Department of Primary Industries

OYSTER CULTIVATION BEST PRACTICE GUIDELINE SERIES – NO: 1

Best Practice Oyster Raft Construction

October 2014

Raft Cultivation Systems

In NSW, rafts systems used for the cultivation of oysters are typically of timber construction with floatation provided by recycled 200 litre plastic drums ("Mauser" type drums), end-capped large diameter PVC, or polyethylene pipe (see Figures 1, 2 and 3). In some instances commercially available box type polyethylene floatation units that may be fixed directly to raft timbers are also used. Raft design is usually a function of the type of oyster growing tray that will be suspended beneath the raft and the lease characteristics.

Figure 1: A typical drum raft constructed using recycled 200 litre plastic drums.

Source: Steve McOrrie

Stacks of trays are suspended beneath the raft horizontally one below the other by sets of paired sling ropes. To ensure good water flow to the oysters, trays are often separated from one another by timber or plastic spacers. Sets of trays are commonly referred to as "modules" and each module may consist of between 3 and 15 trays.

The most common oyster tray used in conjunction with oyster rafts is a 930 x 910 x 100 mm polyethylene plastic oyster tray (Figure 4). In some areas 2400 x 900 x 100mm steel mesh trays, 1800 x 900 x 75mm timber mesh bottom trays (Figure 5), or commercially available 1800 x 930x 50mm plastic trays are also used.

Figure 2: A triple run drum raft constructed using recycled 200 litre plastic drums.

Source: Steve McOrrie

Typically a 930 x 910mm tray may contain up to 10kg of oysters (approx. 20 litres), a 1800 x 900mm tray up to 20kg of oysters and a 2400 x 900mm tray up to 30kg of oysters (clean dry weight).

Figure 3: A typical pipe raft constructed using large diameter (300mm) PVC end-capped plastic pipe.

Source: Steve McOrrie

Submerged trays and oysters are quickly colonised by other marine organisms, commonly referred to as biofouling. To control biofouling, tray modules are removed from the water and placed on top of the raft to air dry for periods ranging from 4 to 14 days (Figures 4 and 5). Drying time is dependent on the time of year, weather conditions and the type of biofouling being controlled.

Figure 4: Modules of commercially available 930 x 910 x 100mm polyethylene plastic trays, air drying to control biofouling. The raft is a prototype constructed from aluminium and double skin crush resistant polyethylene drainage pipe.

Source: Steve McOrrie

Figure 5: Timber 1800 x 900 x 50mm mesh bottom trays air drying on a triple run drum raft, constructed using recycled 200 litre plastic drums.

Source: Steve McOrrie

Given the value of the crop that may be grown or dried on the raft, it makes good sense to ensure that the raft is securely moored, stable and sufficiently durable to cope with conditions at the lease site. They also need to serve as a safe work platform for the loading and unloading and management of stock.

Important Note: Oyster aquaculture leases must be approved by NSW DPI for raft cultivation. Where a lessee wishes to install an oyster raft on an existing oyster lease, the lessee must first seek approval from NSW DPI who will assess the suitability of the lease area for raft cultivation in consultation with NSW Maritime. In some cases approval may not be granted.

Standard Raft Design

Oyster rafts need to be designed to withstand structural stresses caused by a wide range of environmental conditions, including strong winds, tidal and flood currents, and wind and boat generated waves. They also need to be designed to withstand these stresses while the stock is either, submerged and growing, or being air dried on top of the raft to control biofouling.

When using timber, rafts must be constructed from good quality structural grade hardwood. All timber cross members must have a minimum cross-sectional dimension of 150 x 50mm using a single continuous length of timber and not joined timber pieces.

Where possible, longitudinal raft timbers should also be of a continuous length. Where longitudinal raft timbers need to be joined, they should be braced on either side by similar timber of the same dimension and bolted together with a minimum of six bolts, three each side of the join (Figure 6).

Figure 6: Example of timber bracing system used to join longitudinal raft timbers.

Source: Steve McOrrie

All structural horizontal and longitudinal raft timbers must be fixed using good quality galvanised bolts having a minimum diameter of 12 mm. Galvanized washers should be used wherever possible.

Technical Tip: Galvanised bolts should be greased over their full length with a marine grade grease to assist their removal during raft maintenance or repair.

It is essential that the raft design allows for some flexibility while still maintaining a square configuration without compromising the overall strength of the raft.

Technical Tip: The use of a shallow (15cm deep) mortise notch in the raft cross timbers at their point of attachment to longitudinal raft timbers greatly assists in maintaining the raft in a square configuration.

The three common raft designs used by the NSW oyster industry are illustrated in Figures 1, 2 and 3.

Important Note: Nails should never be used to secure or join structural raft timbers.

Common Raft Designs and Dimensions

The following is a guide to the common raft designs used in the NSW oyster industry. In practice these basic designs will vary between farms to suit the needs and preferences of the individual farmers.

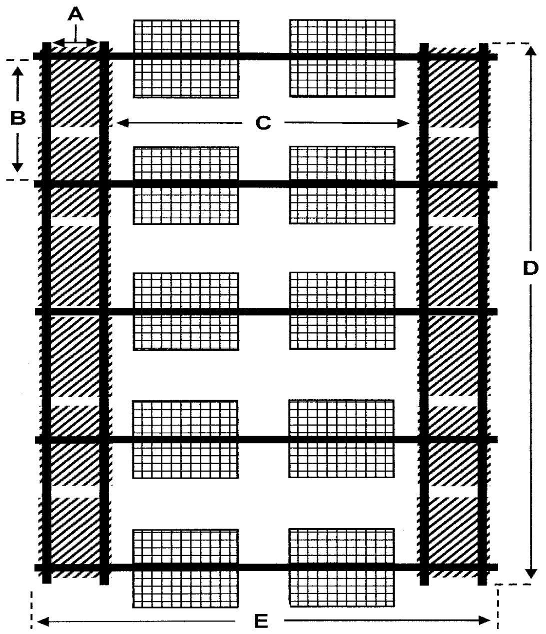
When designing a raft, considerable savings can be made by restricting the raft timbers to standard commercially available timber lengths. In most cases hardwood timber is readily available in lengths of up to 6 metres (usually supplied in multiples of 0.3 of a metre). While lengths longer than six metres can be obtained, they are usually considerably more expensive.

When designing a raft a farmer needs to consider the environment in which the raft will be moored, particularly the depth of water and the tidal current regime. The depth will obviously limit the number of trays in each tray module and the current regime will often determine the overall raft design.

In areas of low current flow a four bay raft design (Figure 7) with a larger inter module spacing may be more suitable than a five bay design (Figure 8). The use of a four bay design will ensure that the raft is not overstocked, which can potentially lead to poor oyster growth. In areas with good water flow a five bay, or a six bay design (Figure 9), may be more suitable.

Figure 7: An example of a four bay raft design suitable for low current flow conditions. This design also allows individual single attachment point tray modules to be lifted without the need to lift other tray modules.

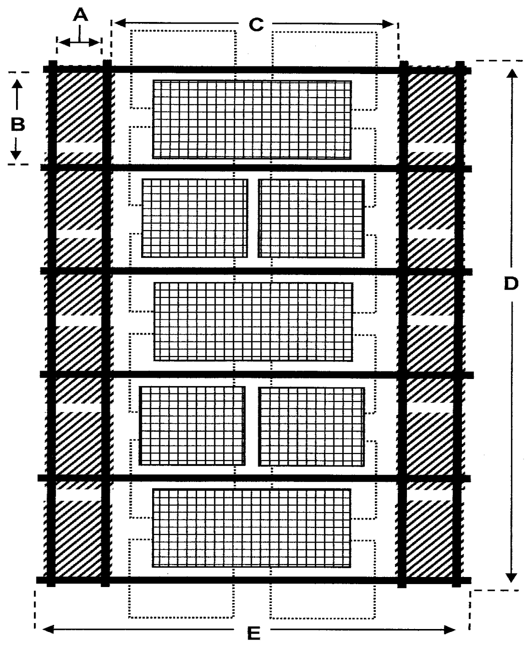
A = 500mm	B = 1400mm	C = 2800mm
D = 6000mm	E = 4000mm	



Source: Steve McOrrie

Figure 8: An example of a five bay raft design suitable for good current flow conditions with various possible tray module configurations.

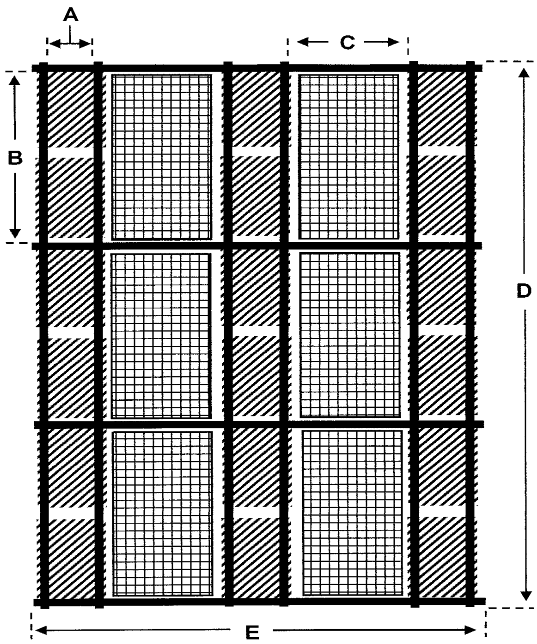
A = 500mm	B = 1100mm	C = 2800mm
D = 6000mm	E = 4000mm	



Source: Steve McOrrie

Figure 9: An example of a six bay raft design suitable for good current flow conditions. This design is also suitable for use with 910 x 930 trays hung in a double attachment point configuration.

A = 500mm	B = 1900mm	C = 1050mm
D = 6000mm	E = 4000mm	



Source: Steve McOrrie

While five and six bay designs can potentially enable a higher raft stocking density to be achieved, care needs to be taken to ensure the raft is not overstocked. Raft overstocking, apart from causing poor oyster growth, may also stress the oysters rendering them more susceptible to diseases and mortality when drying.

While water depth is an important consideration, the size of the tray module permitted will ultimately be determined by the total weight of the biofouled trays being supported by the raft floatation during drying.

There are obviously a number of options for the attachment of tray modules to a raft. When deciding on an attachment method, i.e. single point, double or multiple point module attachment, a farmer needs to give consideration to the weight and shape of the tray module, the configuration of their lifting gear and whether they wish to have the ability to lift individual modules without the requirement to move other modules. To reduce mechanical stress on the raft it is important to ensure that the tray module loading is balanced and evenly spaced.

Due to variations in the availability of suspended oyster food, the carrying capacity of the raft will also fluctuate.

It is important to determine a stocking regime for each raft that will return optimal seasonal oyster growth. In this regard the farmer will need to fine tune the kilograms of oysters per tray as well as the inter tray and inter module spacing to suit the growing conditions. It is good practice to start at a low stocking density and gradually increase the stocking density over time until an optimal stocking regime for the raft or group of rafts is determined.

Raft Stability

Oyster rafts need to be stable when a full load of trays is being air dried on the raft. It is important to ensure that the individual tray modules are secure and not prone to slewing or tipping. Unstable modules could lead to dangerous situations when loading or unloading the rafts and could result in the loss of trays from the raft during rough weather.

To assist the stability of raft modules girth straps should always be placed around the modules. The use of module girth straps will also minimise the risk of trays being lost from the module or oysters being spilled from a tray module should individual sling ropes fail. They will also allow the modules to be recovered, in many instances without the loss of oyster stock.

Technical Tip: The use of one or more tray module girth strap will:

- assist in preventing modules breaking up and spilling stock should a module sling rope, sling hook or base plate fail;
- stabilise tray modules during loading, unloading and air drying; and
- assist in the recovery of modules should they be lost from the raft.

Floatation

It is essential that a raft has sufficient floatation to support the weight of the raft timbers as well as the total weight of the tray modules when the modules are being air dried on the raft to manage biofouling.

Sufficient floatation should be provided to ensure the raft does not exceed the half submerged drum condition when a full load of trays is being air dried on the raft. This will provide an extra floatation safety factor to deal with unplanned events such as the loss or puncture of a floatation device or the accumulation of river born debris against the raft. Table 1 provides a guide to the amount of floatation required when designing a raft.

Table 1: A guide to the displacement and floatation capacity of various floatation devices used in the construction of oyster rafts. Calculations based on floatation in fresh water. *Calculated per meter of pipe.

Floatation Type	Float Displacement (Litres)	Half Submerged Loading (kg)	Sinking Loading (kg)
Drum	200	100	200
Drum	220	110	220
Pipe 250mm	49*	24.5*	49*
Pipe 300mm	60*	30*	60*

To calculate the maximum tray module load of a raft, the total weight of raft timbers also needs to be taken into account. The weight of hardwood timber is a function of its density and moisture content. Table 2 provides a guide to calculating the weight of timber used in a raft design and will assist the calculation of the maximum tray module load the specific raft design can accommodate.

Table 2: Guide to the weight of hardwood timber. Weight based on the density of Spotted Gum *Corymbia citriodora* (740kg/M3).

Dimension	Weight g/m	Length 4.0m	Length 6.0m
100 x 50mm	3.7	14.8 kg	22.2 kg
150 x 50mm	5.55	22.2 kg	33.3 kg
200 x 50mm	7.40	29.6 kg	44.4 kg

When making this calculation the farmer also needs to take into account the increase in weight gain of the growing oysters as well the accumulated biofouling and silt that may have accumulated on the modules and oyster stock. As a rule of thumb, an increase in weight due to biofouling should be at the very least be estimated at 40% of the initial total weight of the stocked module.

Sealing Floatation Devices

Failure of floatation devices can lead to raft instability and flooded devices can considerably increase loading stress on the raft.

Due to their flexible nature, floatation devices such as plastic drums are subject to considerable internal pressure variations caused by loading and unloading of the raft, tidal currents, wave action, direct heating by sunlight and day/night temperature changes. These variations in pressure can cause these devices to expand and contract which can act as a pumping mechanism that will cause the floatation device to flood or collapse if it is punctured, cracked or not properly sealed. It is essential that all floatation device bungs are sealed with silicon based sealants and that the bungs are kept above the water line whenever possible. All floatation devices must be checked regularly for cracks or abrasion damage and replaced if they are suspected of leaking. To prolong the life of floatation drums walking on the attached drums should be avoided.

Securing Floatation Devices

The loss of a floatation device from a raft can also lead to raft instability. Drifting floatation devices can also pose a threat to safe navigation and have other detrimental environmental impacts. To minimise the mechanical damage to round floatation devices such as plastic drums that can be caused by the rafts longitudinal drum runner timbers, a minimum of two cushioning top shoulder straps should be used with each drum (Figure 10).

Figure 10: A 200 litre plastic drum secured to longitudinal raft timbers by two cushioning top shoulder straps and a drum girth strap.

Source: Steve McOrrie

To reduce the likelihood of loss of a partially flooded drum or other floatation device from a raft, each floatation device must be secured to the raft. In the case of drum floatation each drum must be secured to the rafts longitudinal drum runner timbers by at least one girth strap. A girth strap or other floatation fixing system should be of sufficient strength to retain a partially flooded drum or other floatation device in situ preventing it from floating from beneath the raft, or being lost from the raft during strong tidal or flood currents.

Strips of used conveyor belting are ideal for the construction of support straps. Support straps constructed of conveyor belting should have a minimum width of 100 mm and thickness of 10 mm. Conveyor belting needs to be fixed to the longitudinal raft drum runner timbers by a minimum of 2 galvanised coach bolts at each fixing point, or where coach bolts will interfere with punt operation, multiple heavy gauge stainless steel staples.

Mooring Systems

The movement of water through a raft system can result in the generation of enormous pressures on the raft structure and its moorings, particularly when the raft system is fully stocked with submerged oyster trays with a high level of fouling. It is essential that moorings are adequate to secure the raft in position under adverse loading as well as adverse environmental conditions such as those experienced during storms or floods.

The following is guide to moorings for rafts, or raft complexes (a series of rafts joined together) less than 20 metres in length. Where rafts or raft complexes exceed 20 metres, particular attention needs to be given to providing additional moorings to secure the raft within the lease area.

Ropes and Fixings

Ropes used for mooring rafts must be of good quality, have a minimum diameter of 24 mm, have a high abrasive resistance and should be UV stable. While cheap rope is often available, it is often of inferior quality with a low breaking strain. Rope of 24 mm should have a rated breaking strain of at least 7000 kg.

In some instances floating ropes are an advantage. Floating ropes have less tendency to entangle suspended raft infrastructure than sinking ropes such as nylon. Where navigation or boat manoeuvring is an issue ropes may need to be sunk to prevent propeller entanglement. This can be achieved by the attachment of a small cement block to the mooring rope a few metres from its point of attachment to the raft. Silver rope or black polypropylene rope is the preferred choice for raft moorings.

Standard mooring practices should be used when attaching raft mooring lines to mooring blocks and/or anchors. All knots and splicing should show good seamanship and wherever wear is expected appropriate metal thimbles, shackles or abrasion protectors should always be used.

Important Note: Mooring ropes should be attached to major longitudinal raft timbers behind one or more major horizontal raft timbers. Mooring ropes should not be attached solely to horizontal raft timber.

Mooring Blocks and Anchors

Due to the enormous pressures that may be exerted by the raft on mooring gear, insufficiently anchored rafts can drag their moorings into other rafts, deeper water or, in extreme situations, break free posing a serious navigation hazard and cause damage to other rafts, boats and other marine infrastructure.

Important Note: All floating cultivation and associated moorings must at all times remain wholly within the oyster lease boundaries.

A raft, or raft complex, must be attached at the very least at the four corner points to concrete mooring blocks, or other suitable mooring devices. Where rafts are attached to serial mooring blocks a minimum of three blocks must be used and each corner of the raft must be attached to the first mooring block by an independent mooring rope.

Depending on the size of the raft, mooring blocks should between 0.5 to 1.5 tonne each. As a rule of thumb one cubic metre of concrete weighs approximately 2.4 tonnes. To ensure that the mooring block operates properly the length of all mooring ropes should be at least three times the depth of water under the raft. In moderate flow regimes this should be increased to five times the water depth and in strong current velocity areas this should be increased to at least seven times the water depth.

In areas that are subject to periodic flooding, the calculated length of the mooring rope should be increased to take account of the expected flood water depth.

Important Note: Under no circumstances should a raft be bridled and attached to a single mooring line.

Flood Safety Moorings and Flood Posts

In areas that are subject to periodic flood events special care must be given to the design of raft mooring systems. In areas that are at risk of a build-up of flood debris or high flood current velocities or both, flood safety mooring systems or flood mooring posts should be used.

A flood safety mooring systems is a substantial mooring system capable of pulling the raft closer to shore and out of the debris or current steam in the event of the raft dragging its mooring blocks during a flood event. A flood mooring post serves the same purpose as a flood safety mooring system. A flood mooring post is a large diameter post having a minimum diameter of 200mm which is driven into the sea floor to which the raft mooring rope is attached as close to the sea floor as possible.

Important Note: All lease mooring blocks, mooring anchors and mooring posts must be located within the lease area.

The flood safety mooring system or flood mooring posts needs to be placed within the lease boundaries as close to the shore as possible.

Mooring ropes from safety moorings or flood mooring posts need to be attached to the inside or shallow shore side of the upstream end of the raft. Flood safety mooring systems or flood mooring posts and their associated mooring ropes need to be capable of holding the raft during flood conditions and can also be used instead of a mooring block.

Linking Floating Modules

In some instances a farmer may join two or more individual rafts to form a single raft complex. Due to the stresses placed on moorings no more than three six metre rafts should be joined together in line to form a single raft complex. Where rafts are to be joined moorings must be appropriately adjusted to accommodate the increased loadings.

Where individual rafts are to be joined, each raft should be separated by a shock absorbing device such as a small car tyre fitted at the end of each set of longitudinal timbers on either side of the raft (Figure 11).

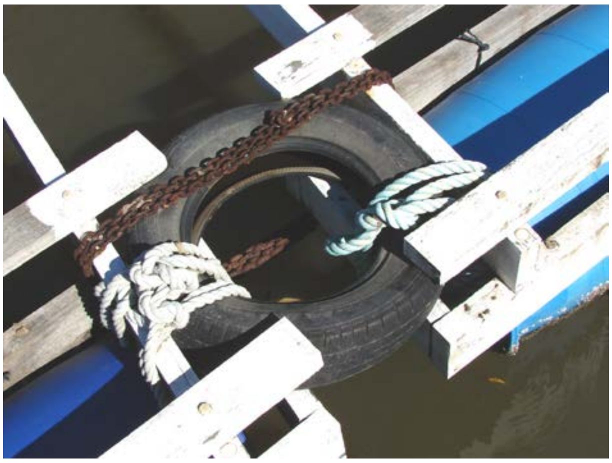
Shock absorbing devices should be capable of returning the raft to a straight condition when conditions cause the set of rafts to flex. The use of shock absorbing devices also prevents the individual joined rafts from climbing on top of one another under different loading conditions.

Where small car tyres are used they should be securely attached to the raft timbers and a series of large diameter holes should be drilled though the lower side wall of the tyre to allow water to drain easily from within the tyre.

A secondary safety chain or large diameter safety rope should always be attached between the modules in conjunction with each shock absorbing devices to prevent raft separating should a cushioning device or its fixing fail.

The use of bolts to attach car tyres to rafts should be avoided as they are often very difficult to remove when a raft needs to be separated. Single ropes without a secondary safety rope or chain should not be used in place of a shock absorbing device.

Figure 11: A small car tyre fitted between consecutive rafts in a raft complex as a shock absorbing and spacing device. Note the use of a secondary safety chain. In practice tyres should be attached at four diagonal points to the raft to minimise side slip.



Source: Steve McOrrie

Environmental Issues

The following environmental issues need to be considered in the use of oyster raft cultivation systems.

Use of Recycled Plastic Drums

The inappropriate use of recycled plastic drums as floatation on an oyster raft poses a number of environmental issues. Plastic drums are used to store and transport a wide range of products some of which can pose a serious threat to human health and the environment.

As plastic drums used on oyster rafts can often leak it is essential to ensure that prior to their installation on an oyster raft that there are no potentially dangerous residual products left in the drums.

To ensure that drums are safe to use, drums must only be sourced from licensed drum recyclers. Licensed drum recyclers are required by law to flush and wash drums to an approved standard before they can be offered for sale. Under no circumstances should used drums that have been acquired direct from the agricultural or the manufacturing sectors be used.

Important Note: Only plastic drums sourced from a licensed drum recycling company may be used for oyster raft floatation.

Due to their potential to contain dangerous substances, unidentified drums found in the marine environment may trigger a HAZMAT response from NSW Fire Brigades. It is therefore essential that recycled plastic drums used as floatation on oyster rafts be clearly labelled as an aquaculture raft floatation drum.

In addition the drum should also be identified with the owners Aquaculture Permit number, which will enable the drum to be returned to its rightful owner.

Important Note: Recycled drums used on oyster rafts should be clearly marked to identify them as an 'Aquaculture Raft Floatation Drum' and if possible should also be marked with the owner's Aquaculture Permit number.

Visual Impact and Prohibited Materials

The general neat and tidy provisions that apply to all aquaculture leases in NSW are specified in the NSW Oyster Industry Sustainable Aquaculture Strategy (OISAS) which can be found at: www.dpi.nsw.gov.au/fisheries/aquaculture

The following OISAS neat and tidy provisions apply specifically to oyster rafts:

- oyster rafts must be designed and constructed to float horizontally to the water surface;
- oyster rafts must be low in height;
- oyster rafts must not be used to store infrastructure, cultivation materials or any waste materials;
- plastic drums and floats fitted to oyster rafts must be adequately secured at all times and replaced if broken or leaking; and
- the use of steel or concrete pontoons is prohibited.

Navigation Marking Requirements

The full requirements for the marking of an aquaculture lease are specified in the NSW Fisheries (Aquaculture) Regulation 2012 and are also outlined in OISAS.

The following marking requirements apply to all oyster aquaculture leases approved for raft cultivation.

At each corner of a raft that adjoins a navigational channel a vertical post must be fitted that:

- is of a minimum height of 0.7 metres above the waterline;
- has attached near the top, two flat white panels (attached at 90 degrees to one another) each of a dimension of 300 mm x 300 mm when sighted from any horizontal position;
- is painted white, including the panels; and
- has reflectors fitted if required by the NSW Maritime.

Important Note: In some areas NSW Maritime may require that the location of raft mooring blocks be identified by a clearly visible float attached to the mooring block and may also require other navigation aids to be fitted to an oyster raft. When in doubt contact your local NSW Maritime Officer.

At the offshore end of a raft located closest to each corner of the oyster aquaculture lease the post described above must have an oyster lease sign fitted (between 1.25 metres and 1.5 metres showing above the water). This post and sign may substitute for the oyster aquaculture lease corner post.

Routine Maintenance

A poorly maintained oyster raft can:

- pose a significant threat to safe navigation;
- drag their moorings or break free and cause significant damage to other rafts and other marine infrastructure;
- result in significant loss of stock;
- attract compliance action from both NSW DPI and NSW Maritime; and
- reflect poorly on the environmental credentials of the NSW Oyster Industry.

It is therefore important that regular maintenance checks be carried out by the owners of all oyster rafts.

Regular Checklist

The following visual checks should be carried out whenever a raft is attended or at a minimum of every 3 months:

- check the location of the raft within the lease boundary, with reference to a known shore position or shore feature;
- check for missing, flooded or popped drums;
- check drums for abrasion, cracks, general damage or leaks;
- check mooring rope attachments to rafts for UV damage, abrasion or cuts;
- check the structural integrity of timbers and timber fixings at the point of attachment of all mooring ropes;
- check that all navigation aids and signs are in place; and

- three months after initial construction, check timbers for shrinkage and adjust bolts and other fixings where necessary.

Annual Check list

The following checks should be carried out at least annually:

- check the structural integrity of all raft timbers and metal fixings;
- check all mooring block and flood safety anchors at their points of attachment for wear or corrosion; and
- check all mooring ropes from their points of attachment at mooring blocks or flood safety anchors to the point of attachment to the raft for damage or fouling by submerged objects.

Raft Approval Process

A leaseholder wishing to undertake raft cultivation on a lease area **must** seek and be granted approval from NSW DPI prior to undertaking any work to establish a raft on a lease.

The leaseholder will be required to lodge with NSW DPI a completed Aquaculture Permit/Lease Variation Preliminary Assessment Application. Under this application process the leaseholder is required to provide the following information:

- a sketch plan (to scale) of the lease area indicating:
    - the proposed location of the raft footprint on the lease area;
    - the depth of water directly under the raft footprint and across the lease area at the lowest low tide (ISLW); and
    - the nature of the bottom substrate on the lease area.
- a sketch plan (to scale) of the raft design indicating:
    - the dimensions of the raft;
    - the dimensions of the timbers to be used in the construction of the raft;
    - the type of and number of floatation devices to be used in the construction of the raft;
    - the type and number of trays to be used in each raft tray drop; and
    - the maximum suspended depth below the water line of the tray drops.
- A sketch plan (to scale) of the raft mooring design indicating:
    - the type, diameter and lengths of all mooring lines;
    - the points of attachment of all mooring ropes to the raft; and
    - the location and dimensions of all mooring devices (e.g. blocks or anchors).

Areas Deemed Unsuitable for Raft Cultivation

The following areas are deemed to be **not** suitable for raft cultivation:

- areas where the depth of water under the raft footprint is less than 1.5 metres at the lowest low tide (ISLW);
- areas where the bottom substrate will not allow the raft and all mooring devices to be maintained wholly and securely within the lease area, particularly in areas prone to flood scour;
- areas where the tidal flow through the raft footprint would cause undue deflection of suspended trays such that the raft could not feasibly be worked except at slack water;
- areas where the dimensions of the lease and the available lease footprint are insufficient to maintain the raft wholly within the lease area at all stages of the tide and wind conditions;
- areas where rafts would pose an unreasonable risk to safe navigation; and
- areas where raft cultivation would not be in the public interest.

More information

Contact NSW DPI, Aquaculture Management, Port Stephens Fisheries Institute on (02) 4982 1232.

Acknowledgments

NSW Shellfish Committee

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