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Cabello L.

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L. Cabello
Coremar, Apartado 218, 30880 Aguilas, Murcia, Spain

SUMMARY – In offshore aquaculture, keys for success include the selection of a good site, a good culture system and the know-how to manage it. The most common reasons for mortality and growth deficiency are related to the quality and management of fry, and the consequent efficiency of management. Control over production systems has to be thorough and needs to be included fully within daily work routines. Daily control forms are needed for the elements being used as well as for those which are stored. Biological control of the species produced, as well as feed management and fish handling also have to be undertaken in a thorough and continuing manner, with properly conducted sampling to determine the quality of the product during its fourteen month growth cycle. Good management and control practices result in cost reduction, improved growth and survival rates, safer working conditions, profitability and commercial prestige.

Key words: Offshore, fish, management.

RESUME – *"Méthodes de production pour la gestion des poissons en mer ouverte". En aquaculture en mer ouverte, les éléments déterminants de la réussite comprennent la sélection d'un site adéquat, un bon système de culture et le savoir-faire nécessaire à la gestion. Les raisons les plus courantes de mortalité et de déficit de croissance sont liées à la qualité et à la conduite des alevins, et à l'efficacité subséquente dans la gestion. La maîtrise des systèmes de production doit être rigoureuse et nécessite d'être pleinement incorporée dans la routine des tâches quotidiennes. Il est nécessaire d'avoir des formes de contrôle quotidiennes pour les éléments qui sont utilisés ainsi que pour ceux qui sont en stockage. La maîtrise biologique des espèces produites, ainsi que la conduite alimentaire et la manipulation des poissons doivent également être menées de façon rigoureuse et continue, avec un échantillonnage réalisé de façon appropriée pour déterminer la qualité du produit durant son cycle de croissance de quatorze mois. Une bonne gestion et des pratiques de contrôle adéquates résultent en une réduction des coûts, une meilleure croissance et des taux de survie plus élevés, des conditions de travail plus sûres, plus de bénéfices et de prestige commercial.*

Mots-clés : *Mer ouverte, gestion des poissons.*

Introduction

According Spanish law, the term offshore is defined by the sea area outside the straight line joining two major capes or promontories (Fig. 1). The seaspace within these capes is correspondingly defined as inshore. In this text, the term offshore is defined more broadly as waters unprotected against wind and prevailing sea action.

Project planning: before deciding on a location, a range of factors needs to be considered, as much for biological performance of the farmed species as for the cost-effective and reliable physical installation. Factors include:

Physical: topography and hydrography, seabed conditions, salinity, temperature.
Climatic/environmental: sunlight, wind, waves, rainfall/runoff, benthic, water column conditions.
Infrastructure: roads, harbour facilties, offices, workshops, power supplies, telecom.
Social: markets, human resources, political/legal conditions, tourism, other activities.

Based on the above factors, decisions can be made on culture species, type of culture, supporting systems for production, market strategies, etc. A technical study and business plan would normally be conducted, with requests for concessions, permissions and other necessary steps.

Human resources: this is complex and diverse, each company having its own approaches, depending in turn on the type and scale of operation. However, some responsibilities are common to all cases. For offshore cages, minimum staff is typically a foreman in charge of boat and workers, a team of three divers and two others (preferably also divers) for stocking, feeding, system inspection and maintenance, net changes, grading, harvesting and other activities. An administrator is usually also needed, with some external assistance. Depending on the size of the farm, a general manager, technical or production director or subcontracted management inputs would be needed.

The question of guarding the farm may be very sensitive, and this is often contracted to reliable local groups. Until effective and reliable electronic systems become available, personal vigilance is the only practical means of guarding offshore systems, but a safe platform (or guard boat) is essential.

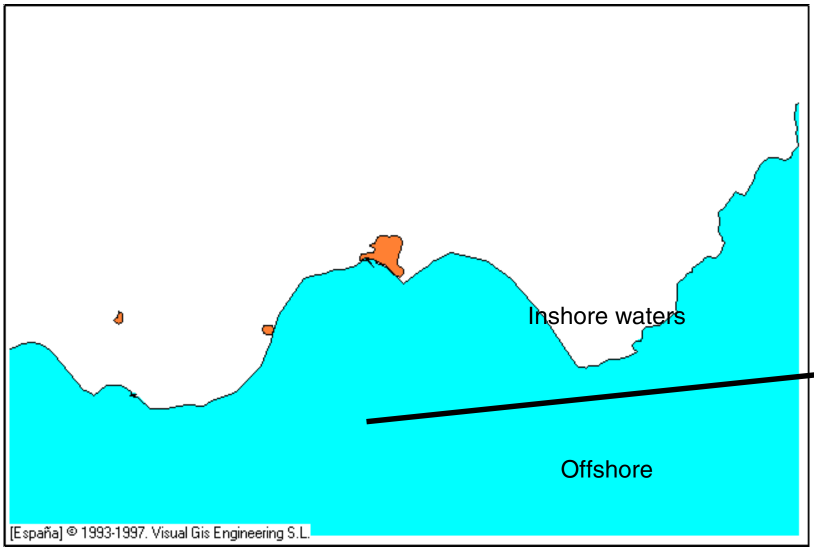

Fig. 1. Delineation of inshore and offshore waters.

The farm system

A typical farm would normally constitute floating cages made of PEH, rubber, steel, with or without platform structures or service units, etc., fixed to the bottom by various mooring types (lattice, long line, individual) according to their calculated effectiveness in resisting local wind and wave forces. The attachment of cages to their moorings will depend on the situation and on the critical points (corner reinforcements, tighteners, buffers, etc.). Cage types are discussed elsewhere in the text. Nets may need to be specifically designed for each site or cage group, with, e.g., reinforcements in points of stress, additional flotation, zip or other opening systems (Fig. 2). A key objective is to try to retain cage position and net shape in varying current and wave conditions.

The choice of net depends on the species, its size, and factors such as weight, ease of handling, and the effects of fouling. For seabass, square mesh nets may be used –5 mm mesh for sizes up to 5 g, 8 mm for up to 12 g, 10 mm for up to 70 g and 16 mm for larger fish. For exposed inshore, or offshore production, yarn thickness should be the maximum for each net size. Hexagonal mesh netting can be very efficient as it can cushion the effects of wave impacts, and can maintain a good open area under varying conditions. However, it has an almost circular form, and can trap seabass as they have a slim snout. For seabream, 10 mm netting can be used for fish up to 5 g, 16 mm for up to 10 g, 24 mm for fish up to 25 g, and 32 mm for larger fish.

All nets should be anti-fouled to reduce algal growth, keep mesh spaces open, sustain good water flow and maintain healthy conditions for the stock. Nets should be protected in the most vulnerable locations, such as the friction zone between the upper net and the cage frame, and net bag corners where loops are installed, and where the net form is subject to forces from several different directions. It is now common practice to suspend the net bag from a flotation line, held inside the cage frame to avoid contact and chafing between the net and the frame. From this, a lighter upper net is taken up to the upper frame or handrail of the cage. In many cases, a light top net is also attached, held up with cross-brace wires from corner stanchions, or from a central support stanchion.

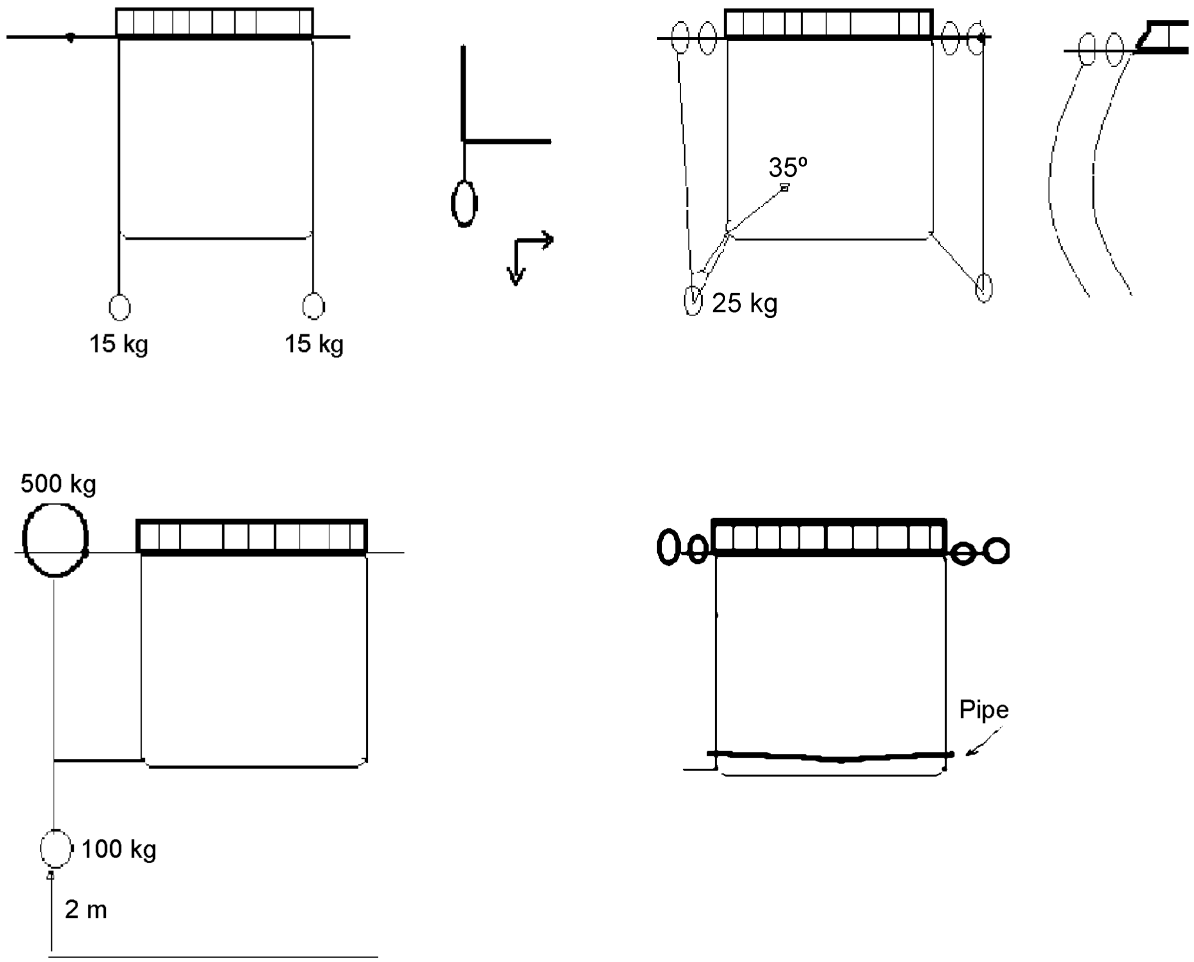

Fig. 2. Options for retaining cage and net position.

It is important to ensure that the cage volume is maintained as fully as possible under the complete range of wind, wave and current action, and that the net does not fold or collapse under extreme conditions, trapping the stock and possibly leading to mortalities. In conventional systems, in which the net is suspended from the cage frame, various devices can be used to maintain net shape:

(i) To hang weights from the nets themselves; this is not very efficient, as it may damage the net, strain cage frames. Though simple, it does not work well, as it is difficult to use heavy enough weights, and the independent movement of the weights cause additional movement to the net.

(ii) To hang weights from the cage frame and then into the nets. This method is better, as heavier weights can be used, but can be dangerous for the side and corners of the net as the weights rub against it, particularly during high current periods.

(iii) To hang heavy weights from buffering buoys. This is probably the best approach, as it makes the whole installation more elastic. The weight should be near the seabed, in case the rope breaks. A minimum 35° angle is recommended between the net side and the weight line.

(iv) To use a PEH or ballasted steel tube frame of the same diameter as the upper cage frame. This can be used either inside or outside the net, moored to the upper cage frame or to the net itself. It is a safe and reliable method but requires great effort at the time of changing nets by divers.

(v) Some farmers use a combination of these systems. In any case, the method will always depend on the environment itself and the existing currents, apart from the type of cage selected.

Production support facilties will be necessary for the safety of staff and stocks. An offshore farm with 12 or more cages normally requires three boats, one fast boat, another for routine feeding and a large boat for heavier work. The fast boat is for quick visits and for emergency runs; a "Zodiac" type semi-rigid inflatable is commonly used, with an outboard diesel or petrol engine and a forward control point. The hull is tough but needs to be properly treated. The second boat is typically a 7 m x 2 m latbottomed steel hull, with good flotation and extensive platform capacity, usually run with an outboard diesel engine. This would have a working load of 2 t and would be used for feeding, sampling and farm monitoring. The large boat, 10-15 m x 5 m, usually steel, with a good seagoing hull shape, inboard diesel engines, forward wheelhouse and a flat rear deck, would be provided with a hydraulic crane, capstan, etc., and would be used for heavy transport, fish slaughtering, net changing, tightening the cage and mooring installation, cage towing, etc. The three boats should be equipped with basic safety measures, including a good first-aid kit, marine transmitter, radio and telephone. For smaller systems, two boats may be sufficient: a smaller boat for transport, lighter feeding and maintenance, and a larger vessel for bulk feeding, maintenance, net changing, grading, harvesting, etc. For larger farms a fixed or floating service platform can be useful, on which to install a feeding system, feed store, power supply, net washer, crew/guard accommodation, etc. Floating platforms are usually designed with a combination of high mass and buoyancy, to provide good stability in open sea conditions.

For the main production system, the number, shape, volume of cages will depend on the experience of the operators and the risks they are willing to take. The type and effectiveness of supporting systems will also be a factor. Though bigger cages may be more difficult to handle, they may involve less routine risk than smaller and lighter alternatives. However, major loss for a large cage represents a far higher business risk. A typical production unit might comprise 8 to 12 cages of 16 m diameter, and 2000 m^3 capacity, producing more than 250 t annually, and at a sufficient scale to develop prototype operations for offshore production (see Fig. 3).

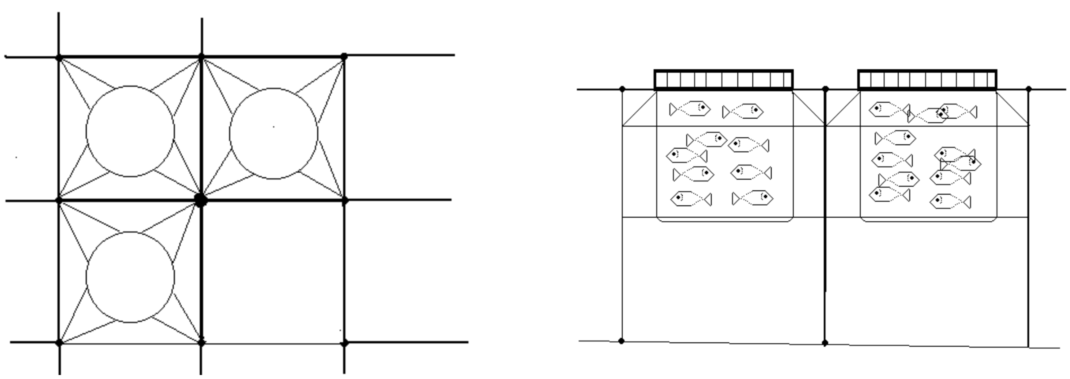

Fig. 3. Typical cage unit and mooring layout.

Shore based facilities will depend on the project but normally include a docking and material handling area, facilities for personnel, workshop, diving equipment store, shower room and gas bottle filling, warehouses for nets, feeds and stores for husbandry equipment, offices, and packing/processing room facilities, including process lines, washing/sorting tables, cool/cold store, ice machine, box store, weighing machines, delivery room, cleaning room, etc. The workshop should be provided with all the necessary equipment for the maintenance of the premises and the repair of cages, boats, nets and operational equipment.

The next sections outline the key husbandry and management stages in operating a typical cage farm for seabass or seabream in exposed inshore or offshore conditions.

Stocking of cages

The numbers of fry and the arrangements for stocking cages need to be considered carefully, to ensure that cages are fully stocked at the appropriate time, and that handling is reduced to the minimum. The hatchery producer should complete any necessary treatments in the nursery prior to delivery, as it is much more difficult and expensive to do these in the cages. Treatments may include photoperiod control, vaccination, parasite treatment, and stock grading and counting.

Fry are usually transported in tanks, normally by trucks, or on a transport vessel. A live-well transport vessel may also be used for larger consignments, but this is less common with Mediterranean species. Loading of fry into transport tanks is usually carried out with transport buckets using a lot of water and few fish. Transport tanks are typically provided with an oxygen injection system and air diffusers, and may also have the possibility of water renewal. When seabass are transported, anaesthetics are usually needed. To reduce activity, stress and metabolic outputs, fish should ideally be acclimatized in colder water (16-18°C), without feeding, for two days before transport. For long distance transport water may need to be renewed on the way, and pH and oxygen levels controlled.

Prior to delivery of the fry, one or more cages and appropriate nets need to be prepared and positioned. A backup water supply should be arranged at the delivery site to avoid last minute problems. Operational routines and tasks need to be thought out in advance, and every production team member needs to know their specific responsibilities and corresponding tasks. Loading the cages is normally done using pipes, though simple chutes (channels) can be used for short distances. Pipes are taken out to the cages, lowering the water level in the tank to reduce the drop and the flow velocity, avoiding the risks of sucking in and trapping air, and preventing fish from being damaged. When the access point is some distance from the cages, it is advisable to unload the tanks onto a delivery bat or barge, from which the cages can be stocked.

To receive the fry, cage nets should be raised leaving a maximum of 2 m depth. Once the fish are in the net, if water quality is good at the reception point, it is advisable to avoid unnecessary handling and leave them alone for five or six days to rest and regain energy prior to moving out to the growing site. In many cases, however, fish are moved out immediately, the cages being towed by boat. Two towing ropes of ~50 m each are usually used, tied to each side of the cage (Fig. 4). Devices also need to be in place to keep the net open, such as weights attached to net frame loops on the side facing the current, or placing a pipe with a chain inside or outside the net (see also Fig. 2).

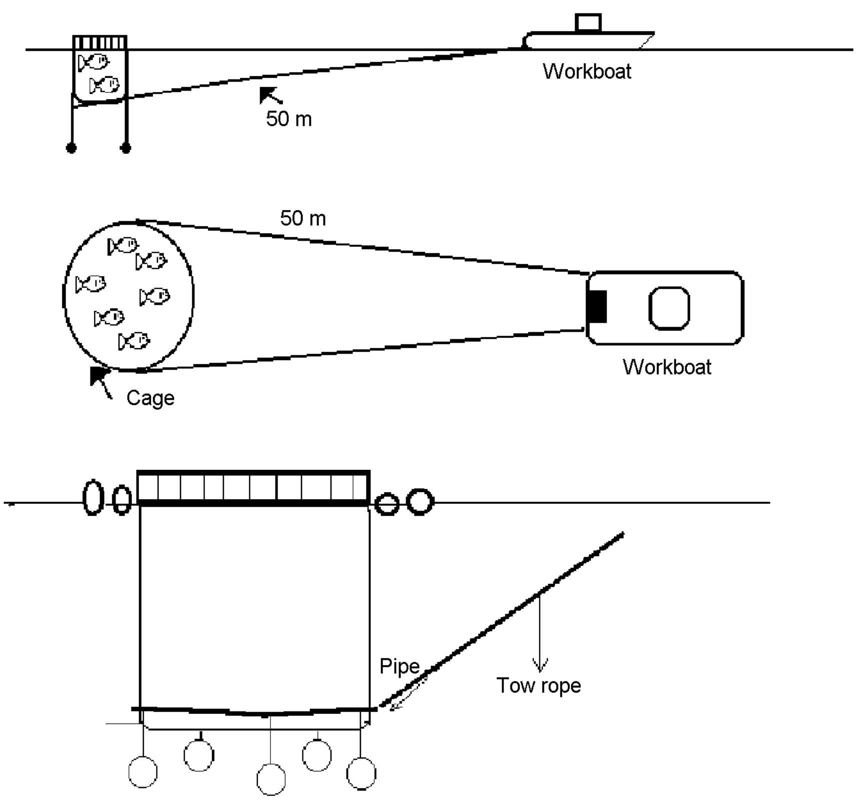

Fig. 4. Methods for towing a net cage.

During the towing period there should be at least one person on the cage and another in the water, watching the fish so as to correct failures and send instructions to the towing boat crew. At most, transport speed has to be the minimum needed for maneuvering the boat, typically no more than half a knot. Clearly, care has to be taken to avoid periods and specific times when tidal currents are significant, or when sea conditions are otherwise difficult. The cages are towed to their places in the mooring system where they can be securely attached.

If a fry transport cage is used, from which stock are to be transferred to a bigger cage, the fry can be best be moved by closing the top of the transport net (by gathering the upper side panels together, or preferably with a top net) releasing the closed bag from its frame, and towing it inside the bigger cage. To do this, one side of the larger net needs to be detached from its frame and dropped low enough to allow the fry net across. Once the fry net is inside, the main net can be raised and reattached, the top of the fry net untied, and the fry net lifted out, leaving the fry in the main cage. This is usually done with a hydraulic crane on the boat (Fig. 5). This system enables the same cage to be seeded several times, without fish being damaged, as it retains the whole volume of the fry net and is done very slowly, allowing fish to make use of the space required and to take time to move.

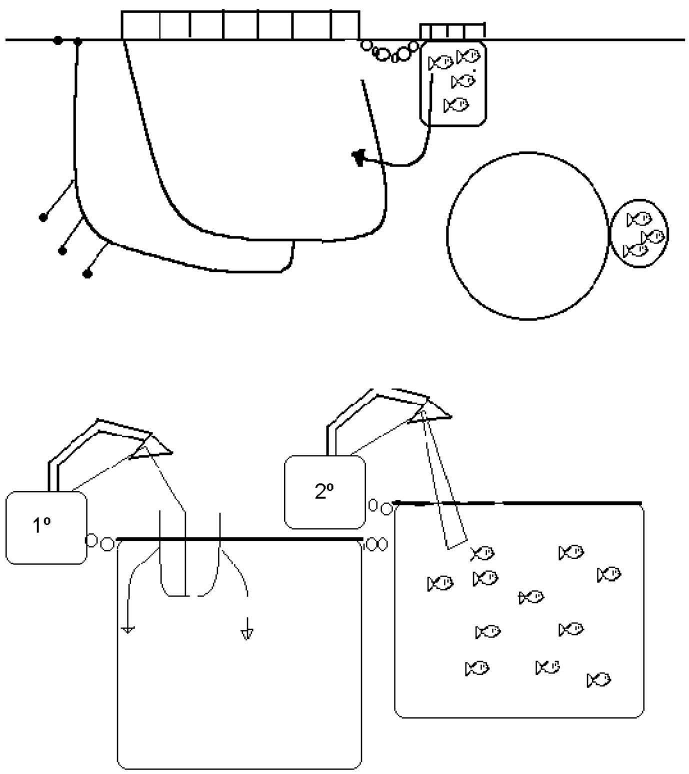

Fig. 5. Movement of fry within cages.

Once the fish are in place, it is important to check their health state, to give them as a basic precaution a strengthening treatment, based on dietary supplementation with vitamins and fish oil, and if some pathology is detected, try and stop it promptly. If the condition cannot be simply diagnosed, a treatment strategy should be adopted based on sound professional advice, to avoid any risks of further weakening the fish, or developing drug resistance. As far as possible, preventative approaches should be sought. For parasites, a bath treatment may be convenient, using a canvas or polyester bag within the cage in which the fish and the treatment are placed, using oxygenated water.

Feeding

Feeds are usually bought ready made, and need to be handled and stored correctly to ensure that they are in good condition and free of excess dust. Manufacturers’ "use by" dates should not be exceeded, and stocks should be rotated on a "first in-first out" to ensure that no feeds used are date-expired. At most, only medicine should be added, for which any blender can be used to mix the feed.

Whether or not automatic feeding systems are installed, it is usually recommended to feed fish under 50 g *ad libitum* and the rest of fish according to a pre-arranged ration. As a simple guide, feeds should be supplied once daily for every 5°C, i.e., starting from 15°C, one feed per day, at 20°C, two feeds per day, more than 25°C, three feeds, etc. In some periods of the year fish usually eat better at certain times, and based on experience, feeds should be more abundant in those periods. Feeds should be distributed around the entire cage, and more abundantly in the middle, preferably from a slightly higher place to enable the response to feeding to be easily seen.

For daily diet calculation within a new project, feeding tables from reliable feed supply companies may be used as the initial source of data. These allow the daily ration to be calculated as a function of water temperature and fish size. As each site has its own environmental and stock holding conditions, the next objective is to develop a feeding table adapted for the site itself. To do so, it is necessary to observe carefully a range of factors including stock behaviour, local temperature and current conditions, response to feeding, the rate of net fouling, wild fish living around the cages, unconsumed feeds falling to the bottom. Using the feed supplier's table as a guide, and measuring the growth and food conversion performance of the stock, it should be possible to adjust this to become more effective. It is also important that staff in charge of feeding routinely monitor and feed back information about fish behaviour so that rations for subsequent periods can be adjusted. Distinct lack of interest in feeding should be taken as an important warning sign for possible disease conditions.

There are several types of automatic or semi-automatic feeders (pneumatic, water, solar, pendulum, self-demand, etc.), which are suitable for different conditions. Key factors to consider are; reliability and durability of the complete feeding system, its accuracy of dispensing feed in terms of quantity and time, its ability to disperse feed across the cage surface, its ability to operate with a range of pellet sizes and qualities (e.g., high sticky, high oil diets) and its reliability in difficult weather conditions. It should be noted that most systems are not selective, and supply feeds even when there is no fish, so their operation should always be monitored. If wrongly adjusted, they can also either underfeed, and lose valuable growth, or overfeed, waste food and add to environmental loading. Given that a commercial farm can use $'000s of feed daily, this is an important source of expense to control.

Stock monitoring

Stock weight should be sampled at least once a month, at least twice a month for smaller fish. Small fish can usually be captured using a dip net with a little feed, but larger fish are caught with an encircling (seine) net typically 1 m deeper than the culture net and 5 m longer than its perimeter length. This should be provided with a bottom draw-rope which can be pulled tight to close the net below the fish, preventing their escape. Once captured, a random sample of 100 to 200 can be moved to an oxygenated tank dosed with an approved anaesthetic. Once anaesthetized, the fish can be weighed and counted, with the aim of determining an average weight. This should be done quickly and in a manner which minimizes scaling or other physical stress or damage. Afterwards the fish are placed in another tank in clean oxygenated water, without anaesthetics so that they regain consciousness before being released back into the cage, therefore avoiding being attacked by other fish (Fig. 6).

A good indicator is the condition index, which relates length with weight, the formula being:

$I = W \times 1000/L^3$, where W = weight, g, L = length, cm

If the index is 1.5 or 1.6, the stock are performing acceptably; if higher, stock may not be being fed correctly (or stock number is undercounted), if lower, fish may be underfed or numbers overcounted.

For batch weighing fish, scales are available which can compensate for movement on the boat or cage. There are also dynamometers which can weigh quite accurately – though the basic principle is that larger weights, provided fish counts are accurate, provide lower error.

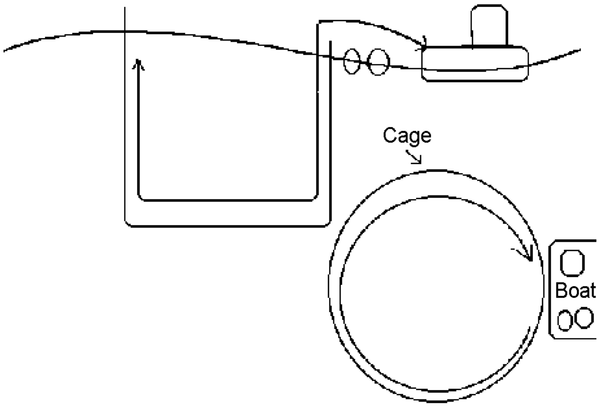

Fig. 6. Seining fish for sampling.

It is possible in any fish farm to generate a large quantity of meaningless data. To derive useful information from this it is necessary to classify and analyse the data and develop appropriate conclusions which are relevant for management. For this purpose a series of data entry forms are recommended to allow data to be classified more rapidly and effectively, allowing better control of the farm and its production. Once data is classified and organized and management information developed, a clear and concise report format can be produced for wider use. In many cases spreadsheet or database entry formats can be used, with standard calculation routines to allow rapid assessments of comparative performance, and projections for future management strategy.

Routine tasks

A number of routine tasks require to be carried out in offshore cage installations, primarily associated with system maintenance, cleaning and net changing. A number of these can be carried out efficiently using surface based staff and equipment, but a certain proportion of tasks can only be performed by divers, either at shallow levels, e.g., handling upper cage elements and nets, or in deeper water, e.g., inspecting moorings and other subsurface structures. Some of the key tasks are outlined below.

Net changing by divers: fish should not be fed from the previous day. Two divers and two members of staff are necessary. Weights or opening frames for the old net are detached, the new net is dropped down one side of the cage, divers draw it underneath the dirty net, and the new net is raised little by little from above, using one or more ropes, and air bags if necessary to make it lighter. Once the clean net is pulled around the old net and attached to the cage frame, a diver enters the old net, ties a rope to its centre floor and feeds it up to the boat crane. The old net is then released from its moorings so that it can fall to the bottom, while, using the crane, the net is gradually pulled out. Weights or opening frames can then be reattached to the new net (Fig. 7). This method is preferred as minimizes stress or damage to the stock, and is relatively straightforward for the staff.

Net changing without divers: fish are unfed as before, and net weights or opening frames detached. In this case, the clean net is placed at one side of the dirty net and both tied together along their upper sides. The joined section is then dropped and the dirty net is pulled across and raised little by little over to the other side, forcing the fish to move across into the new net. Once they have moved over, the new net can be pulled up all around the frame, the dirty net untied and removed, and the weights or opening frames reattached (Fig. 8). This system is efficient for big light framed cage nets.

Once the dirty net is out of the water, it should be left to dry for one or two days in a shaded place, then washed for half an hour in a mechanical net washer, without detergents and with saline water. The open top of the net must be tied up before washing, or the net placed in a special washing bag to avoid tangling. Once washed, before drying, they should be checked over and mended. They should then be stored until their next use, with code tags showing for easy identification. Storage facilties should be cool, dry, dark and rodent-proof.

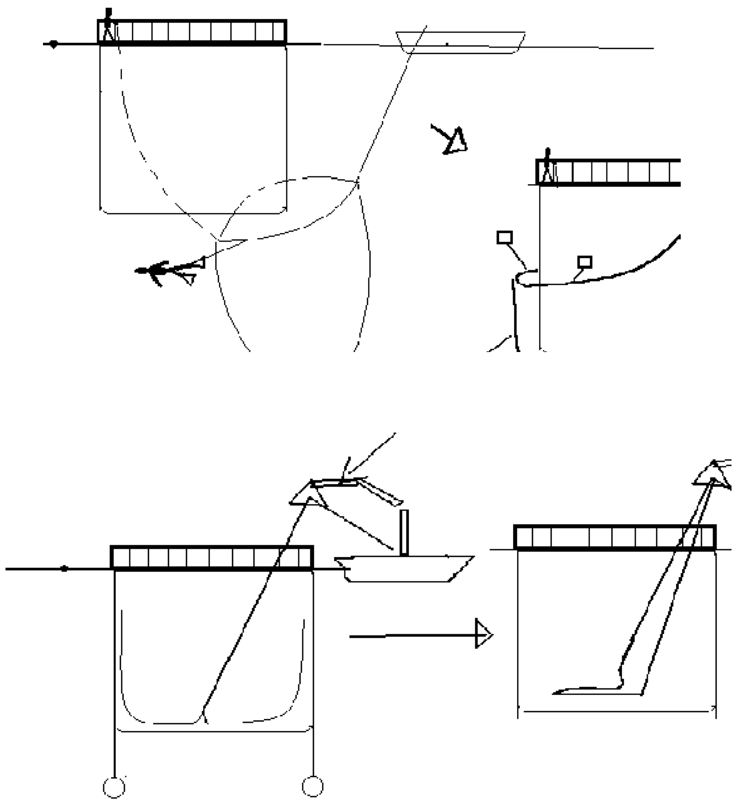

Fig. 7. Net changing with diver assistance.

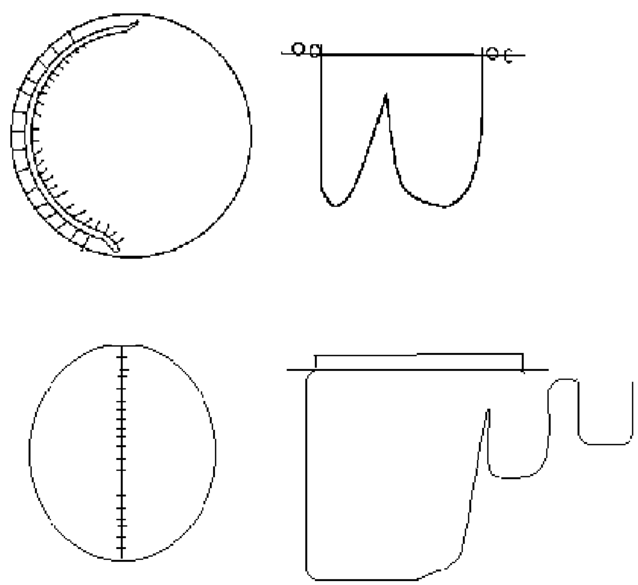

Fig. 8. Net changing without diver assistance.

Inspection of seabed and moorings: these should be inspected by divers every week, using an underwater record pad to show the installation layout and allow divers to record conditions. Two divers, for reasons of safety, are always recommended. A caliper can be used to test damage and corrosion of the main elements, and a still or video camera used to record seabed conditions, mooring positions, etc. Any component that has lost more than 25% of its original dimensions should be replaced. An inspection record book is also needed onshore (Fig. 9).

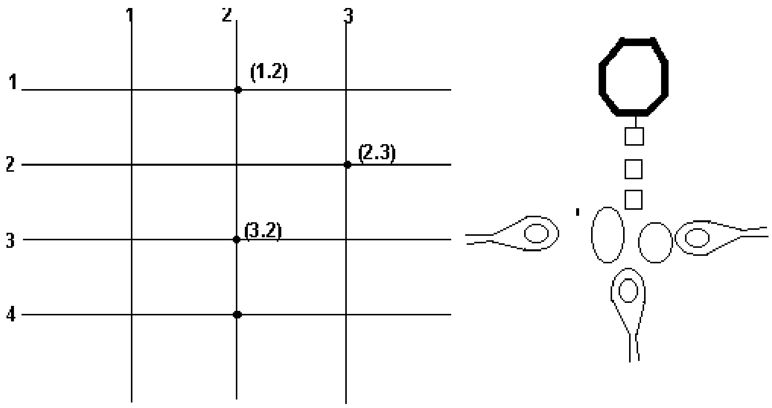

Fig. 9. Typical layout and dimension records for cage system moorings.

If a mooring, buoy or other component has to be tightened, a tightener device, or the boat itself can be used. Tensile strength is usually only in the case that the installation is floating (<800 Kn tension)

For inspecting deep moorings, two divers are necessary, usually specialist divers under subcontract. Immersion should be very well programmed. They must analyse corrosion and wear of elements and carry spares and appropriate tools as needed. For dimensional losses of 20%-25% exchange is advised. Sacrifical anodes are recommended to prevent corrosion of metallic elements.

Net inspection: this is one of the most important aspects of routine maintenance. Basic checking can be done from the surface, but proper inspection has to be done by diving. Nets are the vital point of the farm and should be inspected every day for seabream (because of net chewing) and every two days for seabass. Holes are usually mended temporarily using coloured plastic cable ties, which also mark the net for later repair. The diver should go three times round each cage: once at about 5 m away, once again looking down from the upper level and finally looking up from the base. For seabream in particular, notes of the holes encountered and their characteristics should be taken, as an indicator for feeding. Signs of predator damage and undue wear should also be noted. Nets should be numbered and key details recorded on a net incidence sheet (Table 1).

Table 1. Net record sheet

Net No.	Type	mm	Date of supply	Supplier	Special features	Current location	Date	State	Lot	Days
1	5x5x(5+1)	6	Sep. 97	xxxxxxx		Warehouse	31-Jul.	Ms		
2	40x(8+1)	22	Jul. 98	xxxxxxx		N-3	31-Sep.			

Though double walled netting can be considered, to provide additional security against net damage, it is not widely used for many reasons, among which are included the stress caused to cage structures by the excess weight, the reduction of current flows by the outer net, favouring the growth of algae on the inner net. Fish escaping from the inside net also have hardly any space between both nets and end up dying; the inner net has to be inspected from the inside, which greatly stresses the fish.

Hygiene: cages should be cleaned any time they are left empty, as significant encrustations can build up, damaging the cages themselves and the nets. Anti-fouling treatments have been successfully developed on cages and can be considered, though TBT (tri-butyl tin) compounds should be avoided. While a certain amount of cleaning can be done *in situ*, more thorough cleaning requires the cage frame to be hoisted with the boat craneand cleaned with a high pressure hose and scraper. Where possible, cage frames should be taken ashore periodically and thoroughly cleaned. Steel components can also be stripped down, shotblasted, reprimed and painted. The chains, buoys and ropes of the mooring grid will always be colonized by mussels and barnacles, and these become heavier and potentially more damaging to other components. Routine cleaning of every element, at least twice a year is usually necessary.

Stock grading

This is an essential element for efficient operation, and in using production volume effectively. As fish stocks grow, their size ranges increase, and problems can arise with territorialism and even cannibalism. Feeding also becomes inefficient, as it is impossible to feed the appropriate rate and particle size to the whole range of sizes in an ungraded cage. The opportunity to transfer to bigger mesh, better ventilated cages is also reduced, as smaller fish may still be present.

The use of cage space is also important, and a number of stocking and grading strategies can be adopted, depending on the availability of fry, the cages sizes, growth rates and market targets. As a simple example, with a twelve-cage farm, the first year can be operated with sufficient fry to fill each cage at harvest size, but as stock are harvested out, the empty cages can be stocked with double the harvest number of fish. As other cages are successively emptied, the overstocked cages can then be graded and the stock numbers split so that each cage then holds part grown fish in the appropriate number to grow to market size. The aim of grading is to correctly distribute fish according to number and size into corresponding cages. Very often sizes and numbers will not exactly fulfill targets. Experience suggests that it is better to sacrifice perfect grading for an even distribution of stock.

Machine grading is almost always used, as it is considerably faster, less stressful to the stock, and less demanding of labour than hand grading. The assembly typically comprises a fish pump for taking up the ungraded fish (alternatively, but less ideally, the fish my be taken out in batches using the boat crane and a large dip net), a separator grid, with a return pipe for the pumped water, the grader itself, and the transfer pipes for the graded fish. The grader is normally set up on the large working boat, or on a work barge. For seabream, no treatment is required prior to grading, except perhaps to supplement the diet with some vitamins for four or five days. On the day of grading, fish should not be fed, to reduce oxygen consumption and possible low levels during the grading process. For seabass a broad spectrum antibiotic prevention treatment, supplemented with vitamins and fish oil, and good feeding during the five days prior to grading is advisable. The amounts of antibiotics and vitamins will depend on the manufacturer's specifications. Once the stock are ready for grading, the net can be carefully pulled up and to one side to collect the fish into a more manageable volume. During grading, oxygen should be ready and the pump returns should come back to the cage.

Once the grader pumps are started, a typical target rate is 7000 to 12,000 fish per hour, according to species and size. Seabream should be graded at 25-50 g at any temperature; and seabass at 100-120 g at temperatures between 18° and 21°, to be sure they will carry on eating afterwards. However, at larger sizes, large quantities of anaesthetics will be required as the fish may die due to excess activity and stress. A canvas or polyester bag is needed to isolate fish, change water and supply anaesthetics, the amount depending on the size of the fish.

Every half hour, a sample should be taken from each grader channel to check the number of fish that are being classified and their weight, so that small errors may be quickly corrected. After grading, the fish should be handled carefully and thoroughly monitored. For seabass, antibiotic and vitamin supply will continue for a further five days and for both seabass and seabream, antibiotic baths may be needed to prevent infections due to abrasion, etc.

Harvesting

Fish can be harvested directly from the growing cages, but if possible, it is preferable to have separate harvest cages that can be stocked up as necessary. These are usually smaller and lighter than the main cages – commonly plastic ring types. For offshore systems, these are typically moored in a more convenient, less exposed, but secure inshore location. However, if they are located offshore they will need to be of the same quality standard as the ongrowing cages. The only treatment normally required prior to harvesting is fasting, to improve the condition and post-harvest quality of the stock and to keep the packing boxes as clean as possible. Depending on the withdrawal time for any treatment compounds, the stock will have to have been cleared of treatment for a specified time-commonly three to six months. In some cases, special "finishing" diets may be used to control feed costs and improve post-harvest quality.

With a harvest cage it is usually possible to remove just the amounts required by the market. However, when a culture cage is harvested, an encircling net will be required to contain that part of the stock required. Harvesting is normally done using the boat crane and a canvas net to retain water and keep the fish clean. Tanks from 500 to 1000 litres capacity are normally used, supplied with ice at an ice: fish weight ratio of 1:1, plus a little water. Fish should be cooled down as soon as possible and if cooled down to 1.5°C in 30 minutes, and maintained cold, rigor mortis is delayed by 36 h. If the cold chain remains unbroken, the fish will then keep fresh for the next 12 days. Any change in temperature during the process will imply a decrease in product freshness.

Processing and packing premises should be set up to EC or equivalent regulations, fully inspected and certificated. This requires good levels of interior finish and services, capable of the reliable delivery of high levels of hygiene, and well trained staff who observe correct standards. Premises should be well ventilated, and work areas fully cleanable, free of insects, with wastes washed away and collected safely, etc. It is normal to grade harvested fish to meet specific market demands, and essential to keep close control of quality, of weights and numbers and of cleaning, icing and packing processes to make sure that product is well presented and in optimum condition when it reaches its markets. From harvest to customer, the cold chain must never be broken, and a cool chamber should be available for all the harvest output, allowing for excess storage due to transport delays, etc. Strict control of the process has immediate consequences on final product quality. It is important to realize that after a long and difficult process to produce fish, the benefits of production and the reputation of the company can be lost on the very last hours, due to poor post harvest quality control.