatchery. The need for such a facility has been highlighted recently in the Hambrey and Evans report (Ref: 2016) where they highlighted the need for a strategic facility to work alongside other commercial hatcheries. TLSB have outlined their intention to build a hatchery building with associated photobioreactor building alongside. TLSB state that their aim is to develop mariculture operations that can co-exist with other amenity uses (e.g. tourism, recreation, conservation) of the lagoon (Dr. Jeanette Reis, TLSB pers. comm.) but this would not preclude large scale production of seed shellfish for use at other production sites.

Commercial hatcheries require significant phytoplankton growth capacity and the TLSB's aspiration to develop a dedicated photobioreactor will help to deliver this oyster food supply. The ultimate design for the phytoplankton production system will require careful consideration and will likely be influenced as much by economics as technology.

Some traditional continuous bag based phytoplankton production systems can be considered to be an agricultural system as opposed to novel photobioreactor systems that may require constant technical monitoring. Available space and possible configurations within the planned building may also be an influence on choice of systems.

A commercial-scale hatchery will have technical staff that are able to carry the day-to-day maintenance of phytoplankton cultures and oyster husbandry monitoring. Full-time technical staff could be trained in the techniques required to produce triploid Pacific oyster seed thus adding a further commercial product to the operation.

1.4.3.3 Grow-out Nursery

TLSB's plans outline some extensive sandy areas to the landward side of the lagoon. These sandy areas present the possibility for the development of nursery grow-out sites for hatchery produced seed oysters.

Seed oysters placed into protective containment such as the ORTAC cultivation systems could be on-grown to a size whereby they are robust enough to be farmed within the lagoon or on-grown in other systems. The TLSB has aims for the development of mariculture in the lagoon which will very likely be suitable for cultivation of both native and triploid Pacific oysters as well as other identified species (see Ref: Syvret and Woolmer, 2017).

The sheltered water in the lagoon would lend itself to establishing a grow-out nursery using suspended systems or FLUPSY nursery systems. A floating system would give greater flexibility in siting if there are constraints in the intertidal space. Floating systems offer a level of adaptability to changeable conditions and can be relocated in relation to other lagoon operations such as maintenance dredging.

1.4.3.4 Combined Seaweed Seeding Facility/Hatchery

Discussions with TLSB and Selwyn's Seaweed have highlighted their interest in developing seaweed or macroalgae mariculture in tidal lagoons. In the event that seaweed cultivation is undertaken in TLSB or subsequent lagoon developments such as those being considered elsewhere in Wales, a seaweed seeding facility will be required. There are obvious shared requirements for both seaweed cultivation and seeding operation and a shellfish hatchery operation in terms of the infrastructure required to supply and handle large quantities of clean seawater and the ancillary facilities such as preparation and laboratory facilities. The current description of the TLSB building could be reconfigured to house the necessary tanks required for a seaweed cultivation operation within the lagoon. Shared staffing costs and other overheads including the basic considerations of accommodation costs etc., would result in significant financial advantages for hatchery and seeding operations.

1.4.3.5 Depuration Capacity

Although the proposed building is relatively large it is difficult to envisage how a depuration and dispatch centre of a capacity to service lagoon-based mariculture operations could be accommodated. However, there is scope to provide a small-scale depuration capacity to supply the onsite retail and food outlets outlined in the TLSB plans. Small depuration tanks could be sited within the building subject to the appropriate biosecurity and food hygiene considerations. An onsite supply of fresh shellfish may be a valuable additional service for both mariculture and food business operators.

1.4.3.6 Education, Research and Delivery Collaborations – National Native Oyster/Lagoon Mariculture Centre of Excellence

Discussions with the Sea Fish Industry Authority have highlighted that they have a strategic interest in the development of a shellfish hatchery to address the barriers preventing the growth of the mariculture sector in England and Wales as highlighted in the report by Hambrey and Evans (Ref: 2016). This need to address the shortfall in high quality biosecure shellfish seed has led to the funding of the current aquaculture and hatchery study under their Strategic Investment Programme. Collaborations with delivery partners such as Seafish could result in wider community benefits beyond the development of a hatchery.

A purely speculative concept of a native oyster or lagoon mariculture centre of excellence draws upon the Faulkner Brown watersports/hatchery building design (see Figure 3). In addition to the hatchery facilities the proposed design for the watersports building includes fully equipped training rooms and a restaurant. The hatchery would also present another feature to attract tourists to the shore-side facilities. However, as highlighted in Section 1.2.1, in practise it is likely that a hatchery facility would be better placed on the eastern land works where high quality seawater abstraction would be possible. This would also place the hatchery near to the spatting ponds which could be used for large-scale microalgae cultivation. As such, it may not be possible to place the watersports centre and hatchery together. This has been recognised by TLSB who have now proposed plans for a National Aquacentre to the eastern side of the lagoon.

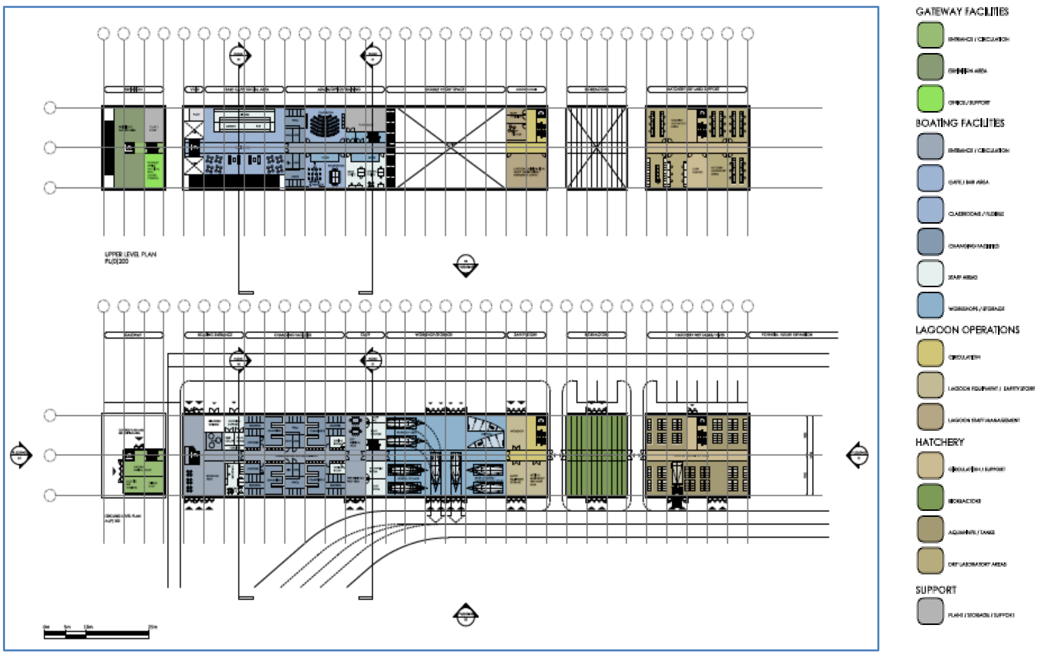


Figure 3. Tidal Lagoon Swansea Bay – Watersports Centre and Hatchery Floorplan. (Source: Faulkner Brown, 2014)

As potentially the first tidal power generation lagoon in the world the development of mariculture within the impoundment will be developing best practice to address novel challenges and to capitalize on new opportunities offered by a more controlled environment. The long-term strategic aim of TLSB's parent company is to develop further such lagoons in the UK and there is interest elsewhere in the world such as India and China.

The lessons learned by mariculture businesses operating in the TLSB will help the future development of mariculture in subsequent lagoons. The options for aquaculture within enclosed waterbodies, and lagoons in particular are reviewed in the other final report for this study entitled 'Aquaculture Opportunities for Enclosed Marine Water Bodies – Tidal Lagoon Swansea Bay Case Study' (Ref: Syvret and Woolmer, 2017).

The Mumbles Oyster Company Ltd. are currently carrying out practical native oyster restoration aquaculture techniques on their site in Swansea Bay and are using this experience to assist native oyster restoration in other areas. They have advised the Blue Marine Foundation in the development of their "vision" for the restoration of the native oyster in the Solent and elsewhere. One of the key shortfalls identified during this work was the lack of co-ordination for native oyster restoration and the vital need for knowledge sharing. Given TLSB's community benefit aim of restoring the native oyster there is an opportunity for the hatchery and associated facilities to form a centre of excellence serving as a focus for knowledge sharing and training both in mariculture and native oyster restoration.

There are many opportunities for research collaborations with R&D institutions and Universities with interests both in mariculture and in native oyster restoration ecology. The Mumbles restoration project has already developed collaborations with researchers from across Europe and the US. Collaborations with conservation charities such as Blue Marine Foundation and with industry bodies such as Seafish could deliver the knowledge sharing aspects of the mariculture and oyster restoration aims while the commercial hatchery and lagoon mariculture would supply the practical knowhow and prerequisite seed oysters.

A commercial-scale shellfish hatchery with strong links to R&D institutions and academic researchers would be a valuable asset for the industry and for restoration practitioners who face many shared challenges beyond those presented by the novel nature of operating in the lagoon.

1.4.4 TLSB Case Study Conclusions

As in 2015 (Ref: Syvret, 2015) the options for this particular site still remain speculative as TLSB await a Governmental decision over whether or not to support TLSB as a pathfinder lagoon project. As a site, TLSB offers many exciting and novel opportunities beyond just a hatchery development due to the integration of visitor, leisure and mariculture around the gateway buildings.

Subject to a full economic assessment, the shellfish hatchery options for this site that could be combined in a number of differing arrangements include the following:

- **Spatting Ponds:** The construction of spatting ponds within the lagoon's eastern wall presents the opportunity for production of spat-on-shell to benefit local aquaculture businesses and also to enable native oyster restoration initiatives to proceed. This could be achieved as a Phase 1 development ahead of any hatchery as permission for the lagoon works, including the spatting ponds, has already been received. Once a hatchery was in operation, production using the remote setting approach would offer another method to help increase production of spat-on-shell.

- **Commercial-scale Hatchery:** The development of a hatchery is an option already described by the TLSB as one of the community benefits to support mariculture and oyster restoration. This current report supports the development of such a facility. The provision of the building and a photobioreactor could potentially make this a flagship facility for helping to grow the local and regional oyster growing industry. There is also scope for such a facility to play a role as a nationally strategic resource.

  Delivery could be achieved in collaboration with commercial partners or industry bodies such as Seafish. TLSB have stated that mariculture operations within the lagoon would need to co-exist with other amenity uses but this would not preclude the eventual development of a commercial-scale hatchery capable of supplying high quality, biosecure seed shellfish to other production areas for both commercial cultivation and restoration efforts.

- **Nursery Site:** The parallel development of nursery capacity associated with the hatchery is likely to be necessary for a commercial operation in order to add value by increasing product seed size before shipment. This could take the form of either suspended FLUPSY type systems or intertidal containment approaches. Clearly there is scope for collaboration with mariculture businesses operating within the lagoon to operate these.

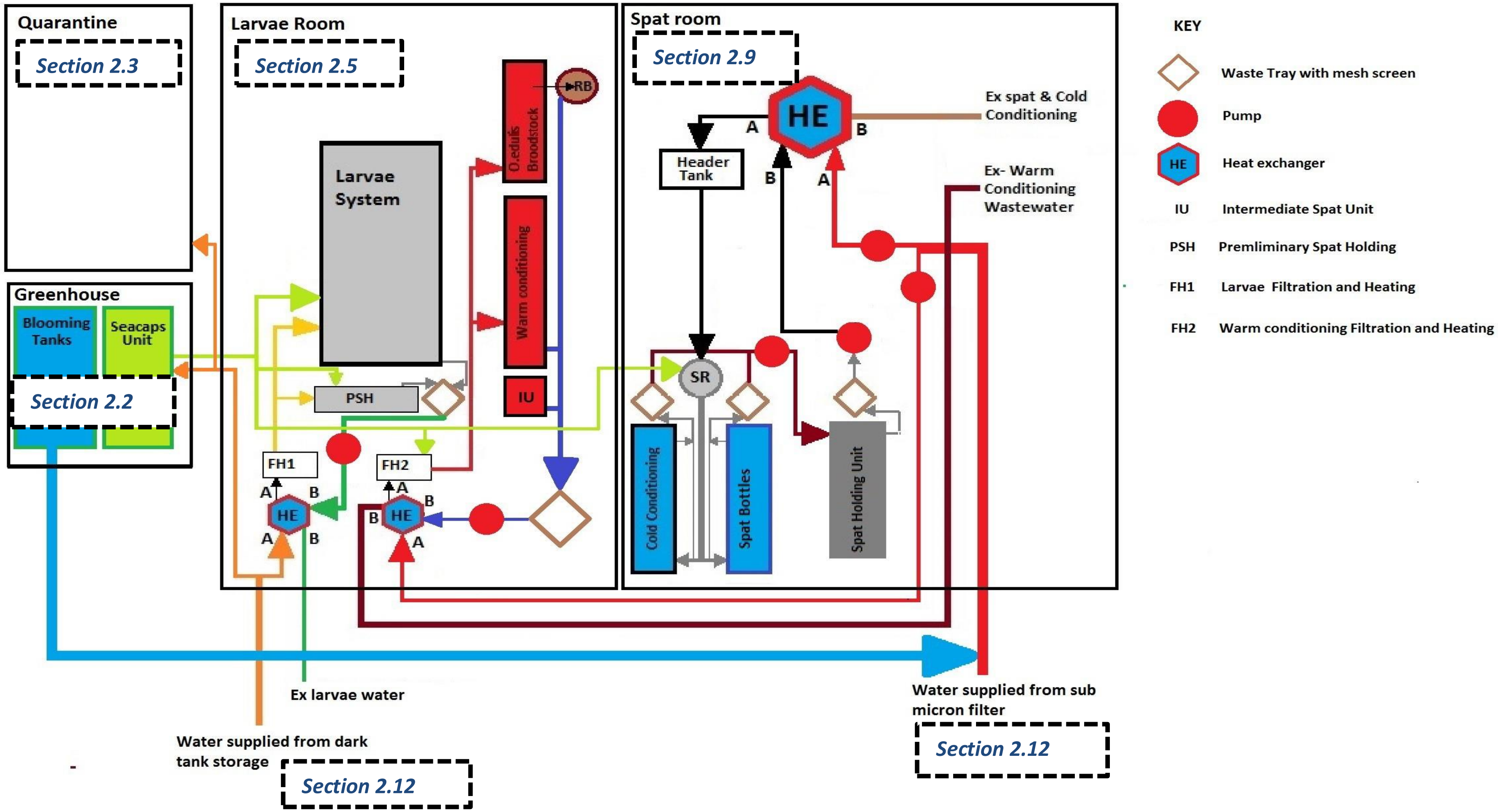
- **Combined Seaweed Seeding Facility/Hatchery:** In the event that seaweed cultivation is undertaken in TLSB, the potential economic savings of shared facilities and staff may make this an economically attractive proposition.

- **Small Volume Depuration:** The addition of a small depuration system in the hatchery building would be valuable for the onsite supply of lagoon grown shellfish to the visitor restaurants and any future retail establishments.

- **Native Oyster/Lagoon Mariculture Centre of Excellence:** Whilst not central to native oyster seed production, an associated development with other delivery organisations could result in important R&D and knowledge sharing spin-offs for a hatchery site and for TLSB.

SECTION 2 – GENERIC SHELLFISH HATCHERY DESIGN – SEASALTER (WHITSTABLE) TEMPLATE

2.1 Hatchery Overview Schematic



2.1.1 Hatchery Space Estimation

Area	Component	Space Requirement	Notes
Hatchery			
	Dark Storage	50 m^2	2 x 100 m^2 tanks (2 m depth)
	Water Treatment Room	15 m^2	Single room, 3 x 5 m
	Hatchery Building	90 m^2	6 x 15 m building with internal divisions for individual systems
	Reception, offices and laboratories	80 m^2	4 x rooms, 4 x 5 m
	Car Park		Adequate space for 10 - 15 vehicles

2.2 Greenhouse Systems

Greenhouse		
Bloom Tanks	400 m^2	4 x tanks (10 x 10 x 1 m)
SEACaps (Phytoplankton production system)	400 m^2	10 x 20 m area situated adjacent to bloom tanks

2.2.1 SeaCAPS Unit

System of 100 continual harvest algae bags; 50 with additional lighting and 50 without. Water supplied from the dark storage tanks (Section 2.15.5). The harvest is pumped to the larvae system and preliminary spat holding bottles, overflow of this is sent to the warm conditioning and the spat reservoir.

The design should also allow the SeaCAPS (or similar microalgae photobioreactors) to be used to inoculate the blooming tanks system.

2.2.2 Blooming Tank System

In total, 4 x 100 m³ square shaped tanks that fall to a single point to be used as a sump to send water to waste for ease of cleaning. They will be harvested by means of a pump with a float switch controlled by a gate valve and a flow meter. Water to be supplied from the sub-micron filter inlet to have a valve to allow control of water level. These tanks should be situated close enough to the SeaCAPS unit (Section 2.2.1) so that they can be inoculated using the system.

2.3 Quarantine

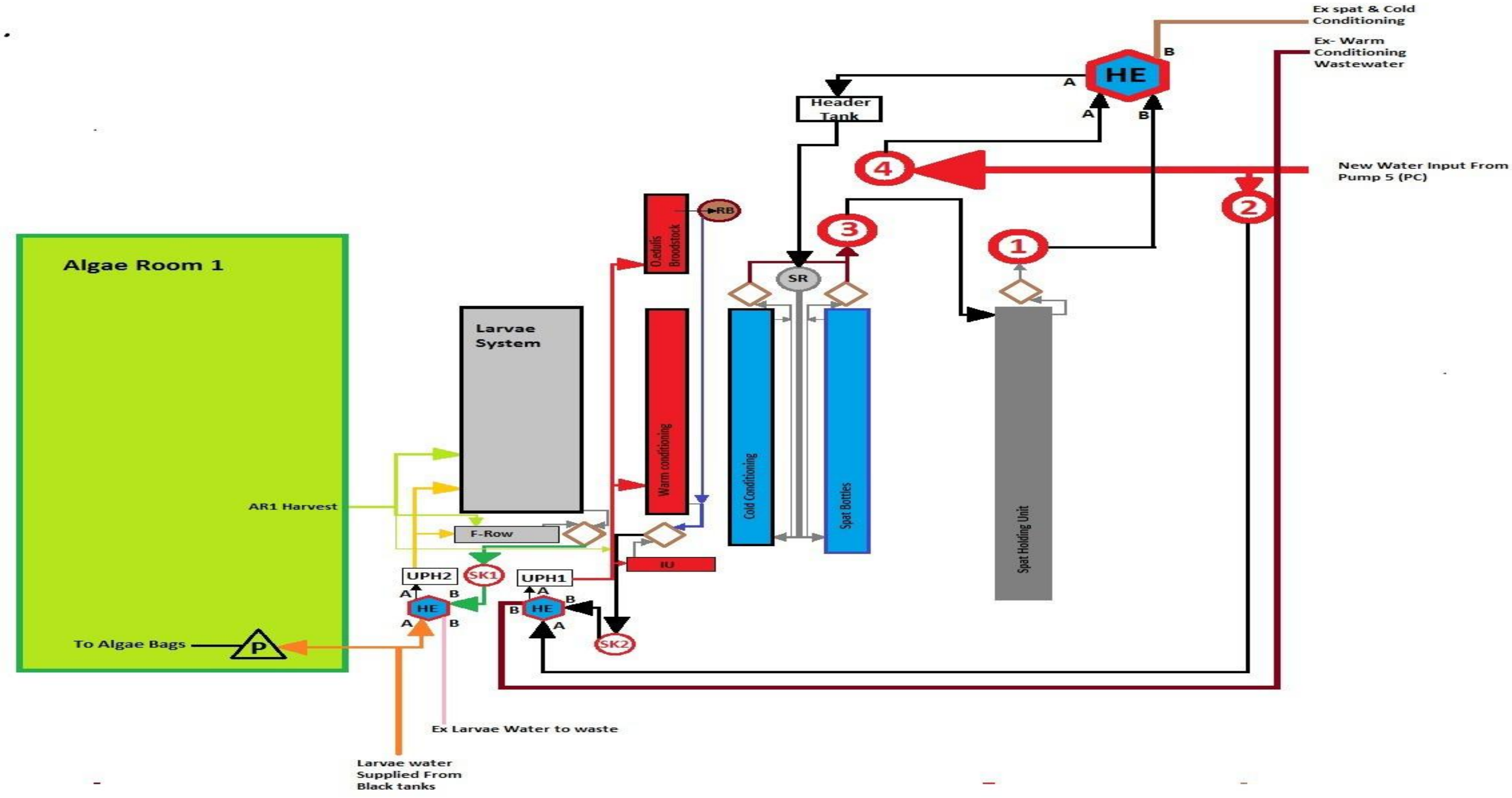
System of large tanks, with sumps for ease of cleaning, filled using water that has come from the ultrafilter and has been dark stored as well, these need not be flow through systems, they can be filled and batch fed from the SeaCAPS unit (Section 2.2.1). Waste water should be sent to general waste discharge after being mechanically screened and UV treated, this will ensure that no pathogenic transmission should occur. This should be a completely separate part of the building with a different entrance, for biosecurity a room in which personal equipment can be stored and a disinfection station for use by personnel upon entry and exit.

A Laboratory (Section 2.3.1) with the necessary equipment to test for various diseases could be a very beneficial addition to this system and would improve the overall efficiency of the quarantine facility.

2.3.1 Laboratory

A laboratory with suitable equipment such as a binocular microscope, invert microscope and stereo microscope, Equipment for analysing water etc. and a flow cytometer. This laboratory will also be used to store the starter cultures and media for start-up and maintenance of main microalgae cultures (see Ref: Laing, 1991 for further details of equipment and cultivation protocols).

2.4 Indoor Systems Overview Schematic



2.4.1 Indoor System Additional Information

Algae Room 1

SeaCAPS algae system (Section 2.2.2), culturing algae to supply the larvae system, with overflow to the conditioning system and intermediate unit. Water is supplied from the supply reservoirs outside. Water supply lines steamed weekly.

Larvae System

A total of 12 flow through units, 6 coned bins to aid with removal of settled spat and six larger volume bins, designed to be able to run as a closed unit or as a flow through unit. Immersion heaters are used in the units to keep the water at 29°, bins are changed on a 24-48 hour basis depending on species, age and density, surfaces of the bin chlorinated whilst drained. Water is supplied from the supply reservoirs outside. Water lines and food lines chlorinated monthly. The water is currently only filtered through a shell filter and briefly protein skimmed. The Seasalter (Whitstable) system is currently being upgraded to include an ultra-mechanical filter removing particles to 0.02µm, biofilter, large protein skimmer and ozoniser followed by ultraviolet steriliser.

UPH – Upstairs Heating Area

Upstairs heating area at Seasalter (Whitstable) consisting of immersion heaters that provide the larvae system and the F-Row (Section 2.4.1.4) with water at 29° and the warm conditioning, and Intermediate Unit with water at 24°. After heating they then pass through a trough which have aerators in and through a 1mm mesh. Currently cleaned once a week and flushed with hydrochloric acid and chlorine monthly.

F-Row

Bottles that hold oyster spat from post metamorphosis to around 800µm with food supplied from the Algae Room 1 harvest. Supply pipe rodded with a brush weekly and flushed with hydrochloric acid and chlorine monthly.

Warm Conditioning

Unit of trays used to hold broodstock pre-spawning, also used to hold post metamorphosed clam spat until they reach 750µm. Food is supplied from the outdoor blooming tanks (Section 2.2.3) the LBS (Section 2.11.2.1) and also the overflow from AR1 (Section 2.4.1.1). Broodstock is washed weekly and clam spat washed daily. Water supply pipes are flushed with hydrochloric acid and chlorine and then pressure washed monthly

Ostrea edulis Broodstock

System of 5 large trays fed with water from the warm conditioning, larvae that are released are taken with the waste water from these trays to the release bin (RB), larvae are kept in this by means of a 105µm banjo mesh which allows water to join the wastewater from the warm conditioning trays. Broodstock is cleaned weekly and the RB drained and chlorinated daily.

IU – Intermediate Unit

System of bottles supplied by the same water as the warm conditioning used to hold oyster spat ranging from 800µm to 1600µm, food supplied from the outdoor blooming tanks (Section 2.2.3), LBS (Section 2.11.2.1) and overflow AR1(Section 2.4.1.1) the wastewater joins the warm conditioning waste. Supply lines get rodded with a brush weekly and flushed with hydrochloric acid and chlorine monthly.

Cold Conditioning

System of trays used to hold broodstock not currently being ripened, it also holds clam spat ranging from 750µm to 1000µm. Water is supplied from SR food being added from the outdoor blooming tanks (Section 2.2.3) and the LBS (Section 2.11.2.1) wastewater joins the spat bottle wastewater. Water supply pipes are flushed with hydrochloric acid and chlorine and then pressure washed monthly.

Spat Bottles

System of bottles used to hold oyster spat ranging from 1.6mm to 2mm, water is supplied from the spat bottle reservoir (SR) with food being added from the outdoor blooming tanks (Section 2.2.3) and the LBS (Section 2.11.2.1). Waste water joins the cold conditioning waste water. Water supply pipes flushed with hydrochloric acid and chlorine and then pressure washed monthly.

Header Tank

Tank elevated above the height of the spat bottles and cold conditioning to allow them to be gravity fed, water is heated to around 18° in the winter and slightly greater during the summer months as the outdoor pond temperatures are higher. Water is passed through a trough where it is aerated and then it fills the spat bottle reservoir (SR), any overflow in the reservoir is directed to the spat holding unit. This header tank is cleaned weekly and pressure washed monthly, the SR is flushed with hydrochloric acid and chlorine monthly.2.4.1.11 Spat Holding unit

System of trays used to hold oyster spat from 2-3mm and clam spat from 1-1.6mm. Water is supplied from the waste water of the spat bottles and cold conditioning units (Section 2.4.1.8). Algae is supplied from the outdoor blooming tanks (Section 2.2.3) and the LBS (Section 2.11.2.1). Stock is cleaned twice weekly and the holding unit itself is drained and rinsed weekly, and deep cleaned monthly.

Heat Exchangers

Heat exchangers, used to recover heat that would otherwise be lost with waste water, ‘A’ and ‘B’ indicate the two separate pathways through these.

Red Circles

Pumps used to transport water between systems, number according to the socket name they are plugged into. Filter meshes changed monthly, pumps are flushed.

Brown Diamonds

Waste trays, they each contain a mesh which is cleaned when needed, usually daily, the trays themselves are cleaned weekly and flushed with hydrochloric acid and chlorine monthly.

2.5 Larvae Room Systems

2.5.1 Larvae Systems

Image 1 and 2

Series of 100 larvae bins; 50 regular 150 litre and 50 steep coned 120 litre. Each bin has an outlet from the SeaCAPS (Section 2.2.2) harvest distribution manifold, and an outlet from the larvae filtration and heating units. The flow of food and water to each bin can be regulated with glass capillaries, they are aerated from the bottom which doubles up as a drainage point. The larvae are retained by means of a double-sided mesh which allows waste to be disposed of by gravity to a tray where it is screened and treated with UV then discharged to waste. Each bin must have an electrical outlet for an immersion heater, and a variety of meshes must be kept to allow the bins to undergo a water change to reduce the build-up of metabolic waste. The total volume of water required for the larvae system is $1m^3h^{-1}$.

Image 1

Image 2

2.5.2 Spawning Bench

Water supplied from the larvae filtration unit with the ability to also be supplied from warm conditioning (Section 2.4.1.5). The spawning bench consists of a tray with a black bottom, and a series of isolation pots to separate spawning broodstock, and collect the sperm/ova. The wastewater is discharged via the larvae waste bin.

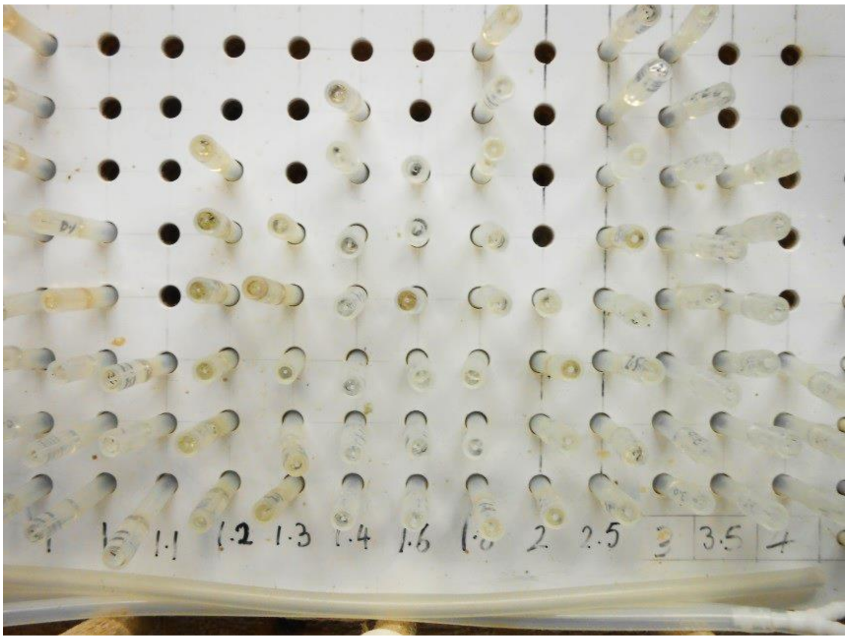
2.5.3 Work Bench

A wet bench for handling larvae and for ease of access to meshes and capillaries, a separate dry bench is required for microscopy work. Larvae are screened and given treatments at this time, the bench should have a larvae water outlet to allow larvae to be washed, this should be gravity fed only. There should be both an acid bath and a disinfection bath to treat all larvae equipment.

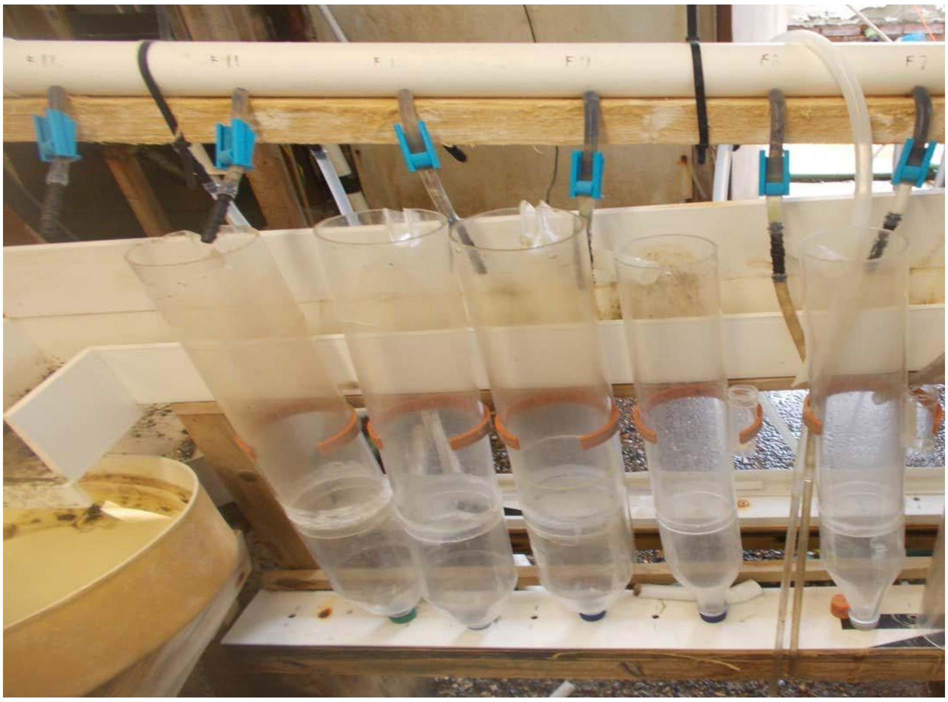
Screens for washing larvae

Banjo filter

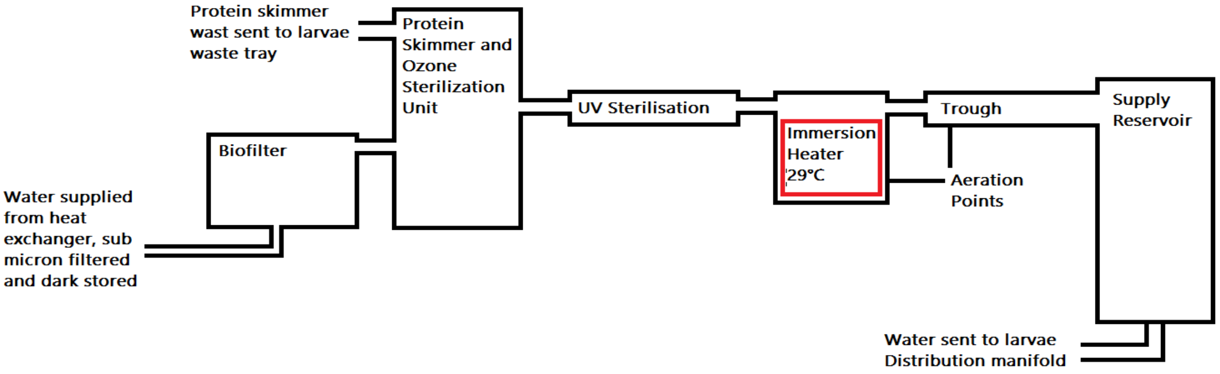
Rack of assorted capillaries for controlling feed and water flow to the larvae.



Preliminary spat holding for newly metamorphosed oyster spat, kept at 29°C and fed from the SeaCAPS unit (Section 2.2.2), these are upwelling systems using glass rods.



2.6 Larvae Filtration and Heating Unit



The water to this system is sourced from the dark storage tanks (Section 2.15.5), the water would have been sub-micron filtered before going into the dark storage tanks. The water is biologically filtered in an upwelling biofilter and sent to a protein skimmer and ozoniser as shown. The water is then gravity fed to the UV sterilisation units where it then passes to a trough which allows some extra retention time and also aerates the water, this will all be kept dark to reduce any risk of fouling by autotrophic organisms. This will fill a reservoir designed to increase the time between sterilisation and use, this reservoir will supply the larvae distribution manifold built from glass and silicon so that it can be steamed. This should be situated upstairs to allow the larvae system to be gravity fed.

2.7 Warm Conditioning System

Image 1

The warm conditioning unit will consist of 40 trays which have a drainage point at the bottom and can be put into an upwelling mode to hold newly metamorphosed clam spat. Temperature is kept at around 22°C. Fed from the blooming tanks and the SeaCAPS unit (Section 2.2.2).

Images 2 and 3

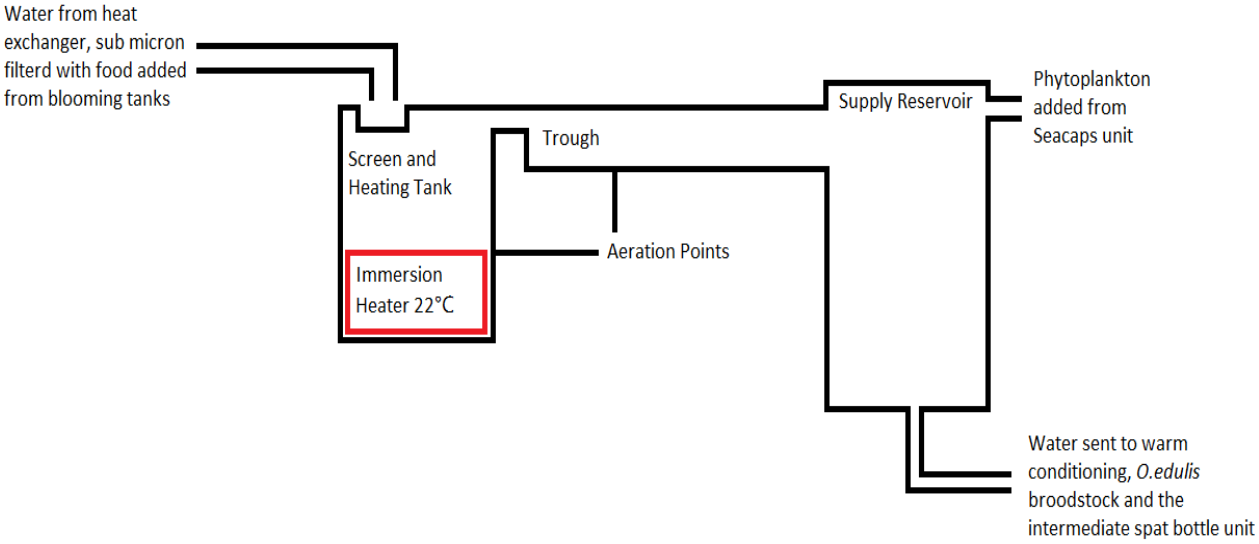
Ostrea edulis conditioning system, consists of 5 conical bins each holding 100 *O. edulis* broodstock, the wastewater from these enters a 6th bin which retains the larvae by means of a double-sided mesh.

Image 4

Intermediate spat unit, this is used for spat that leaves the preliminary spat unit, kept at 22°C

2.8 Conditioning Heating Unit

Situated upstairs at the Seasalter (Whitstable) site, this is used to screen the water arriving from the blooming tanks and the submicron filter, also has the ability to pump water from the spatting ponds (Section 2.15.1) to the main spat water supply when outdoor phytoplankton levels are suitable for food. Water is passed through a mesh screen and then a tank which heats the water to 22°C, after heating it is passed to a trough with aeration points and then allowed to fall into a supply reservoir where it is the gravity fed to the warm conditioning unit (Section 2.7), the *O. edulis* broodstock and the intermediate spat bottles (Section 2.4.1.9).

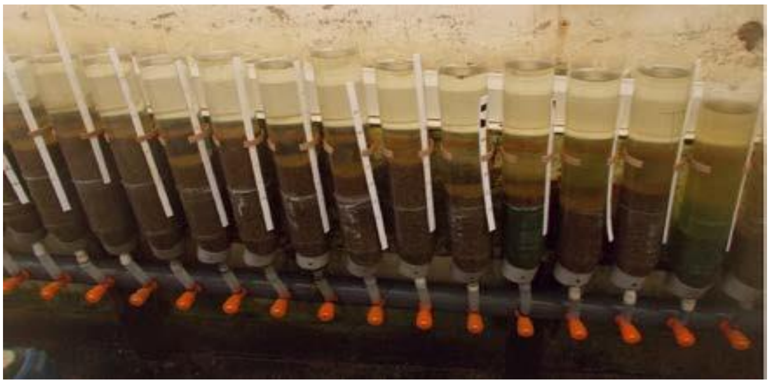


2.9 Spat Room Systems

2.9.1 Cold Conditioning System

System of trays used to hold broodstock and clam spat. Phytoplankton provided from the blooming tanks as well as the SeaCAPS unit (Section 2.2.2). Water runs to a waste tray that screens the water before it is sent to the spat holding unit.

2.9.2 Spat Bottle System



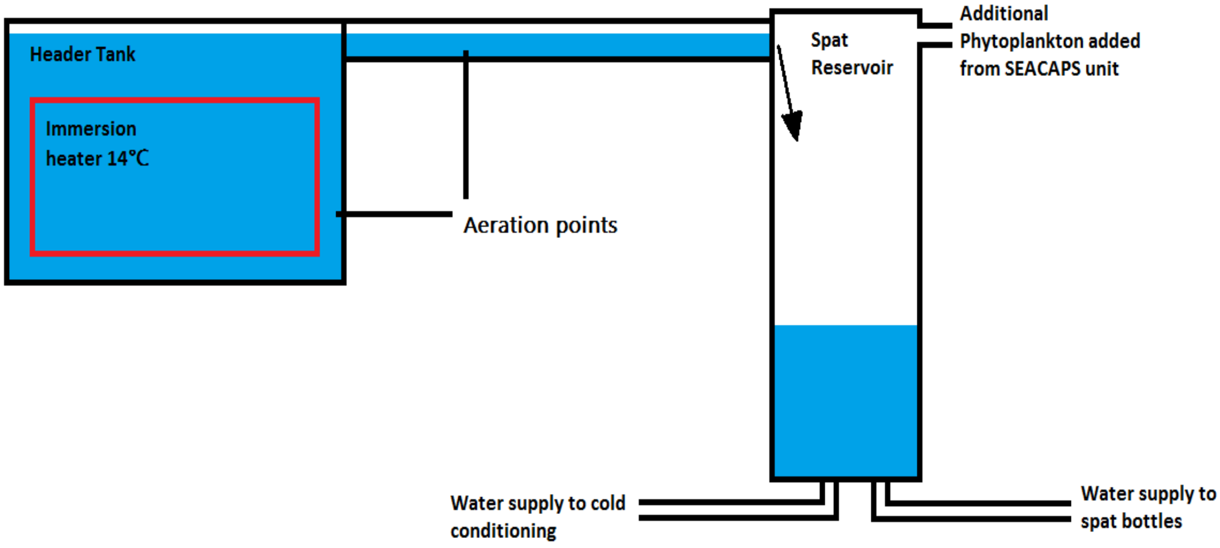
System of bottles similar to that of the preliminary and intermediate units, however a much greater flow is achieved by attaching an inlet to the bottom of the bottles, spat are retained by means of marble. Waste is sent to a tray which screens the waste before sending it to the spat holding unit.

2.9.3 Spat Holding Unit or Micro Nursery

System of upwelling trays suspended in a reservoir used for spat of all species and removes the majority of phytoplankton so water returning to the spatting ponds (Section 2.15.1) can be bloomed.

2.10 Header Tank and Spat Reservoir

Situated upstairs at the Seasalter (Whitstable) site to allow the cold conditioning system (Section 2.9.1) and spat bottles (Section 2.9.2) to be gravity fed, aerators to be placed in the header tank, between the header tank and the spat reservoir there will be a trough with additional aeration points. The spat reservoir is used to hold water for the spat bottles and cold conditioning systems, the water from the trough so that the water can be further oxygenated, it will have additional algae added from the SeaCAPS unit (Section 2.2.1).



2.10.1 Heat Exchangers

Units used to extract and re-use heat that would otherwise be sent to waste.

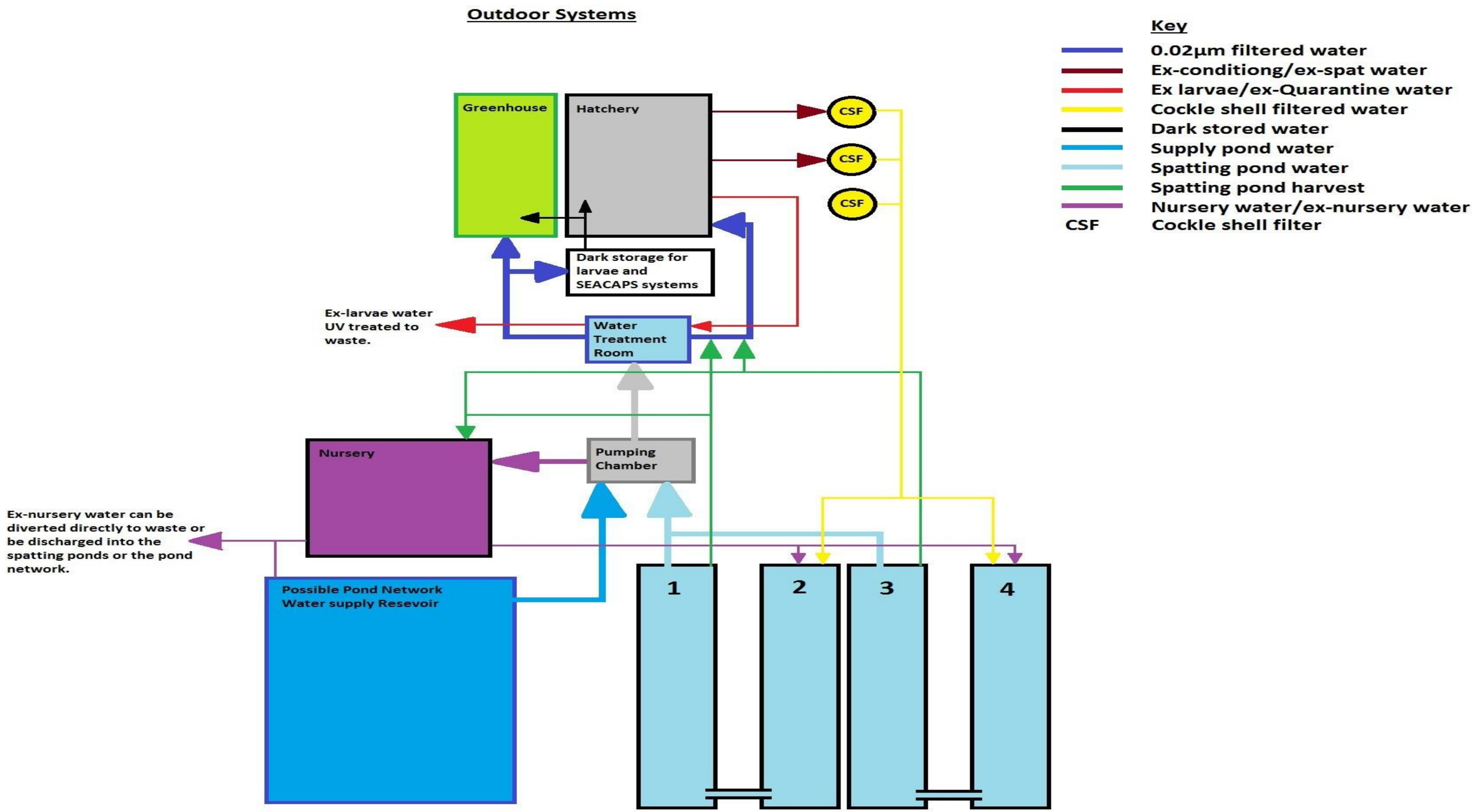
2.10.2 Waste Tray

Tray used to collect water and send it to the pump, built so that it can house a mesh used to screen water.

2.10.3 Pump

Water pump used to move water between systems.

2.11 Outdoor Systems Overview Schematic



2.12 Space Estimation

Nursery	Component	Area	Notes
	Nursery	100 m^2	10 x 10 m
	Nursery Ponds	30,000 m^2	3 x 3 hectare ponds at least 2 m deep

2.12.1 Outdoor System Additional Information

LBS – Large Bag System

Large Bag System, currently comprised of 10 large bags, these can be used to inoculate the Blooming tank by means of a gutter system to BT1 (Section 2.11.2.2) and a pipe attached to the LBS harvest pump for BT2, BT3, BT4 (Section 2.11.2.2).

BT

These are four open top tanks and hold approximately 30m^3 harvesting approximately 500-3,000 L h^{-1} and join the hatchery Intake at two Points BT1, BT2 and the LBS (Section 2.11.2.1) harvest (when not inoculating) join the hatchery at the western end of the main building at Seasalter (Whitstable). BT3 and BT4 join on the eastern end of the main building.

These are primarily filled using water from CS1 which is comprised of ex-warm conditioning water (Section 2.7).

DE – Diatomaceous Earth Filter

This is the diatomaceous earth filter (DE) used to fill BT1 and BT2 (Section 2.11.2.2). When one of these tanks is cleaned, the filter should also be cleaned and the media replaced. The filter and media can then be used to refill that tank.

CSF – Cockle Shell Filters

At Seasalter (Whitstable), these are the cockle shell filters (CSF or similar) and they are mainly used as a mechanical filter but do also act as a biofilter. There are in total four of these, CSF1 supplies the diatomaceous earth filter (DE -Section 2.11.2.3) and is currently supplied with water from the spat room (Section 2.9), and cold conditioning (Section 2.9.1). CSF2 is currently not in use at Seasalter (Whitstable), but is ready to be used when one of the other two shell filters needs to be cleaned. CSF3 is used to supply the 7 large black storage units that make up the supply reservoirs, it is supplied with water from the warm conditioning unit (Section 2.7). CSF4 is currently not in use at Seasalter (Whitstable). Any excess water which cannot enter any of the shell filters is sent to R1D (Section 2.13.1) by means of a float valve.

Supply Reservoirs

Approximately 7 large storage units used to supply the larvae system and both AR1 (Section 2.4.1.1) and the LBS (Section 2.11.2.1), these tanks are cleaned in series so that one tank gets cleaned every four weeks.

DESMI Pump

Large pump used to supply North and South Circuit (Section 2.14) at Seasalter (Whitstable) with new seawater, capacity 3,000 l/min.

Large Nursery

Currently not in use at Seasalter (Whitstable). Supplied by means of a Chabot pump in the pumping chamber and can be discharged to the North or South Circuit (Section 2.14) and directly to the discharge

Small Nursery

At Seasalter (Whitstable) this system is currently holding broodstock and 1.6mm+ *M. mercenaria*, 2mm + *C. gigas* and 3mm + *O. edulis*, supplied by means of a Chabot pump in the pumping chamber and can be discharged to the North or South Circuit (Section 2.14) and directly to the discharge channel.

R1D – Rush 1 Supply Tank and Pipe

Rush 1 supply tank and pipe (R1D), this is supplied by water diverted from the shell filters (Section 2.11.2.4) and so is mixed ex-warm conditioning water (Section 2.7) and ex-spat room (Section 2.9) and cold conditioning water (Section 2.8). At Seasalter (Whitstable) the supply can be diverted into the South Circuit (Section 2.14) by removing a dust cap on the pipe leading to Rush 1. This supply can also be diverted to the nursery when Rush 1 is being drained.

North and South Circuit

At Seasalter (Whitstable) this is a large circuit of ponds used to hold large volumes of water which supply the intake channel, both circuits have the ability to be filled via the DESMI pump (Section 2.10.2.6) or tidally. Each circuit has 3 sub-ponds which can be isolated to bloom with phytoplankton.

Pumping Chamber

Used to supply pump 5 which feeds the hatchery and the Chabot pumps which supply the nursery. The pumping chamber can be fed by the intake channel and North Circuit (Section 2.14) when the intake channel is cleared of macroalgae.

Intake Channel

Used to supply the pumping chamber. At Seasalter (Shellfish) both the North and South Circuit (Section 2.14) can be used to supply the Intake Channel.

Rush 1

Pond used to supply the intake channel with phytoplankton by means of a large pipe raised above the South Circuit (Section 2.14) and can also be pumped to the pumping chamber directly. At Seasalter (Whitstable) the pumping chamber is supplied by the Rush 1 divert tank (Section 2.13.1) and can also be supplied by water from the South Circuit (Section 2.14).

2.13 Outdoor Systems

Spatting Ponds	Component	Area	Notes
	4 x Spatting Ponds	Variable	1 million litres each, area dependant on shape and design

2.13.1 Spatting Ponds – Space Estimation and Overview

These are 4 ponds each of 1000m³ with driveways between 1 and 2 and 3 and 4. At Seasalter (Whitstable) these ponds are aligned north to south and used as an extensive method of gathering spat. There will be a variety of ways to fill these ponds. They should be directly fed from a water source i.e. sea, lagoon etc. as well as waste water from the hatchery clarified by a cockle shell filter (Section 2.15.6). Ex-nursery water should be able to be sent here also. The spatting ponds can supply the hatchery with water, or be harvested as a microalgae culture. They could also be used as a nursery. The spatting ponds should all fall to a sump which can send water directly to waste. There should be a pipe connecting pond 1 and 2 and a pipe connecting 3 and 4

2.13.2 Nursery

System of trays in an upwelling flow design, water to be supplied from either the pond network or spatting ponds (Section 2.15.1) via a large propeller pump pumping 3-4 $m^3\ min^{-1}$ which is situated in the pumping chamber. It is advisable to have 2 propeller pumps in place so a greater flow can be achieved and to be used as backup.

2.13.3 Water Treatment Room

A room containing a 0.02µm filter which has the capacity to supply $25m^3h^{-1}$, $1m^3h^{-1}$ to supply the larvae system (Section 2.5), $8m^3h^{-1}$ for the spat room systems (Section 2.9), $2m^3h^{-1}$ for the warm conditioning unit (Section 2.7), the remaining $14m^3h^{-1}$ will supply the greenhouse system (Section 2.2). The waste water from the larvae and quarantine (Section 2.3) will be treated with UV before discharging.

2.13.4 Pumping Chamber

Concrete chamber that can be isolated and drained so that it can be cleaned easily. Water here will be supplied by the pond network (Section 2.14) or spatting ponds (Section 2.15.1), and will be sent to the nursery and water treatment room.

2.13.5 Dark Storage Tanks

A series of black storage tanks that can hold enough water to supply the SeaCAPS unit (Section 2.2.2) and the larvae system for at least 2 days they should be linked in series and gravity fed to each other with a pump to send the water into the hatchery.

2.13.6 Cockle Shell Filter

Cockle shell filters (see also Section 2.11.2.4), made out of a swimming pool and a large quantity of empty cockle shells. A barrel with holes in the bottom and a few stones in it to hold it down is placed in the centre and the outside of it is filled with cockle shells. Water enters via a float check valve and is pumped out from inside the barrel. Two of these shell filters will be run at the same time, they can then be backwashed or manually cleaned but there will always be a third shell filter ready to swap over during cleaning. All filtered water will be sent to the spatting ponds (Section 2.15.1). When in use, a black cover is put over to discourage macroalgae.

SECTION 3 – HATCHERY INFRASTRUCTURE, SERVICES, LICENSING AND PERMISSIONS

3.1 Introduction

Section 3 outlines the main infrastructure and services that would be required in order to site a new hatchery within England or Wales together with an overview of some of the licensing and permissions that would need to be considered.

In reality of course the exact requirements of a hatchery, particularly in terms of quantified services, are impossible to ascertain until an actual site has been chosen and a decision made about what scale of production will be undertaken and whether other operations will be carried out e.g. use of spatting ponds, seaweed seeding, depuration, final processing of shellfish product etc. Section 2 of the current report has therefore been designed to give indicatory service and infrastructure requirements for a UK based commercial-scale hatchery using the facility at Seasalter (Whitstable) as a case study. Given the potential for a new hatchery within the proposed tidal lagoon at Swansea Bay, Section 3 therefore gives a broad overview of the infrastructure and services for that site based on either a western or eastern facility.

3.2 Infrastructure and Services - Tidal Lagoon Swansea Bay Case Study

As described above, Section 3.2 provides a summary of the practical considerations in terms of infrastructure and services that would need to be considered with a multi-species hatchery at Tidal Lagoon Swansea Bay (TLSB). This case study was first reviewed by Syvret (Ref: 2015) in a report entitled '*Local Oyster Hatchery Feasibility Study*. Report for the Mumbles Oyster Company Ltd. and Swansea FLAG' and has been updated for Section 3 of the current report.

For a general review of how to site, develop and run a shellfish hatchery it is recommended that the reader consult the following:

FAO Fisheries Technical Paper 471 – Hatchery culture of bivalves – A practical manual

http://www.fao.org/docrep/007/y5720e/y5720e00.htm

3.2.1 General Site Selection Considerations

Site selection is a key aspect in determining the success of any type of hatchery development. Of the various environmental site selection criteria that must be considered, the most important is the quality of the seawater which should be of a high quality, correct salinity and free from any forms of microbial or chemical contamination.

Areas subject to periodic harmful algal blooms should also be avoided due to the impacts that their toxins can have both on shellfish and larvae. Profiling of the key environmental variables should be undertaken over an extended time frame to ensure that fluctuations in salinity, temperature, water stratification, pollutants, dissolved oxygen levels etc. are understood.

Ideally a shellfish hatchery should be close to its source of seawater and at a low pumping head as this will help to reduce the overall operational costs. Irrespective of the type of hatchery there will be a need for electrical power, a source of freshwater, a skilled labour force and good communications for transport to and from the site (Ref: Helm and Bourne, 2004). In terms of the space requirement, this will obviously vary between hatchery types but consideration should also be given to any possible future expansion needs.

3.2.2 Seawater at TLSB

The hatchery building as currently proposed is sited directly on the western inner lagoon foreshore and therefore has ready access to seawater entrained within the lagoon. Predictive modelling reported in the TLSB Environmental Statement states that water quality within the lagoon will be of "excellent" quality achieved by the extension of the current sewerage outfall 1.5km seaward to discharge outside of the lagoon walls. Abstraction pipelines directly from the lagoon could be designed and installed during the construction phase of the development. However, as highlighted in Section 1.2.1, in practise it is likely that a hatchery facility would be better placed on the eastern landworks where high quality seawater abstraction would be possible either from the lagoon itself or from the open sea through the use of beach wells placed at the low tide mark. This would also place the hatchery near to the spatting ponds which could be used for large-scale microalgae cultivation. Section 2 of the current report details the overall daily volumes and uses of seawater required to run a commercial hatchery.

The placement of the hatchery near to the spatting ponds was the key recommendation of the current study's Scoping Document and this has been recognised by TLSB who have now proposed plans for a National Aquacentre to the eastern side of the lagoon.

3.2.3 Drainage

Depending on that appropriate consents and permits, waste seawater from a hatchery operation, after appropriate treatment, could be discharged directly back into the sea or lagoon. Obviously, careful consideration will need to be given to whether or not storage of waste water prior to treatment is required, types and scale of disinfection, timing of discharge and number of exit points for discharge water. With careful planning, there is no reason why the discharge water from a hatchery and associated facilities should have any negative impact on overall water quality either within or outside the lagoon.

3.2.4 Access

Vehicle access will presumably be good at this site as it forms part of the gateway development. A well-established road system is in place adjacent to the development including Fabian Way (A483) and links to the M4. Access to the foreshore and lagoon is described by TLSB including jetties for vessels and slipways for vehicles.

3.2.5 Power

Depending on the equipment specification there may be a need to have both single phase and three phase electricity. During the design phase of the hatchery it is vital that the equipment listings specify the expected or desired wattage per individual item and cumulative power needs (see Section 1.3.3). As shellfish are live animals it is essential that there is on-site power generation back-up, such as a generator, that will cut-in automatically in the event of an interruption to power supply. This type of back-up system would need to be monitored and alarmed so that key personnel are alerted in the event of a system failure.

3.3 Biosecurity for Hatcheries

Given the risks posed to native oysters and other native marine species and habitats through potential disease or invasive non-native species introductions it is obviously vital to ensure biosecurity is prioritised at all levels of hatchery and farm operations. Indeed, as described in Section 3.6, it is a requirement for the issue of an APB license that a Biosecurity Measures Plan has been produced and approved by Cefas and that all shellfish movements are recorded.

Awareness of the diseases that can affect the shellfish being farmed is essential. The most significant disease affecting native oysters in the UK is *Bonamia ostreae*, a serious parasitic disease of native oysters for which restrictions on movements are in place. Movements of *O. edulis* in the context of *B. ostreae* can be reasonably undertaken in terms of biosecurity as long as the oyster seed originates from areas which have an equal (or higher) health status as the receiving area. Movements of shellfish from restricted areas, known as Confirmed Designations, within England and Wales will require the permission of the Fish Health Inspectorate (FHI) based at the Cefas Weymouth Laboratory.

3.3.1 Aquatic Animal Health Certification

Recognising that movements of live shellfish for farming can pose a risk of disease transfer, exports of shellfish for farming from England and Wales to the EU must be notified to the FHI at least 5 working days in advance, since they may require a health certificate in which case a physical inspection at the site of origin is required.

Exports to third countries will have to comply with the requirements of the country to which they are being sent, and guidance should be taken from the receiving competent authority. For further information from the FHI on movements of shellfish see the following web-link:

https://www.gov.uk/government/collections/aquatic-animal-health-and-movements-guides

3.4 Hatchery Licensing and Permissions

All hatcheries, irrespective of scales of production, will have some common licensing and permissions requirements. These are described in detail in Section 3.6. There will however be site specific differences in licensing and permissions in terms of seawater abstraction and discharge as well as with regard to planning consent. Resource centres containing depuration plants (see Section 1.4.3) will, under EC Regulation EC 853/2004, require approval by the Local Enforcement Authority.

3.4.1 Aquaculture Production Business Authorisation

Obtaining an APB Authorisation

Under the Aquatic Animal Health (England and Wales) Regulations 2009 all aquaculture production businesses (APB's), including hatchery operations, must be authorised by the competent authority. For England and Wales the competent authority is the Fish Health Inspectorate (FHI) at the Centre for Environment, Fisheries and Aquaculture Science (Cefas).

Applications to establish a new APB, change ownership of an APB or to change use and species at an existing APB can be made by submission to the FHI of a completed Form AW1. This form can also be used to request permission to introduce alien and locally absent species under The Alien and Locally Absent Species in Aquaculture (England and Wales) Regulations 2011.

The information requested by the Form AW1 includes details about the applicant and owner/operator; proposed changes to an existing APB; details of the site to be developed; species to be cultivated; facilities to be utilised; details of entitlement to operate e.g. lease contract. The form can be supplemented with additional information about the proposed aquaculture operation which could include mitigation approaches for any known impacts on that site. The latter is especially relevant where the APB may be located within or near an inshore or offshore European Marine Site (EMS) such as a Special Area of Conservation (SAC), Special Protection Area (SPA), Site of Special Scientific Interest (SSSI) or Marine Conservation Zone (MCZ).

Amendments to Regulation 100 contained within the Conservation of Habitats and Species (Amendment) Regulations 2011 mean that "marine works" (shellfish farm in this case) now includes authorisations for APBs. Therefore, where a proposed shellfish farm will take place within an EMS, the APB authorisation is now subject to the Habitats Regulations Assessment for plans or projects. As such any shellfish farm application in an EMS is now required under Regulation 61 to undergo a Test of Likely Significant Effect (LSE) on the designated features. Therefore, if no other consents are needed, then the FHI as the competent authority must determine whether an appropriate assessment is required, based on information reasonably provided by the applicant, during which they must take into consideration any advice from Natural England and published guidance available from the European Commission. The application can only be consented to if it does not adversely affect the integrity of the EMS, based on the site's conservation objectives.

The general consultation process for APB authorisation is the same for both England and Wales but with different consultees (Mike Gubbins, FHI, pers. comm.). Consultees are granted up to 90 days in which to reply to the consultation process. The consultees used for shellfish sites will include, but are not limited to, the following:

- Food Standards Agency / Cefas Classification and Sanitary Survey teams
- Natural England
- Natural Resources Wales
- The IFCAs
- The Crown Estate
- The Local Authority

Any objections, comments or queries by the consultees will require investigation as part of the APB application process. Before any authorisation of an APB can take place an assessment visit by an FHI Inspector will normally take place. This site visit allows the Inspector an opportunity to follow up on comments by the consultees and the Inspector will normally take this opportunity to discuss with the applicant the detailed conditions of authorisation that the site would be subject to whilst operating as an APB.

Biosecurity Measures Plan

As an integral part of the authorisation process for an APB, the applicant will be required to draw up and have approved a Biosecurity Measures Plan (BMP). This BMP should help to identify disease risks associated with the proposed farm through shellfish movements, site procedures etc. and should then offer risk limitation or mitigation measures in this respect. It would be considered best practice within the BMP, bearing in mind the fact that introductions of non-native species would be illegal, to also consider any non-native or invasive species implications associated with the operation of the shellfish farm e.g. non-native introductions with seed movements.

Guidance and a template for the BMP is available from Cefas. It is recommended that the draft BMP is submitted to the FHI before the site assessment visit by the FHI Inspector. This will then allow the Inspector time to review the BMP and then to offer informed advice to the applicant on finalising the BMP following the site assessment visit.

Following a Form AW1 application, and once a BMP has been approved by the FHI, no LSE has been confirmed (where applicable), a site inspection has been carried out and the consultation process has been finalised then an APB authorisation can be issued.

Surveillance Scheme

Authorised APBs will be assessed for risk in terms of disease prevention and control and will then undergo site visits by Inspectors at predefined intervals. These inspections are designed to help ensure that the APB is operating within its authorisation conditions and as stipulated within the BMP.

Information on designated areas of notifiable diseases is available through Cefas https://www.gov.uk/government/groups/fish-health-inspectorate. It is recommended that this website is reviewed periodically in order to keep up to date with disease occurrences, especially where a hatchery may be involved in bringing shellfish for broodstock etc. in from other areas.

Record Keeping

The authorisation conditions for an APB will state the minimum level of record keeping required in operating a shellfish farm. This will include the following:

- **Movement records;** Cefas will provide a Movement Book, completion of which is considered the minimum level of record keeping in this respect. This Movement Book, or an equivalent electronic format, must be available for inspection at any time. The movements recorded must include all shipments of molluscan shellfish into and out of the mollusc farming area including movements to processing.

- **Mortality records;** The BMP template available from Cefas contains a ‘Biosecurity log book’ template. This minimum level of information should be kept for any stock mortalities and must detail how dead shellfish were disposed of. As with the movement records, these mortality records must be available for immediate inspection and in a format that can be copied for later analysis. It should be noted that any unusual or high mortality levels within farmed shellfish should be reported immediately to the FHI.

- **Annual production and economic data;** Data detailing annual production of shellfish must be submitted annually and is normally either collected during the first site visit of the year or via a postal request, the shellfish producer may also be asked to provide additional economic data related to the business.

SECTION 4 – SPATTING PONDS TO SUPPORT NATIVE OYSTER RESTORATION AND AQUACULTURE GOALS

4.1 Background and Drivers

Support and restoration of the native oyster (*Ostrea edulis*) is central to the biodiversity aims of Tidal Lagoon Swansea Bay. TLSB have committed to building a hatchery with spatting ponds to support a programme of reintroduction of native oysters to Swansea Bay and elsewhere. At present, the Mumbles Oyster Company have oyster beds at Mumbles where they have recently demonstrated the potential for re-establishment of native oyster beds by developing their "Restoration Aquaculture" model (see www.mumblesoystercompany.co.uk). They have however identified that the main barrier for native oyster restoration and associated aquaculture is a guaranteed supply of high quality, disease-free seed (Ref: Syvret, 2015).

Multiple policy and legislative drivers across Wales and Europe have established targets for the restoration of marine species and specifically the native oyster. Native oysters have been identified as one of the Habitats and Species of Principle Importance to Wales. Welsh Government's Marine Biodiversity Task and Finish Group has placed native oysters at the top of their priority list of these species most feasible to restore. This group has identified that development of oyster spatting ponds in Wales are one of the key actions required to enable native oyster restoration work to progress.

There is a growing interest in native oyster restoration and aquaculture in the UK and across Europe. Restoration projects are currently under development or in an active phase in Scotland, the South and East of England and in Germany and the Netherlands. Discussion with stakeholders involved in these projects has highlighted that seed oyster supply is the main constraint in sites considered for restocking for restoration and to enhance wild fisheries.

The development of spatting ponds and supporting facilities alone would address the shared aims of stakeholders and TLSB and enable native oyster restoration and Restoration Aquaculture both locally and nationally. Furthermore, knowledge and best practice developed at the TLSB site could well enable workers in other sites to develop local seed production capacity.

4.2 Native Oyster Reproduction

As protandric hermaphrodites, native oyster are able to change sex, developing when first sexually mature as a male and then alternating up to two times per year for the rest of its life. The native oyster can become sexually mature as a male within a year of settlement.

During reproduction, the female releases her gametes in to the pallial cavity where they are fertilised by sperm released into the water column by male-phase oysters nearby. The larvae are retained in the mantle cavity where they are brooded and develop for a period of 7-10 days. During this time, visual inspection of brooding oysters can reveal the developmental stage of the larvae based on the colour of the spat. Colloquially this is known for the first 3-4 days as "white sick", progressing to "grey sick" during shell formation moving gradually to "black sick" as the gut function increases between days 6-7 until release after 7-10 days depending on water temperature.

In general, a female phase oyster in its 3rd to 4th year may produce > 1,000,000 larvae. Fecundity within the population varies between individuals and across the population between years and is determined by environmental factors such as food availability and temperature.

In the UK, spawning in wild populations generally occurs once the sea water temperature reaches 15^{o}C and will continue over the summer period between May-September and even as late as October.

The free swimming native oyster larvae spend between 10 – 14 days in the plankton where they actively feed on phytoplankton and particulate organic matter. When released, the larvae measure around 190 µm in diameter, and during its time in the plankton it will increase its shell size by 50% to 270 µm.

The larvae actively seek out suitable settlement substrata and show a preference for shell cultch and other hard substrates. Settlement success and metamorphosis has been attributed to temperature and post settlement food availability.

The role of a spatting pond is to provide optimum conditions for this reproductive process to take place and to promote settlement onto spat collectors or shell cultch material for relaying and growing on.

4.3 Overview of Spatting Ponds

Whereas the development of a multispecies shellfish hatchery is a technically complex undertaking, spatting ponds represent a somewhat more agricultural approach to seed oyster production. Oyster ponds have been used since Roman times for aquaculture production and were described by Pliny the Elder (23-79 C.E.) in Baiae (Naples) where oysters are still produced today. The use of spatting ponds to produce native oyster seed to support restocking and regeneration of wild fisheries has been reported in the UK as far back as the 1800's. Lord Montagu of Beaulieu writing in the late 1880's described his efforts over 10 years in developing spatting ponds and documented the variable levels of success he had achieved in rearing spat for restocking purposes (http://plymsea.ac.uk/27/1/Letter_on_oyster_culture.pdf).

An oyster spatting pond functions as an enclosed water body into which ripe broodstock are placed and, post-spawning, supports oyster larvae through maturation until settlement on shell cultch. Compared to hatchery seed production this approach is relatively low tech and may appear agricultural but the correct design of the ponds and specifics of the process are important for success.

There are a range of designs and orientations of native oyster spatting ponds currently in operation in Europe. These include relatively large elongated bunded ponds, symmetrical dug ponds and above ground tank-type ponds (see Figures 4 - 7). In general, these ponds are excavated and waste material used to raise the surrounding ground level or to form bunds. Pond depth from the authors own observations varies between 1-2 m. The pond is lined with either butyl rubber or high density polyethylene (HDPE) membrane liners such as those used in agricultural slurry lagoons.

Water supply and flow control varies between sites but in general there is a requirement for adequate fresh seawater supply and the ability to control the flow out of the pond. This enables retention of the larvae within the pond during its larval stage and then helps to provide adequate food/nutrient bearing water-flow immediately afterwards.

Figure 4. Example of an elongated 7 x 70 m spatting pond at Seasalter Shellfish (Whitstable) Ltd.

Figure 5. Extensive pond development at Seasalter Shellfish (Whitstable) Ltd. These include clam on-growing, oyster nursery, phytoplankton production and spatting ponds.

Figure 6. A 25 x 25 x 1.5 m spatting pond at Carltron Point Hatchery in Ireland. Note the water outlet in far left-hand corner, this arrangement maintains water levels when flow is open.

Figure 7. 25 x 25 x 1.5 m ponds in Denmark

4.4 Nursery Ponds and Phytoplankton Production

Phytoplankton food can be augmented using the spatting pond itself and additional adjacent ponds. Shellfish hatcheries routinely utilise ponds for phytoplankton production and similar methodologies may be used with spatting ponds to help promote growth in newly settled spat (see Figure 8).

Figure 8. France Nassain hatchery with extensive phytoplankton production and nursery pond system

It is possible to use the ponds as a nursery by utilising a floating upweller system (FLUPSY) equipment to enhance the water flow and food availability to the growing seed oyster (see Figure 9). High productivity pond production of phytoplankton can be achieved by the addition of nitrogen sources in the form of urea and silica to promote diatom formation. The small seed oysters are suspended in containers through which enriched water is upwelled. This approach can be applied in open waters but has been successfully utilised in pond nursery.

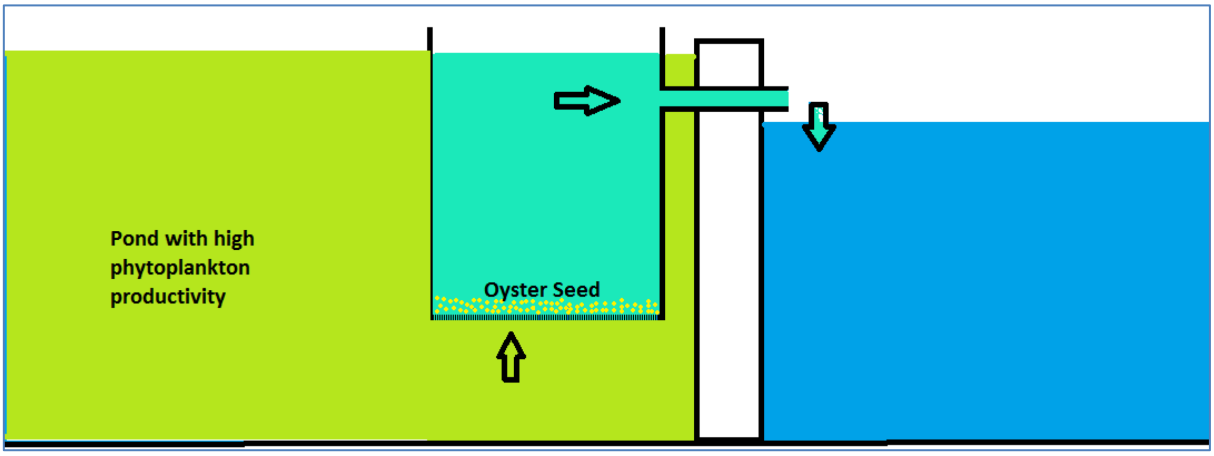


Figure 9. Simplified FLUPSY nursery concept

4.5 Simplified Pond Production Process

Figure 10 provides a simplified pond seed production process. Broodstock conditioning takes place after collection of animals from wild stocks. This collection takes place in late spring when the water temperature is approaching the 15 °C spawning temperature. Animals may be placed directly into the ponds or first into separate tanks where their food supply can be enhanced in order to help increase the quality of the eggs, an important factor in post-metamorphic success.

During this time the cleaned ponds are filled with fresh seawater and environmental factors such as temperature, salinity and phytoplankton levels are monitored.

The broodstock are placed in the ponds in either oyster bags or trays at high densities in order to promote successful fertilisation. Larval monitoring is carried out to detect the release of larvae into the ponds. Larval release is a continual process in native oysters unlike other species which may synchronise their spawning.

Cultch material can placed into the pond in a variety of ways including simply placing shell on the sides and bottom of the ponds or through the use of oyster bags or mussel stockings of shell either suspended down the sides of the pond or on headlines across it. Settlement plates such as coupelles (Chinese hats) may also be used to collect spat.

Settlement is monitored by sampling the shell cultch or settlement plates. When the rate of settlement has tailed off the process is complete and the seed can be moved to a nursery system or to a relaying site.

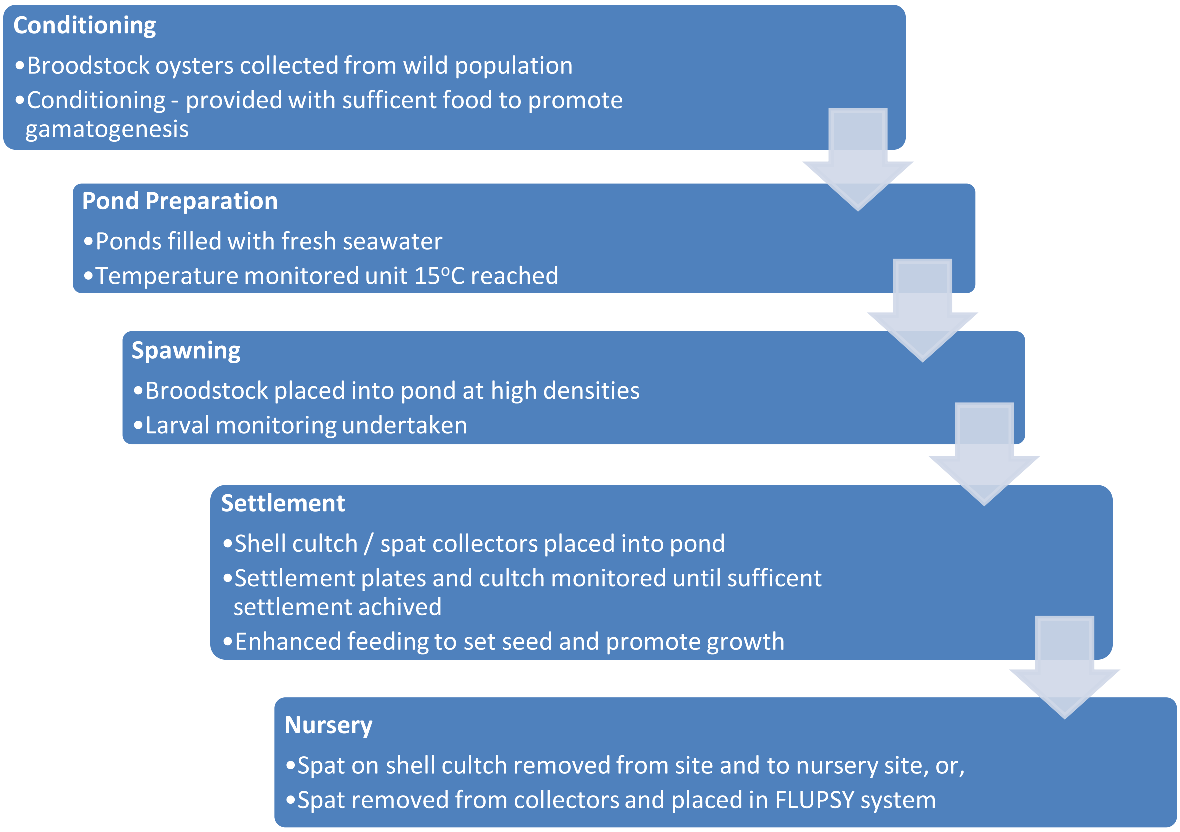


Figure 10: Schematic of simplified pond seed production process

4.6 The Product – Seed-on-shell and Individual Seed

From our experience, a 1000 m^3 spatting pond can produce 3.5 million settled seed–on-shell oysters per cycle which after 6 months results in ~1 million 15 mm seed (see Figure 11). Using shell cultch as a settlement substratum results in the production of seed-on-shell which, although bulky to transport, is ideal for relaying in restoration initiatives. Recent trials have shown that spat-on-shell can perform well in an aquaculture context when grown in suspended oyster baskets.

The use of spat collectors, such as coupelles (see Figure 11), enables the production of individual seed oysters for the aquaculture industry. Once the spat have set on the collector and grown to a size where removal is possible without significant mortality then the seed can be manually or mechanically removed for on-growing.

Figure 11: Developmental stages of spat-on-shell produced in spatting ponds

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APPENDIX 1 – PROJECT ENQUIRY SHEET

This is the project enquiry sheet used by new finfish farm developers to properly understand and develop their project. This version of the sheet is aimed at finfish, and a specific shellfish sheet is being developed, but this gives a good indication of the level of detail required at the early planning stages.

GENERAL DETAILS			
Client		**Contact name**	
Address			
Email		**Skype name**	
Phone no.		**Enquiry date**	
Start date		**Project code**	

PROJECT DELIVERABLES	
STAGE:	
Project remit/goal	
Growth model	
Production plan	
Biological calculations	
System engineering	
Bill of Quantities	
Technical plans	
Construction and Installations	

AREAS TO BE DEVELOPED (i.e. Broodstock, Nursery, Hatchery, Processing,	1	
	2	

Waste water treatment, etc.)	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	

Site Details	*Country*		*Google/ map coordinates*	
	City		*Land available (m^2)*	
	Water source		*Water available (m^3/hr)*	
Notes				
PROJECT DETAILS				

DATA SOURCE:	

Species name	

Water requirements						
	Temp (°C)		TAN (mg/L)		NO_2 (mg/L)	
	NO_3 (mg/L)		TSS (mg/L)		DO_2 (mg/L)	
	TSS (mg/L)		PO_4 (mg/L)		N_2 (mg/L)	
	pH		ppt		CO_2 (mg/L)	
Notes						

Feed	CP %		Lipids %		Sinking/ Neutral/ Floating	
	P %		Total P %			

Notes	

Target growth performance	FCR		SGR		TGC	
	Mortality %					
Notes						

Production plan	*Production schedule*					
	Tonnes fish/ Year		Tonnes caviar/ Year		Batches/ year	
	Start size (g)		End size (g)		Hatchery days	
	Nursery days		Total grow out days		Harvests	
Notes						

Husbandry requirements	Max density (kg/m³)		Avg density (kg/m³)		Grading required	
	Grading at size(s) (g)					
Notes						

Broodstock system	System	Tank (m³)	Tank #	Max density (kg/m³)	Duration (days)	Size in/out (g)	
Notes							

Hatchery system	System	Tank (m³)	Tank #	Max density (kg/m³)	Duration (days)	Size in/out (g)	
Notes							

Nursery system	System	Tank (m^3)	Tank #	Max density (kg/m^3)	Duration (days)	Size in/out (g)	
Notes							

Production system	System	Tank (m^3)	Tank #	Max density (kg/m^3)	Duration (days)	Size in/out (g)	
Notes							

Depuration system	System	Tank (m^3)	Tank #	Max density (kg/m^3)	Duration (days)	Size in/out (g)	
Notes							

Ancillary systems and/ or supporting equipment options (i.e. dewatering systems, heat recovery systems, feeding robots)	
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