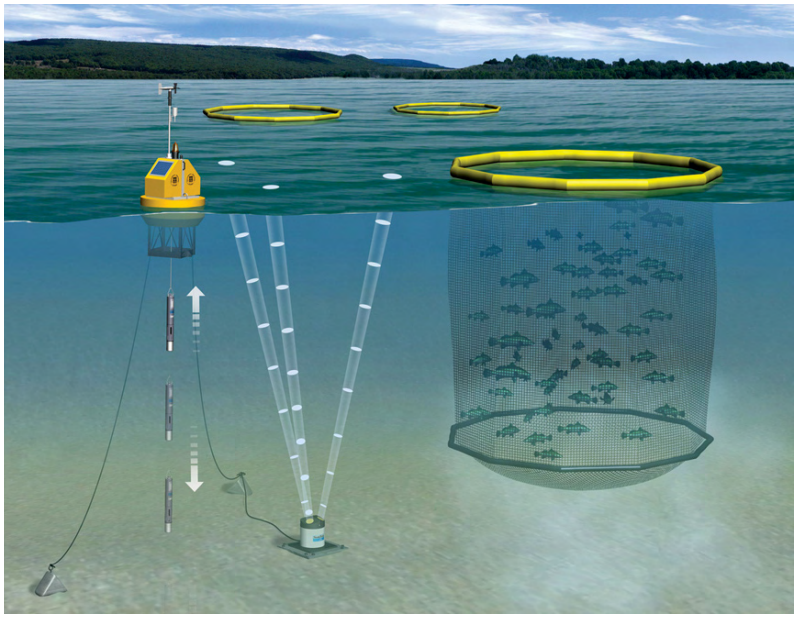
YSI Environmental

Application Note

Considerations for Sea Cage Aquaculture in Marine Environments

The use of offshore cages, or pens, to culture marine finfish has been used successfully to culture a number of species for many years. Success with cage systems is common in Australia, Norway, and Chile with cage culture being used since the 1950's in some regions.

The consumer popularity of marine finfish in recent years has led to an increase in the demand for the culture of traditional species and also experimentation with several newer species. This popularity has led to an increased demand for marine aquaculture sites in several areas.



A complete YSI sea cage monitoring solution. A YSI buoy with a vertical profiling 6600 V2 along with a SonTek/YSI Argonaut provides continuous monitoring of water quality, current and wave data.

In South Australia, for instance, the South East region has seen expansion in Atlantic Salmon (*Salmo salar*) farming in recent years and has increased as culture sites become available as a result in changes to the Marine Aquaculture Management Plan for the region. The Southern Bluefin Tuna (*Thunnus accoyii*) industry has grown steadily in terms of both whole weight production and value. Interest in Snapper (*Pagrus auratus*) culture has declined due to slow growth rates and the replacement of the species with two new and possibly more economical species: Yellowtail kingfish (*Seriola lalandi*) and Mulloway (*Argyrosmus hololepidotus*).

A sea cage operation nestled into a sheltered bay with good water flow.

Site Selection

Site selection is probably the single most important factor that determines the commercial viability of an aquaculture operation.

An aquaculture operation should be located, designed and operated to provide optimum water quality and to avoid conditions that may induce stress, reduce growth or predispose the fish to disease. Some biological and natural distribution information for the species should be known before a site is selected for cage grow out. It is important to understand if the species is found naturally in that location, if the temperature limits of the area are within the limits the species can flourish under and if other water quality parameters will prevent the fish from being stressed. The area should be of a suitable depth, have good tidal flow with optimal conditions and ideally be sheltered from intense wind and wave action. Additional site selection criteria should also include accessibility to the cages and the ability to move them out of potential harmful events such as algal blooms and/or low DO events. Continuous, unattended monitoring systems that can send alerts when conditions are close to unacceptable ranges are invaluable in these situations.

The main physio-chemical parameters that need to be considered in grow out systems include factors such as water temperature, water quality, dissolved oxygen, alagal blooms and light. Other than a limited ability to influence the quality of the surrounding water by modifying feeding and other management practices, open, offshore grow out systems are inherently dependent on natural conditions to provide a suitable growing environment.

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Sea Cage Growout

Inside a sea cage off the coast of Hawaii.

The type, size and design of a sea cage best suited for a particular application is dependent upon several factors that include the species selected for culture, site conditions, environmental features and capital investment. Sea cages can be relatively productive and, in a suitable site, support high stocking densities. However, the need for adequate clearance beneath cages and suitable flushing characteristics may limit the suitability of many near shore areas for large scale sea cage production systems. Advantages of sea cages include the use that can be made of offshore water bodies, which extends areas of suitable coastal water. Other advantages include the ease of expansion involving the addition of more cages to a site, all of which can be moved relatively easily to take advantage of better water quality and avoid adverse conditions. Disadvantages of sea cages include the complete lack of control the aquaculturist has over water quality, weather conditions, and potential disease outbreaks. As well, algal blooms and other pollution can cause serious losses to stock levels.

Preventing these losses can nearly be eliminated with monitoring systems designed to alert when potential water concerns are present. A complete system setup to perform continuous water quality monitoring along the vertical water column coupled with velocity and directional information will allow for an accurate understanding of conditions inside and around the cages.

YSI 6600 V2 multiparameter instrument with wiped optical sensors.

A buoyed, or cage mounted, YSI 6600 V2 can be used to vertically profile the water column and send data remotely for parameters such as; dissolved oxygen, pH, ORP, temperature, chlorophyll, turbidity, blue-green algae, salinity and conductivity. The wiped sensor technology helps prevent biofouling on the sensing portion of the probes reducing labor and maintenance costs while providing more accurate data.

In addition to water quality parameters it is important to know the current and wave height data in order to make informed decisions about cage placement or movement. This information also provides valuable data to prevent damage to the cages and to determine whether or not it's safe for a site visit. SonTek/YSI accoustic Doppler products are vital products in the effort to prevent potentially hazards algal blooms or low DO events from decimating livestock by understanding the water dynamics in these areas.

Fundamental design criteria should take into consideration accessibility, ease of maintenance and the safety of the complete system. The design and engineering of sea cage aquaculture production systems should give consideration to the following principle elements; the net or cage bag, frames, collars and supports, linkages and groupings, mooring systems, and access to water quality data.

Cage Management

The major reason why the growth potential of properly fed fish is not fully realized is that stocking density has exceeded the carrying capacity of the system. An optimum density and proper feeding rate are musts for economical production. If rearing records are accumulated at a particular site for at least three years, the optimum stocking density and feeding rate for maximum growth and feed efficiency relative to season and fish size can be estimated.

The depth, area and speed of the water current at the culture grounds determine the culture density of finfish species. A maximum stocking density of fish will only be achieved if environmental conditions are favorable and may only be realized after many years of data are collected at the site. The mesh size of the netting should be increased as the fish grow to allow for maximum water exchange.

Cage culture requires frequent net exchanges because of biofouling which clogs the mesh and restricts water exchange. By treating the netting with anti-fouling agents, nets can be used for longer periods without replacement; however, the addition of any such materials should only be used if allowable under local environmental regulations. Cages can be purchased, such as steel cages, which have characteristics which resist fouling and have anti-predatory functions as well.

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An ideal cage management husbandry practice also includes fallowing certain sections of the site. This involves moving the cages over different area of the sea bed in order to minimize the build up of organic wastes in any one area. The additional benefit is allowing these areas enough time for the environment and natural marine processes to assimilate any wastes.

Environmental Considerations

An important factor associated with seas cage culture is the capacity of the environment to deal with the wastes. The intensity of the production system to some degree determines its effect on the environment.

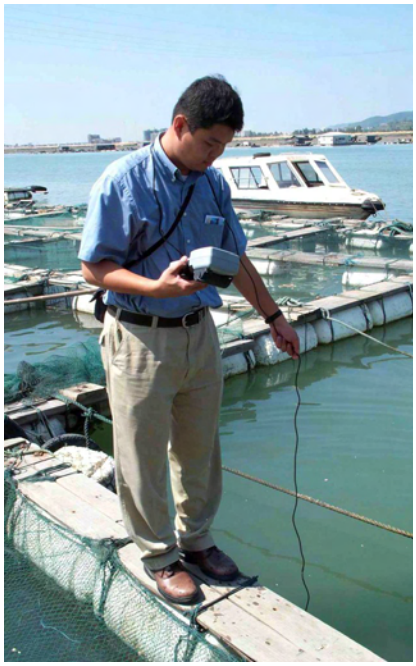
Environmental concerns over sea cage systems include:

- eutrophication as a consequence of increased nutrient loadings (fecal and uneaten food waste will settle on the sea beneath the cage)
- the impact cages may have on wild fish populations; disease, water quality impacts
- the effect escapees may have on wild populations
- loss of visual aesthetics of the surrounding area and
- the use of chemicals to control parasites and disease.

Sea cages, if not well managed, may have an impact on the environment in that large quantities of uneaten food and feces sink to the bottom beneath cages, which may effect water quality, kill stock and create deleterious impacts on the surrounding environment.

Under the cages, oxygen depletions may occur due to decomposition of accumulated waste materials. During certain times of the year, the oxygen depleted layer may actually rise due to convection and cause oxygen depletions and associated mortalities in cages. Eutrophication in culture areas can lead to the development of phytoplankton blooms that have caused mortality at levels of thousands of tons of cultured fish annually in Japan.

It must be noted that a well managed farm with good husbandry practices will have a negligible impact on the environment. An efficiently run operation will have several people monitoring and observing various aspects of the operation on a daily basis. With proper monitoring equipment many of these tasks can be continuous and on-going with minimal oversight. Proper feeding amounts can have serious implications, not only financially, but also ecologically on the local environment.



Handheld sampling around small-scale sea cage operation with a YSI 550A.

Understanding the amount of feed eaten is also important in order to reduce the amount of feed supplied that may go to waste. Differences in season will also play a major role in the amount of food consumed on an aquaculture farm. Some farmers using cages in some regions must undergo an accredited environmental monitoring program in order to comply with environmental requirements.

Economic Considerations

Under suitable site conditions, offshore cage farming systems would usually be expected to be cheaper to establish and operate than onshore farms with equivalent production capabilities and provide more attractive financial returns on invested capital. However, the suitability of the site is an important factor.

In some locations, the number of sheltered sites with the features needed for successful cage culture is limited. Those that may be available will be subject to strict environmental controls and competing use of the resource. Increasing constraints are likely to be placed on the expansion of near shore cage farms, particularly those with the potential to affect the sea grass meadows found along many of the temperate coastlines. As such, the growth of the industry may be limited unless more exposed sites further from the shore are used. These sites will require the use of more sophisticated and production systems. They will also be more labor intensive to operate under poor weather conditions. There are however numerous sites with this technology being efficiently used in the offshore aquaculture industry and there are instruments available to continuously monitor the health of the surrounding waters.

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