Culturing Giant Scallops in Newfoundland Waters

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ABSTRACT

Naidu, K. S., and F. M. Cahill. 1986. Culturing giant scallops in Newfoundland waters. Can. MS Rep. Fish. Aquat. Sci. 1876: iv + 23 p.

Giant or sea scallops can be farmed in the sea much like crops are farmed on land. Some special gear, seed scallops (spat), and a bit of sea bottom are about all that is required. This document describes briefly how one goes about starting up one's own scallop farm. Among the topics considered are gear fabrication, scallop seed collection, initial rearing of young scallops and their subsequent growth to market size in marine farms. Both off-bottom (cage culture) and on-bottom techniques are discussed.

RÉSUMÉ

Naidu, K. S., and F. M. Cahill. 1986. Culturing giant scallops in Newfoundland waters. Can. MS Rep. Fish. Aquat. Sci. 1876: iv + 23 p.

On peut procéder à la culture des pétoncles dans la mer tout comme on cultive des plantes. Il suffit d'avoir qualques engins spéciaux, des embryons ou larves de pétoncles (naissain) ainsi qu'un peu de fond marin. Le présent document décrit brièvement la manière de s'y prendre pour lancer sa propre culture de pétoncles. Parmi les éléments discutés se trouvent la fabrication d'engins, la collecte du naissain, l'élevage des jeunes pétoncles ainsi que leur croissance subséquente jusqu'à une taille merchande. Les techniques d'élevage en suspension (culture en cage) et sur le fond sont traitées.

INTRODUCTION

Growing crops on land is referred to as agriculture (agri ≡ land), growing animals in water is called aquaculture (aqua ≡ water). Scallops can be farmed in the sea much like land crops are cultivated on land. At present most fish species, with a few notable exceptions (oysters, mussels, trout) in North America are gathered through harvesting wild or natural populations. Essentially this is a form of hunting. This situation is changing. Increasingly more and more countries are realizing that farming some animals can be a viable alternative to fishing wild populations. As much as 10% of the world's fishing production now comes from aquaculture. Companies like Cambell Soup, Coca-Cola, General Mills and Kraft have made large investments in high unit value fish, eg. salmon and prawns (Anon, 1980).

With the exception of trout and mussels, aquaculture remains undeveloped in Newfoundland. The culture of some species has been looked into by the Provincial and Federal Departments of Fisheries and the Marine Sciences Research Laboratory of Memorial University of Newfoundland. Significant progress has been made in the culture of mussels and scallops. As shellfish farming can be a profitable business, it was decided to publicize our experience in scallop culture so that fishermen or community groups might participate in the venture and benefit from it. This document is intended for potential culturists contemplating the farming of scallops along the near shore.

BACKGROUND

The Japanese are the undisputed leaders in the manipulation and culturing of scallops. About 70% of all scallops produced there is culture dependent and drawn from culture farms. We have imported their techniques and modified them to suit local conditions. With some effort and proper management, handsome returns are possible from a scallop farm. Pound for pound it has fetched a better price than either lobster or salmon.

LIFE HISTORY

It is important to have some basic knowledge of the life history of the scallop if we are going to collect its young and subject them to culture. The breeding cycle of the sea or giant scallop has been described in some detail by Naidu (1970). Only the main points are presented here.

Reproduction in scallops is very similar to many fin-fish species commonly found in our waters, eg. cod, herring, etc. Sexes are separate. Unless completely spawned out (spent) the sexes are easily distinguished. Males have a cream-coloured, crescent-shaped organ (testis) that produces and stores sperm. The shape of the female organ (ovary) is similar but is reddish, the color intensity varying with the stage of development. The ovary produces and stores eggs. A healthy ten-year old female may release 80-100 million eggs (Thompson, Marine Sciences Research Labratory, Memorial University of Newfoundland, St. John's, pers. comm.). At least as many sperm are released by the male. The majority of scallops spawn in the fall when sea water temperatures begin to

drop. Spawning is generally epidemic and synchronous. Fertilization is external. Fertilized eggs develop in the sea, often being transported over great distances. The larvae of scallops have no resemblence to the characteristic shape of adult scallops as we know them. They are invisible to the naked eye (microscopic) and carried around in water currents. They remain pelagic for about two months when they transform into tiny scallops by putting on their permanent external shell. This is called metamorphosis. At first these small scallops are hardly visible to the naked eye and look like tiny specks of dust. At this time the animals settle to the sea bottom where they will spend most of their adult lives. This transformation from larvae into shell-on scallops is a most critical time. Clean surfaces are required for initial attachment. Certain types of seaweeds, pebbles, old shells, etc. provide suitable natural attachment surfaces for scallop larvae. Such materials are collectively referred to as substrates. Settlement also can be achieved on man-made or artificial substrates by placing them in water masses known to contain scallop larvae. This is the principle upon which collecting large numbers of baby scallops (seed or spat) is based.

The free-swimming larval stage is very critical to the survival of young. It is generally thought that the majority of scallop larvae die during this stage because their ability to survive depends on where water currents take them and on the type of sea bottom on which they eventually land. Substrate surfaces must be relatively clean and acceptable to the delicate larvae. Silt and mud can literally choke very young scallops. At first the tiny scallops remain attached or anchored to some object. Gradually they become detached and free. Small scallops are capable of swimming. They literally take bites of water and propel forward clumsily. Adult scallops are relatively sedentary and normally remain in an area filtering food organisms and carrying out other essential life functions. Within two to three years of hatching scallops become sexually mature to start the reproductive cycle all over again.

SITE SELECTION

As in any culture proposition, judicious selection of culture sites is of paramount importance. As considerable as our indented coastline is (approximately 11,000 miles), only the south and south-west coasts appear amenable to scallop culture. The following criteria should be kept in mind before deciding to embark on scallop culture:

a. Scallops should occur naturally in the vicinity of the area being considered. Obviously if there are scallops in an area, conditions must be suitable for natural settlement and chances are that scallop spat or seed scallops may be collected more readily than in areas where only chance settlement occurs.

b. There should be no conflict with other fishing, recreational interests, or with navigation.

c. Incidence of ice during winter months should be minimal, preferably non-existent. The chance of damage to or loss of gear and equipment is considerably greater in areas where arctic ice is encountered frequently. Local ice formation is not as serious as gear can be sunk during winter months.

d. Small bays, baylets or inlets with narrow sill entrance frequently can be ideal, provided there is no massive river discharge.

e. Although freshwater itself can be harmful, the presence of a river discharging into a relatively open coastline (eg. within a Bay) can create extremely favourable conditions for settlement, survival and growth of scallops. However care must be exercised in keeping scallops away from fresh water.

f. Ideally the grow-out site should be in close proximity to the area where spat are collected and close enough to home base to monitor on a year-round basis.

CULTURE METHODS

Four basic steps are involved (Fig. 1):

I Obtaining seed scallops or spat
II Intermediate hanging culture to accelerate initial growth
III Off-bottom growth in cages
or
Ranching juveniles on the sea bottom (bottom culture)
IV Harvesting.

For convenience we can examine each stage in detail separately.

SPAT COLLECTION

Obtaining seed scallops or spat

The first prerequisite in culturing scallops is spat procurement. Large numbers of seed scallops must be collected from nature. We already have identified the biological basis for spat procurement. We do this by setting out artificial substrates in the sea where larvae are abundant. For best results collectors are placed near natural scallop beds.

Various types of substrates have been used experimentally in Newfoundland. Two of the most commonly used materials are monofilament gillnetting and a polyethylene (plastic) film (Trade name: Hizex)[1]. Because of its availability, durability and better performance, we prefer monofilament gillnetting. We have noted already that larvae settle on such substrates and that the spat detach after initial contact with the substrate. In order to trap those that do fall off, the substrates are usually placed within fine-meshed enclosures. Onion bags are excellent for this purpose and increase the efficiency of the collecting device. The larvae are small enough to go through the 1.5 mm (0.06 in) meshes and attach to

[1]Reference to Trade names does not imply endorsement of commercial product by the authors or by the Department of Fisheries and Oceans.

gillnet filaments. Within months the scallops become too big to fall through and are literally trapped within.

Construction of spat collectors

A collecting unit consists of monofilament gillnetting packed inside an onion bag (Fig. 2). Each onion bag is 75 x 42 cm (30 x 17 in). It is open at one end with a draw string to close it. About 500 gm or 1 lb of used but clean monofilament is packed into each onion bag as loosely as possible (Naidu et al. 1983). The size of the gillnet mesh is not important. It is not necessary to weigh out this amount. Approximate weights will do. If you are fortunate enough to have a new web cut off 7 meshes (6½" mesh). Regardless of whether new or old gillnetting is used ensure that the material is fluffed up to as large a volume as possible within the onion bag. Do not compact the gillnet filaments within the bag. Use the draw string to close off the end and form a half hitch around the top. This unit now is ready to be fastened to a collector line.

Fifteen to 20 such units are fastened to a 7 mm (3/8") polypropylene rope measuring 15 to 20 meters, depending on the number of units used. A 75 cm (30 in) spacing between individual bags should be maintained (Fig. 3). The units are tied to the line with a rolling hitch and excess string tucked through the rope to prevent slipping. Approximately 3 m (10 ft) of rope is left at each end to fasten the line to anchors. Five to seven 3"x4" cylindrical cork floats are attached to the line - two at each end and the rest approximately equally spaced between. It is best to thread the floats before bags are individually attached (Fig. 4).

Setting out of spat lines

Collecting lines are set out in the fall, after scallops have spawned out (late September/early October). When setting out lines always remember that you have to retrieve them the following year. Locational bearings are important in this regard. Ideally they should be set out on a relatively flat sea bottom. They are moored in arrays, each array consisting of about 6 to 10 separate spat lines. Grapnels or concrete blocks, the latter measuring 8" x 8" x 16", are used at the end of each spat line to moor the array along the sea bottom. Because of the way the lines are set out, you will need only one more grapnel or concrete block than there are lines. An array consisting of 6 lines, for example, will require 7 anchoring devices. This system allows you to reduce the total number of anchoring devices used, thus reducing the overall weight. Large grapnels also can be used at either end with concrete blocks in between.

The following procedure is recommended when setting out lines. The idea is to have these lines taut, about one fathom off the sea bottom where scallops occur naturally. Fasten the free end of the first line to a grapnel or concrete block and lower it to the sea bottom. Next, tie the opposite end to a second anchoring device, but this time secure the second spat line to it as

well. When using concrete blocks we frequently use plastic-coated clothes' line looped into the block for attachment. This prevents chaffing of the line. As the second anchoring device is lowered the boat should steam ahead slowly. This stretches the first line to its full length. Care must be taken to ensure that the lines are not drawn too taut as this may force individual units to the sea bottom. Repeat this procedure until the required number of lines are set in the array. The last line in any one array may be stretched out by looping some extra rope around the last grapnel or concrete block and releasing it as the line becomes taut. The total number of lines in any one array will of course depend on the ability of the vessel and crew to retrieve those lines. Remember the lines get heavier with time! The lines are left in the water for a full year.

If ice is not a problem in the area a small subsurface float may be used to mark one end of the collecting line. Do not use marker floats if there is any risk of ice in the area as these may cause the lines to be dragged away. Unmarked lines are located easily by dragging a grapnel along the bottom until it hooks one of the lines. Bearings taken when lines were set out should help their relocation at this time. The use of phantom buoys near the area where lines are set also may help in relocating lines without undue risk of vandalism.

Retrieval of spat lines

Collecting lines are left undisturbed a full year after they are set out. This should allow sufficient time for scallop larvae to settle within the collectors and spat to grow to a sufficient size to facilitate easier handling. Spat or seed scallops are ready to be picked in September-October the following year when they are approximately one year old. When an array is relocated one end of the line is resurfaced and several lines are removed from the array. Do not detach individual spat units at this time and do not remove too many lines at any one time. Remember scallops, like fish, die quickly when they are out of water. It is essential, therefore, to reduce the amount of time scallops are out of water to a minimum. Bring the lines immediately to the nearest wharf or shore location, keeping bags submerged in salt water. It is best to wait for a cool calm day for picking spat. Never pick or handle scallop spat on warm, sunny days. It is desirable not to handle spat when air temperature is above 10°C.

Before proceeding further you will need a large tub (minimum 15-20 gallons) containing salt water, several pearl nets and a main line (see page 6) set out to carry the pearl nets. It is probably best to get salt water with a pump, drawing the water up from well below the surface to ensure there is no fresh water. Now remove one line (not an array of several lines) from the water and cut the individual bags ensuring the bags themselves are not damaged. Open up the onion bag in the tub of salt water. Turn the bag inside out. Shake the gillnetting in the water until all scallops drop off. Sometimes it may be necessary to remove a few scallops by hand. Inspect the substrate carefully to ensure you do not miss any. When all scallops are removed, stuff the loose monofilament back into the onion bag and store the

bags in an open area outdoors. The monofilament and most of the onion bags may be reused in subsequent spat collections.

When a complete line is finished, carefully strain out scallops and other organisms by pouring the water containing spat through a fine-meshed (3-4 mm) sieve (Fig. 5). Next pick out all live scallops. Young scallops are easily recognized (Fig. 6a). Apart from their size at this stage (approximately 5 to 20 mm or ½ to ¾ in), they are identical to the adult scallop as we know them. Sometimes a second species of scallop, the Iceland scallop, settle out on collectors as well (Fig. 6b). With experience these are readily distinguished from the young of sea scallops. Generally, they tend to be somewhat smaller and lighter in color in comparison to sea scallops which are usually orange-brown to brown. The use of color alone, however, is unreliable as many sea scallop shells are pure white. A more reliable method is to examine the wing bases (ears) of the scallops. In sea scallops they are equal; in Icelandics one of the "ears" protrudes more than the other. The only other species likely to cause problems with identification is the common cockle (Fig. 6e). They tend to be "fatter" from sea scallops which are always flat.

The number of seed scallops collected from any one bag will vary widely from year to year and even within any given year. This will depend in part on the type and quantity of substrate employed. In average years, one would reasonably expect to collect anywhere from 50 to 200 scallops per bag. We have collected upwards of 300 and 600 seed scallops per bag in Hizex and monofilament substrates respectively.

Dead scallops, shells and other organisms, such as starfish, clams, mussels and marine worms should be discarded (Fig. 6c, d, e and f). You are now ready for the second phase.

INTERMEDIATE CULTURE IN PEARL NETS (BLUE BAGS)

The next step is to place seed scallops in special bags called "pearl nets" and re-suspend them in the sea to accelerate their growth. This is commonly called intermediate culture.

A 'blue-bag' or pearl net is a special pyramid or conical-shaped cage that is used specifically in scallop culture (Fig. 7 and 8). The round-bottom conical bag is preferable to the one with a square frame as it prevents "bunching" of scallops in corners. The bags are made of 9 mm mesh nylon. A vertical pocket along the height of the bag permits easy access into the bag. The size of the aperture or pocket is controlled by a length of plastic line. A braided nylon twine, looped at the apex (top) goes through the centre of the blue bag, enabling a number of bags to be strung one after another.

Seed scallops obtained from spat collectors now must be transferred into blue bags. Place about 50 spat into each bag, close the bag, and replace scallops in water until you have a string of about 10 bags (Fig. 9). There is no need to count to exactly 50 scallops. Approximate after one or two counts. You then should have a good idea of how much volume is involved. Again remember not to have scallops out of water for any length of time. When you

have a line of blue bags, it should be brought to the grow-out area where a main line would already have been set out to receive the seed scallops.

A main line is simply a system used to support a large number of blue bags or lantern nets (see page 8) containing scallops at various stages of growth, including through intermediate culture (Fig. 10). The surface line is 50 m (27 fm.) of 2.5 cm (1 in.) polypropylene rope. Attached to each end of this is 50-70 m (27-38 fm) of 2.5 cm (1 in) anchor rope with a 100-150 kg (200-300 lb) grapnel at each end. Ten or twelve 100 cm (40 in) single-eye inflatable buoys fastened to the surface line keeps the system afloat. The specifications given here are for a main line set in 18 m (10 fm) water. Longer anchor ropes would be necessary in deeper water but it is probably best to confine the main line to less than 25 m (14 fm).

Approximately 15-20 blue bags each containing 50 scallops, are strung out vertically from a main line. Each of these is referred to as a branch line. The uppermost blue bag should be about 2 m (7 ft) below the surface. A small weight is attached at the end of each branch line. Branch lines are spaced at 2.5 m (8-9 ft) along the main line giving each mainline a carrying capacity of 20 lines. A full compliment of branch lines (20 lines), each containing 15-20 blue bags with 50 scallops/bag would carry a total of 15,000 to 20,000 scallops.

In areas where there is no danger to gear by ice, the main line(s) may be left intact over winter. If ice is a common occurrence, it is best to sink the whole system about 5 m (3 fm) below the surface. Sand bags and/or removal of some buoys along the main line will reduce the buoyancy of the system sufficiently to sink the gear. Care must be taken to ensure that none of the blue bags come into contact with the bottom as this will reduce growth rate and increase mortality of scallops in culture.

Once scallops are in blue bags and strung out along a main line, they should be left undisturbed for a further full year. Scallops then would be 2 yr old.

ADULT CULTURE

At the end of two years scallops will be in the 40-50 mm range. One has a choice at this stage. You can either continue to grow the scallops in special cages called lantern nets, or, alternatively, the scallops can be removed from blue bags and released on the sea bottom and left to grow on their own. With cage culture, scallops are grown in captivity to commercial size (100 mm or 4 in). Various types of cages suspended from main lines are employed. With on-bottom culture the young scallops simply are released on the sea bed and allowed to grow to commercial size when they are harvested either by dredging or diving. Regardless of the method used it is essential to grow out spat in blue bags after removal from spat collectors. We will examine the two options in greater detail.

Cage Culture

Live scallops may be removed from blue bags and transferred into lantern nets in the fall of the third year. Lantern nets are frequently referred to as accordian trays or nets because of their configuration. The stocking of these trays may take place on a wharf or preferably on water, again ensuring that air temperature is on the low side (below 10°C) and that scallops are not kept out of water unnecessarily.

Lantern nets or accordian trays are much larger than pearl nets. Cylindrically shaped, each tray is about 170 cm high (when fully extended) and 50 cm in diameter (5½ ft and 20 in respectively). It has 10 separate compartments or levels. The tray is reinforced with plastic coated wire and is wrapped with 25 or 40 mm mesh (1 in or 1.5 in). The compartment separators are made of the same netting. There is a vertical pocket along the whole length of the tray to allow easy access into the compartments. Four lengths of nylon twine meet on top of each tray to form a loop from which the cages are hung (Fig. 11).

Two-year-old scallops removed from blue bags initially are placed in the 25 mm (1 in) mesh accordian trays. Twenty scallops are placed in each of the 10 compartments. The pockets are closed as soon as all 200 scallops have been put into the tray. This is done by joining the two free margins using a zig-zag threading pattern with a flexible plastic twine provided for this purpose. This should take only a couple of minutes. Replace tray in water. A second tray is stocked similarly with a further compliment of 200 scallops, again using 20 scallops per compartment. Replace the whole tray in water as soon as the second tray is completed. Continue this operation until you have as many cages as you and your boat can handle. Now you are ready to transport the cages to a main line that has been set out already for this purpose. Construction and setting out of the main line is similar to that for pearl nets. A main line should carry up to 20 branch lines, each containing one accordian tray (i.e. 20 trays or 4,000 juvenile scallops). It might be possible to perform this work on the water if a sufficiently large vessel is available rather than going back and forth from the wharf. Once again, main lines carrying accordian trays may have to be sunk for safe overwintering. This ought to be done as late in the year as possible and only if ice is a problem in the area.

The following spring (year 4), as soon as ice (if any) has disappeared, all main lines, both those containing blue bags and accordian trays, should be resurfaced so that the whole system is restored to its original state. This is done by removing the extra weights and/or adding extra floats along the main line. All gear should be inspected carefully at this time and repairs made as necessary.

A frequent problem with gear submerged in salt water is fouling by a variety of marine fauna (animals) and flora (plants). Cages and lines therefore have to be cleaned. Seaweeds growing on the outsides of cages not only add weight to the system, but also can reduce water circulation, thereby reducing food availability and growth rate of scallops. It is therefore very important to clean cages as necessary, but at least twice a year. This is done

by either scrubbing with a heavy brush or with a jet of salt water directed at those areas that need to be cleaned (Fig. 12). Avoid directing the high velocity water jet at the scallops!

By the fall (year 4) scallops in accordian trays will have grown to the point where further thinning will be required. A safe rule of thumb is to ensure that the combined surface area of all animals in culture gear is always less than the area supporting those animals. Thinning of animals is quite straightforward. Remove all animals from the 25 mm (1 in) mesh accordian trays and discard dead scallops. This is best done by opening the pockets along the total length of the tray and rotating the tray, while fully extended, so that the pocket is along the bottom. All scallops should fall out. Never drop or throw scallops around. Always treat them gently. Now place live scallops into the larger 40 mm (1½ in) mesh accordian trays, but this time use only 10 scallops per compartment. The trays then should be returned immediately to main lines. Again, one tray should be used on a branch line and twenty branch lines can be used along the main line. More main lines will be needed with time because of the thinning process. Remember to sink gear in late fall/early winter if ice is expected to be a problem.

Final cleaning of lantern trays may be undertaken the following spring. By now (year 5) the scallops should be sufficiently large for harvesting. Lantern trays are removed from the main line for the last time and brought to a shore facility where scallops are removed and shucked for adductor muscles or meats. This is the only portion of the scallop that commonly is consumed in North America. A small market may exist also for scallop roes as it almost invariably does, for example, in Europe and Japan.

So far we have examined the procedures involved for raising scallops in cages that are suspended in the water column. As you may have already suspected the method is labor intensive. Unless you are able to perform most of the work yourself, this route may not be cost effective. A small-scale undertaking in conjunction with the bottom culture method that we are about to describe may, however, be rewarding.

Bottom Culture

This method involves growing scallops on the sea bottom for most of the culture period. In fact, the more expensive accordian trays are not used at all. The procedures already described for collecting spat and accelerating their growth in blue bags remain exactly the same. The only difference is instead of transferring scallops from blue bags to accordian trays, the young or juvenile scallops (2-year-olds) are released on the sea bottom to grow on their own. Depending on the area, the scallops should reach commercial size within three years after transplanting to the sea bottom. Again, harvesting is done through traditional dredging methods or by diving.

Selection of a suitable on-bottom grow-out site is most important for overall success and is particularly critical to growth and survival of scallops. Large coves or inlets with a flat, predominantly sandy bottom suitable for dragging have been found to be suitable. Depths should not exceed

approximately 10 fm. In this route, freshwater discharge from a nearby river may prove beneficial because of increased productivity in these areas. Remember the scallops are on the bottom and therefore are not exposed to reduced salinities. Another important thing to remember is to transplant juveniles where predators are few. Inshore enemies of small scallops include starfish and a variety of crabs. Frequently it is difficult to control their numbers. It is best therefore to avoid such areas and associated problems. One of the reasons for accelerating spat growth in blue bags, before releasing them on the sea bottom, is to increase their chances of escaping from predators and consequently improving survival. Releasing spat directly from spat collectors usually results in catastrophic mortalities in the young and therefore is not recommended to the prospective culturist.

The site selected should be sufficiently large to contain several discrete year classes of scallops to facilitate establishment of a rotational cycle within a relatively small area.

It has been shown that bottom culture is the cheaper method of farming scallops in Newfoundland (Frishman et al. 1980). Capital expenditures and labor costs are reduced considerably in comparison with cage culture. Vandalism and gear damage also are minimized.

SHELLFISH LEASE

Traditionally, wild animals including fish and shellfish occurring naturally are considered property of the State and their harvesting is controlled through the issuance of a permit or a licence. To ensure you have exclusive ownership of the scallops you are growing in an area you should procure a shellfish lease for that area. Such a lease gives you the exclusive right to ownership of all shellfish in that area as well as protecting you from outside interference.

Leases are granted for the use of the sea bottom only. The lease does not give the lessee control of the water column above his lease, nor does it convey permission for the placement of floating or fixed structures that might pose a hazard to navigation. Special application to MOT (Ministry of Transport) is needed for the right to place such structures in the water above the lease. This right is obtained through approval under the Navigable Waters Protection Act. The decision of approval for the use of the water column above a leased area is made by MOT after consultation with the Department of Fisheries and Oceans.

The following procedure should be followed for obtaining a bottom lease for shellfish culture:

1. Make application in writing to the Department of Fisheries, Government of Newfoundland and Labrador, P. O. Box 4750, St. John's, Newfoundland A1C 5T7. The application should include:

   a. A detailed outline of proposed operations
   b. A map indicating the location of the proposed site

c. An estimate of the size (hectares) of the proposed site

Upon receipt, the Application will be assessed and a field investigation conducted if necessary. The investigation will determine if there are any conflicts with existing or proposed fisheries, or with recreational use of the area in question.

ACKNOWLEDGMENTS

We would like to thank Mr. G. King for his assistance with photography and Mr. W. Squires for proofreading the manuscript.

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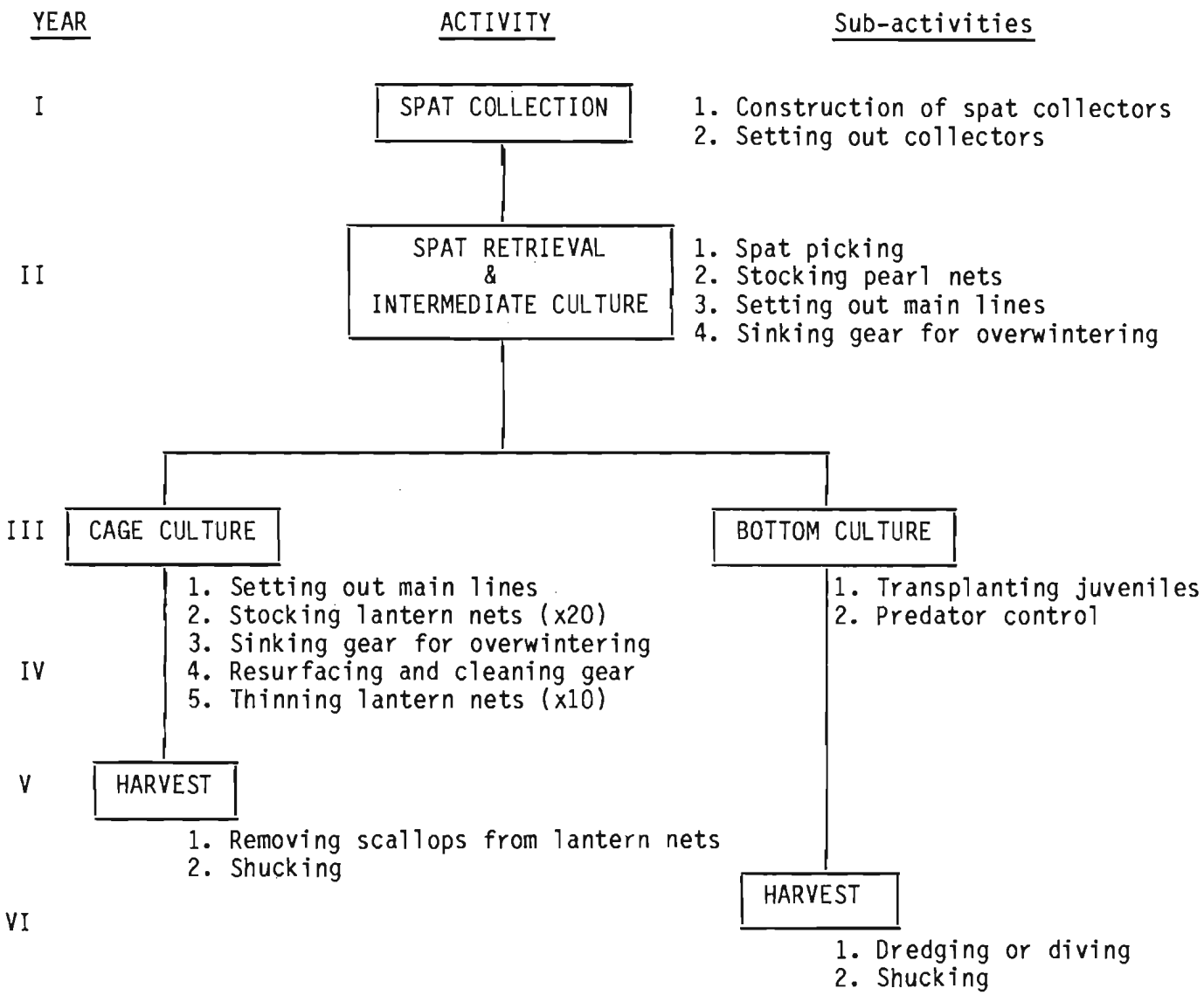

Fig. 1. Schematic representation of scallop culture procedures.

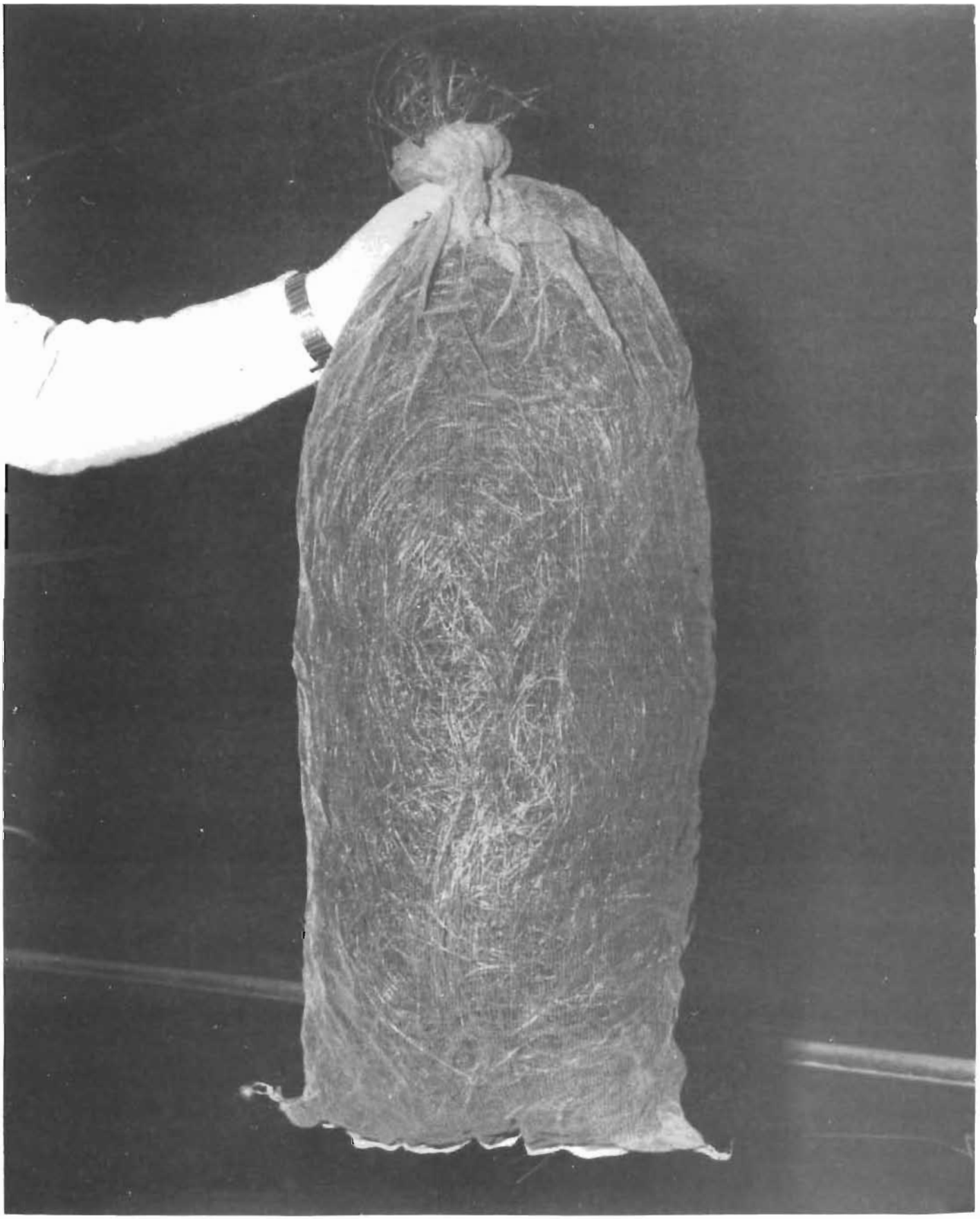

Fig. 2. Single collecting unit (monofilament gillnetting inside an onion bag).

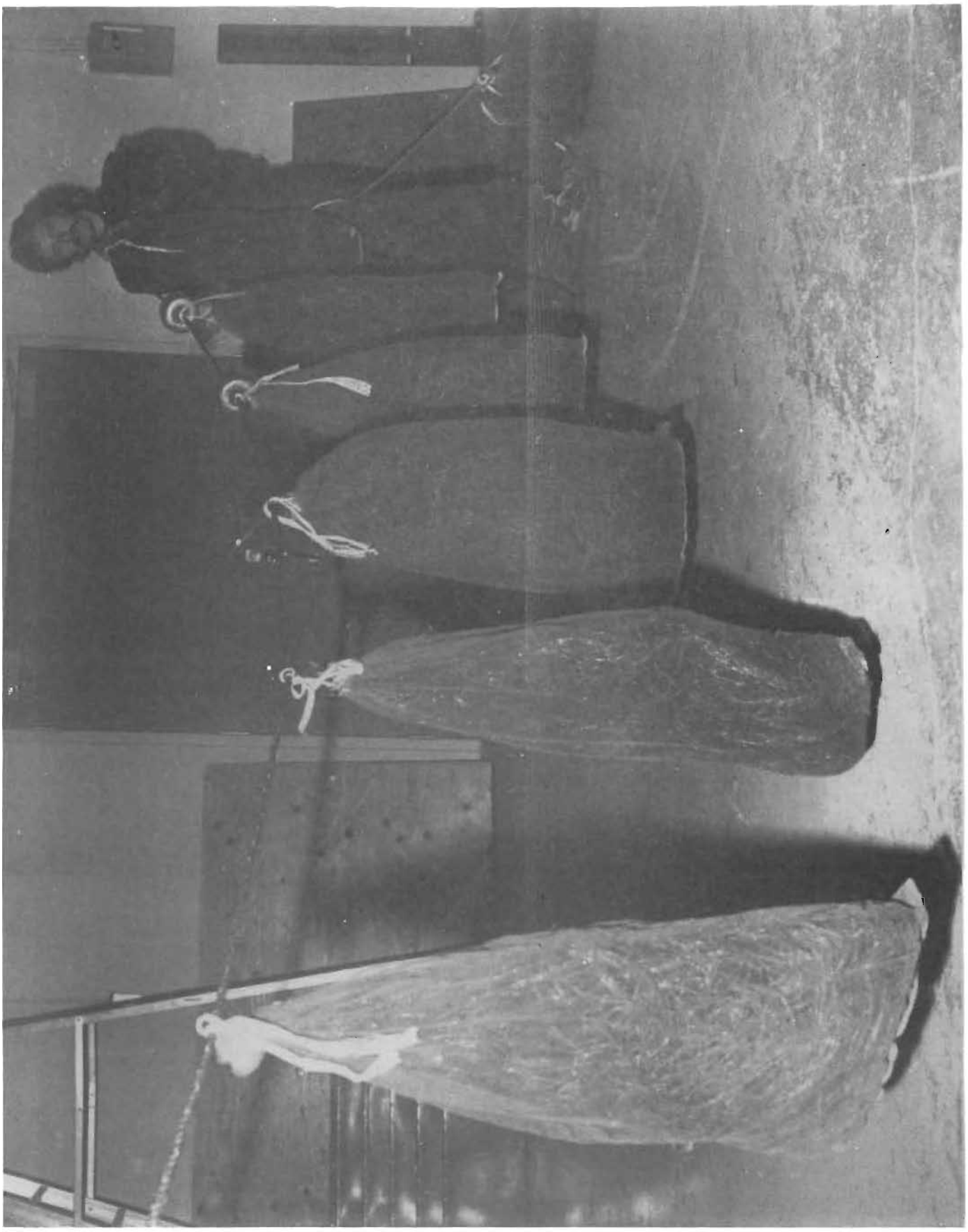

Fig. 3. Collecting line showing several units attached to spat line.

Fig. 4. Collecting line showing attachment of float and onion bag.

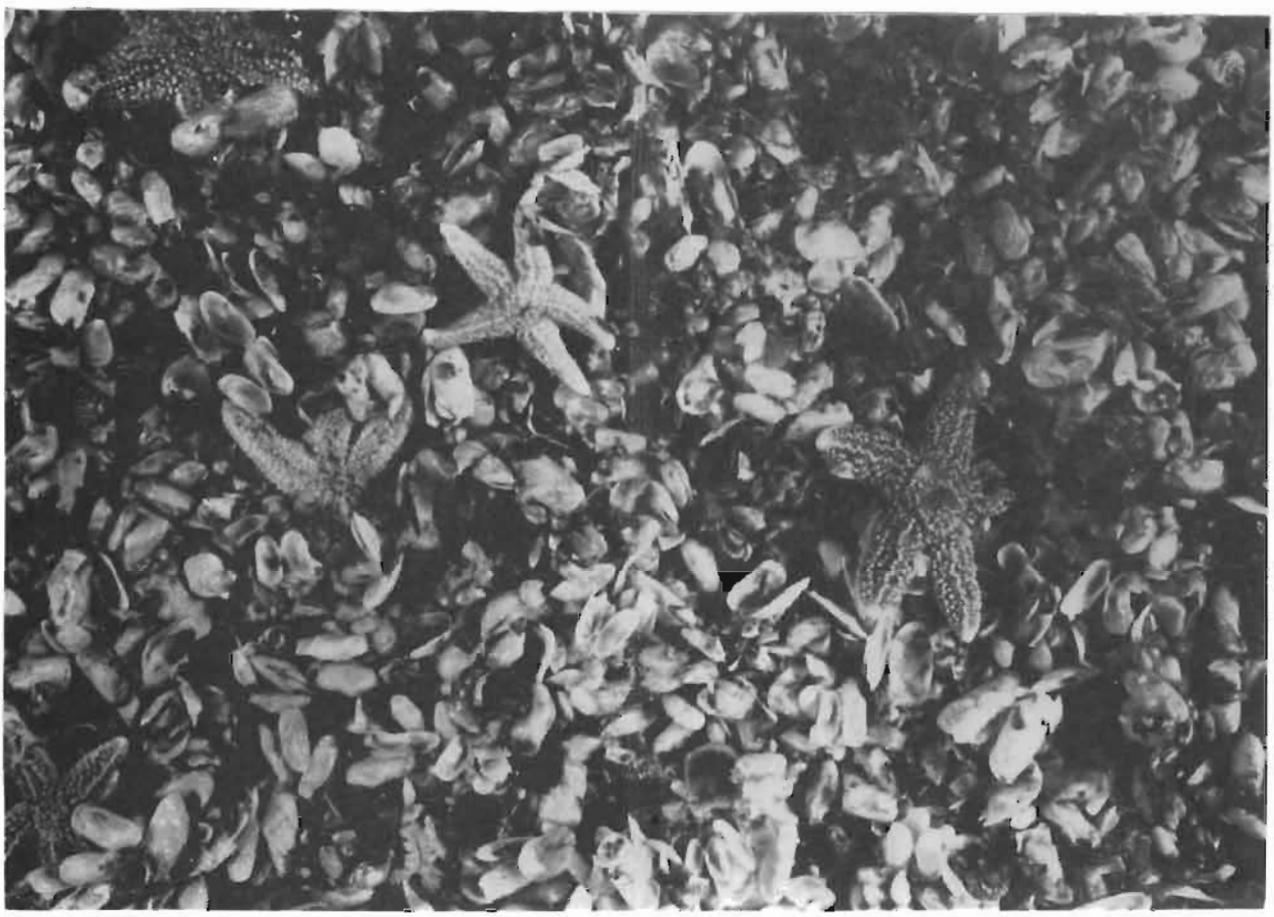

Fig. 5. Typical contents from a scallop collector.

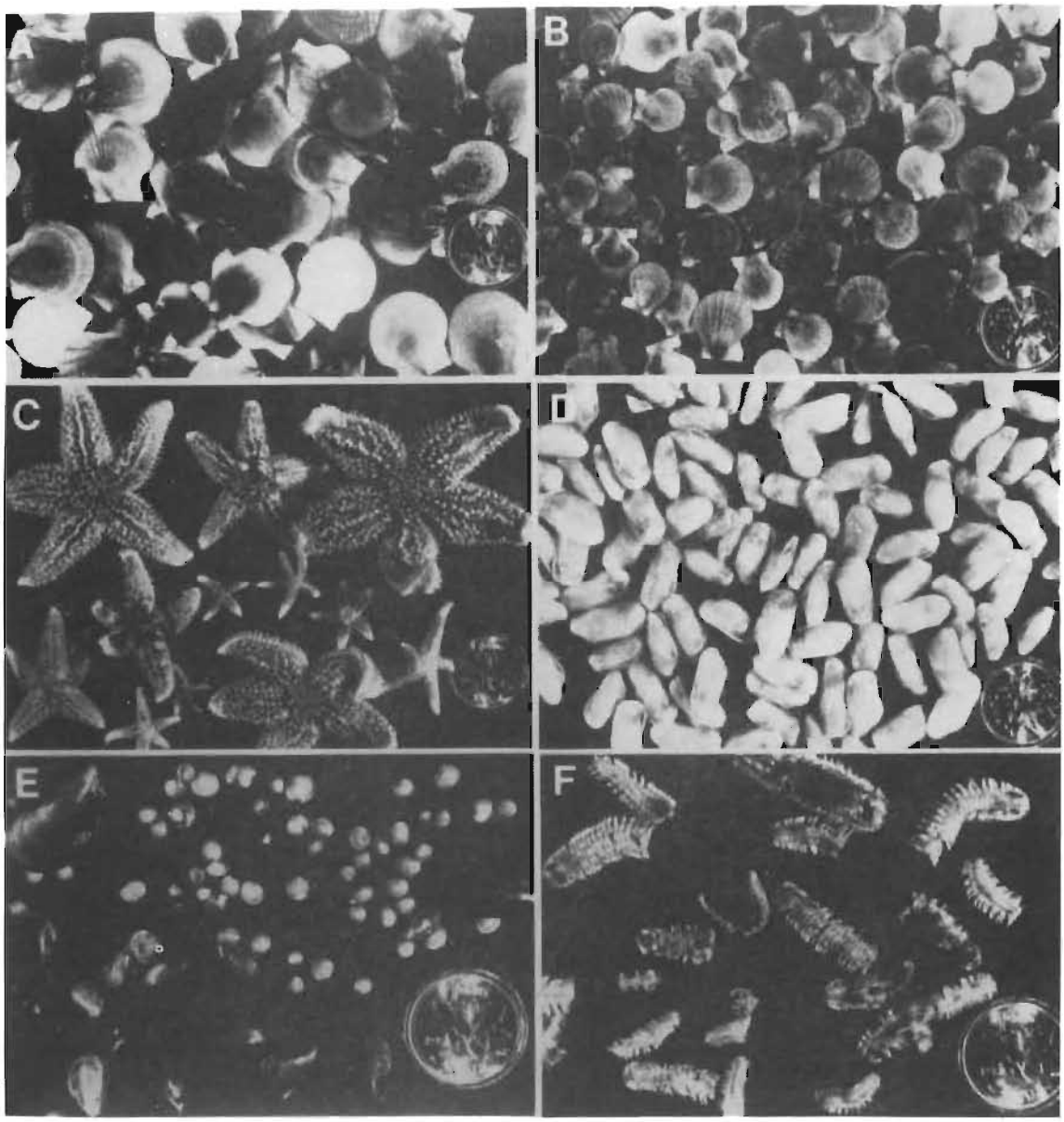

Fig. 6. Organisms commonly settling on artificial substrates: (a) sea scallops, (b) Iceland scallops, (c) starfish, (d) clams, (e) mussels and cockles and (f) polychaetes (marine worms).

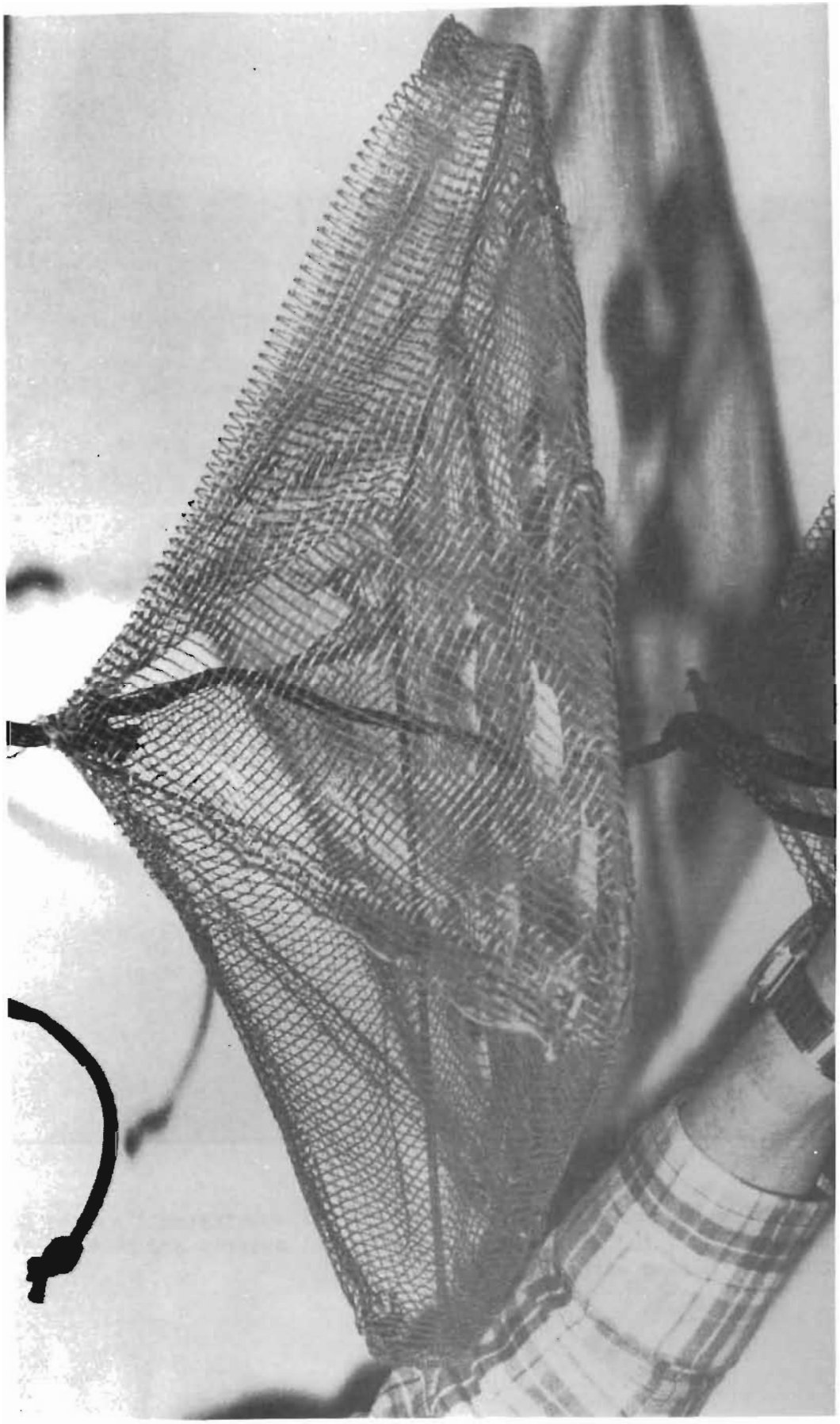

Fig. 7. Pyramid-shaped blue bag.

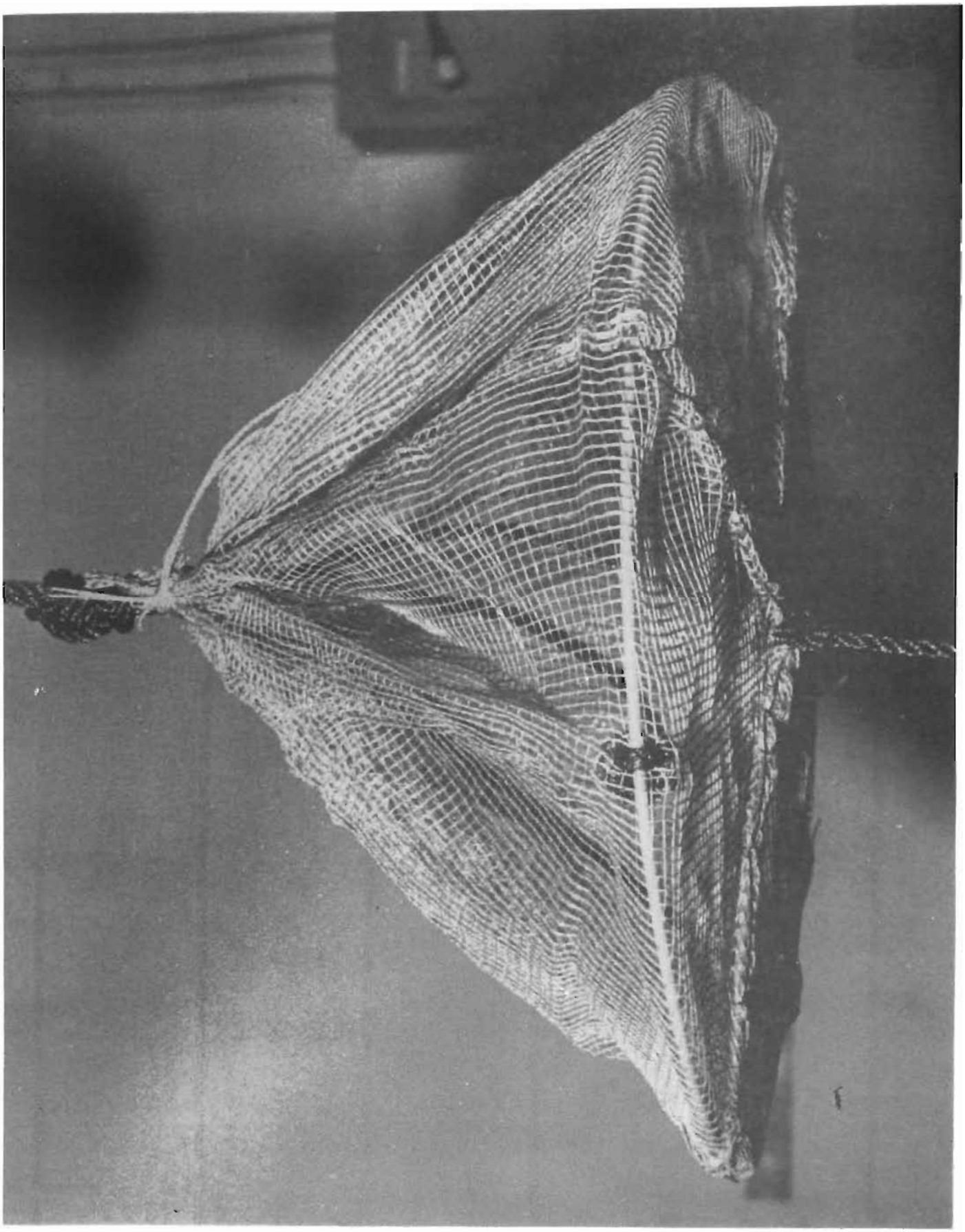

Fig. 8. Conical-shaped blue bag.

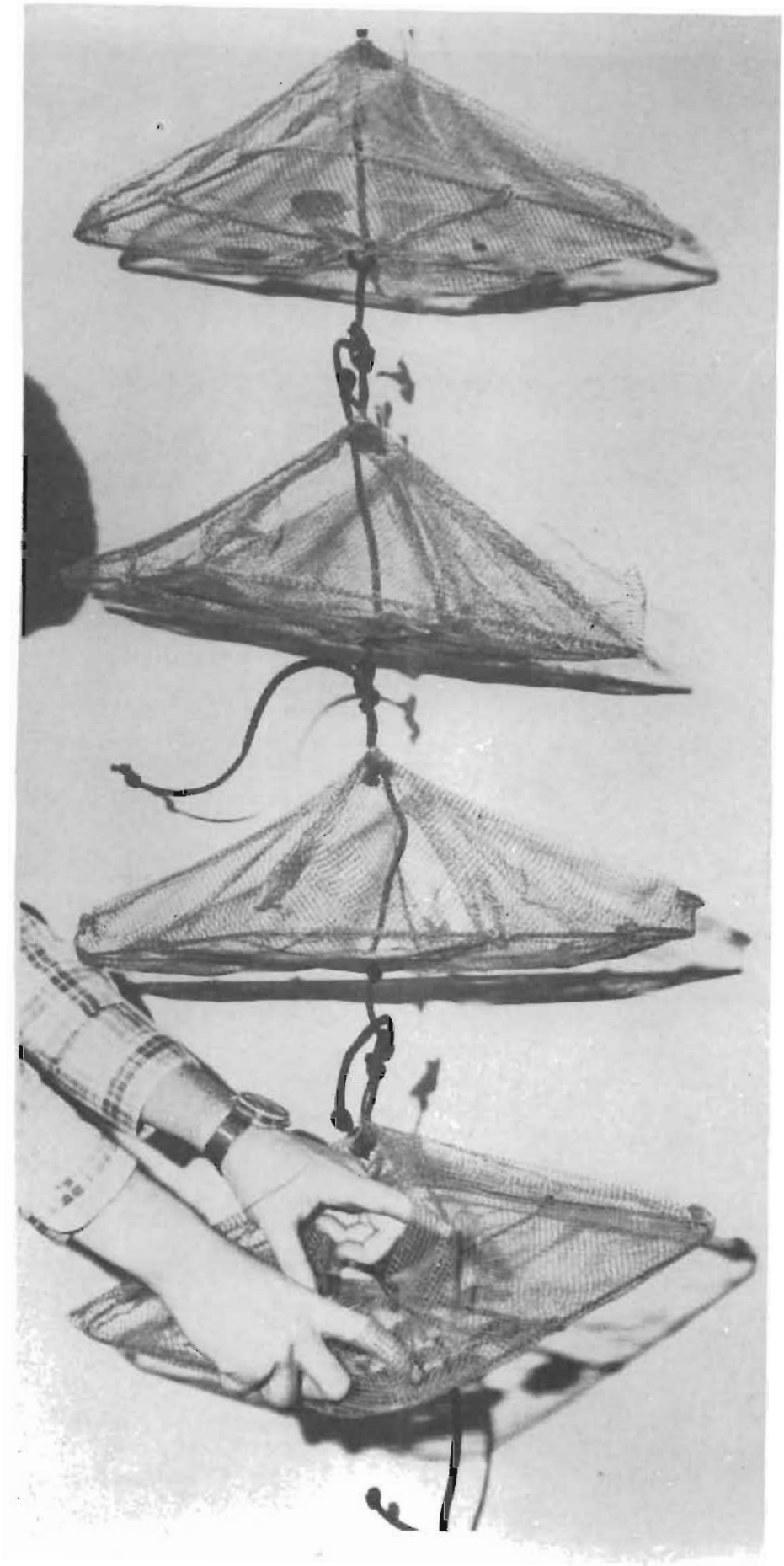

Fig. 9. Branch line of blue bags.

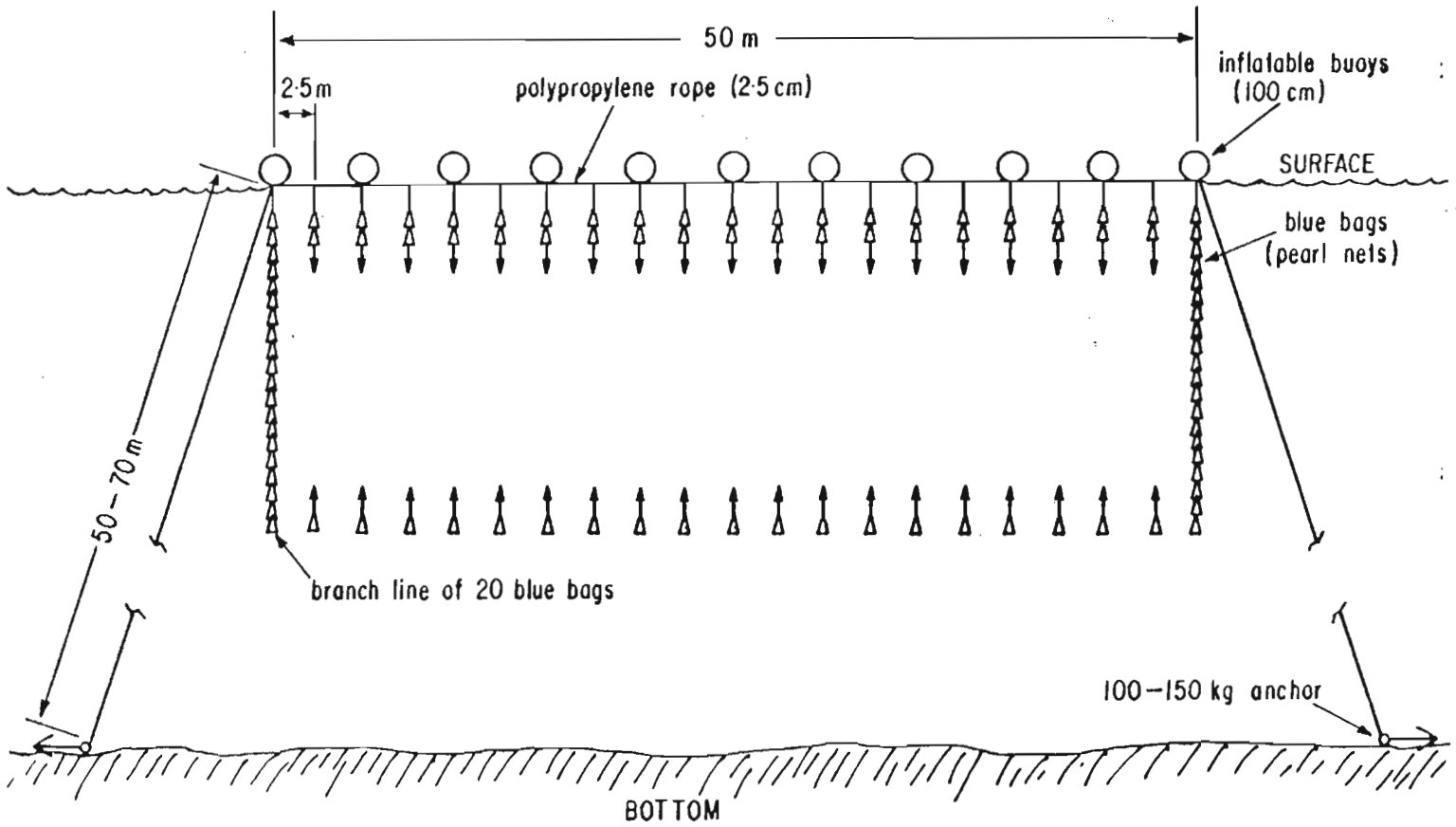

Fig. 10. Main line with blue bags.

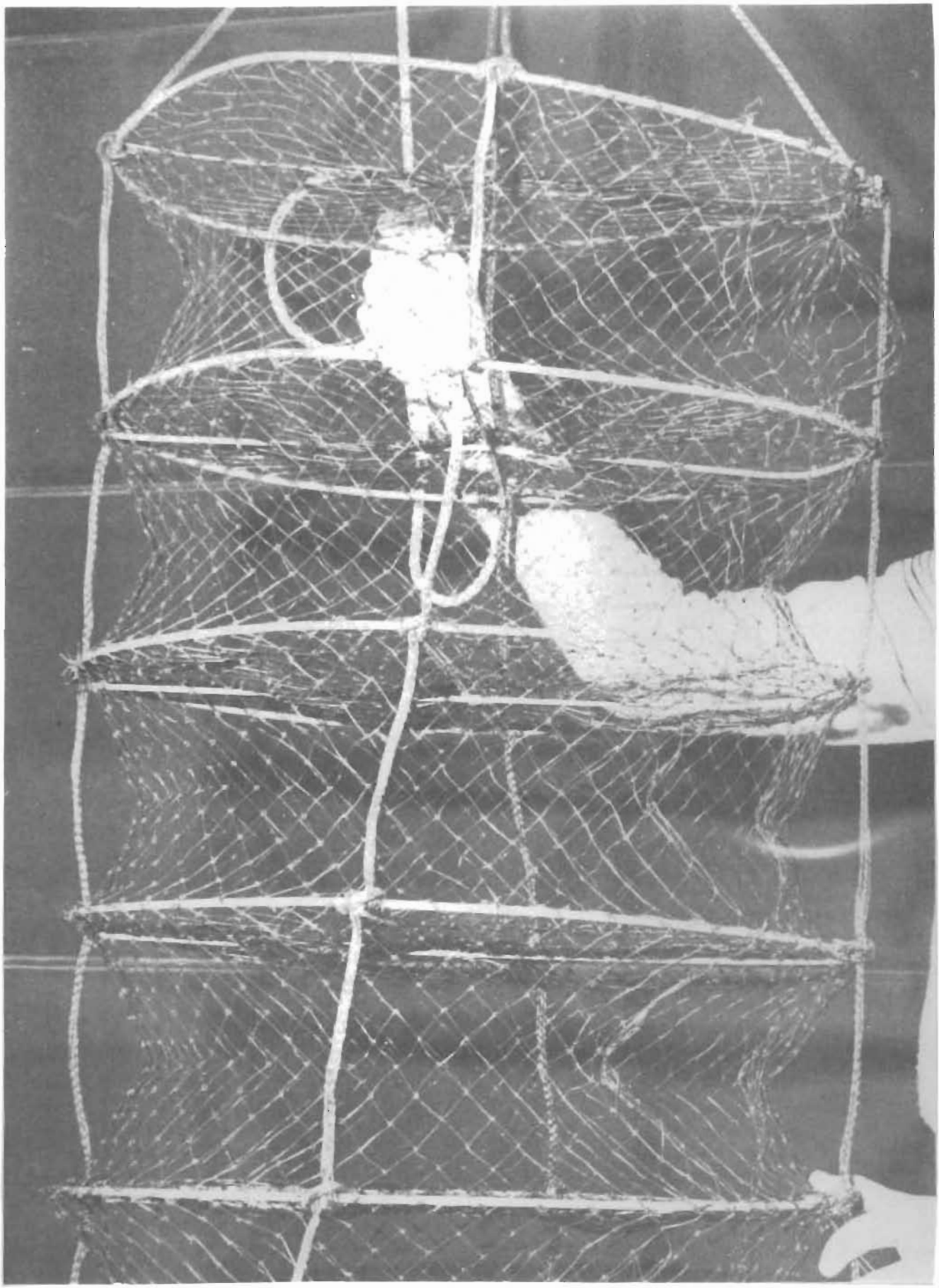

Fig. 11. Lantern net (Accordian tray).

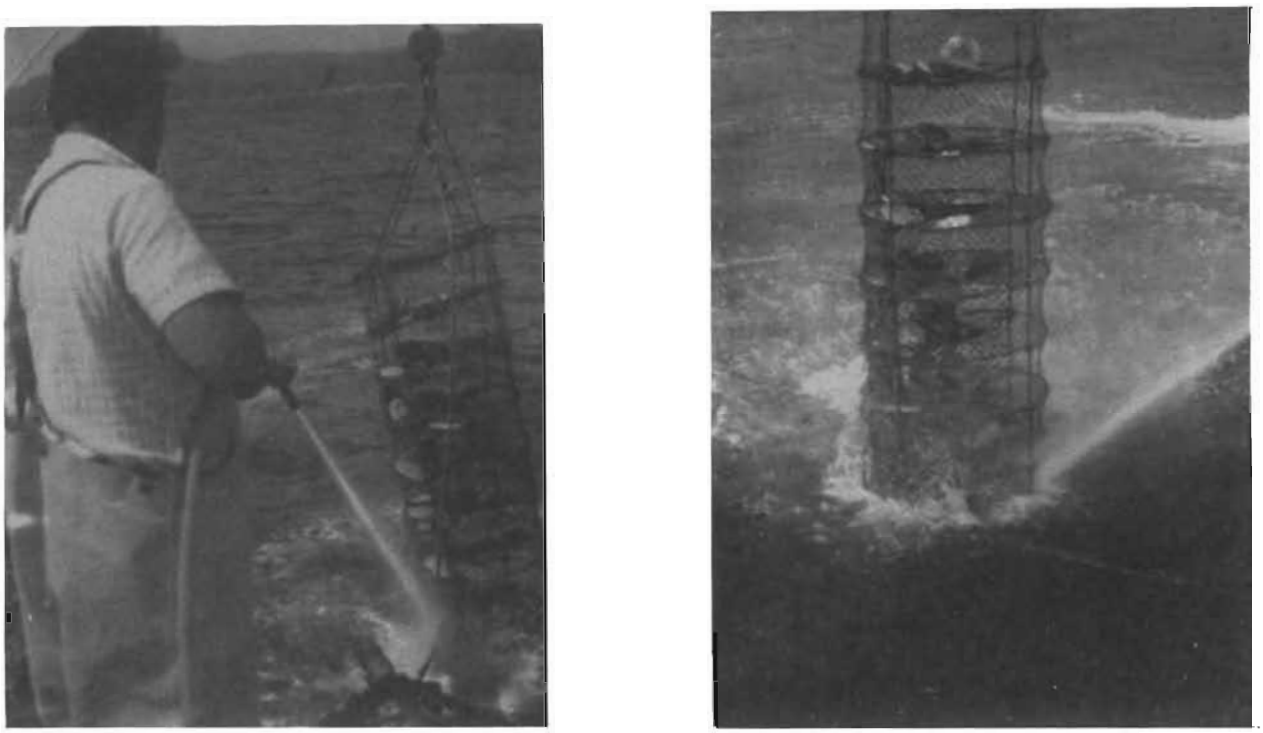

Fig. 12. Cleaning cages with jet of water.