HAWAU-G-00-001

Aquafarmer Information Sheet

Collecting Black-lip Pearl Oyster Spat

by Maria Haws, Ph.D.
Director, Pearl Research and Training Program,
University of Hawaii Hilo, Hilo, Hawaii, USA

and Simon Ellis
Regional Aquaculture Extension Agent
College of Micronesia, Land Grant College Program, Pohnpei, FSM

CENTER FOR TROPICAL AND SUBTROPICAL AQUACULTURE

Introduction

Farming the Black-lip pearl oyster (*Pinctada margaritifera*) to produce pearls has been a viable industry in the tropical Pacific region since 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 and sustainable methods that are suitable for rural and under-developed areas. **Spat** collection is one of these methods.

All pearl farms need a steady supply of young pearl oysters (spat) to keep the farm in operation. Spat collection is the process of attracting larval pearl oysters onto artificial substrates, a process commonly used in the pearling industry because it is cheap and simple. While spat collection methods vary depending on the region and materials available, over time, pearl farmers have developed reliable techniques. The purpose of this information sheet is to describe in detail these spat collection methods, the anticipated benefits and where to obtain further assistance.

Biology

Pearl oysters are generally either male or female, although there are occasional hermaphrodites (individuals that are simultaneously male and female). Fertilization occurs randomly when pearl oysters release eggs and sperm into the water (spawning). Spawning is known to be related to fluctuations in water temperature, with peak spawning times occurring when temperatures are highest.

After fertilization, the eggs develop into a free-swimming, microscopic stage called **larvae**. The larvae spend 2-3 weeks swimming in the water column before undergoing metamorphosis. During **metamorphosis**, larvae undergo major physical and behavioral changes. One of the most noticeable changes is that the animal loses the ability to swim and attaches to a solid object by excreting a tuft of sticky threads, called a **byssus** (Figure 1). This process is called settling or setting. It is at this point that larvae become spat. The precise factors that determine where a larva settles are not completely known, but larvae appear to set most abundantly in dark areas or on dark materials that offer protection. However, once set, pearl oysters can detach and move to another area so it is important that the spat collectors be maintained so that they present a hospitable environment for spat.

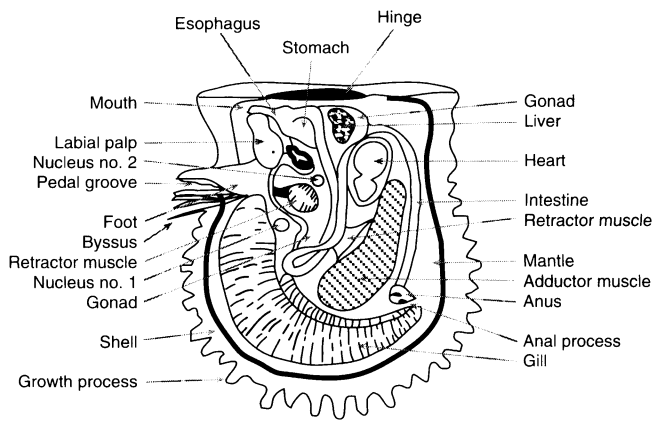

Figure 1. Internal anatomy of a pearl oyster (from George, 1967 modified).

Obtaining pearl oysters

There are three methods a farmer can use to obtain pearl oysters. The following describes each method and its advantages and disadvantages.

Collection from reefs

In most areas, when pearl farming starts, farmers begin by taking adult or young pearl oysters directly from the reef. The one advantage of this is that only the ability to dive is

required. There are many disadvantages. First, older pearl oysters do not produce as high quality of pearls as younger ones. Additionally, most farms make a considerable amount of their revenue from the second and third pearls that a pearl oyster may produce; adults collected from the wild may be too old and past the period at which they will be useful for second and third implants. In many areas, there may not be enough pearl oysters present to support large farms. Even if a local pearl farming industry starts out by using wild-collected pearl oysters, it will soon be necessary to look for other sources.

Hatchery production

Pearl oysters can be artificially bred in hatcheries. Hatcheries could be a source of large numbers of pearl oysters at relatively low prices. Only a few Black-lip pearl oyster hatcheries now exist, and the supply of spat they offer may not be sufficient to meet the demand. Most hatcheries also sell pearl oysters when they are small. The small spat take a long time to reach maturity on the farm and losses to predators may be high, making it potentially cost prohibitive. If hatcheries offer spat at economically feasible prices, then this can become a viable alternative to spat collection.

Spat collection

Spat collection offers the advantages of being a relatively inexpensive and simple way to obtain spat. Spat collection occurs when any material designed to attract spat settlement is placed in the water and tended. Properly designed spat collectors also protect the small spat while they grow. They are harvested when they reach the desired size. Spat collection can only be done if there are enough adult pearl oysters in the surrounding waters to reliably produce high numbers of spat. Spat collection may not work well in areas with high water exchange, such as very open lagoons or nearshore areas that are not enclosed, since larvae may not be retained long enough for them to settle on the collectors before being washed out to open water. However, there are some cases where successful spat collection has occurred in areas with high rates of water exchange. It may be advisable to experiment with a small number of collectors before launching a costly and time consuming large-scale effort. Spat collection requires periodic maintenance of the collectors and lines for up to one year before harvesting the spat.

How to conduct spat collection

It is important to select the correct type of material, choose the right areas, place the collectors into the water at the right time, and provide proper maintenance of the collectors and the lines. It may take several attempts to work out the proper procedures for successful spat collection in a new area, but if adult pearl oysters are present, it should eventually be possible. Repeated experimentation is often needed.

Collector materials and construction

The choice of material is very important as it will influence the likelihood of pearl oyster larvae setting upon it, and the ease and cost of collecting spat. Pearl oyster larvae set on a wide variety of materials in nature, but appear to prefer dark materials and the undersides of hard objects, which may offer protection. Although many artificial and natural materials can be used to make spat collecting devices, the best types are inexpensive, dark plastic materials that can be compressed in various ways to form lightweight, compact devices that offer a large surface area and protective spaces. The most commonly used materials are either polypropylene shade cloth or thick black plastic sheeting. If shade cloth is used, it should be of the knitted or knotted type, since this prevents unraveling. A shade rating of 60-70% is best.

The following describes two of the most common ways of constructing spat collectors.

Accordian-style collectors

This style of collector (Figures 2 and 3) is made from strips of shade cloth which are threaded accordian-fashion onto a length of line, then compressed into a thick mass measuring 0.6-2 m in length and 8-12 cm in width. By using long lengths of material and by compressing it into a thick mass, a large surface area is provided for many spat to set. A general rule of thumb is to use 25 m of material for every 1 m in length of the collector. Bunching the material provides protection in the center of the collector for the young pearl oysters to hide from hungry fish and other predators. Small collectors measuring about 8 cm wide and 1 m long can be used when testing new areas (Figure 3). Commercial collectors

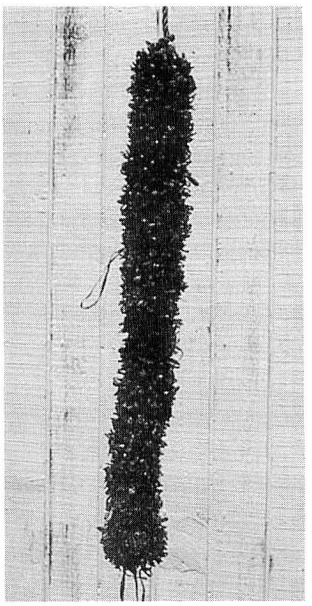

Figure 2. Accordian-style shade cloth spat collector (Maria Haws).

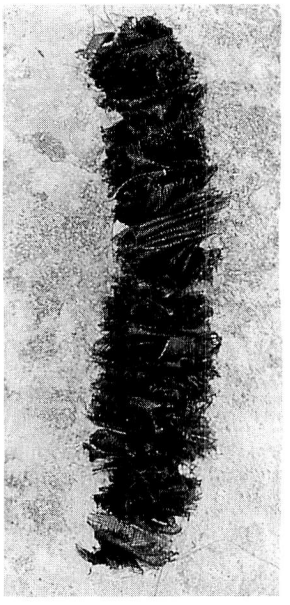

Figure 3. Experimental shade cloth spat collector (Simon Ellis).

for proven areas measure up to 2 m long, and are slightly thicker, about 12 cm.

The core line holding the material should be knotted at both ends to hold the material firmly in place. Knots should also be tied one or more times in the middle to keep the material evenly spaced along the line. These internal knots should be placed at least every 60-70 cm along the collector. About 1 m of free line should be left at the end of the collector to attach it to the mainline (Figure 4). Melt the core line at both ends to prevent fraying.

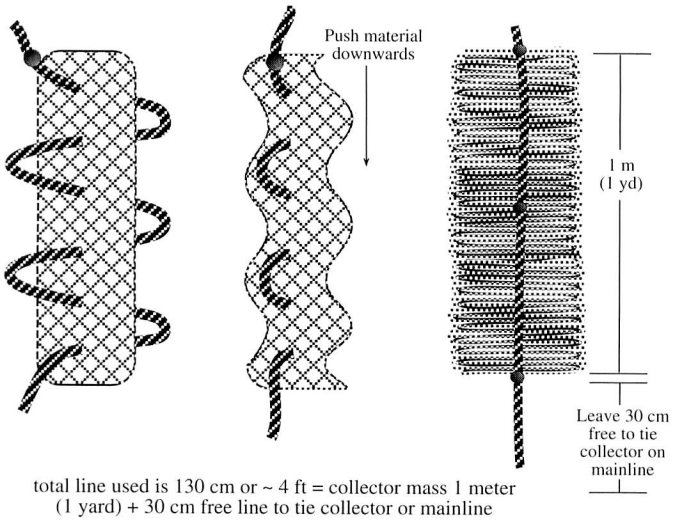

Figure 4. Schematic diagram of a shade cloth spat collector.

A machine to rapidly manufacture spat collectors can be made out of readily available and inexpensive materials (Figure 5 and 6). This machine consists of two wooden intermeshed, toothed wheels powered by a hand crank. Strips of shade cloth are fed through the toothed wheels which fold the strips of shade cloth. These are then pushed onto the long needle by the machine operator. The needle is often a used car radio antenna or similar object. Once a sufficient quantity of folded shade cloth has been threaded onto the needle,

Figure 6. Spat collector manufacturing machine (Simon Ellis). An example: dimensions may vary.

it is transferred onto a length of line attached to the needle and compressed.

Spat bag collectors

Another way to make collectors is to cut strips or panels of any black plastic material (shade cloth, black plastic sheeting) and place these into a fine-meshed spat bag (Figure 7). The material should be loosely wadded so that water can pass through it. The accordian-type collector can also be inserted into a spat bag. The bags are then tied closed and hung on the mainline. Spat bags are used to protect the young spat from predators such as fish. However, there is some evidence that in areas where predatory snails are a serious problem, the use of spat bags can make matters worse by trapping the young snails inside the bag where they will continue to feed on the pearl oysters.

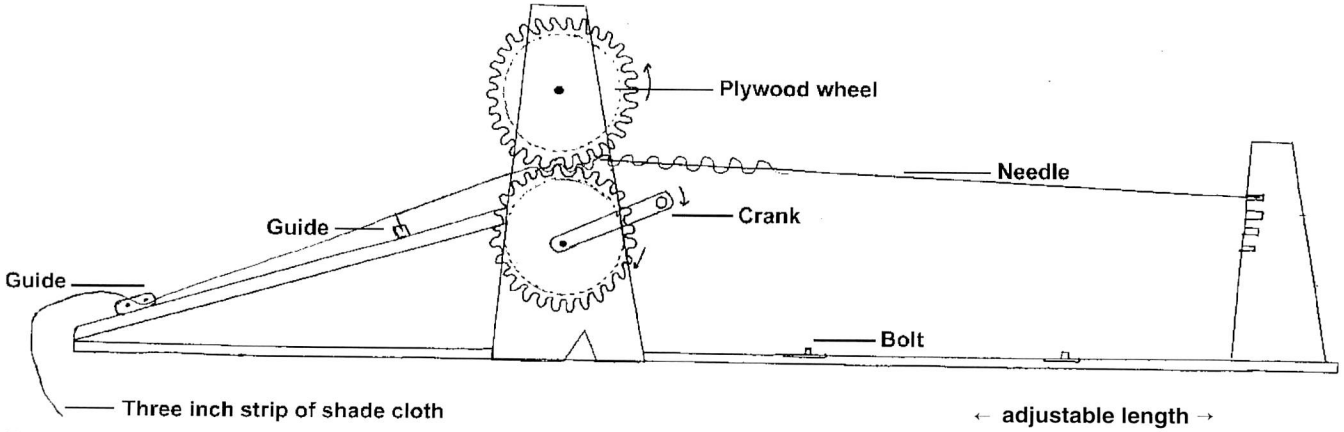

Figure 5. Schematic diagram of a spat collector manufacturing machine (Maria Haws).

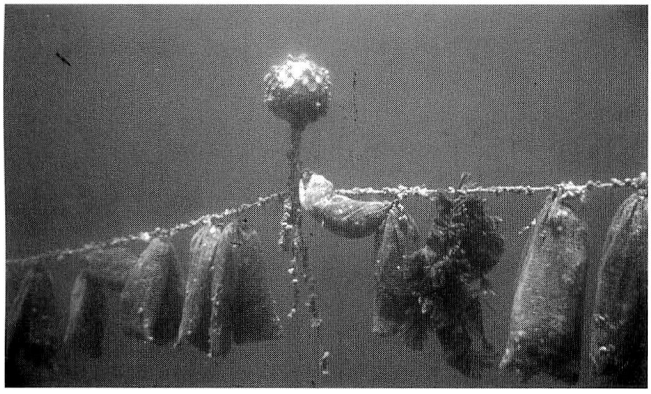

Figure 7. Spat collectors in spat bags (Maria Haws).

Collector placement

It is important to locate spat collection lines in areas where larvae are expected to be present, and where they are retained long enough to reach the point of metamorphosis (2-3 weeks). The best areas for spat collection are enclosed lagoons where the water exchange rate is low enough that the larvae are not washed out to sea before they can set. More open lagoons may also be good sites provided there are sufficient numbers of larvae in the lagoon at any one time. A large number of adult oysters in a lagoon is often an indicator that spat collection will be successful. Spat collection may not be feasible in areas where pearl oysters are very rare. If this is the case, hatchery-produced spat may be the only option.

When spat collection is attempted in a previously untried area, it is often difficult to determine which areas will attract the most spat. Sites must be chosen that will have the highest chances of retaining the pearl oyster larvae for the 2-3 week period it takes them to settle. Areas with high numbers of adult or young pearl oysters indicate that spat have settled there. Areas of a lagoon far from passes or areas where there are eddies in the current are often good sites. One example of this is on the down current side of patch reefs, since currents tend to form eddies there.

When first attempting spat collection, spat collectors should be placed at as many sites as possible to determine which areas are best. After the first harvest is conducted, sites that yield large numbers of spat should be chosen as the locations for the next round of collection, while sites which yield poor results can be abandoned.

When to place spat collectors

Peak spawning times will coincide with the time of highest water temperatures, although some spawning will occur throughout most of the year. In the South Pacific, March and April are the peak spawning months, with a smaller, second peak in October. Although there is little data available for the U.S. Affiliated Pacific Islands and other areas in the northern hemisphere, it is expected that similar spawning peaks will occur during periods of high water temperatures. In order for them to work most effectively, collectors should be placed in the water one month before the expected spawning peak. There is some evidence that pearl oysters may prefer to set on materials that have been in the water long enough to be covered with bacteria and algae, but not so long that other large animals have covered the available space.

Since it is not known when the spawning peaks occur in the Northern Hemisphere, it is recommended to set some collectors out each month for a year when first attempting spat collection. By observing when the heaviest spat fall occurs, peak spawning times can be determined. During the second year of spat collection, most of the collectors can then be put in the water one month before these peak times.

How to set out the collectors

Spat collectors are best hung on submerged mainlines similar to those used for pearl farming purposes (Figure 8). A mainline is a length of rope anchored to the bottom and suspended with floats. The tension between the floats and the anchor lines keeps the line taught and at the correct depth. A fairly shallow depth appears to be the best place to collect the most spat so the mainline should be maintained at a depth of about 1 m, so that the collectors will hang at about 1-3 m below the surface at the lowest tide. This depth keeps the lines away from passing boat traffic but keeps the collectors close to the surface. The collectors should be tied to the mainline using a slipknot that holds firmly, yet can be pulled loose with one hand. Using a knot that requires cutting to release the collector shortens the core line, making it difficult to use the collector again.

When the collectors are first set out, they will float upwards. As animals and plants begin to colonize them, the increased weight will cause them to hang downwards. This is normal and should be expected. However, during the first week or so when the collectors float upwards, care must be taken to make sure that they are always submerged so that they do not become a hazard to boats. Keeping the collectors submerged will also protect them from excessive wave action, which can easily detach the small spat.

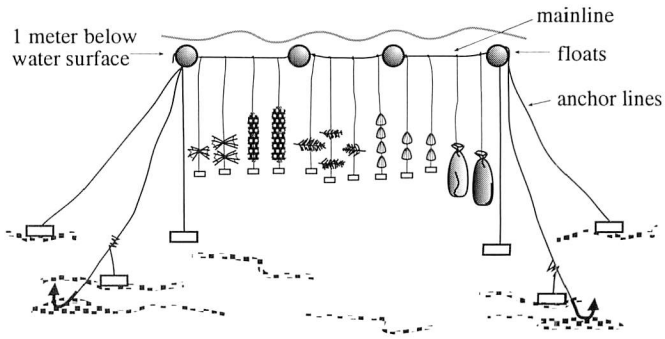

Figure 8. Different types of spat collectors on a submerged mainline (modified from Gervis & Sims, 1992).

Predators of pearl oyster spat

Fish and octopus

Trigger fish, puffer fish, tusk fish, eagle rays and many other fish that regularly eat shellfish can quickly devour large numbers of pearl oyster spat. Other large predators include octopus that can pry open the valves of the oysters. Fish and octopus predation can generally be avoided by setting the longlines in 20-30 m of water and at least 30 m from any reef areas. Any predatory fish seen in the area of the longlines should be speared or trapped.

Ranellid snails

Ranellid snails (gastropods) of the genus *Cymatium* (Figure 9) are probably the most consistently destructive predator of pearl oyster spat and the hardest to control. These snails are ubiquitous throughout the tropical Pacific and have a planktonic larval phase that can last many months until the larvae encounter a suitable settling substrate. *Cymatium* infestations occur when larval snails settle on a collector line. The snail attacks the oysters by inserting its large proboscis into the shell. One adult or subadult *Cymatium* can attack and kill up to 10 juvenile oysters per week.

Cymatium are easily noticed on the collector lines and their presence is also indicated by large numbers of dead shells in one area or on one collector.

Prevention of *Cymatium* predation in spat collection is not possible. The only known method for control of these animals is regular inspection and removal of visible snails. Care should be taken not to arbitrarily remove non-predatory snails and other animals from the cages as they may be helpful. If inspection is carried out on a 1-2 week schedule, then mortalities related to this predator can be kept to a minimum. It should be noted that *Cymatium* outbreaks are episodic and have been correlated to heavy rainfall.

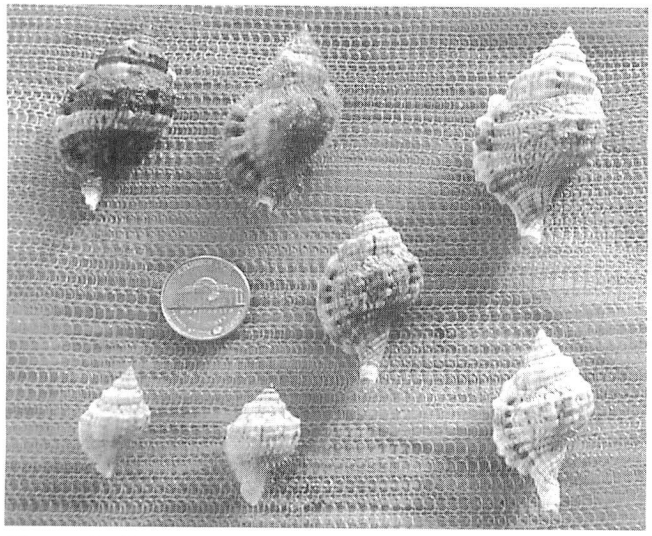

Figure 9. Cymatium *snails (Simon Ellis).*

Maintaining collectors and lines

As **biofouling** accumulates on the mainline and collectors, the entire structure will begin to sink (Figure 10). If this is not corrected, the line will sink to a depth at which no spat will be collected, and may even sink to the bottom of the lagoon. At this point, the line and collectors will become entangled, spat will be lost, and the line will be difficult to retrieve. It is therefore important to use preventative maintenance to keep this from happening.

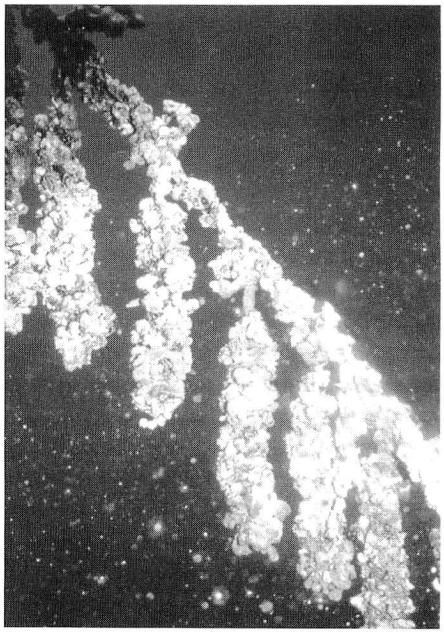

Figure 10. Spat collectors covered in biofouling (Maria Haws).

The mainline should be deployed at least a month before the collectors will be set out. This gives the line time to stretch and be readjusted to provide a stable base for the collectors. The mainline should be checked and adjusted weekly after it is placed in the water. The line must be maintained at the proper depth, and there should be no sideways shifting of the line. If shifting occurs, new anchor lines or guy lines must be added to stabilize the line.

Once the spat collectors are tied to the line, they should also be checked weekly for the first month. They should be observed at both low and high tide to be sure that they are at the correct depth, that wave action is not too high causing excessive movement of the collectors, and that any additional weight is not causing the line to sink.

After the first month, the line and collectors should be checked every two weeks. If the line begins to sink, more floats must be added. Remove biofouling from the longline and floats, but do not attempt to remove this from the collectors, since small pearl oyster spat may be lost doing this.

Spat identification

About a month after the collectors have been set out, they should be checked for pearl oyster spat. The spat will usually be located towards the center of the collector where they seek shelter from predators. Carefully examine the center of the collectors for the presence of spat without taking them apart, then return them to the mainline. Check collectors from different parts of the mainline, since spat settlement is often greater on certain areas of the line. The reasons for this are not clear, but may be related to how the currents in the area transport the pearl oyster larvae. The collectors should be examined monthly, and records kept of the number of pearl oyster spat found on each collector. This information will help determine which times of year are best for setting out collectors.

Pearl oyster spat can be difficult to identify when very small. Pearl oysters of the genus *Pinctada* are easily distinguished from bivalves that are not pearl oysters, but distinguishing between Black-lip pearl oysters (*Pinctada margaritifera*) and related species is often difficult. Figure 11 shows pearl oysters that are between 2 and 5 months old. The most obvious identifying feature of Black-lip pearl oyster spat is the dark emerald green color near its hinge. This green fades to brown near the edge of the shell, although the brown area may be tinged with green. As the spat grows, the green area may fade almost completely until only the smallest hint remains near the **umbo**. Pearl oysters more than 5 cm that remain a bright green over most of the shell are probably not Black-lip, but a related species (Figure 12). Black-lip pearl oysters also have growth processes (spines) that give the edge of the shell a jagged look and the body of the shell a scaly appearance. The growth processes are usually broad and flat and the tip is often wider than the base. In related species, the spines are more pointed.

If there is doubt about the identity of a particular pearl oyster, it is best to let it grow until it can be identified with certainty. When pearl oysters reach a size of about 4-5 cm, their identity should become clear.

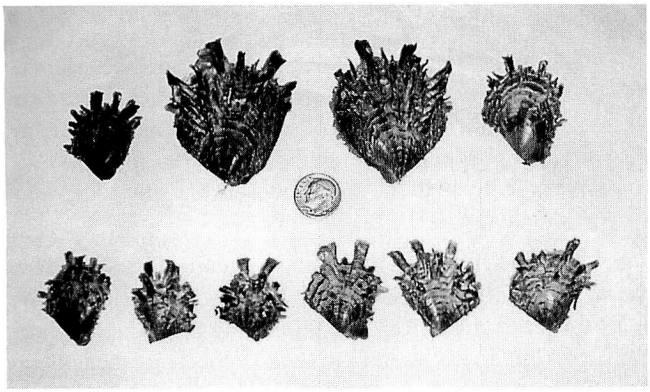

Figure 11. Black-lip pearl oyster spat between 2 and 5 months of age (Simon Ellis)

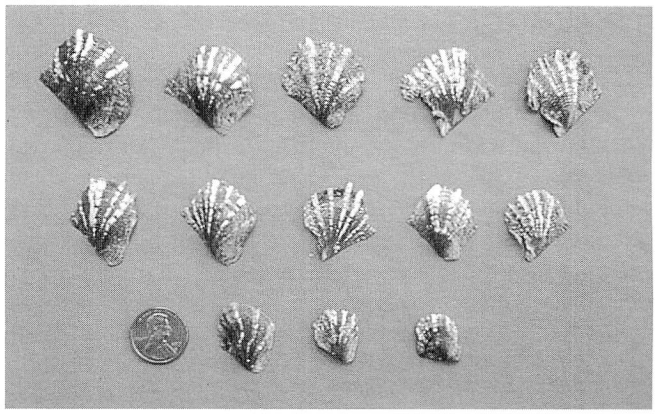

Figure 12. "Look-alike" pearl oyster spat (Simon Ellis).

When to harvest

Once pearl oysters have been found on the collectors, there are two ways to handle them. In areas where spat set is abundant, such as French Polynesia, the spat is left on the collectors for one year. Although many are lost to natural mortality and predation, enough will survive to stock the pearl farms. Harvesting consists of cutting the pearl oysters off the collectors and transporting them to the farm where they will be cultured until ready to **graft**, at an age of approximately 18 months after first setting on the collector. Pearl formation will occur 6 to 12 months after grafting.

In cases where pearl oysters do not set in high numbers, it may be advisable to remove the pearl oysters when they are small and grow them out in protected containers. In this case, the spat should be cut off the collectors when they are large enough to identify (2-3 cm) and placed in spat bags, lantern baskets, or covered trays (Figure 13).

Post-harvest care

Spat can be kept in a variety of containers including spat bags, lantern baskets, covered trays, or even pocket panels with small mesh (Figure 13). The main objective of spat care is to maintain conditions so that the fastest possible growth and maximum survival are obtained. This means that spat must have enough food and space to grow fast, while they are protected from predators.

It is important not to crowd pearl oysters in any container, since this will limit the amount of food available for each one. Except for very small spat (less than 1 cm), there must be at least 12 cm of space between each spat. Young pearl oysters tend to clump together and stick to each other by the byssal threads, which may interfere with their ability to feed. Containers must be inspected at least weekly. Any spat that are clumped together must be gently separated by cutting the byssal threads.

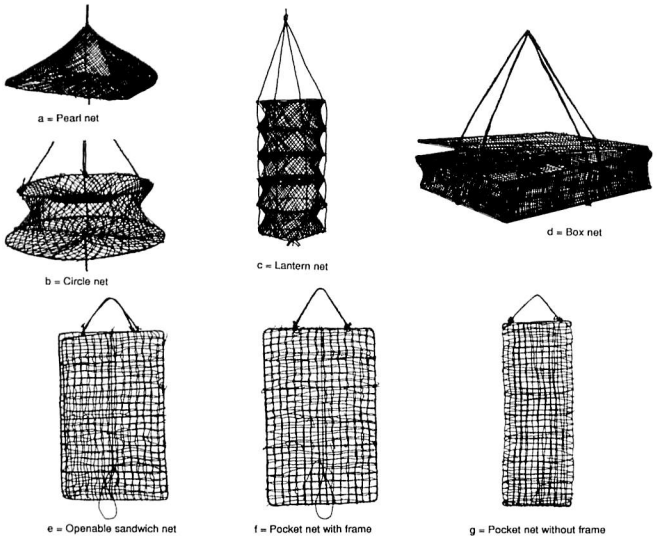

Figure 13. Containers for on-growing pearl oyster spat (Gervis & Sims, 1992).

Note: Pearl oysters should never be pulled from a substrate. The byssus is attached directly to the gut of the animal and tearing them from the substrate can kill them. Use a sharp knife to gently cut the byssus at the point where it is attached to the substrate.

The containers or spat bags must be cleaned weekly so that water flows freely over the spat and supplies sufficient food. Although it tends to be hard to clean spat bags this frequently, it is necessary in order to quickly grow the spat large enough so that they can be placed in pocket panels. As spat size increases, they must be redistributed into new containers to allow them sufficient room to grow.

Although containers can protect spat from most predators, some can still enter the containers and attack the spat. The most problematic are *Cymatium* and crabs. All containers must be inspected weekly and predators removed. If this is not done, just one of these predators can kill all the spat in a container.

Once spat reach the size of 5-10 cm, they can be placed in special pocket panels with fine mesh. Pearl oysters measuring 10 cm or more can also be drilled and hung on chaplets. Once spat are transferred to pocket panels or chaplets, they should be cleaned monthly before grafting occurs.

Pearl oysters must be a minimum of about 13 cm long or about 18 months old before they can be implanted. Many of the publications in the "Further reading" section (page 8) provide further details on the later stages of pearl oyster culture.

Economic benefits

Pearl farming in general tends to be a long-term venture with large capital outlay before profits are realized. Spat collection is one facet of pearl farming that can provide fast profits to a farmer with limited capital outlay. In many parts of French Polynesia, people operate spat collection lines and sell the oysters directly to the pearl farmers who take care of the grafting and oyster husbandry.

Once the time of spat set is determined in a particular area, a spat farmer has to set the collectors only once or twice per year. While there is some cost and time involved in initially setting the mainlines, proper treatment and maintenance of this equipment will result in years of use. Collectors have a limited life span of 1-2 years depending on the level of spat set and must constantly be replaced. Collectors are often made by the women in the family or as a family activity in the evening. Making spat collectors can often provide more income than traditional handicraft production.

Further assistance

Before starting a spat farm it is important to contact your local marine resource department to seek technical assistance and to ensure that any existing local laws on marine leasing and oyster collection are followed.

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

CTSA, The Oceanic Institute
41-202 Kalanianaole Hwy.
Waimanalo, HI 96795, USA
Tel. 808-259-7951, Fax 808-259-8395
e-mail:chenglee@hawaii.edu

University of Hawaii, Sea Grant Extension Service
2525 Correa Road, HIG 237
Honolulu, HI 96822, USA
Tel. 808-956-2862, Fax 808-956-9106

Dr. Maria Haws, Director
Pearl Research and Training Program
University of Hawaii
200 W. Kawili Street
Hilo, Hawaii 96720, USA
Tel. 808-933-9460, e-mail: Haws@aol.com

Further reading

Aquilina, B. and W. Reed. 1997. Lure of the pearl. Kimbooks Pty., Australia. 135 pp.

Clarke, R., D. Sarver and N.A. Sims. 1996. Some recent history and prospects for the Black-lip pearl oyster, *Pinctada margartifera* in Hawaii and Micronesia. Twenty-sixth Regional Technical Meeting on Fisheries, Noumea, New Caledonia. 10 pp.

George, C.D. 1967. The cultured pearl, its history and development to the present day. *Lapidary J. Am.* July-August-September: 1-6.

Gervis, M.H. and N.A. Sims. 1992. The biology and culture of pearl oysters (Bivalvia: Pteridae). ICLARM Studies and Reviews 21. 49 pp.

Haws, M. 1999. Pearl farming: a manual of basic methods. CTSA publication #127, in review.

Haws, M. and S.C. Ellis. 1999. Producing pearls using the Black-lip pearl oyster (*Pinctada margaritifera*). CTSA Aquafarmer Information Sheet, #141. 8 pp.

Periodicals

Out of the Shell. Coastal Resource Research Network Newsletter, Lester Pearson International, Dalhousie University, 1321 Edward Street, Halifax, NS Canada B3H 3H5.

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

Glossary

Byssus: threads (bysaal threads) secreted by the oyster to attach itself to the substrate.

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.

Larva, (pl. larvae): an early developmental stage of the pearl oyster life cycle lasting 2-3 weeks when the pearl oyster is a microscopic and free-swimming organism.

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

Spat: juvenile pearl oyster.

Umbo: area just above the hinge of the shell.

Acknowledgments

This publication was prepared as part of the work under a project titled "Aquaculture Extension and Training Support in the U. S. Affiliated Pacific Islands - Year 11." Funding was partially provided by the Center for Tropical and Subtropical Aquaculture through a grant from the Cooperative State Research Service of the U.S. Department of Agriculture (grant #98-38500-5947). This publication is also funded in part by a grant from the Pacific Aquaculture Development Program which is sponsored by the U.S. Department of the Interior, Office of Insular Affairs (grant # GEN 103). The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture, U.S. Department of the Interior, the Center for Tropical and Subtropical Aquaculture, the Pacific Aquaculture Development Program or any staff of those agencies.

This publication was funded in part by a grant/cooperative agreement from the National Oceanic and Atmospheric Administration (NOAA), project #A/AS-1, which is sponsored by the University of Hawaii Sea Grant College Program, SOEST, under Institutional Grant No. NA86RG0041 from NOAA Office of Sea Grant, Department of Commerce, UNIHI-SEAGRANT-TR-99-06.