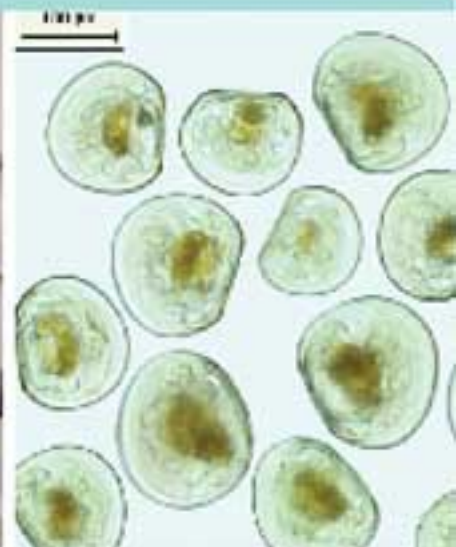


# Installation and operation of a modular bivalve hatchery



**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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Prepared by  
**Samia Sarkis**  
FAO Consultant  
Bermuda

Compiled and edited by  
**Alessandro Lovatelli**  
FAO Inland Water Resources and Aquaculture Service

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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.

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# 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.

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\* "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

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# Glossary

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

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

<b>Polar body</b>	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
<b>Posterior</b>	the rear, away from the head
<b>Primary oogonia</b>	arising from primordial germ cells during the initial (premeiotic) stage of oocyte development, and differentiates into an oocyte in the ovary
<b>Prodissoconch</b>	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
<b>Pseudofaeces</b>	false faeces, waste material not taken into the digestive tract
<b>Seed</b>	a young scallop with no specific definition to size
<b>Settlement</b>	behavioural process when mature bivalve larvae seek a suitable substrate for attachment
<b>Shell height</b>	in scallops, the straight line distance measured perpendicularly from the umbo to the ventral margin of the shell
<b>Shell length</b>	in scallops, the straight line distance from the anterior to the posterior margins of the shell
<b>Spat</b>	a newly settled or attached bivalve (also termed post larval or juvenile in bivalves)
<b>Spatfall</b>	the settling or attachment of young bivalve molluscs, which have completed their larval stages
<b>Spawning</b>	release of ova, fertilized or to be fertilized
<b>Statocyst</b>	formed by invagination of the epithelium in bivalve larvae potentially providing the ability to detect gravity
<b>Straight-hinge larva</b>	early part of larval stage, sometimes termed D-stage
<b>Testis</b>	male reproductive organ
<b>Trochophore</b>	the first free-swimming planktonic stage of a mollusc larvae or bivalve embryo
<b>Umbo</b>	beak-like projections at the dorsal part of the shell; it is the oldest part of a bivalve shell (also called the umbone)
<b>Upwelling</b>	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)
<b>Veliger larva</b>	the larval stage of most molluscs, characterized by the presence of a velum
<b>Velum</b>	ciliated locomotory organ of the larva
<b>Ventral</b>	pertaining to the under or lower side of an animal
<b>Vitellogenesis</b>	formation of the yolk of an egg
<b>Zygote</b>	diploid cell resulting from union of male and female gametes

# Abbreviations, acronyms and conversions

<b>AFDW</b>	Ash-Free Dry Weight
<b>ANOVA</b>	Analysis Of Variance
<b>BBSR</b>	Bermuda Biological Station for Research Inc.
<b>C</b>	Control
<b>CCMP</b>	Centre of Culture for Marine Phytoplankton
<b>CI</b>	Condition Index
<b>CO<sub>2</sub></b>	Carbon Dioxide
<b>DOPA</b>	Dihydroxyphenylalanine
<b>DW</b>	Dry Weight
<b>EDTA</b>	Ethylene Diamine Tetraacetic Acid
<b>Fisher's PSLD</b>	Fisher's Protected Least Significant Difference
<b>FT</b>	Flow-Through
<b>GF/C</b>	Glass Fibre with particle retention of 1.2µm
<b>GI</b>	Gonadal Index
<b>HCL</b>	Hydrochloric Acid
<b>ID</b>	Inner Diameter
<b>int-ext</b>	Interior-Exterior Connection
<b>LNSW</b>	Low Nutrient Seawater
<b>MI</b>	Muscle Index
<b>NPT</b>	National Pipe Thread
<b>MNPT</b>	Male National Pipe Thread
<b>No</b>	Number
<b>OD</b>	Outer Diameter
<b>PLSD</b>	Protected Least Significant Difference
<b>pers.obs.</b>	Personal Observation
<b>PPT</b>	Parts Per Thousand
<b>PUFA</b>	Polyunsaturated Fatty Acid
<b>PVC</b>	Polyvinyl Chloride
<b>Q-water</b>	De-ionised Water
<b>SA</b>	Surface Area
<b>SCUBA</b>	Self-Contained Underwater Breathing Apparatus
<b>SD</b>	Standard Deviation
<b>TFS</b>	Typical Filtration System
<b>USD</b>	United States Dollar
<b>UV</b>	Ultra-Violet

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

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

<b>inch</b>	inch
<b>ft</b>	foot
<b>yd</b>	yard
<b>mi</b>	mile
<b>ft<sup>2</sup></b>	square foot
<b>yd<sup>2</sup></b>	square yard
<b>mi<sup>2</sup></b>	square mile
<b>m<sup>2</sup></b>	square metre
<b>ha</b>	hectare
<b>km<sup>2</sup></b>	square kilometre
<b>cc</b>	cubic centimetre (= ml)
<b>m<sup>3</sup></b>	cubic metre
<b>ft<sup>3</sup></b>	cubic foot
<b>yd<sup>3</sup></b>	cubic yard
<b>µl</b>	microlitre
<b>ml</b>	millilitre (= cc)
<b>l</b>	litre
<b>µg</b>	microgram
<b>mg</b>	milligram (milligramme)
<b>g</b>	gram (gramme)
<b>kg</b>	kilogram (kilogramme)
<b>mt</b>	metric tonne (1 000 kg) (also written as tonne)
<b>oz</b>	ounce
<b>lb</b>	pound
<b>cwt</b>	hundredweight [value differs in UK ('Imperial') and US units - see weight conversions]
<b>t</b>	ton [value differs in UK ('Imperial') and US units - see weight conversions]
<b>psi</b>	pounds per square inch
<b>psu</b>	practical salinity units
<b>gpm</b>	('Imperial' = UK) gallons per minute
<b>mgd</b>	million ('Imperial' = UK) gallons per day
<b>cfm</b>	cubic feet per minute
<b>ppt</b>	parts per thousand (also written as ‰)
<b>ppm</b>	parts per million
<b>ppb</b>	parts per billion (thousand million)
<b>min</b>	minute
<b>hr</b>	hour
<b>kWhr</b>	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:

---

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



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

**Weight:**


---

1 $\mu\text{g}$	0.001 mg = 0.000001 g
1 mg	0.001 g = 1 000 $\mu\text{g}$
1 g	1 000 000 $\mu\text{g}$ = 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 $\mu\text{l}$	0.001 ml = 0.000001 l
1 ml	0.001 l = 1 000 $\mu\text{l}$ = 1 cc
1 L	1 000 000 $\mu\text{l}$ = 1 000 ml = 0.220 UK gallon = 0.264 US gallon
1 m <sup>3</sup>	1 000 l = 35.315 ft <sup>3</sup> = 1.308 yd <sup>3</sup> = 219.97 UK gallons = 264.16 US gallons
1 ft <sup>3</sup>	0.02832 m <sup>3</sup> = 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 <sup>3</sup> /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 $\mu\text{g/g}$
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 $\mu\text{l/l}$
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 m <sup>2</sup>	10.764 ft <sup>2</sup> = 1.196 yd <sup>2</sup>
1 ha	10 000 m <sup>2</sup> = 100 ares = 2.471 acres
1 km <sup>2</sup>	100 ha = 0.386 mi <sup>2</sup>
1 ft <sup>2</sup>	0.0929 m <sup>2</sup>
1 yd <sup>2</sup>	9 ft <sup>2</sup> = 0.836 m <sup>2</sup>
1 acre	4 840 yd <sup>2</sup> = 0.405 ha
1 mi <sup>2</sup>	640 acres = 2.59 km <sup>2</sup>

**Temperature:**


---

°F	(9 $\div$ 5 x °C) + 32
°C	(°F - 32) x 5 $\div$ 9

**Pressure:**


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1 psi	70.307 g/cm <sup>2</sup>
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## 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<sup>-1</sup> in scientific journals, 1 g/kg as 1 g kg<sup>-1</sup>, 12 mg/kg as 12 mg kg<sup>-1</sup>, and 95 µg/kg as 95 µg kg<sup>-1</sup>. A stocking density of 11 kg/m<sup>3</sup> would be written as 11 kg m<sup>-3</sup>. This SI system is not normally used in daily hatchery records, however for the purpose of standardization, it is used throughout this publication.