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Final report

Floating Upwelling System

Harvest Road Oceans

May 2022

Important disclaimer

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Department of Primary Industries and Regional Development
Gordon Stephenson House
140 William Street
PERTH WA 6000
Telephone: (08) 6551 4444
Website: dpird.wa.gov.au
ABN: 18 951 343 745

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FINAL REPORT

FLOATING UPWELLING SYSTEM

HARVEST ROAD OCEANS

May 2022

LEEUWIN COAST

HARVEST ROAD

Contact information

Harvest Road Oceans Pty Ltd
Mr. Robert Michael
39 Roe Parade, Emu Point WA 6330
Rob.Michael@harvestroad.com

Dept of Primary Industry and Regional Development
Scott Bennett
Aquaculture Research & Development
Primary Industries Development
39 Northside Drive, HILLARYS WA 6025
Scott.Bennett@dpird.wa.gov.au

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Disclaimer

Contents

Preamble

A Floating Upwelling System or FLUPSY is a mechanical system for the culture of seed stock during the nursery stage of commercial bivalve production.

A FLUPSY floats in a waterway and suspends pots with screen mesh bottoms. These pots, known as upwellers, contain juvenile oysters (spat) and allow an upwelling current of water to flow through the upweller. This current of water supplies food and oxygen and removes waste products and carbon dioxide. The upwellers hang on a central gutter serviced by a submerged pump that provides a water height differential between the inside of the gutter and the outside environment, this drives the water flow.

A prototype FLUPSY was designed, constructed, and supplied in 2021/22 by the Western Australian Department of Primary Industries and Regional Development (DPIRD) to Harvest Road Oceans (HRO) for commercial trial. The trial was undertaken at HRO's farm site at Emu Point, Albany and supported by DPIRD's aquaculture research and development team, with rock oyster spat (*Saccostrea glomerata*) supplied by the Albany Shellfish Hatchery.

Currently HRO undertake nursery operations at the intertidal lease area of the Albany farm. Oysters in the size bracket of 2.38mm to 6.35mm are kept in 1000µm mesh inserts fitted to Hexcyl baskets and hung on suspended intertidal lines, followed by trays fitted with 2mm mesh and suspended on intertidal rails. The operational implications and spat performance in the FLUPSY are the two main factors being considered in this early trial.

It must be noted that this is a preliminary trial. The data gathered from this trial gives a starting point for the determination of more focused and detailed work to determine more accurate and definitive operational parameters for the FLUPSY.

The FLUPSY

DPIRD staff transported the FLUPSY from Hillarys Boat Harbour to Albany where assembly was undertaken, including

1 *DPIRD technical staff deliver and assemble the FLUPSY.*



modifications to adjust the height and buoyancy of the unit to allow the gutter to hang at the appropriate water level and installatin of the upwellers. The upwellers were fitted with 1000µm and 1440µm screens.

2 Left- Completed FLUPSY at "C" jetty. Middle- FLUPSY pot showing the screen bottom. Right- Spare pump.

Trial

Commencing on 9/2/22 and concluding on 22/3/22, the first trial was undertaken at Emu Point in pen 4 on "C" Jetty. The stock of spat available governed the densities and number of replicates applied in the trial. Where quantities allowed, the grades of spat were split into high- and low-density treatments, with two replicates of each. Where the quantity did not allow a split, the grades of spat were stocked into a single pot as a low- or high-density treatment depending on the number, with no replication.

Table 1 Stock supplied from the hatchery.

Grade	Volume (ml)	Weight (g)	Total number
2.38	3421	5140	797,471
3.0	655	936	95,191
3.25	2969	4200	316,680
4.0	1542	2065	79,172
5.0	1400	731	15,241
6.35	100	141	1,441

3 Left- Weighing the spat to stock the upwellers for the trial. Right- Upwellers ready to deploy to the FLUPSY.

Table 2 Trial Stocking regime.

Grade	Density	Number of replicates	Weight per replicate (g)	Number per replicate
2.38	Low	2	857	132,912
2.38	High	2	1,713	265,824
3.0	Low	1	936	95,191
3.25	Low	2	700	52,780
3.25	High	2	1,400	105,560
4.0	High	1	2,065	79,172
5.0	Low	1	731	15,241
6.35	Low	1	141	1,441
3-4	Low	2	997	51,528
3-4	High	2	1,993	103,055
3-4	Standard	12	193	10,000

Assessment of the FLUPSY focused on.

- Growth of the stock.
- Optimum operational stocking density.
- Any noticeable impacts on spat shape.
- Maintenance, labor, and routine work requirement.
- How much fouling the structure attracted.
- What water flow rates are achievable through the upwellers.

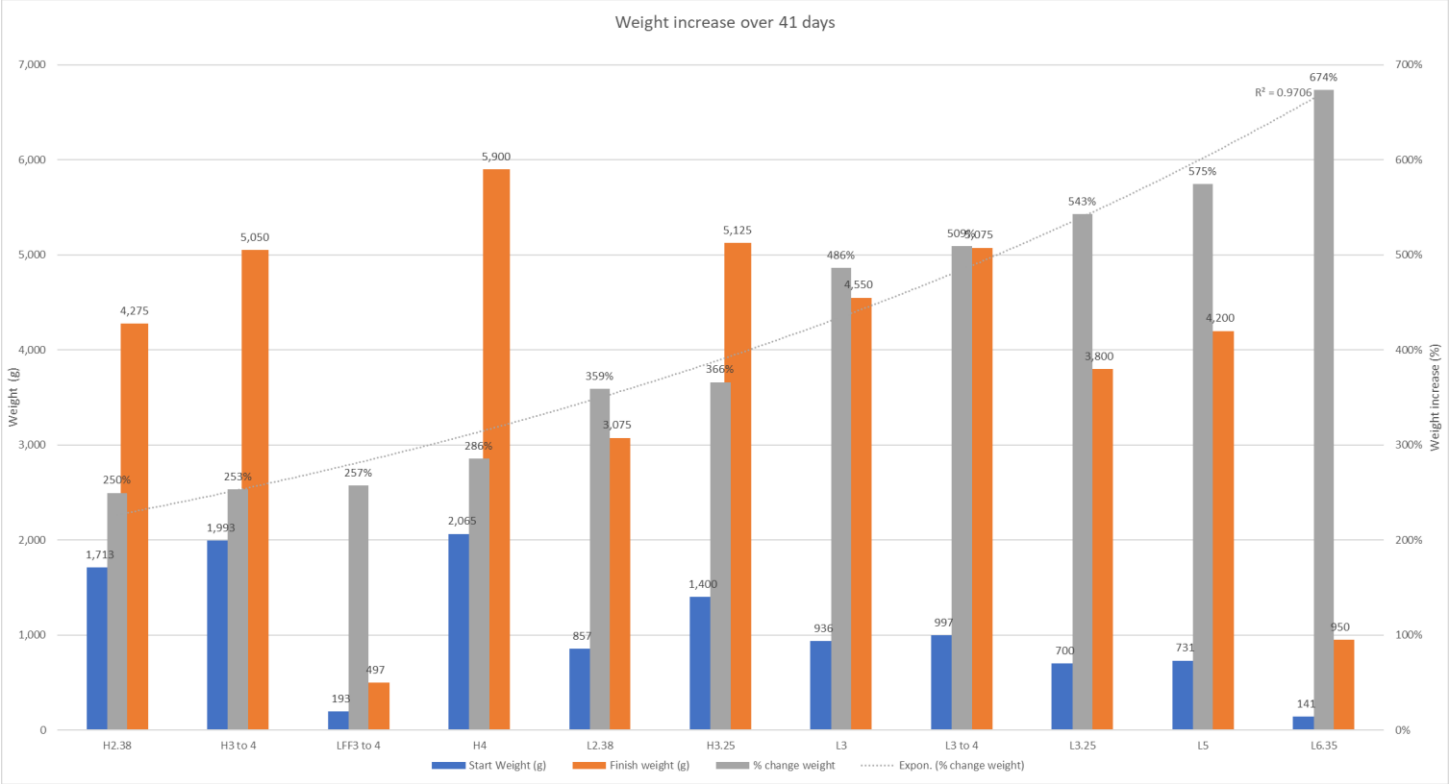
Results

Spat performance and growth

Table 3 Results of the 41-day trial period.

Density	Start grade	Date	Start Weight (g)	Start Density (g/m^2)	Date	Finish weight (g)	Finish Density (g/m^2)	% change weight
High	**H2.38**	9/02/2022	1,713	11,863	22/03/2022	4,275	29,605	250%
High	**H3 to 4**	9/02/2022	1,993	13,802	22/03/2022	5,050	34,972	253%
Flip farm standard	**LFF3 to 4**	9/02/2022	193		22/03/2022	497		257%
High	**H4**	9/02/2022	2,065	14,301	22/03/2022	5,900	40,859	286%
Low	**L2.38**	9/02/2022	857	5,935	22/03/2022	3,075	21,295	359%
High	**H3.25**	9/02/2022	1,400	9,695	22/03/2022	5,125	35,492	366%
Low	**L3**	9/02/2022	936	6,482	22/03/2022	4,550	31,510	486%
Low	**L3 to 4**	9/02/2022	997	6,904	22/03/2022	5,075	35,145	509%
Low	**L3.25**	9/02/2022	700	4,848	22/03/2022	3,800	26,316	543%
Low	**L5**	9/02/2022	731	5,062	22/03/2022	4,200	29,086	575%
Low	**L6.35**	9/02/2022	141	976	22/03/2022	950	6,579	674%

4 Results of the 41-day trial period.



Operational stocking density

A drop in spat performance can be seen across the treatments. Using this information, to form an operational guide, an arbitrary determination has been made designating 1000g to be a low stocking density and 2000g to be a high stocking density. Using this, a stocking guide has been determined.

Table 4 Stocking guide.

Count data		***Number per pot***		***Total FLUPSY stocking capacity at each grade (30 pots)***	
Grade	Count/g	Low density (1000g/pot)	High denisty (2000g/pot)	Low density (1000g/pot)	High denisty (2000g/pot)
2.38	155	155,150	310,300	4,654,500	9,309,000
3.0	87	87,000	174,000	2,610,000	5,220,000
3.25	75	75,400	150,800	2,262,000	4,524,000
4.0	36	35,517	71,033	1,065,500	2,131,000
5.0	21	20,850	41,700	625,500	1,251,000
6.35	10	10,295	20,590	308,850	617,700

Spat shape, colour and appearance

The new shell growth and shape of the oysters held in the FLUPSY system presented as a thin frill with a consistently well-formed cup. The colour of the oysters changed through the trial from a pale or straw colour, typical of indoor land-based systems, to a darker more pigmented colour, typical of oysters cultured in outdoor systems with access to wild food. The oysters did not attach to the mesh

or walls of the upwellers, nor did they grow into each other and form “doubles”. When compared to oysters cultured in inserts or trays the shape and general appearance of the oysters was considered desirable and of a high quality.

5 Left- Tray reared oysters with uneven and flat growth adhered to the mesh and each other. Middle- FLUPSY reared oysters with a well-formed cup. Right- Oyster grown in inserts showing a large size variation.

Water Quality

Throughout the trial temperature and salinity ranged from 20.3 to 22.1^{o}C and 33 to 36‰ respectively. The dissolved oxygen levels ranged from 76 to 99% saturation outside the upwellers and were consistently 1 to 2% of saturation lower inside the upwellers.

Food availability

The specific food density at the FLUPSY location is not known. However, data collected for WASQAP management at two sites in Oyster Harbor, adjacent to the “C” jetty, gives indicative data on algae cell density and food availability. This excludes other food sources such as bacteria, zooplankton and organics that may be contributing to the diet.

Table 5 Dalcon environmental WASQAP results for phytoplankton.

Date	***OHA1** Phyto ρ (Cells/ml)*	***OHC7** Phyto ρ (Cells/ml)*
17/01/2022	201.05	65.95
8/02/2022	102.02	73.22
21/02/2022	19.26	36.62
8/03/2022	6.42	2245.15
21/03/2022	227.80	74.81
11/04/2022	168.53	287.34

Operational performance

Day to day operation routine work

The FLUPSY and the spat contained in it was serviced between 07:00 and 09:00 Mondays, Wednesdays, and Fridays. This included: measurement of water temperature, salinity, and oxygen saturation inside and outside of the upwellers; removing the upwellers from the water and hosing with fresh water to clean the pot sides, the mesh floor and the spat themselves before returning them to the water; brooming the central gutter and any surfaces that showed a buildup of fouling; noting observations made and filling in the data sheet; and resetting the pump speed and checking valve settings.

Floatation and buoyancy

During normal operation the height differential between the internal gutter water level and external water level drives the water flow through the upwellers. During the assembly process a portion of the floatation had to be removed to get the gutter to sit low enough in the water to allow for normal operation. If the gutter becomes evacuated its buoyancy increases and the FLUPSY rises in the water, and this reduces water flow through the upwellers. In extreme examples it stops altogether. In the current configuration of floatation, the FLUPSY is quite sensitive to weight distribution. Keeping the FLUPSY low in the water is important to maintain water flow through the upwellers, however, this leads to a situation where the FLUPSY sinks during cleaning when the upwellers are out of the water and up on the walkway.

6 Central gutter showing maximum flow through the upwellers.

Pump speed and water flow

Stocking capacity is in part a function of water flow through the upwellers. The pump evacuates the gutter and gravity drives the flow of water through the upwellers. Increasing the pump speed caused the buoyant gutter to raise the FLUPSY out of the water and stop the flow. The pump speed needed to be balanced against the weight to maintain a consistent flow of water through the upwellers.

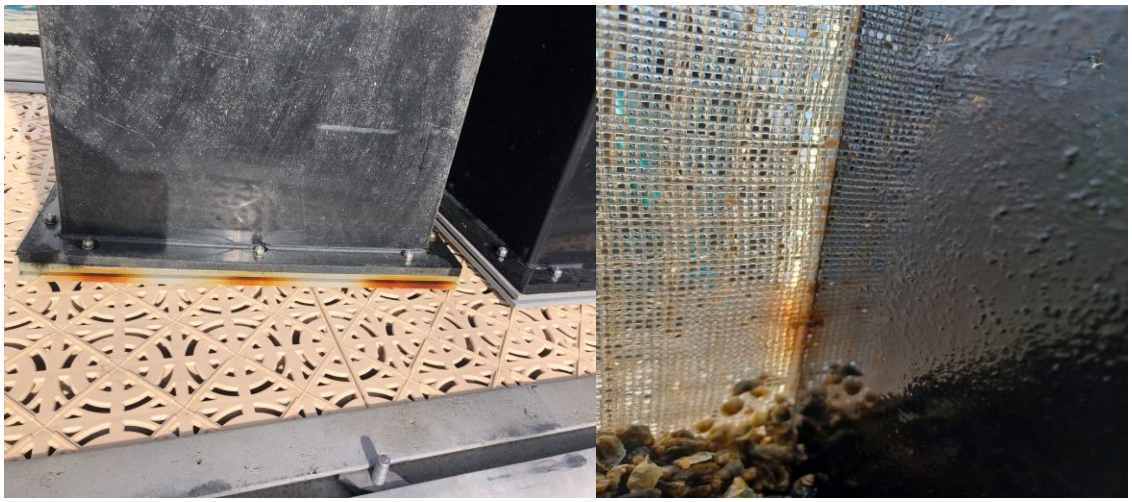
A maximum water flow of 10 to 15L per minute was recorded through each pot. With 16 of the 30 upwellers in operation the pump was set at 60%. With 30 upwellers in operation the pump can be set at 100%.

Maintenance and corrosion

The pump proved to be a low maintenance component of the FLUPSY. The pump shaft is fitted with anodes with no corrosion and only slight pitting on the anode surface seen over the period to April 2022.

Corrosion is an issue on other components of the FLUPSY. The bolts, nuts and washers mounting the screens onto the upwellers and the protective metal screen on the bottom of the upwellers are all showing signs of corrosion. This is impacting the nylon mesh that supports the oysters and may lead to a breach of the screens.

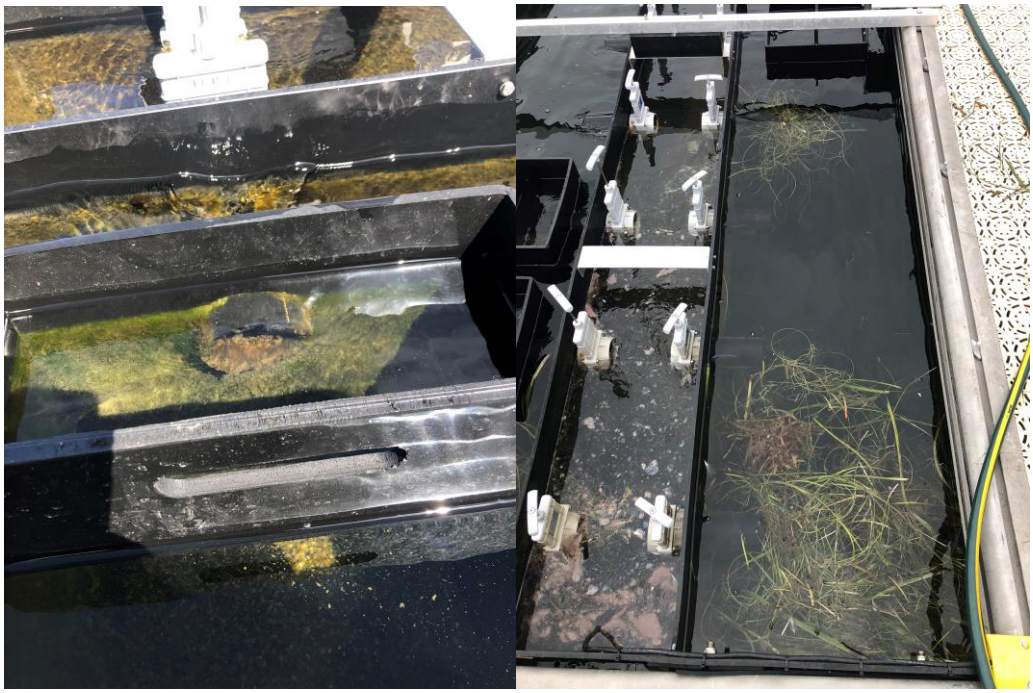
7 Left- Corrosion on nuts and bolts. Right- corrosion stain on nylon screen.



Fouling and cleaning

During the observation period the FLUPSY was cleaned three times per week with a broom to remove loose and soft fouling. Divers removed hard and difficult to reach fouling such barnacles once over the 3-month period. Flotsam such as seagrass, macroalgae, bird feathers and oil were often present but did not cause significant problems.

8 Left- soft fouling in the upwellers and gutter. Right- flotsam in and out of the gutter.



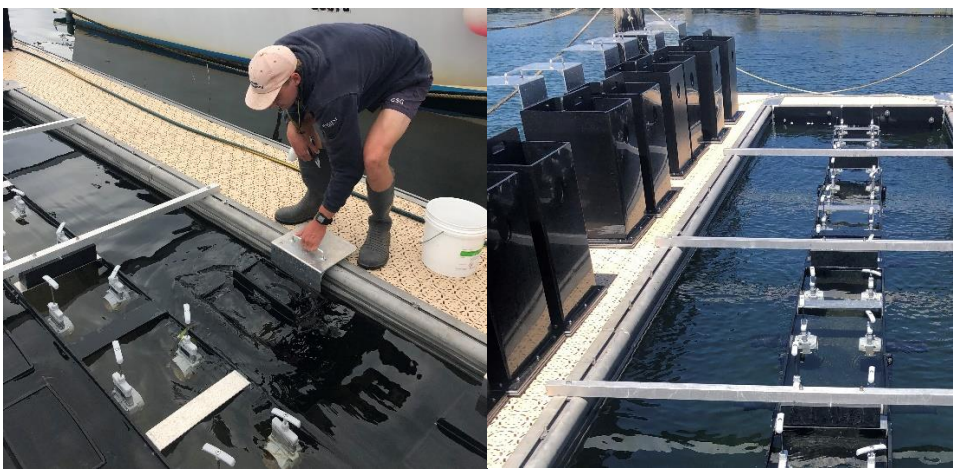
Vandalism

No incidence of vandalism occurred however, 3 fish lures were found embedded in the FLUPSY on separate occasions.

Safety

A risk assessment and control process was undertaken and manual handling (specifically lifting of the upwellers from the water onto the deck of the FLUPSY) was identified as the most significant safety risk to workers. This process involves lifting the upwellers from floor level and raising them out of the water at approximately 200mm away from the workers center of gravity up to waist height then twisting to move the pot onto the deck. The upwellers weigh 13kg dry plus several kilograms of oysters and the weight of the water that is retained. This can reach a total of approximately 40kg. Back strain has been an issue and as a mitigation strategy to this risk, a gantry is being fabricated and installed to lift the upwellers.

9 Left- Lifting upwellers from the water. Right- upwellers sitting on the FLUPSY deck.



Cost

The costs associated with the FLUPSY's operation are shown below. These are for the 41-day trial period only.

Table 6 Operational costs across the 41-day trial period.

Power including supply *	$289.45
Water including service charge*	$365.72
Wages including on costs of 25%	$2,196.43
Consumables- sun screen, grease and oil	$50.00
Tools	$50.00
Pen fees*	$340.00
Contactor services- electrical	$170.00
Total	$3,461.59

* These costs are indicative and are currently included in the pen fees. They are shown here so that future operators may consider them in their calculations.

Discussion

Over the three-month period the FLUPSY was in operation, observations were made in relation to potential modifications to improve the FLUPSY. The following recommendations are worthy of consideration for inclusion in the FLUPSY.

- Offset the upweller pipes so that flow from one is not directed into another.
- Make the upweller flange internal instead of external to allow for easier handling of the upwellers and prevent them catching between the rail and the gutter.
- Add a lock box to the FLUPSY for storage of tools, lubricants etc.
- Reduce the height and weight of the upwellers.
- Reduce manual handling of upwellers by adding a gantry.
- Change the wing nuts, that secure the upwellers, to a quick release clip to prevent them rattling loose.
- Build a jinker to transport the FLUPSY and allow for easy launch and retrieve.

Proposed further work

The work undertaken in this trial is preliminary and provides a baseline for further and more detailed work.

More work is required to improve the mechanical aspects of the FLUPSY, such as floatation, buoyancy, and stability; improved access and egress; determine the suitability for other locations with different environmental conditions; investigate options for operation of the FLUPSY remotely from mains power.

Further trials are required to better define bivalve performance in the FLUPSY, such as carrying capacity and growth performance of oyster spat in various environmental conditions; refine stocking density and response of various sizes to density and the relationship between flow rate and density.

Summary

Harvest Road Oceans found the FLUPSY to have great potential for the commercial nursery production of oysters during this preliminary 41-day trial. A direct comparison with traditional systems was not the main purpose of this preliminary project, however the limited comparison that was made found that the growth of oysters in the FLUPSY was similar compared with those of the same grade on the

flip farm. The compact size of the FLUPSY and high stocking densities of oysters that were able to be held in it was a major benefit compared to traditional systems.

As detailed in the report, DPRID and HRO have identified several modifications that are required to make the FLUPSY easier and safer to use. Many of these changes are currently being implemented by DPIRD in collaboration with HRO. Once implemented, further studies can be conducted comparing and quantifying the benefits of the FLUPSY relative to traditional systems, including over different seasons.

-End-