Cage Mooring Systems

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Introduction

Moorings are required to keep the cages in a fixed position and to reduce the transfer of excessive forces generated by wind, currents and waves to cages. In well protected bays and seawater sites and freshwater sites, the forces of exerted by environmental factors are reduced, small mooring system can used. Open sea cages where cages are exposed to greater environmental forces require more effective mooring systems. Mooring depends on the type of cage, how exposed the sites are exposed to weather, and the requirement for positional precision. Mooring failures were common place in the early days of coastal farming, but a better understanding of the problems, and more sophisticated analysis has largely reduced these risks. Cage and mooring design is "site specific", and careful and combined choice of cage type, nets and most specifically moorings, has a considerable bearing on the ability of fish stocks to survive in major storms, on exposed sites.

The mooring system for a fish farm consists primarily of ropes, floats and anchors. In addition, several smaller components like shackles, connection plates, chains, rings etc. The moorings influence the stress acting on cage structural members and the behavior of the cages in rough weather, and can affect production, profitability and staff safety. They are therefore an important – indeed -, integral part of the cage system and should be carefully designed. Thus the collar, net and mooring components of a cage system should be designed together, although in practice the cages are usually chosen or built first with the mooring system being designed as an afterthought.

Mooring requirements should be determined by the design and type of the cages and the characteristics of the site. It would first be necessary to quantify the incident forces that are likely to act on the cage under the worst possible weather conditions, and then to evaluate the proportion of energy transferred to the mooring lines and anchors. Two types of analysis can be used: quasi static and dynamic response. The loadings transferred to mooring lines vary enormously depending on current and wave conditions, cage design and number of lines employed.

Mooring design for a specific cage system and site

Wind and current forces are proportional to the square of the velocity. Thus an increase in current from 1 knot to 2 knots will generate 4 times the drag on a rigid submerged body. Effect of wave force is more difficult to compute, because the dynamic response of a system depends on so many factors. A change in the mooring system will change the internal loads on the cage system. In general a mooring system should be designed not only for specific cages, but also for the expected site conditions of water depth, wind, waves and current.

Mooring components :

For a proper mooring system for any type of cage, a number of elements need to be assembled together, correctly specified and installed, physically and operationally compatible with each other, and effective in use and maintenance. Important components include the anchor or mooring unit on the seabed, the rising line, which connects the anchor to the surface system, and the surface or subsurface mooring grid. The major elements comprise several smaller sub-units – particularly links, shackles, droppers, safety lines, buoys, etc., which in effect are integral in the complete system.

Anchor specifications

A range of different types is available, commonly from the shipping/fishing industry. Major options are usually between gravity or dead weight devices – mooring blocks or mass anchors, which rely primarily on their weight, and those which rely on their ability to wedge into the seabed substrate. The holding coefficient of the anchor (k) is defined as (R) the horizontal force divided by the mass of the anchor. The holding coefficient(k) depends upon the angle between the anchor and the cage and thus the ratio between water depth and line length and the nature of the substrate. The simplest and cheapest type of marine anchor is the dead weight or block anchor, which typically consists of a bag of sand or stones or a block of concrete or scrap metal. To prevent block anchors being displaced on the bottom, good friction between anchor and the bottom is necessary; this depends on the bottom condition and is given friction coefficient. Block anchors have low holding power per unit-installed weight. Block anchors are not recommended for use in rocky ground. Concrete block anchors may be simply fabricated using wooden shuttering, tyres or any other convenient object as mould. Steel rods for strengthening and eyebolt for a mooring attachment are usually incorporated. Once fabricated, the blocks can be transported to the waters edge at low tide and floats attached, so that they can be floated to the required location at high tide. Once installed, they are difficult to recover. There are numerous types of embedding anchor. The holding power of an embedding anchor is related to its frictional resistance in soil, and so is dependant on fluke area, soil penetration and the mechanical properties of the soil rather than simply the mass of the anchor. They designed to be dragged down into the ground like a plough and become fixed. The holding capacity of drag anchor has been reported to be upto 25 times the weight with good bottom conditions. Embedding anchors are very efficient, i.e. they have a high holding power to mass ratio. Under optimum conditions, they are 10-500 times as efficient as block anchors. They are more expensive than block anchors in terms of cost per unit holding power and have to be bedded in properly. The use of two anchors connected together gives greater holding power than the sum of independently moored anchors. There are numerous other type of anchor, combining the properties of block and embedding types, while others are designed for particular types of substrate. Prior to choosing or installing anchors it is advisable to survey the sea bed. Anchors should be positioned first. The position of the anchors can be accurately established using a global positioning system or by taking bearings with respect to local. Easily visible land marks. Rising line components A range of materials and configurations may be used, the most common of which involves a chain section at the lower end of the line, a synthetic rope in the main upper length, and various elements of buoyancy or weighting to adjust the profile of the line, and its response geometry when subject to varying load. A range of different types and specifications may be available for chain and rope. Key issues concern weight and tensile strength, elasticity (length change with applied tension), stretching, dimensional wear, degradation. Float units need to be specified according to volume and shape, and to their resistance to deformation when submerged Mooring lines must perform two functions: they must withstand and transmit forces. The loads imposed on a cage mooring system are principally dynamic. It is important that mooring lines have a high breaking strength and can absorb much of the kinetic energy of rapidly changing force s, otherwise theses forces will be transmitted directly to the anchors. Natural fibre rope is not suitable as it is easily abraded and prone to rotting. Steel cable, although immensely strong, is expensive and heavy. Chain is extremely strong but again is heavy and is usually used in conjunction with synthetic fiber rope. Synthetic ropes of same diameter nylon and PES are considerably heavier than PP or PES. However, nylon is much stronger on a per unit weight or equivalent diameter basis than ropes fabricated from the other materials. Braided ropes are lighter than laid ropes and are generally weak. They also cost more and have few advantages other than they are easier and more pleasant to handle and do not kink. Although it can cost twice as much as PE or PP rope of equivalent strength, nylon has high extensibility and thus energy absorbing properties, an important factor in designing cage moorings. Ropes should not be attached directly to either shore or sea anchors, but instead should be connected via a section of chain. The chain serves to increase the effectiveness of the mooring system, which directly act as an efficient type of anchor and improves the holding power of existing anchor by both reducing the angle between the mooring line and anchor and by increasing energy absorbing properties of the mooring line. Moreover, a section of chain is necessary at the anchor since it is much resistant than synthetic fibre rope to the prevailing high abrasion forces. There are several types of chains are available. Wrought iron is very variable in quality; the best has excellent corrosion resistance while the poorer grades are inferior in all respects. Mild steel chain, with low carbon and manganese contents has been widely recommended for cage anchorages. A fairly heavy grade of chain is recommended. The total length of the mooring line should be at least three times the maximum depth of water at the site and where the rope joins the chain, a galvanized heavy duty thimble should be spliced into the rope and a galvanized shackle of the appropriate size should be used to connect the chain and tot eh rope. An alternative mooring line composed mainly of chain is occasionally employed. Typically 12- 25 mm chain, two or three times the maximum depth of water in length is connected from the anchor to a float positioned 10m or so from the cage and a section of rope –PES or nylon- used to link the floats to the cages. The buoy minimizes the vertical loading on the cages and must be sufficiently large to support the mass of the chain in the water and to resist the vertical forces imposed by the cages on the mooring system. Under shock loads, the chain/buoy acts as a spring absorbing much of the energy that would otherwise be transmitted to the anchor. Two types of mooring systems be used: multiple and single point. The former is more common and involves securing the cages in one particular orientation while with the latter the cage are moored from one point only, allowing them to move in complete circle. Single point moorings tend to be used with rigid collar designs in sheltered sites. They use less chain and cable than multiple point moorings and because they adopt a position of least resistance to the prevailing wind, wave and current forces, both inter cage forces and torsional forces at linkages are reduced. Single point mooring systems also reduce the enormous net deformation seen in conventional mooring systems and have been used with successes to moor large offshore cages. Cages moored from a single point also distributes wastes over considerably larger areas than those secured by a multiple point system. The orientation of cages with multiple moorings depends upon the nature of the site and upon the type and group configuration of the cages. If particularly exposed or if currents are strong, then it may be best to secure cages in the position of least resistance to the prevailing wind and current forces. Where a site is sheltered and water circulation is poor, it may be better to moor cages so that water exchange is maximized. However, there may be restrictions on mooring orientation imposed by the site size or by suitability of mooring grounds. The number of mooring lines used determines the distribution of forces to the anchors. Most methods of mooring involve the use of ropes and chain to link the cage or cage group to anchors or pegs secured to the sea bed. The mooring line is often termed as a 'riser'. Although this is most common system there are alternatives. Some cages may use a submerged rope or cable based mooring grid, to which cages may be attached temporarily using near horizontal lines. One further alternative is to drive long posts into substrate and to attach cage directly either with ropes or with metal hoops or tyres that permit some vertical tidal and wave induced movement. In theory the number and dimensions of posts required and the to depth to which they must be buried could be computed from the estimates of the forces acting on the cage system and data on the soil characteristics, but in practices it is determined by experience. Although sometimes employed in sheltered and shallow inland and coastal sites with suitable substrates, this method of mooring is not widely used.

Installation methods:

The installation of mooring systems is an important aspect of the overall development of a cage site, and requires to be planned with care.

i. Working base: a suitable and secure area for storing and laying out the mooring components needs to be identified – ideally a level, surfaced area.

ii. Workboat or mooring vessel: capable of moving and positioning the mooring components and operating in the expected site conditions

iii. Cranes: dockside and on mooring vessels – capable of lifting and moving the mooring elements safely at the required horizontal reach.

iv. Access: – for materials to be taken to the assembly areas, for mooring components to be taken safely to the intended cage site.

v. Marking out: key locations in the mooring site can be marked out on a hydrographic chart, checked on site with GPS or conventional optical surveys; local transect markers can be identified, and temporary positions marked with light lines and floats.

vi. Making up moorings: the mooring lines and grids need to be adjusted to length and assembled to form the appropriate sub-components, which would then be finally linked together on site once the anchors are laid. Primary work can most easily be done on shore, using temporary measure lines or markers to help lay off the line lengths. Further adjustments can be done at sea, and all components and connections given a final check before installation.

vii. Laying anchors and risers: if blocks are used, these can be set at the intended site, using positioning co-ordinates to define the location. For embedding anchors, these should be dropped a suitable distance outwards (i.e., opposite the direction of tension) from the place of intended location, and tensioned inwards to their final position. Laying of moorings and lines should be done carefully, taking particular care not to foul anchors with riser line, to tangle or snag the line, or to endanger staff.

viii. Tensioning the rising lines: these need to be finally adjusted to ensure that the cage and/ or mooring assembly is correctly and evenly tensioned around its axes.

ix. Diver swim of rising lines: finally, it is very important to check the whole system visually – to ensure that blocks or anchors are cleanly placed and/or embedded, that lines are lying properly and are not kinked or tangled, and that connections are sound.

Mooring maintenance

Cage moorings are a dynamic system, which must respond to motion, under load, every minute of the years it is installed. Maintenance is critical, to ensure that components are physically sound and that linkages are secure. Critical dimensions of items subject to wear – chain links, brackets, shackles, splicing eyes, need to be checked periodically, bolts and shackle pins need to be tightened, and riser lines may need to be adjusted. With a rigorous and effective system of maintenance of both cages and moorings, with clearly defined parameters for replacement or repair, a well designed and installed system should be capable of reliable and secure operation. Mooring systems must be checked at regular intervals and fouling removed from buoys and mooring lines. it is essential that any mooring inspection assesses component strength to see if it deviates significantly from design strength and that it should also assess likely deterioration in the interval to the next inspection.

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