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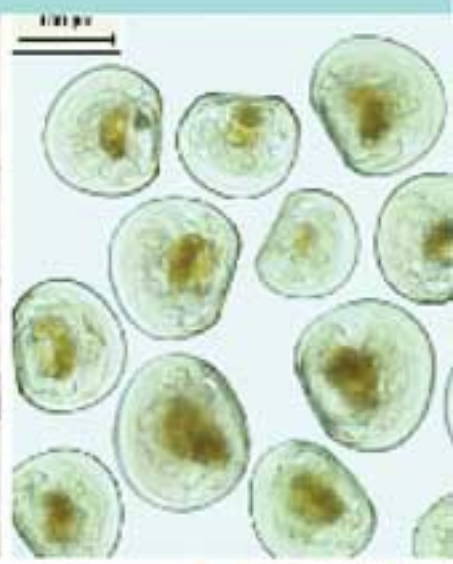
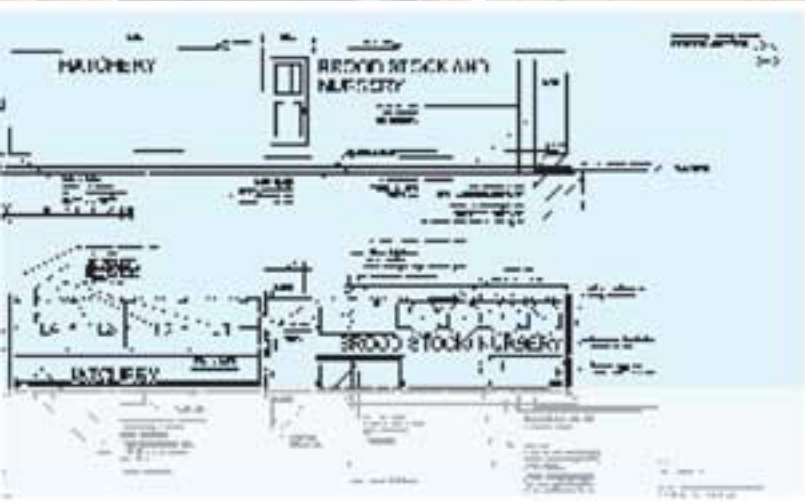
Installation and operation of a modular bivalve hatchery





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Cover photographs and drawings:
Clockwise from top left: A spawning female Manila clam (courtesy of Brian Edwards);
interior of a small bivalve hatchery; photomicrograph of six-day old sand scallop (*Euvola ziczac*) larvae;
technical layout plan of a modular bivalve hatchery; technical detail of a semi-recirculating
nursery raceway system (drawings by Souhaila Sarkis).

Installation and operation of a modular bivalve hatchery

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Preparation of this document

This manual is part of the publication programme of the Aquaculture Management and Conservation Service of the Fisheries and Aquaculture Department of the Food and Agriculture Organization of the United Nations (FAO) and complements the FAO Fisheries Technical Paper No. 471 entitled "Hatchery culture of bivalves: a practical manual" published in 2004.

This manual was written for those interested in establishing an aquaculture operation, with minimal experience in this activity, limited technical support and restricted access to information. It stems directly from one of the author's experience and differs from other manuals by its precision and amount of detail, going one step further in providing a practical template in the building of a hatchery which can be directly copied or modified if needed. Because it focuses on developing aquaculture in resource-limited areas, the manual has been written with the assumption that the user has little, if any, information sources. For this reason, the manual stands as an entity, providing not only the technicalities of setting up and operating a hatchery, but also makes some of the scientific background, deemed useful to the aquaculturist, readily accessible.

The interest in producing this technical manual was generated by the efficiency of the modular hatchery developed and tested over the course of 4 years at the Bermuda Biological Station for Research Inc. (BBSR) for tropical scallop culture. This facility was designed around the facts that little space was available for the building of a hatchery, the budget was small, and proof techniques needed to be developed, prior to a substantial investment. This resulted in a cost efficient, compact, portable hatchery housed in insulated containers. It is a concept, which can be adapted to any region with, as its only requirement, access to "clean" seawater. This modular hatchery may be easily expanded or modified for other bivalve species.

This manual is therefore a technical guide enabling the replication of such a modular hatchery, and also includes detailed protocols pertaining to all aspects of scallop culture, as developed in Bermuda. Protocols reported here were initially written for unskilled personnel, providing a complete and basic outline of the procedures required. However, these protocols have also proved useful throughout years of operation, as they provide an easy routine to follow for all, including more experience personnel, preventing any careless mistakes easily made throughout the course of a chaotic hatchery day!

The manual is divided into chapters, each of them focusing on a rearing phase and providing: a) Technical drawings with descriptive text; b) Scientific background on biology and culture aspects; and c) Operational and culture protocols. The manual concludes with an economic summary of the set-up of such a modular hatchery and of the labour requirements based on operation in Bermuda. Although the costs given are specific to Bermuda, a detailed equipment list is provided as an appendix, presented as a template which can be used for the calculation of region-specific costs. Other appendixes provide details on required calculations, techniques, equipment list and templates to be copied for routine/maintenance checks.

Last but not least, all those involved in the development of this manual have to be gratefully acknowledged for their dedication, hard work, long hours and enthusiasm. Dr Neil Bourne was the first to provide us with the confidence to pursue our ideal. We also thank him for his constructive criticisms of this manual. Those involved in the

aquaculture technique developments and construction of the hatchery from its infancy, were: Doerte Horsfield, Paul Farrington, Mike Helm, Andrew Cogswell and Claudia Hohn. Data for the economic summary was compiled by Charles King.

The technical drawings were prepared by Souhaila Sarkis, registered Landscape Architect. She is gratefully thanked for her thorough and accurate work. The amount of detail given is a first in the description of an aquaculture facility. For printing purposes the original drawings have been reduced and are not to scale. Scaled drawings are available as PDF files in the enclosed CD-ROM at the back of the manual allowing the reader to print any of these for ease of use and consultation (original paper size format: 11”x17”). The CD-ROM also contains PDF files of all chapters.

A final thank you to Dr Sandra Shumway and Dr LeRoy Creswell, for putting in the time to ensure that this manual is scientifically sound and clear in its presentation. Preparation of the manual has been under the overall coordination of Alessandro Lovatelli, Fishery Resources Officer (Aquaculture), FAO.

The graphic layout of the manual was prepared by J.L. Castilla Civit.

Photos are courtesy of Mike Helm, Souhaila Sarkis and Samia Sarkis, unless otherwise noted.

Abstract

Limiting factors such as minimal capital investment, lack of technical support or expertise, and available physical space, may put severe restrictions on setting up a hatchery. Not all investors have the means or the will to take the risk to support a large commercial aquaculture operation without substantial proof of its production capacity. For these reasons, the set-up of an inexpensive modular hatchery may be a simpler option to the start-up of a large commercial operation, or maybe sufficient to the needs of a smaller operation.

This manual is intended to stand on its own, as a guide for installation and operation of a bivalve hatchery. Based on years of experience in a resource-limited region, the need for optimal space usage coupled with a restricted budget, has resulted in a modular "portable" hatchery/nursery complex housed in insulated fiberglass containers. With its only requirement being access to "clean" seawater, this model may be easily adaptable to any region. Although the described facility is compact, it is by no means an experimental laboratory, but a hatchery geared towards production. Its functionality has been repeatedly tested over a four-year period, focusing on culture of subtropical/tropical scallops. The developed procedure is suitable for commercial production, the scale of which is dependent on the tankage capacity. In other words, the modular hatchery described here may be expanded by the addition of identical modules, increasing the number of tanks available and hence production.

The described hatchery comprises basic culture facilities for the rearing of bivalve species such as a dedicated seawater system providing a continuous supply of filtered seawater, a temperature control system for seawater, larval rearing tanks for closed or flow-through systems, and flexible usage stacked raceways for spat rearing. The detailed to scale drawings provide a clear guide intended for ease of replication of the facility. An accompanied written text provides further description of the physical facility. Nonetheless, it is not the intent of this guide to dwell into engineering details, but simply to describe a system that works.

This guide also considers the operation of the hatchery, and for this reason contains simple stepwise protocols. These protocols include both maintenance of the hatchery, such as the cleaning of raceways during spat rearing, and culture procedure, as spawning induction.

The modular hatchery is designed for flexibility and may be used for a range of bivalve species and some gastropods. However, protocols given for culture techniques are based on rearing procedures of subtropical/tropical scallop species developed in the pilot hatchery. For additional support, at times necessary in more isolated regions, concise scientific information is provided on various biological aspects of bivalve reproduction and growth.

The manual is divided into chapters for each stage of rearing: broodstock conditioning, algal culture, hatchery, nursery, growout and economic considerations. Every chapter is an entity, and the first five include both the physical requirements and culture considerations and procedures for the relevant rearing stage. The final chapter on economic considerations provides an insight into the labour involved for each stage of production, along with a list of equipment and supplies, which may be used as a template for a new installation.

Keywords: modular hatchery, installation, operation, culture, bivalves, technical drawings, rearing protocols.

Sarkis, S.; Lovatelli, A. (comp./ed.)
Installation and operation of a modular bivalve hatchery.
FAO Fisheries Technical Paper. No. 492. Rome, FAO. 2007. 173p.
Contains a CD-ROM.

Contents

Chapter 3 – Hatchery: facilities and techniques for larval culture

Chapter 4 – Nursery: facilities and culture of post-larvae

Chapter 5 – Growout of juveniles: transfer from nursery to field

List of figures

List of tables

List of protocols

List of technical drawings

***** "Pg" refers to the number of the technical drawing.

Technical drawing notes and pipe conversion

Please note:

1) All valves, pipes and other fittings are of PVC (Schedule 40) unless otherwise specified in drawings.

2) The subtropical scallop culture model for hatchery and nursery facilities represents an existing complex in Bermuda, built in accordance with the Bermuda environmental regulations. Installation in other countries is subject to local federal and regional environmental regulations and building code.

3) All drawings are metric. Please refer to chart below for imperial conversions.

Nominal NPT pipe size to nominal metric size conversion chart

Nominal pipe size (Inches/U.S.)	Nominal pipe size (Metric)
1/8″	6 mm
3/16″	7 mm
1/4″	8 mm
3/8″	10 mm
1/2″	15 mm
5/8″	18 mm
3/4″	20 mm
1″	25 mm
1-1/4″	32 mm
1-1/2″	40 mm
2″	50 mm
2-1/2″	65 mm
3″	80 mm
3-1/2″	90 mm
4″	100 mm
4-1/2″	115 mm
5″	125 mm
6″	150 mm

List of appendixes

Glossary

Adductor muscle	large muscle near centre of scallop that pulls the two valves together
Algae	aquatic plants that reproduce by cell division or spores
Anoxia	deficiency or absence of oxygen in the blood and tissues
Anterior	front or head
Banjo filters	in hatchery terminology, a ring meshed on both sides affixed to the outflow of a tank preventing larval loss through drain
Blastula	a hollow ball of cells, one of the early stages of embryonic development
Bivalve	mollusc of the Class Pelecypoda, having a shell of two valves that are joined by a hinge
Byssus	thread-like filaments used by bivalves to attach themselves to a substrate
Cilia	hair-like structures whose rhythmic beat induces a water current in bivalves
Cleavage	the series of mitotic divisions, usually occurring with no increase in cytoplasmic mass that first transforms the single-celled zygote into a multicellular blastula
Ctenidia	leaf-like appendages that function in respiration and filtration of food from water (used interchangeably with the term gills)
Cultch	material used to collect bivalve spat
Detritus	fragmented or decomposing organic material from plant and animal remains
Diatom	a single-celled algae of the Class Bacillariophyceae; cells are enclosed in a siliceous shell called a frustule, cells can form chains
D-larva	the early veliger larval stage of bivalves, also known as straight-hinge larva
Dribble spawners	in this case used for scallops which do not spawn completely, but partially over a period of time
Dorsal	the back or part of an organism away from the ground
Downwelling	in hatchery terminology, a growing system in which the flow of water enters at the top of a spat holding container (compare with upwelling)
Ectometabolites	a product of metabolism
Embryo	organism in early stages of development; in bivalves, prior to larval stage
Epiphytes	animals or plants living on the surface of the seabed or other substratum
Eye spot	simple organ that develops near centre of mature larvae of some bivalves and is sensitive to light

Fecundity	the potential reproductive capacity of an organism or population expressed in the number of eggs (or offsprings) produced during each reproductive cycle
Fertilization	union of egg and sperm
Flagellate	group of single-celled algae characterized by having a locomotory organ called a flagellum
Follicle	small sac-like structure in the ovary, a group of cells surrounding the oocyte and probably concerned with its nutrition
Gamete	mature, haploid, functional sex cell capable of uniting with the alternate sex cell to form a zygote
Gametogenesis	process by which eggs and sperm are produced
Gastrula	the embryonic stage of development consisting of two layers of cells enclosing a sac-like central cavity with a pore at one end
Gill	a leaf-like appendage that functions in respiration and filtration of food from water (see ctendia)
Gonadal Index	in this case the relationship of gonad weight to shell weight, reflecting gonad growth or depletion
Gonads	the primary sexual organ: testis producing sperm or ovary producing eggs
Growout	the process of growing seed to market size
Hermaphrodite	having both male and female reproductive organs in the same individual (animal)
Hypoxia	insufficient levels of oxygen in blood or tissue (short of anoxia)
Inoculum	culture of an organism (alga, rotifer), which is used as a starting point for another culture
Larva	a stage of bivalves from the embryo to metamorphosis
Mantle	the soft fold enclosing the body of a bivalve which secretes the shell
Meiotic division	process in which normal number of chromosomes (2n) is reduced to the haploid (n) number
Metamorphosis	in bivalves, the period of transformation from the larval to the juvenile stage
Microalgae	small cell-size algae, either single celled or chain forming diatoms, cultured as foods for larvae and spat in a hatchery
Muscle Index	in this case, the relationship of muscle weight to shell weight, reflecting muscle growth or depletion
Oocyte	Cell, which develops into an ovum
Ovary	the sex organ which produces the egg or eggs in a female organism
Pediveliger	Larval stage of molluscs that still has the swimming ciliated organ (velum) and sensitive foot needed for settlement and attachment
pH	a measure of acidity
Plankton	floating or weakly swimming aquatic organisms, can be phytoplankton (plants) or zooplankton (animals)

Polar body	minute cells released during meiotic division of the egg after the sperm has penetrated the egg; contains excess chromosomal material to produce a haploid egg
Posterior	the rear, away from the head
Primary oogonia	arising from primordial germ cells during the initial (premeiotic) stage of oocyte development, and differentiates into an oocyte in the ovary
Prodissoconch	Bivalved shell formed by larva prior to metamorphosis. It may be possible to distinguish an earlier, smaller prodissoconch-I from a later, larger prodissoconch-II that encloses the entire animal
Pseudofaeces	false faeces, waste material not taken into the digestive tract
Seed	a young scallop with no specific definition to size
Settlement	behavioural process when mature bivalve larvae seek a suitable substrate for attachment
Shell height	in scallops, the straight line distance measured perpendicularly from the umbo to the ventral margin of the shell
Shell length	in scallops, the straight line distance from the anterior to the posterior margins of the shell
Spat	a newly settled or attached bivalve (also termed post larval or juvenile in bivalves)
Spatfall	the settling or attachment of young bivalve molluscs, which have completed their larval stages
Spawning	release of ova, fertilized or to be fertilized
Statocyst	formed by invagination of the epithelium in bivalve larvae potentially providing the ability to detect gravity
Straight-hinge larva	early part of larval stage, sometimes termed D-stage
Testis	male reproductive organ
Trochophore	the first free-swimming planktonic stage of a mollusc larvae or bivalve embryo
Umbo	beak-like projections at the dorsal part of the shell; it is the oldest part of a bivalve shell (also called the umbone)
Upwelling	in hatchery terminology, a growing system in which a flow of water is induced through the base of a spat holding container (compare with downwelling)
Veliger larva	the larval stage of most molluscs, characterized by the presence of a velum
Velum	ciliated locomotory organ of the larva
Ventral	pertaining to the under or lower side of an animal
Vitellogenesis	formation of the yolk of an egg
Zygote	diploid cell resulting from union of male and female gametes

Abbreviations, acronyms and conversions

AFDW	Ash-Free Dry Weight
ANOVA	Analysis Of Variance
BBSR	Bermuda Biological Station for Research Inc.
C	Control
CCMP	Centre of Culture for Marine Phytoplankton
CI	Condition Index
CO_2	Carbon Dioxide
DOPA	Dihydroxyphenylalanine
DW	Dry Weight
EDTA	Ethylene Diamine Tetraacetic Acid
Fisher's PSLD	Fisher's Protected Least Significant Difference
FT	Flow-Through
GF/C	Glass Fibre with particle retention of 1.2µm
GI	Gonadal Index
HCL	Hydrochloric Acid
ID	Inner Diameter
int-ext	Interior-Exterior Connection
LNSW	Low Nutrient Seawater
MI	Muscle Index
NPT	National Pipe Thread
MNPT	Male National Pipe Thread
No	Number
OD	Outer Diameter
PLSD	Protected Least Significant Difference
pers.obs.	Personal Observation
PPT	Parts Per Thousand
PUFA	Polyunsaturated Fatty Acid
PVC	Polyvinyl Chloride
Q-water	De-ionised Water
SA	Surface Area
SCUBA	Self-Contained Underwater Breathing Apparatus
SD	Standard Deviation
TFS	Typical Filtration System
USD	United States Dollar
UV	Ultra-Violet

Not all of the following abbreviations have been used in this manual. However, they are provided as reference when reading other documents.

<	less than
>	greater than
n.a.	not analysed or not available (also written as N/A)
µm	micron
mm	millimetre
cm	centimetre
m	metre
km	kilometre

inch	inch
ft	foot
yd	yard
mi	mile
ft²	square foot
yd²	square yard
mi²	square mile
m²	square metre
ha	hectare
km²	square kilometre
cc	cubic centimetre (= ml)
m³	cubic metre
ft³	cubic foot
yd³	cubic yard
µl	microlitre
ml	millilitre (= cc)
l	litre
µg	microgram
mg	milligram (milligramme)
g	gram (gramme)
kg	kilogram (kilogramme)
mt	metric tonne (1 000 kg) (also written as tonne)
oz	ounce
lb	pound
cwt	hundredweight [value differs in UK ('Imperial') and US units - see weight conversions]
t	ton [value differs in UK ('Imperial') and US units - see weight conversions]
psi	pounds per square inch
psu	practical salinity units
gpm	('Imperial' = UK) gallons per minute
mgd	million ('Imperial' = UK) gallons per day
cfm	cubic feet per minute
ppt	parts per thousand (also written as ‰)
ppm	parts per million
ppb	parts per billion (thousand million)
min	minute
hr	hour
kWhr	kilowatt-hour

Conversions

This section of the annex should be used in conjunction with the abbreviations section. Please note that the words gallon and tonne have different values depending on whether the source of the text you are reading is 'British' or 'American' in origin.

Length:

1 µm	0.001 mm = 0.000001 m
1 mm	0.001 m = 1 000 µm = 0.0394 inch
1 cm	0.01 m = 10 mm = 0.394 inch
1 m	1 000 000 µm = 1 000 mm = 100 cm = 0.001 km = 39.4 inch = 3.28 ft = 1.093 yd
1 km	1 000 m = 1 093 yd= 0.621 mi
1 inch	25.38 mm = 2.54 cm

1 ft	12 inch = 0.305 m
1 yd	3 ft = 0.914 m
1 mi	1 760 yd = 1.609 km

Weight:

1 µg	0.001 mg = 0.000001 g
1 mg	0.001 g = 1 000 µg
1 g	1 000 000 µg = 1 000 mg = 0.001 kg = 0.0353 oz
1 kg	1 000 g = 2.205 lb
1 mt	1 000 kg = 1 000 000 g = 0.9842 UK t = 1.102 US t
1 oz	28.349 g
1 lb	16 oz = 453.59 g
1 UK cwt	112 lb = 50.80 kg
1 US cwt	100 lb = 45.36 kg
1 UK t	20 UK cwt = 2 240 lb
1 US t	20 US cwt = 2 000 lb
1 UK t	1.016 mt = 1.12 US t

Volume:

1 µl	0.001 ml = 0.000001 l
1 ml	0.001 l = 1 000 µl = 1 cc
1 L	1 000 000 µl = 1 000 ml = 0.220 UK gallon = 0.264 US gallon
1 m³	1 000 l = 35.315 ft^3 = 1.308 yd^3 = 219.97 UK gallons = 264.16 US gallons
1 ft³	0.02832 m^3 = 6.229 UK gallons = 28.316 l
1 UK gallon	4.546 l = 1.2009 US gallons
1 US gallon	3.785 l = 0.833 UK gallon
1 MGD	694.44 GPM = 3.157 m^3/min = 3 157 l/min

Concentration – dissolving solids in liquids:

1 %	1 g in 100 ml
1 ppt	1 g in 1 000 ml = 1 g in 1 l = 1 g/l = 0.1%
1 ppm	1 g in 1 000 000 ml = 1 g in 1 000 L = 1 mg/l = 1 µg/g
1 ppb	1 g in 1 000 000 000 ml = 1 g in 1 000 000 l = 0.001 ppm = 0.001 mg/l

Concentration – dilution of liquids in liquids:

1 %	1 ml in 100 ml
1 ppt	1 ml in 1 000 ml = 1 ml in 1 l = 1 ml/l = 0.1%
1 ppm	1 ml in 1 000 000 ml = 1 ml in 1 000 l = 1 µl/l
1 ppb	1 ml in 1 000 000 000 ml = 1 ml in 1 000 000 l = 0.001 ppm = 0.001 ml/l

Area:

1 m²	10.764 ft^2 = 1.196 yd^2
1 ha	10 000 m^2 = 100 ares = 2.471 acres
1 km²	100 ha = 0.386 mi^2
1 ft²	0.0929 m^2
1 yd²	9 ft^2 = 0.836 m^2
1 acre	4 840 yd^2 = 0.405 ha
1 mi²	640 acres = 2.59 km^2

Temperature:

°F	(9 ÷ 5 x °C) + 32
°C	(°F - 32) x 5 ÷ 9

Pressure:

1 psi	70.307 g/cm^2

Scientific units

Scientists have a different way of writing some of the units described in this glossary. They use what is called the Système International (SI). The units are referred to as SI units. For example: 1 ppt, which can be written as 1 g/l (see concentration above) is written as 1 g l^{-1} in scientific journals, 1 g/kg as 1 g kg^{-1}, 12 mg/kg as 12 mg kg^{-1}, and 95 µg/kg as 95 µg kg^{-1}. A stocking density of 11 kg/m^3 would be written as 11 kg m^{-3}. This SI system is not normally used in daily hatchery records, however for the purpose of standardization, it is used throughout this publication.