Aquafarmer Information Sheet

Producing Pearls Using the Black-lip Pearl Oyster *(Pinctada margaritifera)*

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Introduction

The Black-lip pearl oyster *(Pinctada margaritifera)* has long been an important species in the Indo-Pacific region because of its beautiful shell, which is lined with a shiny and **iridescent** coating called **nacre**. Traditionally the shell was used to make jewelry, decorations and tools such as fishing hooks and knives. With the advent of international trade and "western contact," demand for the shell increased rapidly for use as buttons and decorative inlay. Such was their popularity that over-fishing to meet this foreign demand for the shell rapidly depleted the abundance of Black-lip pearl oysters in many places. As a result of this over-fishing, many areas of the Indo-Pacific still have very low populations of Black-lip pearl oysters today.

Pearls are formed naturally when the oyster is irritated by the presence of a foreign particle in its body. This is usually a small piece of rock or a grain of sand. To get rid of the irritant, the oyster lays down a layer of the shiny, iridescent nacre around the particle to form the pearl. Natural pearls are extremely rare (1 in 2,000 oysters may have one) and are generally small and irregular in shape. However, such was their value that researchers in the early 1900s found a way to implant a nucleus into pearl oysters that would produce a round pearl. Oysters were now more valuable alive than dead as they could be used to grow the precious pearls rather than just being sold for the shell. This revolutionized the pearling industry, putting the emphasis on "farming" pearls rather than collecting them from the wild.

The Black-lip pearl industry started in French Polynesia with the first harvest in 1976. Today the industry in French Polynesia alone is worth approximately US$140 million per year. Farming Black-lip pearl oysters for pearls in the U.S. Affiliated Pacific Islands has substantial potential, and although oyster populations remain low in many areas of the region, farms currently exist in the Republic of the Marshall Islands and the Federated States of Micronesia. Pearl farming can be done on many economic levels using various approaches ranging from family or community arrangements to commercial-scale enterprises. Certain aspects of pearl farming do not require large capital outlay and use low technology, sustainable methods that are suitable for rural and under-developed areas.

The purpose of this information sheet is to alert prospective farmers to the economic benefits of pearl farming and also to describe the sites, equipment and commitment needed to become a successful pearl farmer. In addition, there are sections that provide a general description of pearl farming and information on where to get further help in starting a farm.

Biology and environmental requirements

Black-lip pearl oysters are bivalve molluscs, which means that they have two shells (also called valves) that house and protect their body parts (Figure 1). They are found attached to hard substrates as deep as 40 m, usually in association with reef habitats. Pearl oysters start life as males and

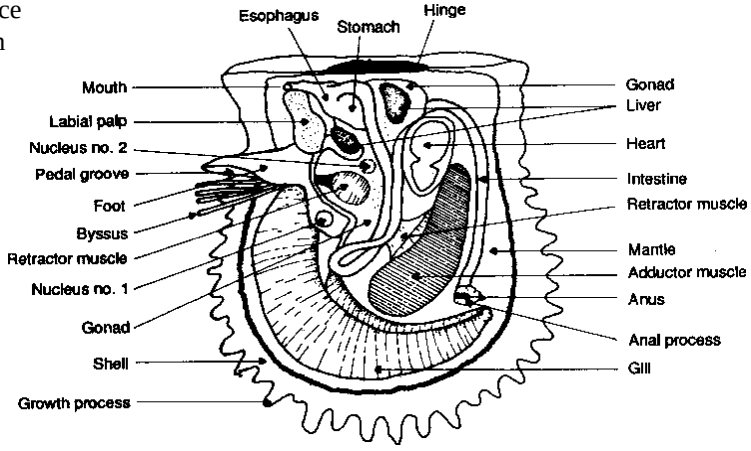

Figure 1. Internal anatomy of a pearl oyster (from Cahn, 1949).

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change into females after 2-3 years. Each female can release millions of eggs into the water, which are fertilized externally by sperm from the male. Eggs hatch and the oysters pass through various **larval** phases during which they remain swimming freely in the water. At between 25 and 35 days of age the larvae start to spend more time crawling on the bottom and finally **metamorphose** into a juvenile pearl oyster that attaches itself to the substrate. Black-lip pearl oysters feed by filtering water across their gills to trap plankton and other digestible materials.

Black-lip pearl oysters are widely distributed throughout the tropical Indo-Pacific and are hence native to all the U.S. Affiliated Pacific Islands. Water temperatures should range between 25-30 °C and salinity should remain above 33 ppt. Black-lip pearl oysters can withstand some silt in the water but too much can interfere with their feeding.

Pearl farming

Starting and successfully running a fully integrated pearl farm generally requires a large commitment of time and money. It takes 2-4 years to obtain the first harvest of pearls and the farmer must have capital to sustain the farm through this time. The different areas essential to successful pearl farming are described in the following sections.

Site selection

Selecting a good site determine whether a farm is successful or not. Poor sites may cause slow growth, mortality or disease and most importantly, poor-quality pearls. The following guidelines should be followed in order to select a good site.

1. *Water quality* - Clean, pollution-free seawater is needed. Choose a site away from potential pollution sources such as garbage dumps, chemical or oil depots, large areas of human population and freshwater run-off such as rivers.
2. *Depth* - A depth of 25-35 m is optimum.
3. *Water movement* - A slight current is recommended to bring in clean water and new food supplies for the oysters. Excess current or wave action makes the farm hard to work on and may cause poor growth of the oysters.
4. *Security* - Pearls are extremely valuable. Farms should be located in an area where they can be watched either by the farmer or someone the farmer trusts.
5. *User conflict* - Areas with heavy boat traffic or fishing activity should be avoided. This will limit potential damage to the farm from propellers and fishing lines and give the farm less exposure to human traffic in general.

Obtaining pearl oysters

Pearl oysters for farms are obtained in one of three ways: collection of wild juveniles and adults; **spat** collection; and hatchery-reared animals. Collection of wild animals is often done when starting a farm for the first time as it provides a ready source of animals for almost immediate grafting. However, wild collection is unsustainable because it quickly exhausts local oyster populations. Wild-caught oysters also produce poorer quality pearls than those kept on the farm from an early age.

Spat collection is the process of attracting the free-swimming larval stages of pearl oysters to settle on a substrate that is hung in the water. This is the most common method used to obtain Black-lip pearl oysters today as it is cheap and easy to do. Different materials can be used to attract pearl oyster spat but black polyethylene shade cloth material seems to work best. This is bunched in some way to provide folds in which the spat can hide to avoid predators. Collectors should be hung on longlines approximately 1-2 m below the water surface (Figure 2). Lines should be anchored at a depth of 20-30 m of water and at least 30 m from the reef edge to reduce fish predation. Black-lip pearl oysters generally **spawn** in a seasonal pattern with two yearly peaks

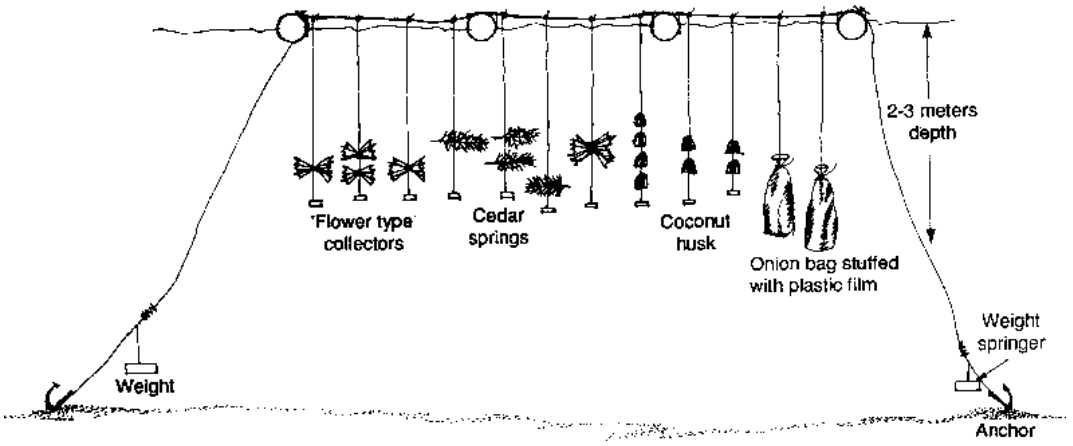

Figure 2. Longline structure with different types of spat collectors (from Gervis and Sims, 1992).

in spat settlement. If farmers are aware of the time of these peaks then they can set their collectors to coincide with maximum spat fall.

Hatchery rearing of Black-lip pearl oysters is a well understood but less commonly used method for obtaining animals. At the end of 1999 there was only one Black-lip hatchery in the U.S. Affiliated Pacific Islands in Majuro, RMI. Therefore it is likely that a farmer will need to obtain their oysters using wild or spat collection methods.

Farm construction and layout

A pearl farm is simply a structure that allows the oysters to be suspended in the water column at a depth of 3-7 m. This depth protects the oysters from rough weather while still making them accessible to farm workers. Three methods are primarily used for constructing pearl farms: longlines, rafts and underwater trestles. Farmers should choose the method that is cheapest and most convenient for the site that they have chosen.

Most Black-lip pearl oysters are farmed on longlines, which are lengths of strong rope anchored to the bottom and suspended with floats at the desired depth. The floats also provide tension in the line and keep it taught. Longlines are cheap and easy to install and are well-suited to the lagoon type farming conditions that prevail throughout the U.S. Affiliated Pacific Islands.

Rafts (Figure 3) are generally used in well-protected areas because they float on the surface. They are usually constructed from barrels or other large floats and bamboo or wood lashed together. Rafts would only be suitable for well-protected bays in the U.S. Affiliated Pacific Islands.

Trestles (Figure 4) have a similar trellis structure to rafts except they are attached by legs to the ocean floor. While sturdy and long-lasting, this system has the disadvantage of being more costly than longlines and, like rafts, keeps the oysters in high densities thereby increasing the chances of disease outbreak. Trestles are suitable only for shallow bay areas and have been used in French Polynesia for holding oysters after seeding and as spat nurseries.

The choice of how to suspend the oysters from the farm structure is also important. Juvenile oysters are usually kept in lantern nets, box nets (Figure 5) or mesh bags until they are around 10 cm in length. At this point they can be transferred into pocket panels (Figure 5) or onto chaplets (Figure 6). A pocket panel is a wire frame with a series of mesh pockets into which individual oysters are placed. Chaplets are lengths of rope onto which oysters are hung by a piece of wire that has been threaded through a hole drilled in the shell hinge. Chaplets are cheaper than pocket panels in general but oysters are sometimes lost from chaplets because the wire holding them to the line snaps.

Grafting or seeding

The **grafting** process is one of the most expensive and critical aspects of pearl farming. Grafting (also called seeding) is the process whereby a bead or nucleus is implanted into the oyster to form the pearl. This is a surgical procedure carried out by a highly skilled technician who must be paid by the farmer. The technician first selects a donor oyster and removes the **mantle,** which produces the nacre for the pearl. The mantle is trimmed and cut into small (2 mm) squares. One piece of the mantle is inserted into the **gonad** of the

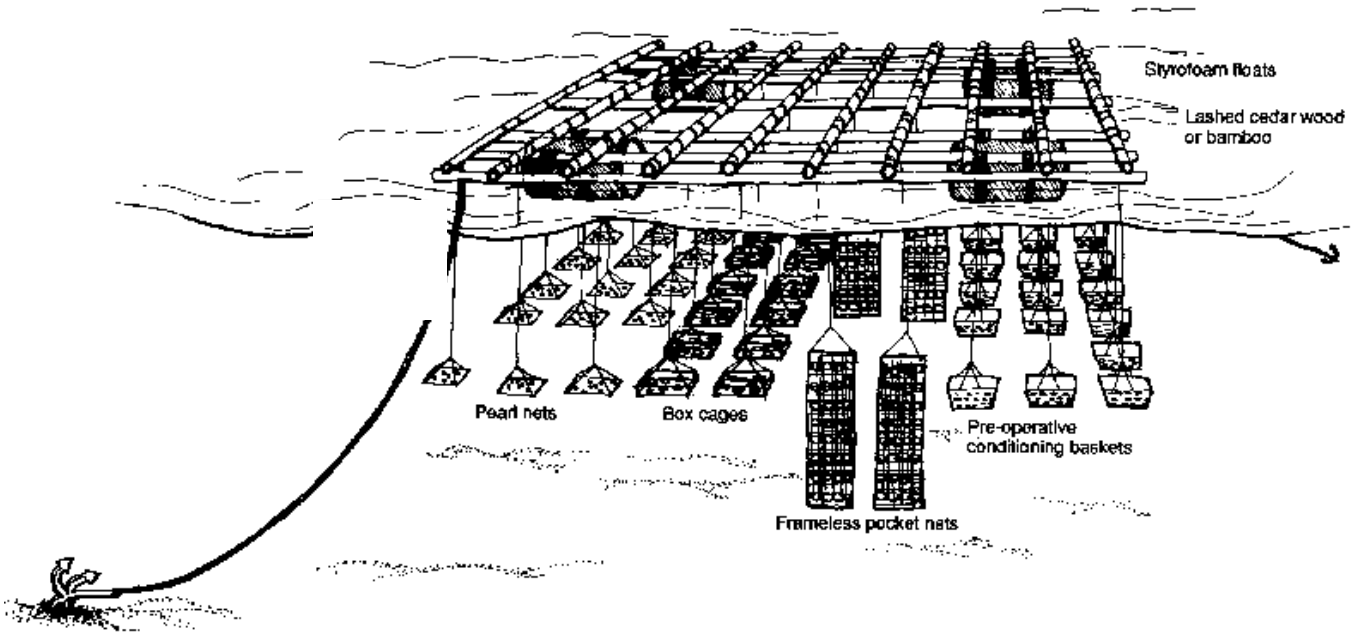

Figure 3. Raft pearl farm structure (from Gervis and Sims, 1992).

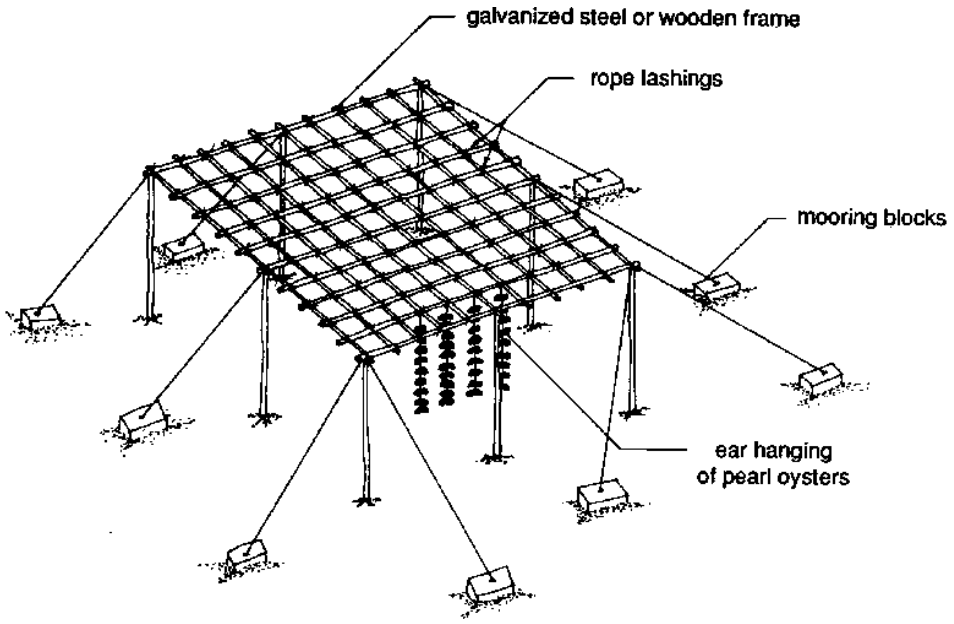

Figure 4. Trestle pearl farm structure (from Gervis and Sims, 1992).

pearl oyster, through a small incision made by the technician. This is followed by a round nucleus, which is pushed onto the mantle tissue so that they touch. If the technician has done his or her job properly, the mantle tissue will grow around the nucleus forming the **pearl sack** and laying down an even layer of nacre onto the nucleus, which forms the pearl. Pearl production takes 18-24 months from seeding to when the nacre is 2-3 mm thick. After grafting, approximately 10% of the oysters will die and a further 20% will reject the nucleus. Numbers greater than this may indicate a poor technician or onset of disease. Oysters that reject the nucleus still have some value. The residual graft and tissue inside the oyster forms an irregular pearl known as a **keshi**. This can be harvested at the same time as the pearls and sold for jewelry.

Technicians demand a high salary for their work, but if they are good, their work will provide high returns for the farm. In addition to their salary, technicians will require room and board while working on the farm and a "seeding platform" on which to work. This is usually a shed built on or close to the farm where oysters are brought for seeding. It must be built on a solid foundation and protected from strong breezes.

Although hiring a seeding technician is expensive, the cost can often be lowered by offering a portion of the harvest profits as payment rather than paying all the fee up front. This also gives the technician a strong incentive to do the best job possible of seeding. Technicians will often only travel to an area if they are guaranteed a large amount of work. Small farmers can overcome this problem by forming a cooperative to hire the technician to service all the farms.

Farm maintenance

Pearl oysters, especially after seeding, are valuable animals and therefore must be properly maintained. All areas of the farm should be visited every 2-3 days to check for broken or damaged lines. Repairs should take place immediately. **Fouling** such as algae, sponges and other bivalves occurs rapidly on the shell of pearl oysters. This can interfere with feeding and also damage the shell if left unchecked. Oysters should be cleaned once every 4-6 weeks. Large farms have automated cleaning machines but most farms rely on gasoline powered, hand held pressure sprayers to remove fouling. In addition the lines and floats that hold the oysters must be cleaned on a similar schedule.

Small pearl oysters or spat require extra care. They must be carefully separated if kept together, as they have a tendency to clump together. Their holding containers must be inspected frequently to rid them of predators such as crabs or snails, which can rapidly kill many spat.

Harvest

Harvesting the pearls is as important a process as seeding because oysters that produce a high quality pearl can be re-implanted with a new nucleus to produce another pearl. A seeding technician (often the same one that did the initial implant) makes an incision in the pearl sack and removes the pearl. The pearl is examined and if it is of a high quality, a new, larger nucleus is inserted into the pearl sac and the oyster is returned to the farm. Oysters can be re-implanted up to 2 times, each time with a nucleus the size of the harvested pearl. For example, if an initial nucleus of 5 mm diameter produces a 7 mm pearl, then a 7 mm nucleus can be

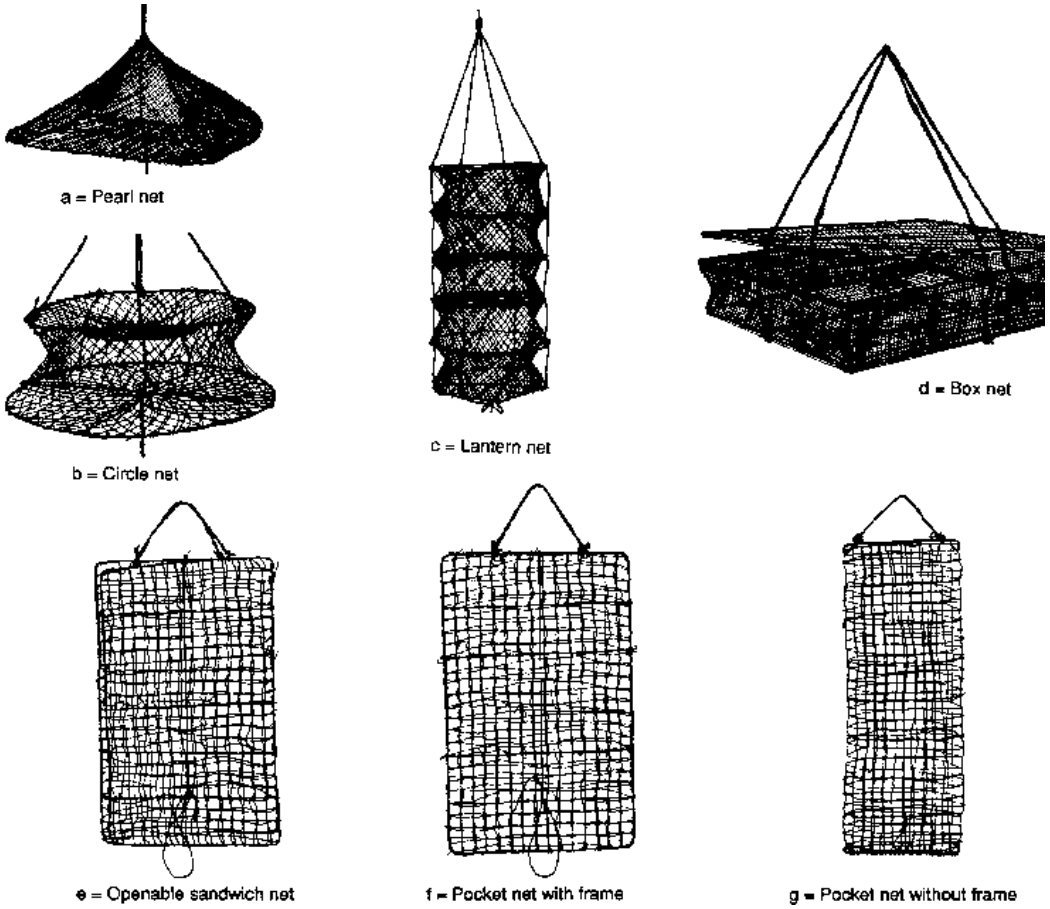

Figure 5. Containers used to hold pearl oysters (from Gervis and Sims, 1992).

re-implanted into the oyster. Because large-diameter pearls fetch a much higher price than smaller ones, the larger pearls produced by re-implantation eventually contribute greatly to the farm's income.

Marketing

Not all pearls are created equal. A pearl is graded depending on its size, color, shape and how it reflects the light (luster). It is essential for the farmer to have some idea of pearl grading in order to obtain a fair price for the pearls. Pearls are graded into categories of A, B, C or unsaleable. On the average only about 5-10% of the harvested pearls will be classified as grade A. These will provide about 95% of the farms income. If the technician has done a good job at least 800 (80%) of every 1,000 pearls harvested will have a market value. The rest are essentially worthless.

The farmer generally sells the pearls in lots of 100 or more to a buyer. Each lot of pearls usually contains pearls of all grades. The buyer may be a jeweler, the grafting technician or someone who accompanies the technician. In some areas such as French Polynesia there are auctions where farmers can sell their pearls. An alternative to selling pearls in lots is to market them independently to jewelers or wholesalers. However, this usually requires special knowledge of pearl grading.

Maximizing farm profits does not just mean selling pearls. Keshi and half-pearls (**mabe**) can also be sold to supplement farm income as can the meat and the shell of the oyster. The shell can be made into polished ornaments and jewelry such as fishing lures, earrings, pendants and necklaces.

Economics

It is very difficult to give an example budget for operating a pearl farm because each farm has a unique structure, location and size. However, this section will list a number of parameters that should be budgeted by a prospective farmer to one degree or another in the construction and running of a farm. It should again be noted that it takes 2-4 years of operation before the first pearls can be harvested from a farm. The major expenses of starting and operating a farm are listed on the following page.

Figure 6. Pearl oysters held on chaplets (photo by Maria Haws).

Capital costs

- Cost of obtaining pearl oysters either by spat collection, hatchery production or wild adult collection
- Equipment and supplies
- Farm structure (lines, rafts, underwater trestles, floats)
- Farm and seeding platform
- Boats

Operating costs

- Labor
- Electricity, water, telephone or radio
- Gas and oil for boats or vehicles
- Replacement costs for equipment and supplies
- Licenses or permits
- Fees for grafting technician
- Marketing expenses

The following are some of the major factors that influence costs.

1. *Farm size* - In general, 3,000 pearl oysters is the minimum number needed for a profitable farm because there are certain fixed costs which will be too high if fewer pearl oysters are available for cultivation. The size of the farm will also determine the quantity of materials such as lines and floats needed, and the labor costs of maintaining the farm.
2. *Labor* - Pearl farming is labor intensive. A pearl farm with 3,000 pearl oysters and several spat collector lines, will require a full-time farmer with 1 or 2 part-time assistants. Since it takes a minimum of 2-3 years to reach the first harvest, an alternative source of income must be available to support the farmer, as well as sufficient funds to hire some workers during this time.
3. *Equipment, supplies and facilities* - The cost of equipment will be determined by the size of the farm and by the type of facilities already available in your location. Often farmers can benefit by sharing certain equipment or facilities such as SCUBA compressors or grafting platforms.
4. *Location* - The farther the pearl farm is from the farmer's house or boat dock, the more it costs to buy gas to reach it. Also the amount of ropes, floats and anchors will vary according to the type of site chosen.
5. *Spat source* - Since spat collection is the main source of young pearl oysters, the number of spat collectors needed must be estimated along with the cost for collector materials, lines and gas to service the lines. If spat are purchased from a hatchery, this cost must be taken into consideration. Whichever method is used to obtain spat, the cost of raising them to grafting size must also be calculated. The smaller the spat collected or purchased, the higher the cost of caring for them until they reach grafting size. If adult pearl oysters are used, transportation and diving costs must be considered.
6. *Grafting* - Hiring a grafting technician and paying his or her expenses is one of the major expenses for any farm. A technician will usually charge US$3-4 per pearl oyster seeded, or will take part of the harvest as a share. The expense of his or her transportation, lodging and meals will depend on where the farm is located.
7. *Marketing expenses* - Selling pearls can be a lengthy, complicated process requiring local and foreign travel, communications and presentation costs. Start making marketing contacts well before the harvest, and budget for the expenses incurred in finding a buyer who is willing to pay a good price for your pearls.
8. *Miscellaneous expenses* - It is important to allow for extra funds to pay for things such as repairs, miscellaneous expenses, communications costs, permit fees, taxes, etc.

Further information

This information sheet is designed to give only basic information on pearl farming. Before starting a farm it is important to contact the local marine resource department to seek technical assistance and to ensure that any existing local laws on marine leasing and oyster collection are adhered to.

CTSA, Hawaii Sea Grant and the College of Micronesia Land Grant program operate an aquaculture extension network designed to provide information and assistance in all forms of tropical aquaculture. They can be reached at the following addresses:

Regional Aquaculture Extension Agent
COM Land Grant
P.O. Box 1179
Kolonia, Pohnpei, FM 96941
Tel. 691-320-2728
Fax 691-320-2726
e-mail: sellis@mail.fm

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The Oceanic Institute
41-202 Kalanianaole Hwy.
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e-mail: Haws@aol.com

Further reading

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Pearl Oyster, Information Section Marine Resource Division, Secretariat of the Pacific Community, B.P. D5, 98848 Noumea Cedex, New Caledonia.

Videos

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Glossary

Fouling, biofouling: small plants and animals that colonize the shell of the pearl oyster.

Gonad: reproductive organ producing either sperm or eggs.

Grafting: also known as seeding or nucleus implantation. This is a surgical procedure in which the nucleus and a small piece of mantle tissue are inserted into the gonad thus starting development of a cultured pearl.

Iridescent: exhibiting a display of colors producing rainbow effects.

Keshi: the word “keshi” means poppy in Japanese. Keshi pearls are a by-product of the grafting process that occur when the implanted piece of mantle tissue secretes nacre around itself producing small, irregularly shaped pearls without a nucleus.

Larval, larvae: an early developmental stage of the pearl oyster life cycle when the pearl oyster is a microscopic and free-swimming organism. This period last 2-3 weeks.

Mabe or half pearl: dome-shaped secretions of nacre developed over an artificial form that is attached to the shell.

Mantle: part of the tissue of the oyster that lays down the nacre.

Metamorphosis: developmental stage involving anatomical and behavioral changes that transform the free-swimming larvae to a settled adult.

Nacre or mother-of-pearl: The iridescent material lining the inside of mollusk shells. Nacre is composed of calcium carbonate crystals (aragonite) deposited between layers of organic material. Nacre is one of the types of shell material formed by the epithelial cells in the mantle tissue.

Nucleus: a small, polished bead made from the shell of freshwater mussels used as the core of cultured pearls.

Pearl sack: the tissue containing the nacre-producing epithelial cells which enclosed the developing pearl. The pearl sac develops out of the transplanted piece of mantle tissue (the graft) that is inserted into the gonad during grafting. This term may also be used to refer to the extreme end of the gonad where the nucleus is inserted.

Spat: juvenile pearl oyster

Spawn, spawning: release of eggs or sperm by the pearl oyster into the water.

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