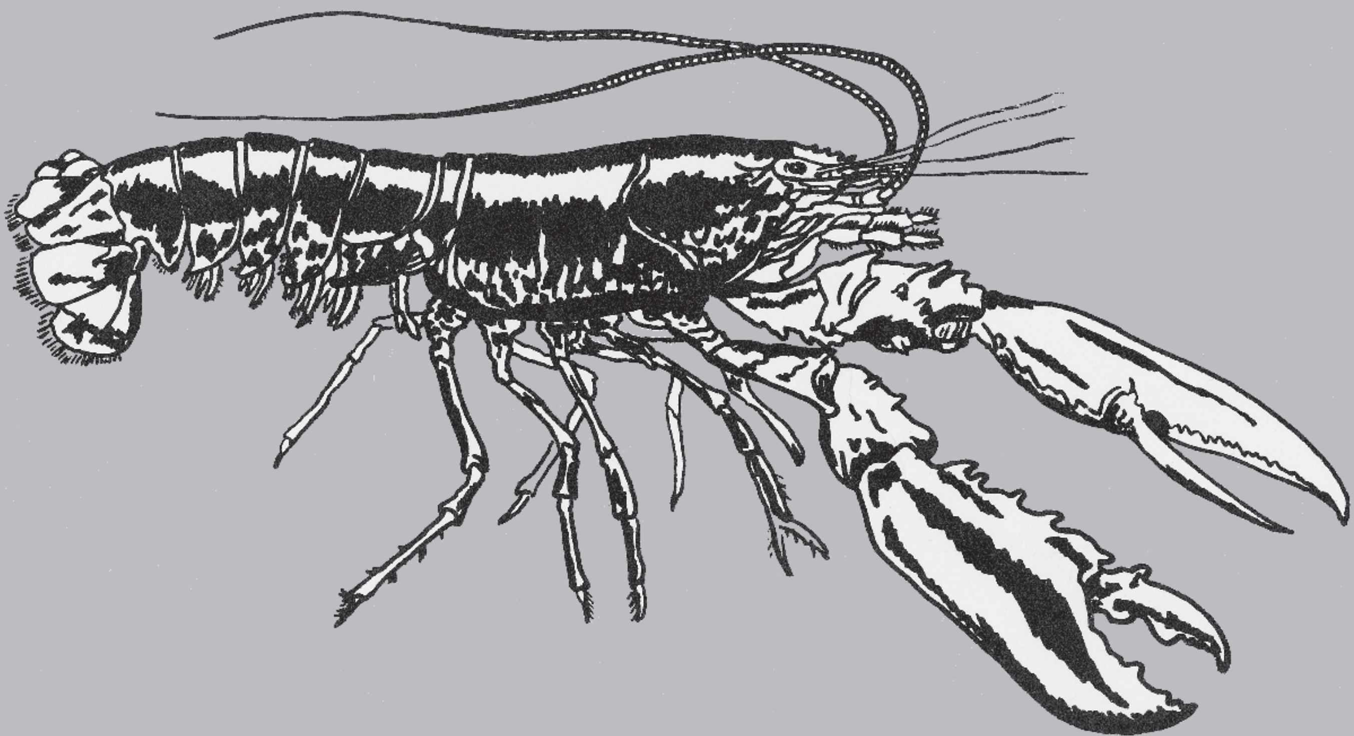
Storage and care of live lobsters

T.W. Beard and D. McGregor



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Storage and Care of Live Lobsters

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1. INTRODUCTION

With a buoyant consumer demand for live lobsters both at home and in Europe, many fish and shellfish merchants may be considering the live storage of these crustaceans for the first time.

The main advantage of live storage is that lobsters can be maintained in prime condition. They may also be purchased when abundant and relatively cheap, then stored to be sold when demand and prices are at a peak. Live storage also permits flexibility of marketing and dispatch, particularly for those merchants or fishermen who are geographically isolated from the major markets. For example, large consignments can be built up, and customers supplied with shipments of lobsters of equal quality, at convenient times or on demand, and advantage can be taken of bulk packing and transportation.

To be effective, however, it is essential that the method of storage used does maintain the lobsters in prime condition to attract top market prices. The basic techniques for successful lobster storage are quite simple but will only be effective if good husbandry practices are followed.

The development of trade in the American lobster (*Homarus americanus*) from North America and Canada has led to the implementation of a system of licensed deposits. This is designed to prevent the introduction and spread of Gaffkaemia, a disease of lobsters which may be carried by lobsters from abroad. Compliance with the appropriate Orders (see page 22) should prevent our native stocks of European lobsters (*Homarus gammarus*) becoming infected and reduce the risks of cross infection when both species may be held in live storage on the same premises.

This laboratory leaflet contains a brief summary of the lobster's biology, to help in understanding the animal. Examples of different types of storage system are described, together with a discussion of the major water quality factors affecting storage. An outline of the licensing system and legal obligations is presented, advice is given on the prevention of diseases, together with disinfection procedures if a disease outbreak should occur. A glossary of technical terms is also included (Appendix 1), a recipe for manufacturing artificial sea water (Appendix 2), a table for converting weights and measures (Appendix 3), a list of useful contacts (Appendix 4), along with a further reading list for those wishing to pursue certain points in greater detail (Appendix 5).

2. LOBSTER BIOLOGY

The lobster belongs within a large class of invertebrate animals called Crustacea. Most crustaceans are marine but there are many freshwater types, for example the freshwater crayfish, and even a few terrestrial representatives such as the common wood-louse.

The two most important species of clawed lobster are: *Homarus gammarus*, the European lobster, which inhabits Eastern Atlantic waters from the Arctic Circle to Morocco and into the Mediterranean, with the British Isles at its centre of distribution; and *Homarus americanus*, the American lobster, sometimes also known as the Canadian lobster, and found on the eastern seaboard of North America from Newfoundland in Canada down to Delaware, USA. Although these two species of lobster are very similar in appearance, there are differences, particularly in colour and habits. The main features which distinguish the two species are:

European lobster

Rostrum	No spine on lower rostrum margin
Claws	Spines white or white-tipped Underside of claw creamy white or very pale red

American lobster

Rostrum	Well-developed spine on lower rostrum margin
Claws	Spines red or red-tipped Underside of claw orange/red

The following description and biological details apply to the European lobster; the main external and internal features are shown in Figure la and b.

A characteristic of crustaceans is that they shed (or cast) their hard external skeleton (the exoskeleton) at intervals in order to grow, which is known as moulting. At moult, water absorbed by the body tissues causes the lobster to swell, thus rupturing the old shell at the joint between the head and the tail. It withdraws its head and claws from the front part of the old shell, and then with a quick flick the tail comes free. After it has freed itself, further absorption of water stretches the new shell, already formed under the old one, before it has time to harden. In very small lobsters, this hardening process may take only a few hours but in larger lobsters it may take weeks before the shell is fully hard again. In the period between moults, the water absorbed at moulting is gradually replaced by new body tissue. Juvenile lobsters may moult a number of times each year for the first two or three years but the rate of moulting decreases as they grow; large lobsters moult only once every one or two years. Marketable size is reached after 26-30 moults (5-7 years).

The two large claws are usually quite different in size and shape. The smaller, slender one, known as the cutter claw, has sharp inner edges set with small teeth and serves for holding and tearing the prey. The larger,

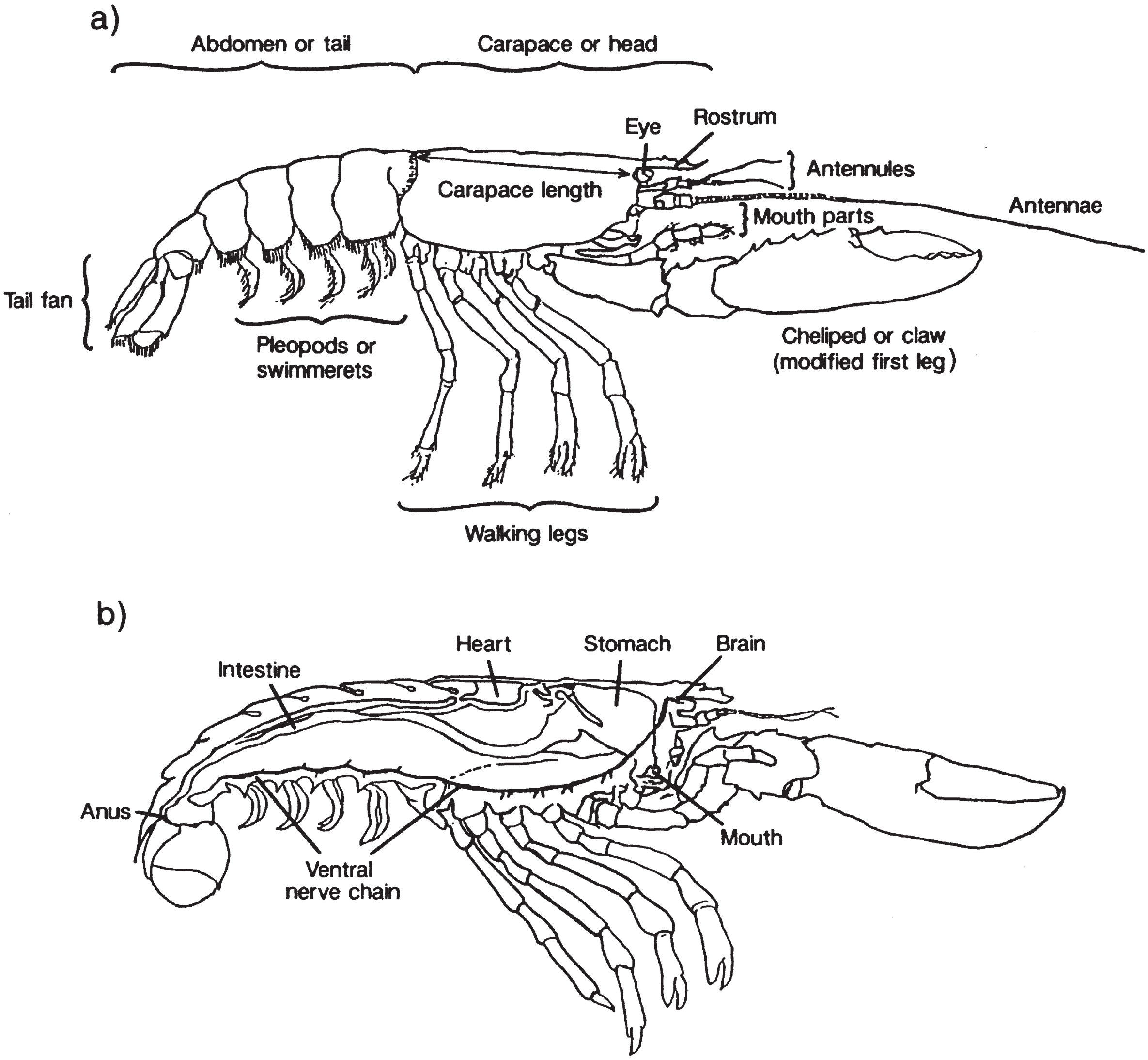


Figure 1. The European lobster (Hormarus gammarus): (a) external features; and (b) internal features.

or crusher claw, has inner edges equipped with blunt rounded nodules for crushing. The cutter claw may be on either the right or the left side. Claws or legs which are lost, for example through fighting, will grow again but it will take a number of moults before they regain their original size.

Male and female lobsters may be recognised by examination of the first pair of pleopods, which are situated under the tail immediately behind the legs (see Figure la). In the female, these pleopods look like separate, short filaments whilst in the male they are joined together forming a stout rod. Female lobsters also tend to have a broader abdomen with deeper side plates, a modification to accommodate the eggs. Female lobsters reach sexual maturity at five or six years of age, at a carapace length of between 80 and 85 mm. Males mature at a slightly smaller size. Mating usually occurs between a hard-shelled male and a soft, newly moulted female who releases a special hormone at this time which discourages the male from eating her. Spawning usually occurs in the summer when the female extrudes the eggs which stick to the pleopods under her tail where they hang in bunches. A female carrying eggs is said to be “in berry”. Females care for the eggs by cleaning the egg-mass with the rear pair of legs and by regularly beating the pleopods to provide a good circulation of water around the eggs. The eggs are carried for up to twelve months, depending on temperature. Their colour gradually changes from olive green through black to red as the embryo develops and the yolk within the egg is used up. Hatching occurs at night and the larvae swim up to the surface where they drift with the currents, preying on the microscopic animals forming the zooplankton. This planktonic larval period lasts for 15 to 35 days at the sea temperatures around the British Isles, and in this time the larvae moult three times (Figure 2, pp 8 & 9). There is a marked change in habits and shape following the third moult. The young lobsters, which now look like miniature adults, sink to the bottom to seek a suitable substrate and settle down to an existence on the sea bed. Little is known of the habits of these juvenile lobsters as they are very rarely found or observed in the wild. Research has suggested that they may inhabit areas quite different from those favoured by the adult. They may remain within the crevices formed by piles of stones and boulders or spend most of their time in burrows. It is known that juvenile lobsters are capable of building quite extensive tunnel systems in a suitable substrate.

Adult lobsters are usually found on rocky areas of the sea bed down to depths of 100 metres or more, and tend to be most abundant where there are many crevices in which they may shelter or hide. Sandy areas may be colonised if there are suitable stones or rocky outcrops under which the lobster can burrow. Lobsters are primarily nocturnal animals and emerge from cover as darkness falls to forage for food before returning to shelter when the light level starts to increase. They are carnivorous and eat a wide variety of marine animals. Stomach analyses have shown the presence of crustaceans, molluscs, worms, starfish and fish. Normally they are solitary animals, and aggressive competition for shelter and territory forms a major part of their behaviour

3. LOBSTER CONDITION AND CARE

The need for careful handling really starts with the fisherman catching the lobsters. If shell damage is to be avoided, they must not be dropped or allowed to fall when they are removed from the pots. Lobsters left lying on deck exposed to the sun and wind will suffer a serious drying effect which weakens them.

Lobsters represent a valuable resource to commercial fishermen and with increasing pressure on stocks, it is important that the resource is managed in a sustainable manner. In support of this local management groups, particularly Sea Fisheries Committees, have introduced and are operating V-notching schemes to protect mature animals and allow them to reproduce. V-notching involves cutting a V-shaped notch in the inner section of the tail fan of lobsters and crawfish to identify mature animals which can then be returned to the sea to breed. Legislation introduced in 2000 makes it illegal to land lobsters or crawfish that have been V-notched.

To prevent drying out, lobsters prior to storage need to be kept carefully, preferably in single layers, separated by damp sacking, which helps to maintain a moist atmosphere. This moist air is essential, as it prevents the gills from drying out and enables respiration to continue. The container holding the lobsters needs to have holes in the base to allow excess water to drain away. If held in static, unaerated water, lobsters rapidly exhaust the available oxygen and then die. They can, however, survive out of water for quite long periods if kept cool and in moist air. Secure banding of the claws before storing them away is advisable to prevent them damaging each other during transit. When selecting lobsters for storage, the initial condition of the animal is most important. Lobsters should appear alert and respond positively (by tail flexing or defensive posture) when handled. Lethargic behaviour, coupled with a weak, limp appearance, is a sure sign that things are not as they should be. Damaged animals or those with "nicked" or "plugged" claws should not be accepted, as infection can easily enter the lobster through such damaged areas with potentially severe consequences for all of the other stock. Recently moulted (soft) lobsters have a very poor flesh condition and should not be landed.

After being held for long periods out of water, lobsters will be in a weak condition. They stand a better chance of survival if lowered gently, tail first, into the water so that the air from under the carapace can be expelled. If new arrivals are kept separate from the other stock for 24 hours, they will be able to recover from the strain of travelling without being harassed by the stronger lobsters already in the storage system. In addition, any weak ones can be spotted more readily and removed for immediate sale. Ideally, a new intake should be inspected for mortalities every few hours, but all tanks must be inspected at least once daily. Prompt removal of all dead and moribund lobsters is essential, otherwise decomposition of the corpses will soon affect water quality adversely. It is useful for records of all mortalities to be kept in order to build up a picture of what could be regarded as a "normal level" of mortality. It is important to distinguish between immediate post-travelling deaths and the day-to-day mortalities which can be expected even in the best-run storage system. The capability of observing the stored lobsters at all times is a necessary requirement, as abnormal behaviour patterns can give a valuable early warning of deteriorating conditions. Staff will soon develop an awareness of what is normal or abnormal during their daily contact with the lobsters. This is why water clarity is so important. Lobsters are mainly nocturnal animals and, as such, do not like strong light. Dim lighting over the storage area during the day is best, with supplementary lighting being used only when working in the immediate area. The avoidance of sudden increases in light levels is advisable. For example, do not switch all of the lights on during the dark period or first thing in the morning. Ideally, the dim lights should be on a time switch so that they come on first. Lobsters are also sensitive to disturbances and will become stressed if subjected to excessive vibration and/or noise caused, for example, by pumps and motors or by staff working noisily in adjacent areas.

During storage, lobsters do not require feeding. In good condition they can live for several months without feeding, especially if kept at low temperatures (less than 10°C). There is no apparent deterioration in the flavour of the flesh when cooked and only a slight decrease in the yield of meat even after a number of weeks without feeding. However, this does not mean that lobsters can be held indefinitely. It is essential to develop a good stock-management system to ensure rotation of stock and avoid holding animals for too long.

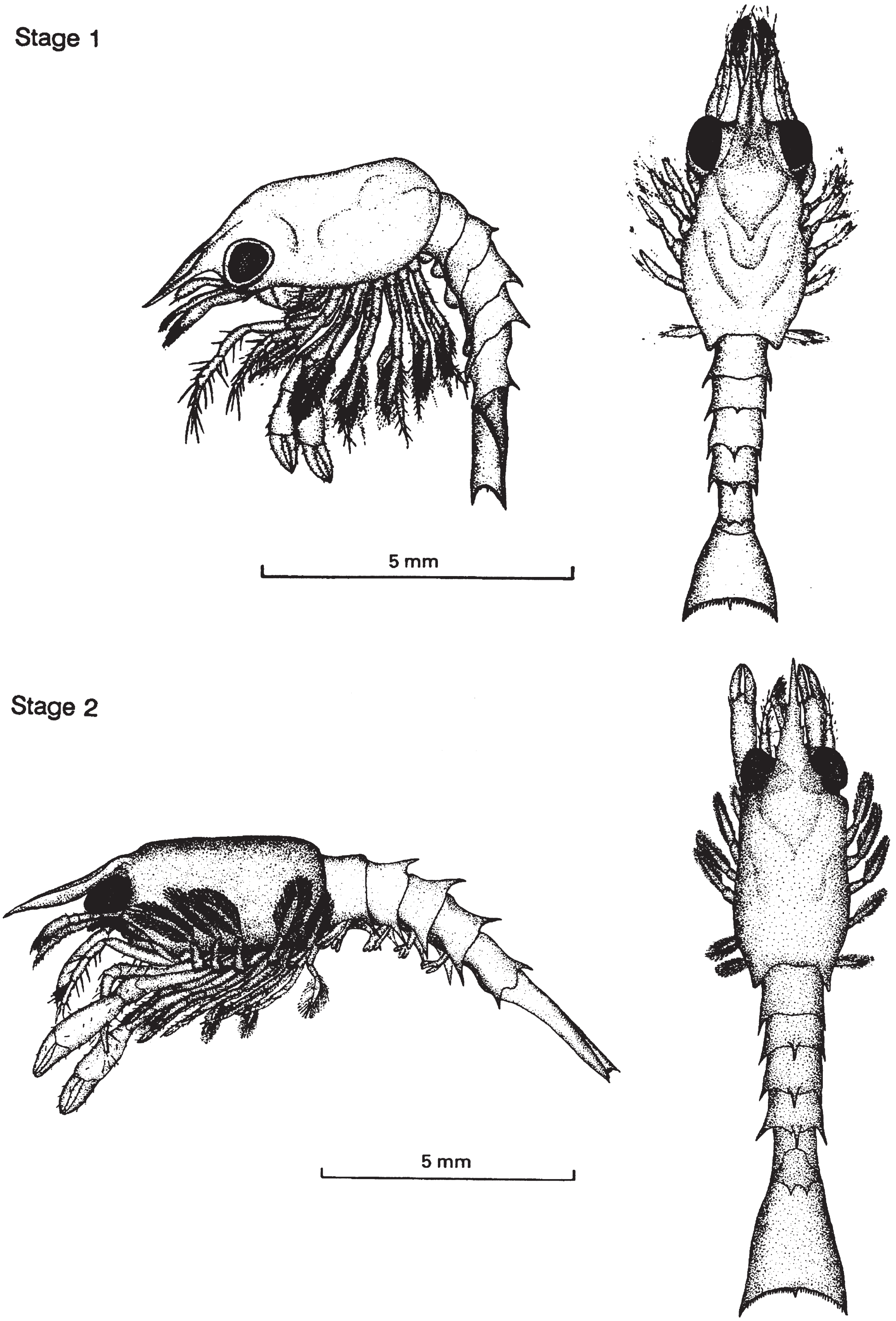
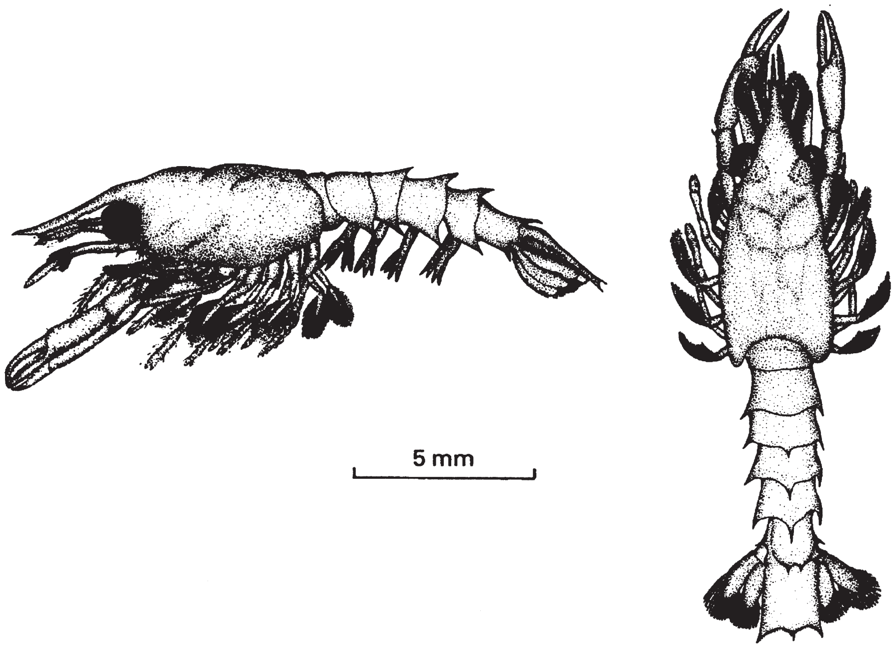


Figure 2. ***The four larval (free swimming) stages of the lobster (Homarus gammarus). (From Nichols and Lawson, 1978; reproduced by kind permission of the International Council for the Exploration of the Sea.)***

Stage 3



Stage 4

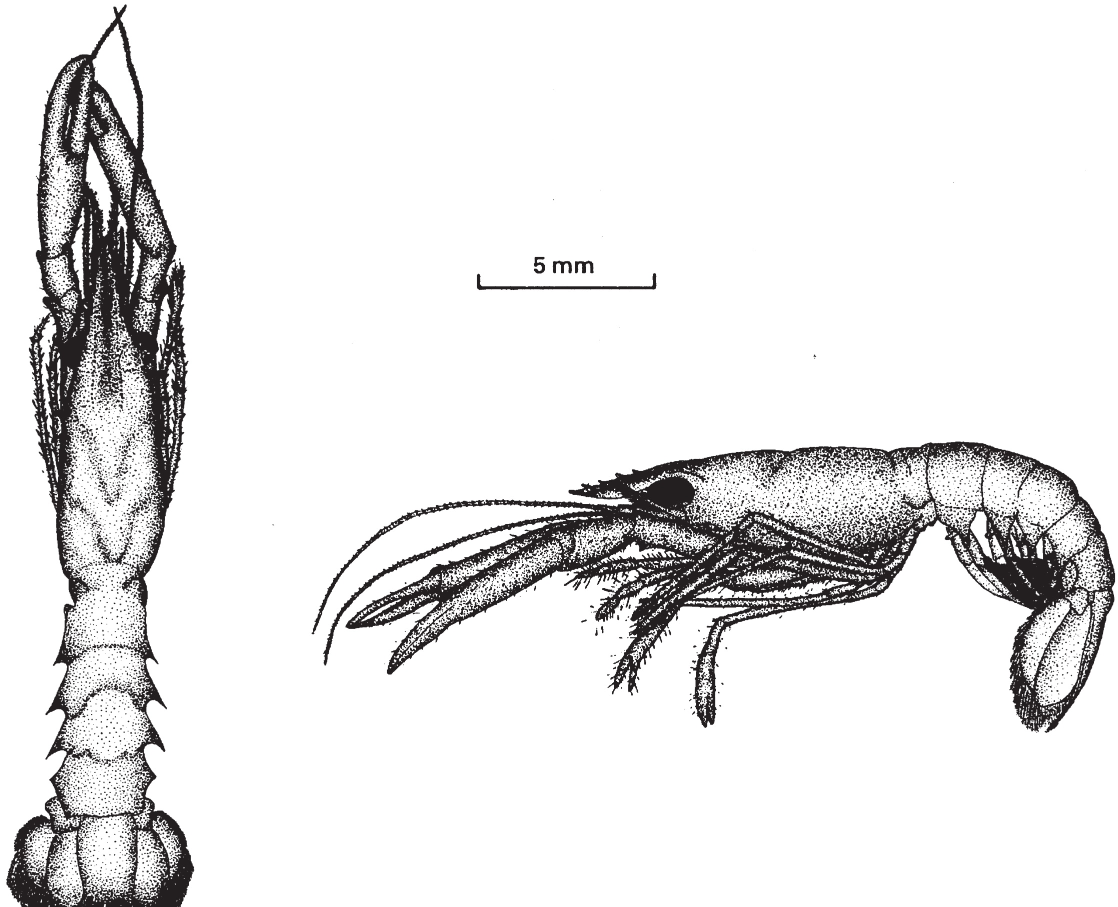


Figure 2 continued.

4. TYPES OF STORAGE SYSTEMS

Storage systems can range from simple ponds, embayments or keep boxes held in the sea, to inland recirculation systems using artificial sea water and complex water treatment facilities. They may hold only a few pounds or several thousand pounds of lobsters for periods ranging from a few days to several months. Special decorative units are available for owners of specialist seafood restaurants or large hotels who may wish to display live lobsters, crabs and crawfish in their restaurants.

4.1 Ponds, embayments and keep boxes

Ponds and embayments depend entirely on a suitable site being available. Such sites are usually found in geographically isolated areas and are commonly used as temporary stores for building up numbers of lobsters prior to a bulk shipment to market. Methods of construction and operation are usually tailored to particular sites but some generalised examples are shown in Figure 3a-c. Where the site is unsuitable for such modifications, moored keep boxes (see Figure 3d) can provide a cheap and useful method of short-term storage. They must be carefully situated in areas free of freshwater run-off from streams and rivers, because fresh water has a tendency to remain on top of denser more saline water and is lethal to lobsters. Certain areas prohibit the use of moored keep boxes, however, so local harbour and Sea Fisheries Committee bye-laws should always be consulted. The use of deep keep boxes, where the lobsters are piled in layers, is not advisable.

4.2 Tank systems

Most tank storage systems are built to suit the site or to fit into an existing building. Consequently, although most systems will differ in detail, they will have certain basic features in common.

Shallow tanks, with a water depth of 15-25 cm, have a number of advantages. For example, they are cheaper and easier to construct and have a high ratio of surface area to water volume which helps in promoting good gas (oxygen) exchange. They also permit easier access and inspection of stock, and corpses can be easily seen and removed. Smooth internal surfaces will reduce the possibility of damage to the lobsters by abrasion and also facilitate cleaning. Lobsters often collect in the corners of rectangular tanks because these tend to be darker; they also afford contact with the sides, which lobsters prefer. Unfortunately, however, corners are usually the places where water circulation is poorest. So, if the internal corners are rounded, this will help to prevent lobsters aggregating at these points and assist in better water flow patterns within the tank. It is also easier to promote good water circulation within the tank when the lobsters are kept in a single layer (i.e. only one lobster deep). In the simplest systems, sea water is pumped continuously through the tank or tanks, and returned to the sea some distance away from the original inlet (Figure 4). Unfortunately, sites where sea water quality is suitable for this kind of operation are very limited. Many, apparently suitable storage sites, have low salinity at low tide or sea water with a high suspended solid load or are contaminated by pollutants from boat and harbour operations. To counter these problems, many tank systems employ some means of filtering, recirculating and cooling the water so that some, or all, of it can be used again (i.e. recycled) before being discharged back into the sea. If properly designed and operated, such facilities enable the owner to reduce the quantity of new sea water required and to operate in areas where conditions may not be perfect. Generalised arrangements of systems incorporating filters and methods of recycling are shown in Figure 5.

Inland storage systems are usually in areas where space is at a premium. Consequently, multi-layered

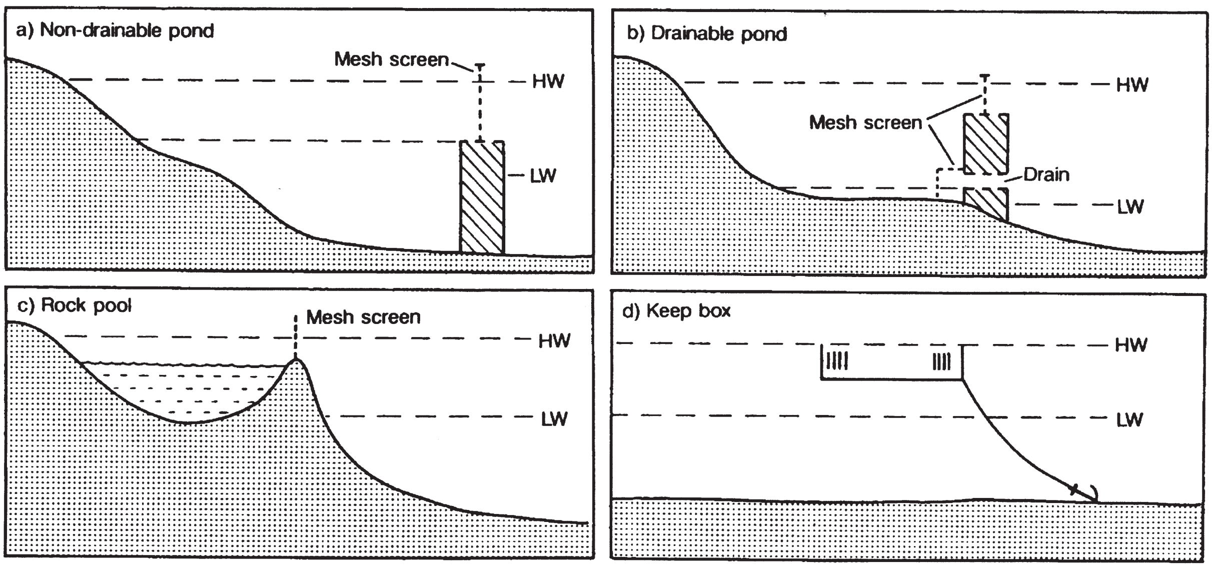


Figure 3. Examples of ponds and keep boxes.

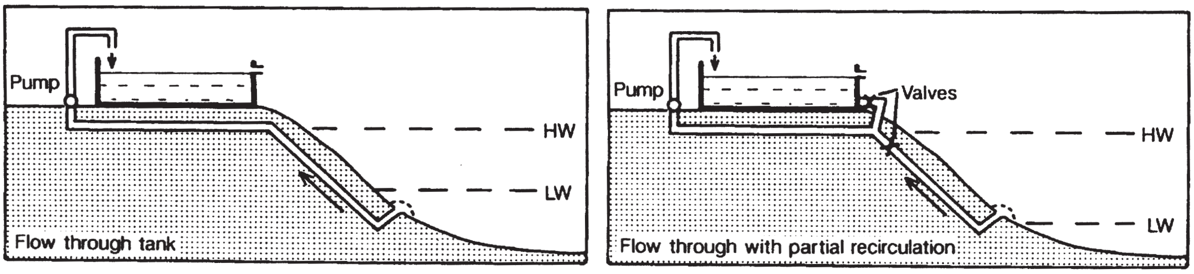


Figure 4.* *Coastal tank storage systems.

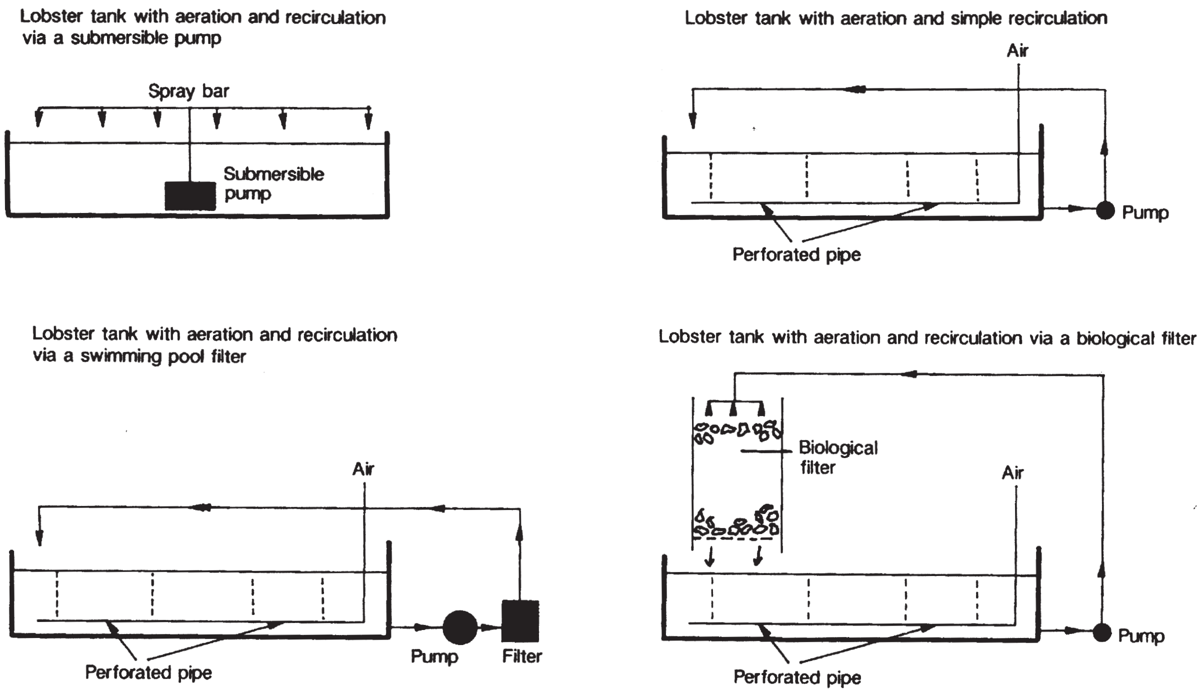


Figure 5.* *Storage tanks incorporating filters and recirculation of sea water.

tray systems with higher densities of lobsters and more complex water treatment may be used. A generalised example is shown in Figure 6. This type of tray system requires very careful design. If the trays are too close together, easy monitoring and access for removal and replacement of stock are hindered. Also, water is usually run from the upper trays to the lower trays, thus leading to poor water quality in the lower trays and hence more stress for those lobsters. In these inland storage sites, the use of artificial sea water (see Appendix 2) may be more practical than shipping-in natural sea water and may also prove to be less expensive.

With any storage system, it should always be borne in mind that failure of equipment or power supply could result in very expensive losses of stock. It is sensible, therefore, to provide for such occasions by installing stand-by equipment, alarm systems and fail-safe devices. If possible, tanks should be self-draining (i.e. the water will drain out of the tanks if the inflow stops), because lobsters rapidly exhaust the oxygen in static water and then die, whereas they can survive for quite long periods in cool, damp air.

4.2.1 Materials

There are a number of potentially toxic materials which must be avoided during the construction and operation of a storage system. Copper and its alloys, brass, bronze, etc., are toxic, as are lead, zinc and some formulations of stainless steel. In particular, care needs to be taken to avoid using pumps with brass impellers, or copper in piping, including chiller coils. Anything galvanised is zinc-coated and therefore potentially toxic.

The most common materials used for construction of lobster holding systems are concrete, brick, stone, wood and plastics such as glass fibre, ABS and PVC. Wood, however, should be used with caution, because it may have been treated with preservatives or insecticides which could prove toxic. It is recommended that only plastic pipework, valves and pump impellers be used.

When a new system is commissioned, it is always sound practice to fill the system with water, switch

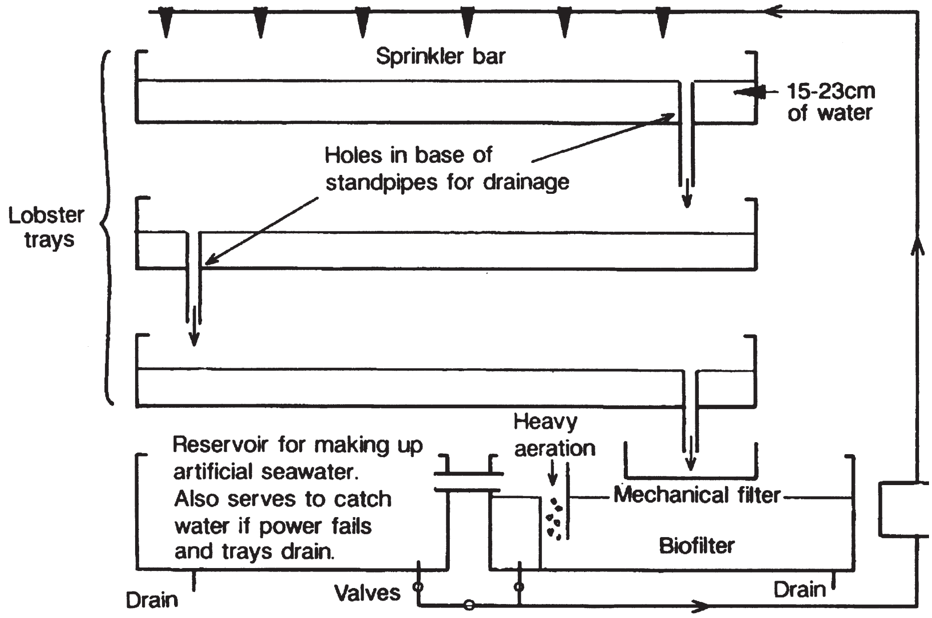


Figure 6. Example of a multi-layered tray storage system.

on all circulating pumps and aeration devices, leave circulating for 48 hours and then drain. Ideally, this procedure needs to be repeated several times in order to flush out any potentially toxic compounds that may leach or dissolve out of the materials used in the construction. A small number of lobsters can then be placed in the system to test its suitability for full-scale use.

Commissioning the system in this way allows potential design or mechanical faults to be identified without putting too many animals at risk. Points to look for during this period are inadequate flow rates, "dead spots" noticeable in corners or under filters due to poor circulation, drains taking too long to drain, and leaking pipe joints.

Checks should also be made to ensure that compressors or blowers used for aeration are producing oil-free air. Care should be taken to site the air intake point where it cannot draw in airborne contaminants such as exhaust fumes or insect sprays. For example, insecticides such as fly sprays are extremely toxic to lobsters, and may be carried into the water even when applied at some distance from the tanks (e.g. in packing areas).

5. WATER QUALITY

5.1 Background details

During storage, lobsters are totally dependent for their survival on the quality of the water in which they are contained. If the incoming sea water is of poor quality, or they are held in tanks where poor water conditions have been allowed to develop, then poor survival will result with the risk of mass mortalities being substantially increased. Successful lobster storage requires that a number of key water quality factors are kept in balance simultaneously. Adverse levels in any one of these conditions will undoubtedly affect the ability of the lobster to withstand changes in another. In other words, most water quality factors interact and together will have a more serious effect on the lobster than changes in any one factor which occurs in isolation.

The three major water quality factors for lobster storage are oxygen, temperature and salinity. However, other factors, which include waste materials excreted by the lobsters (ammonia and organic wastes), and suspended solids (e.g. silt), must also be considered. Experience suggests that they too are often associated with the onset of serious mortalities. Each of these factors is discussed in the following sections with the aim of increasing the reader's awareness of the care that must be taken in choosing the source of sea water for the storage system and also how to treat and care for it once it is in the tanks.

5.2 Why measure water quality?

Regular measuring and recording of the major water quality factors are essential to build up a picture of what is "normal" for the system. Records also need to be kept of the weights of lobsters bought in and sold out, and also the weights of dead and discarded lobsters. After a period of time, analysis of these records will show the changing patterns and trends in water quality which develop as the number of lobsters in the system increases and decreases with the trading pattern. It will then be possible to establish a safe maximum total weight of lobsters which the system will support at different times of the season.

Initially, water quality checks need to be made at frequent intervals over a 24-hour period and from a number of different points around the system. This initial survey will need to be repeated for a number of different stocking levels. It is essential to determine for each water quality factor where in the system, and at what time, it is at its worst. From these initial observations a picture can be built up so that on most occasions checks in only one or two specific places, at particular times, will be sufficient to confirm that all is well.

Methods of measuring the various water quality factors are described under the individual sections. These measurements, however, will only be of use if the equipment used to take them is maintained in good condition. Oxygen meters must be re-calibrated at regular intervals and thermometers and hydrometers regularly checked against other instruments. All equipment, including test-tubes, bottles, etc., should be thoroughly washed and rinsed in fresh water after use.

5.3 Oxygen

In common with most living organisms, lobsters require oxygen to live and they obtain this from the sea water which surrounds them. The main organs for extracting the oxygen are the gills, which are situated in gill chambers on either side of the head under the carapace (see Figure 1). The gills are thin-walled, feather-like structures which are well supplied with blood vessels through which the oxygen is transferred from the surrounding water to the blood. Water is drawn through the gill chambers, from back to front, and over the gills, by the beating of a special organ called the gill bailer, which is situated at the front of the chamber. If a lobster is viewed head-on through the side of an aquarium, these gill bailers can be seen beating on each side of the head. The direction of the water flow through the chamber can be reversed, if necessary, to clear particulate matter which may have settled on the gill surfaces.

The rate of oxygen consumption by the lobsters depends mainly on water temperature, but other factors, especially stresses such as overcrowding, will increase oxygen consumption above the normal rate. For instance, when lobsters are first put back into the water after transit they will have a greatly increased oxygen demand for a few hours.The quantity of oxygen dissolved in sea water depends mainly on temperature. Figure 7 illustrates this relationship and shows that, as the temperature increases, the saturation or maximum value decreases. However, lobster activity, and therefore its demand for oxygen, increases with temperature (Figure 8). Because of this link between dissolved oxygen levels and temperature, it is essential to ensure that water flow and aeration are sufficient to provide adequate oxygen for the number of lobsters being held at the prevailing temperature.

Lobsters can tolerate low oxygen levels (e.g. 50% saturation or 4.5 mg/1 at 10°C) for short periods but the aim should be to keep the water well aerated (i.e. above 80% saturation at all times).

In most coastal installations, the incoming sea water is generally fully saturated with oxygen and, hence, holds an amount of oxygen appropriate for its temperature and salinity. Once in the storage tanks, however, this oxygen is consumed both by the lobsters and by the millions of micro-organisms suspended in the sea water and attached to all surfaces within the system. The oxygen consumed by these micro-organisms can be quite substantial. Replacing this oxygen by pumping in fresh supplies of sea water is expensive, particularly when a cooling system is operating. Conventional aeration (e.g. airstones) is not very efficient in shallow tanks, so other means of replacing the oxygen need to be considered as well. Simple, cheap alternatives involve recycling some or all of the water through venturi, cascade or sprinkler arrangements and then back into the tanks (Figure 9). In this way, the water gains oxygen from the air each time that it passes through the recycling system.

Dissolved oxygen levels in sea water can easily be measured using an oxygen meter, which will give a direct readout of dissolved oxygen in either milligrams per litre or percentage saturation, and may also incorporate temperature measurement. The maximum solubility at normal atmospheric pressure is termed 100% saturation. The most convenient type of meter is one where the electrode is designed to be totally submersible and is attached to 1-2 metres of cable. The case should be waterproof or at the very least splash-proof. Oxygen meters must be calibrated at regular intervals and this calibration must be carried out at the same temperature as the water to be tested.

Although oxygen meters are relatively expensive, they are very worthwhile investments. Dissolved oxygen is probably the most important water quality component; the levels of dissolved oxygen largely dictate the carrying capacity of the system.

Simple inexpensive kits are also available to measure dissolved oxygen. These involve adding some water from the system to a test reagent and comparing the resulting colour with a scale provided.

5.4 Water temperature

The higher the water temperature, the greater the requirement for good husbandry practices and careful observation. Lobster activity, and its demand for oxygen, increases with temperature, but sea water holds less oxygen at higher temperatures. A lobster must therefore progressively pump more water over the gills as the temperature rises to obtain the same amount of oxygen.

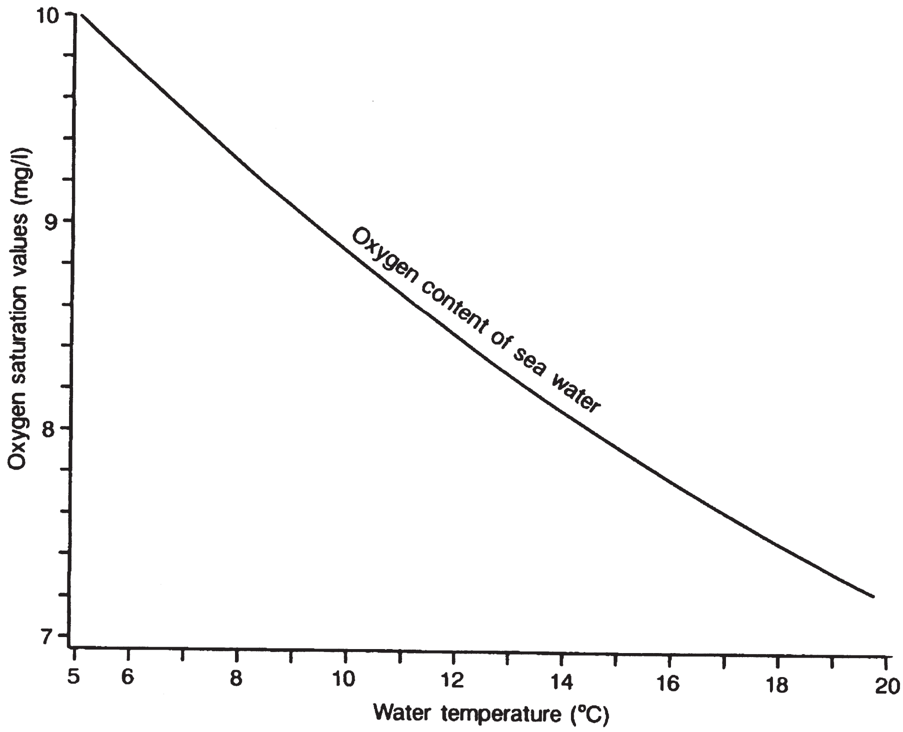


Figure 7. The effect of water temperature on the oxygen content of sea water (salinity 34‰).

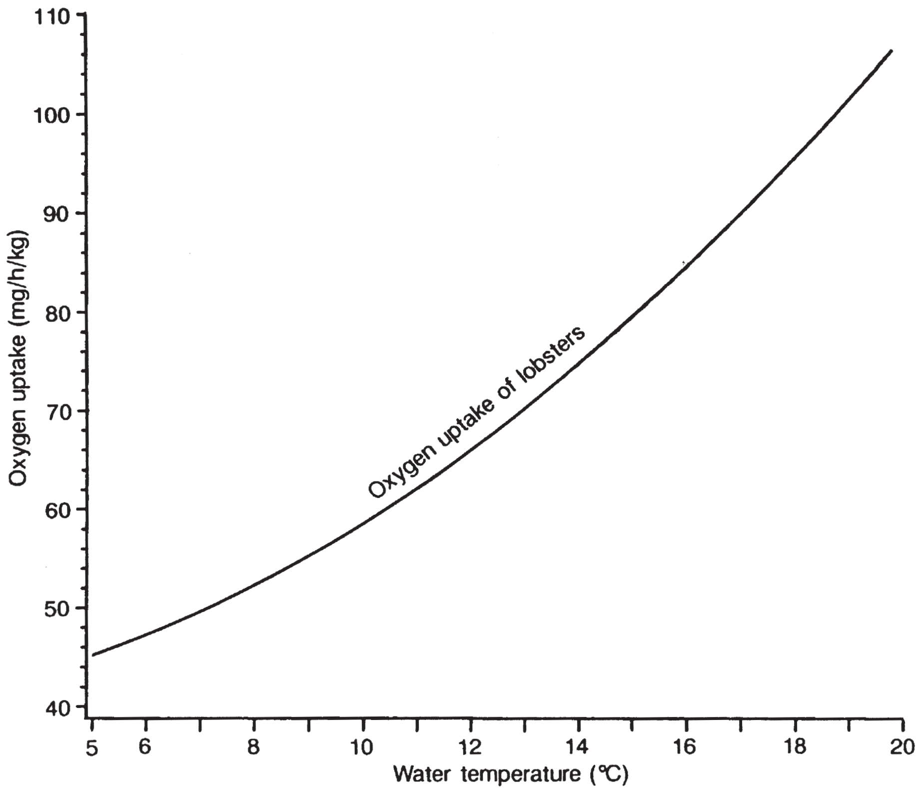


Figure 8. The effect of water temperature on the oxygen uptake of lobsters.

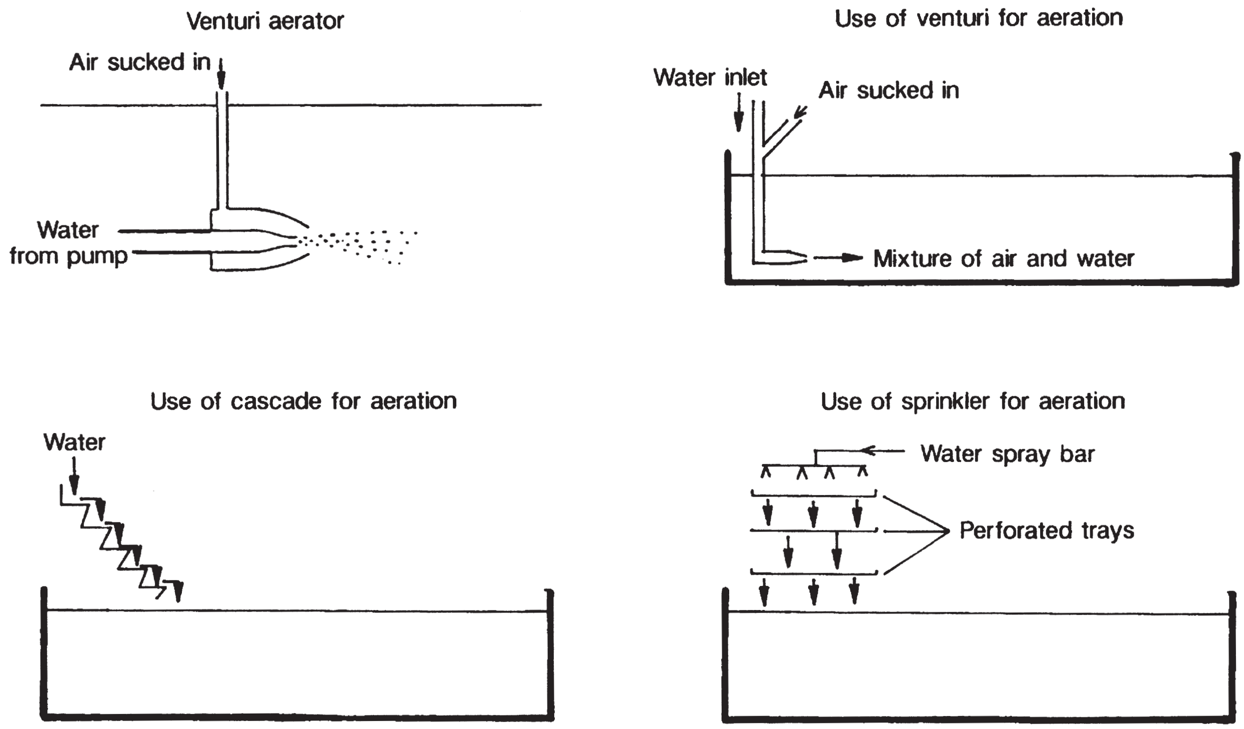


Figure 9. Examples of aeration devices

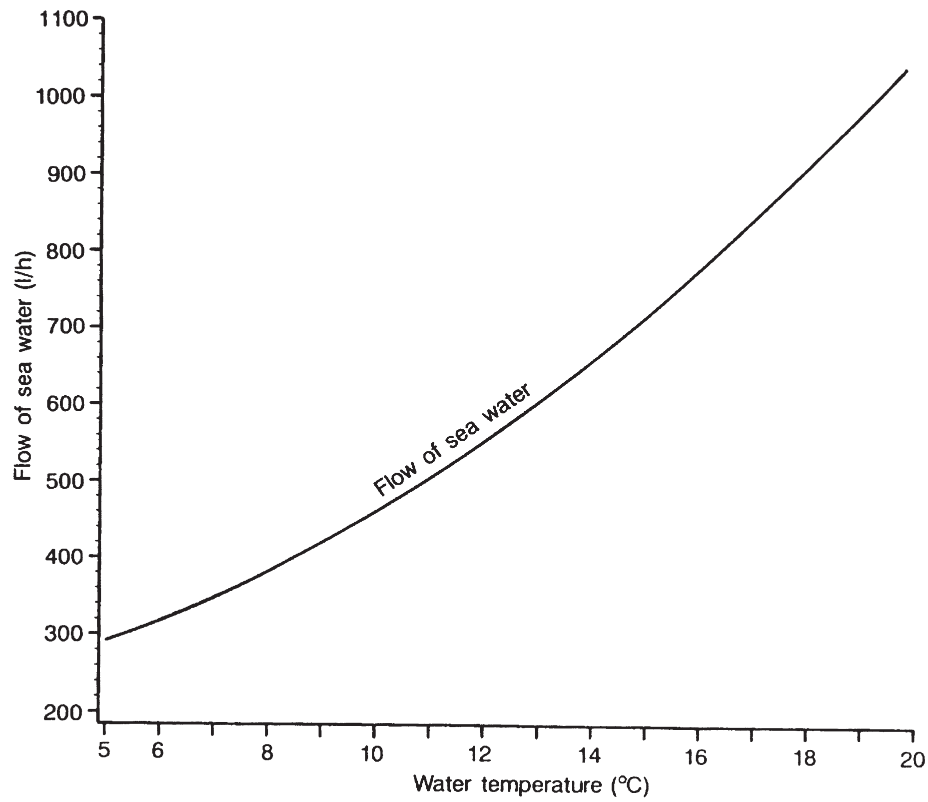


Figure 10. The flow of sea water needed each hour by 50 kg of lobsters over a range of temperatures

The net effect is that the flow of sea water needed to provide sufficient oxygen for a certain weight of lobsters increases as the temperature rises. This relationship between oxygen requirement, temperature and water flow is illustrated in practical terms in Figure 10 which shows that, at 5°C, 50 kg of lobsters require 290 litres of sea water each hour to supply their oxygen requirements; at 10°C, one-and-a-half times more water is needed; at 15°C, two-and-a-half times as much is needed and, at 20°C, three-and-a-half times as much is required.

There are therefore a number of advantages in keeping the water in the storage system as cool as possible. Lobster activity, its demand for oxygen and the amount of waste material it produces are all reduced. In addition, greater amounts of oxygen are available in the water.

In practical terms this means that, for a given flow rate, the lower the temperature the greater the number of lobsters which can be held. Also, at low temperatures, decomposition of dead animals will be slower with less effect on water quality. There is also some indication that diseases such as Gaffkaemia (see page 21) can be held in check by low temperatures (e.g. 5-10°C (41-50°F)).

Temperatures below ambient can be maintained in storage systems by the use of refrigeration equipment, but for flow-through systems this may be prohibitively expensive and impractical. There is a wide choice of refrigeration equipment available but not all is suitable for use in sea water. Refrigeration units with copper or copper alloy cooling coils should not be used. Copper dissolves readily in sea water and can rapidly accumulate to levels which are toxic to lobsters. Copper coils coated with a plastic or similar non-toxic material may be suitable, but these must be inspected regularly for signs of damage or corrosion. High quality marine grade stainless steel or titanium would be more suitable.

Temperature can also be used as an important guide to the oxygen-carrying capacity of the sea water. It is easily measured using mercury in glass or electronic thermometers. These electronic instruments, although more expensive initially, are certainly more robust than glass thermometers. However, experience has shown that cheap thermometers can sometimes be inaccurate by a number of degrees, so such thermometers should be checked regularly against a more expensive, accurate one to ensure correct reading.

5.5 Salinity

In this leaflet, salt content or salinity of sea water is expressed as the number of parts by weight of salt in one thousand parts by weight of water. You may also see salinity expressed as ‘practical salinity units’ (psu). This is a measurement based on conductivity and for all practical purposes covered in this report the two measurements may be considered to be the same.The unit “parts per thousand” is usually indicated by the symbol ‰. Thus, water with a salinity of 35‰ contains thirty-five grammes of salt in 1000 grams of water (1 litre), or 35 kg in one cubic metre (m^3) (1000 litres).

In the open sea around the British Isles, salinities of 32-34‰ are usual, with only small seasonal changes. Salinities are usually lower at neap tides than at spring tides, and lower at low tide than at high tide. The salinity of sea water decreases on moving from the open sea into an estuary, as a result of the increased quantity of fresh water coming from the river. In tidal estuaries, salinities are subject to considerable variation during each tidal cycle. In addition, local areas of low salinity may be found close inshore adjacent to freshwater discharges from streams or outfall pipes. Also, water near the surface may be of considerably lower salinity than that found at deeper levels. This is because there is a tendency for fresh water which is less dense to run over denser saline water. For this reason, intakes to sea-water installations should be placed on or near the sea bed in the deepest water.

Typically, lobsters are animals of the open coasts found in waters having a salinity of 32‰ or more. They cannot tolerate low salinities, or rapid changes of salinity, and do not occur in significant numbers in estuaries or other areas subject to low salinities. It is possible to store lobsters in water with a salinity down to 25‰ but the minimum value usually considered as acceptable in commercial storage units is 27‰. Lobsters exposed to low salinity may show a characteristic swelling in the middle of the body between the head (carapace) and the tail region. Behavioural changes may also be noticeable. For example, lobsters may adopt an elevated stance as if standing on “tip-toe”. If these extreme conditions continue, they will weaken and die.

Salinity can be measured directly with a simple “dip-in” optical instrument called a refractometer. This is dipped momentarily into the water and the salinity may be read on the scale viewed through the eyepiece. An alternative method is to use an hydrometer, which is a cheaper instrument, which measures the specific gravity of the water. For rough work, only the specific gravity need be considered, but for a more accurate estimate the temperature of the water must also be taken, so that the salinity itself can be obtained by reference to a table or graph (Figure 11). Distilled water has a specific gravity of about 1.000 and “full” sea water of about 1.026, but these values vary a little in accordance with the water temperature. It is important to distinguish clearly between salinity and specific gravity when describing sea water, for the specific gravity is often referred to by the last two numbers only. There is a variety of hydrometers available for the measurement of specific gravity, but care should be taken to ensure that the graduations are sufficiently apart to permit accurate reading.

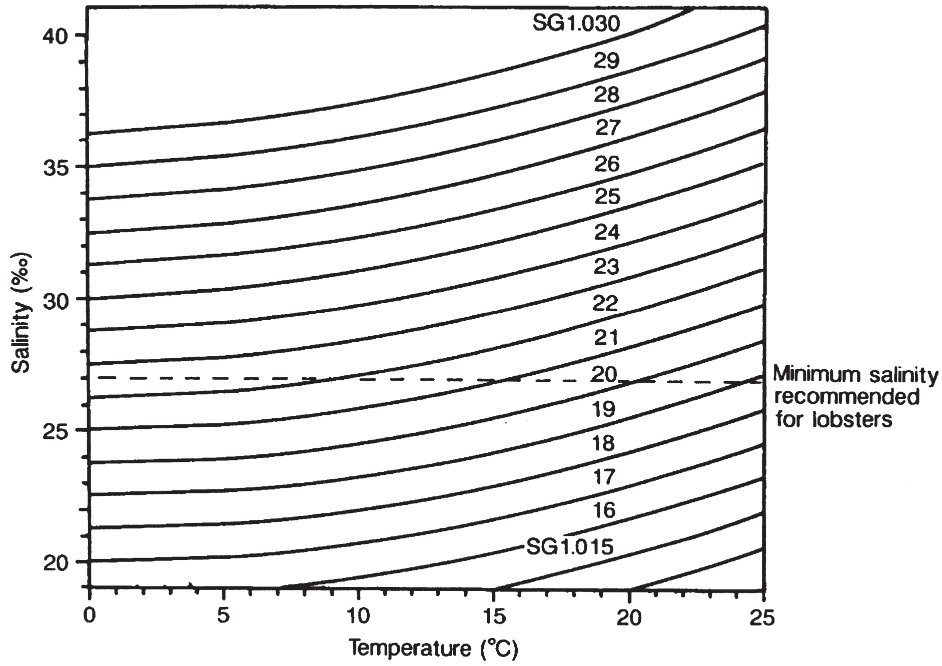


Figure 11. Conversion graph (specific gravity/salinity)

5.6 Ammonia

Ammonia is the main metabolic waste product produced by the lobster. This is excreted directly into the water and can be fatal if allowed to accumulate.

Peak ammonia levels in the water usually occur shortly after a fresh consignment of lobsters is put into the storage system after being kept in air for a number of hours. Waste products will have been stored in their bodies during this period and these accumulations will then be excreted all at once when they are put back into water. They will also have a greatly increased oxygen demand during this period.

In "flow-through" systems, a flow of sea water which is sufficient to provide the animal's oxygen requirements is generally more than adequate to prevent the build-up of ammonia. Problems with ammonia are only likely to occur in newly built or heavily stocked systems where the water is continually recycled. Ammonia can be removed from the water by encouraging the growth of certain groups of bacteria which can utilise ammonia as a food source, providing sufficient oxygen is also present. This concept is discussed later in sub-section 5.7.2. Simple test kits for measuring ammonia levels in sea water are available. The approximate concentration of ammonia can be found by comparing the colour, which develops in the sample after the addition of several chemicals, with a range of standard colours printed on a card. These standard colours are indicative of a range of ammonia concentrations usually expressed as mg/1 of total ammonia. The toxicity of ammonia depends mainly on the acidity (pH) of the water, but temperature and salinity will also cause minor changes. At a temperature of 10°C, a pH of 8.0, and salinity of 30‰, levels of total ammonia above 6 mg/l should be considered to be dangerous, between 4 and 6 mg/l should give cause for concern and under 2 mg/1 should be safe for short periods. The aim should be for zero readings or, at the very least, those returning to zero within a few hours.

5.7 Filters

A clear understanding of the functions performed by filters is essential to their successful design and operation. Filters are used to perform two major roles: one is mechanically to remove fine solids such as silt and suspended organic particles, the other to encourage the biological breakdown of dissolved organic compounds and excreted ammonia into harmless substances. Attempts to combine both functions in one filter are seldom successful, except in special cases such as with very lightly stocked display systems.

5.7.1 Mechanical filters

Low levels of suspended solids, such as silt, are not in themselves usually harmful to lobsters during storage. Their impact lies in the secondary effects which they produce if allowed to accumulate in the tanks, for example in "dead spots" or in patches beneath the filter. These accumulations will also contain lobster faeces, regurgitated material and other organic wastes. This mixture will rapidly go anaerobic producing the gas hydrogen sulphide which smells like bad eggs, and is extremely toxic to aquatic animals.

From a husbandry point of view, cloudy or murky water prevents easy inspection of the stock for the removal of dead animals. It also inhibits observation of

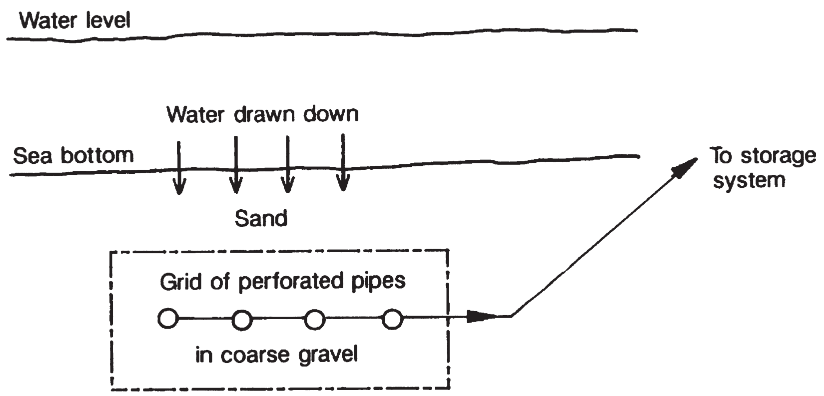


Figure 12. Sub-sand extraction of sea water

the behaviour of the animals which can give a valuable early warning of adverse conditions developing. High levels of suspended solids can also cause blocking of filters, particularly when fine gravel or sand has been used as filter material. Low levels of suspended solids may be removed by directing the water flow through layers of nylon wadding placed in a convenient and accessible point in the system. This wadding will need to be removed and washed regularly otherwise, as it blocks, the water will just run over the surface.

In areas with high levels of suspended solids in the sea water, the use of sub-sand extraction (see Figure 12) or pressure sand filters to pre-filter the water before it enters the system is recommended. The pressure or rapid sand filter commonly used for clarifying swimming pools, providing it is of all plastic construction, may easily be adapted for use in lobster storage. It will, however, require regular back-washing to remove the accumulated debris. A sand filter should not be allowed to stand out of use whilst full of sea water, since anaerobic conditions will rapidly develop, often within hours, and turn the water and sand foul. If the filter should subsequently be brought back on line, the foul water would enter the system with disastrous results for the lobsters.

5.7.2 Biological filters

The purpose of a biological filter is to neutralise the effect of the ammonia produced by the lobsters. This is achieved by bacteria first converting the ammonia to nitrite and then to nitrate, a process called nitrification. This conversion of ammonia to nitrate is necessary because ammonia is highly toxic to most aquatic creatures at quite low concentrations. Nitrite is less toxic and nitrate is considered to be relatively non-toxic. Nitrification is carried out by two kinds of aerobic bacteria which feed on dissolved inorganic substances. One of them, *Nitrosomonas*, oxidises the ammonia to nitrite and the other, *Nitrobacter*, oxidises nitrite to nitrate. Both kinds require oxygen in order to function, so the water going though the filter must be well aerated.

A typical biological filter consists of a bed of stones, gravel or purpose-made plastic rings which provide a large surface area on which the nitrifying bacteria can grow. The simplest types of biological filter are percolating and submerged filters.

The percolating filter, where water trickles downwards over a column of filter material (Figure 13a), is probably one of the safest designs, because the filter drains automatically if the flow stops for any reason. It will, however, remain moist and aerobic for up to several days due to the moist air which occupies the spaces between the stones or plastic rings. Consequently, there will be no risk of stagnant or foul water entering the system when the pumps are restarted. Tall, percolating filters are more efficient than shallow ones but are not always possible or convenient to install and may increase pumping costs.

Submerged filters, which may be upflow or downflow (Figure 13b and c) are easier to install. Unfortunately, they are more prone to the development of anaerobic conditions if circulation fails or if dead spaces occur due to blockage by detritus. This latter risk is reduced if the filter material has plenty of large spaces betwen the granules and is not expected to serve as a mechanical filter as well. The choice and size of filter material is critical. Sand and gravel provide the necessary large surface areas and are relatively cheap. They are, however, heavy and inclined to block if material which is too small is used. Blockages tend to occur in patches within the filter bed, causing channelling of the water flow through only limited regions of the filter. This frequently happens if a stone/gravel/sand/shell filter is expected to act both mechanically and biologically at one and the same time.

Pre-filtering the water through a mechanical filter before it goes through the biological filter can substantially reduce the risk of blockage. Also, modern filter materials, such as plastic rings or plastic honeycomb sheets, are specifically designed to prevent blockage by the microbial growths which develop. All new biological

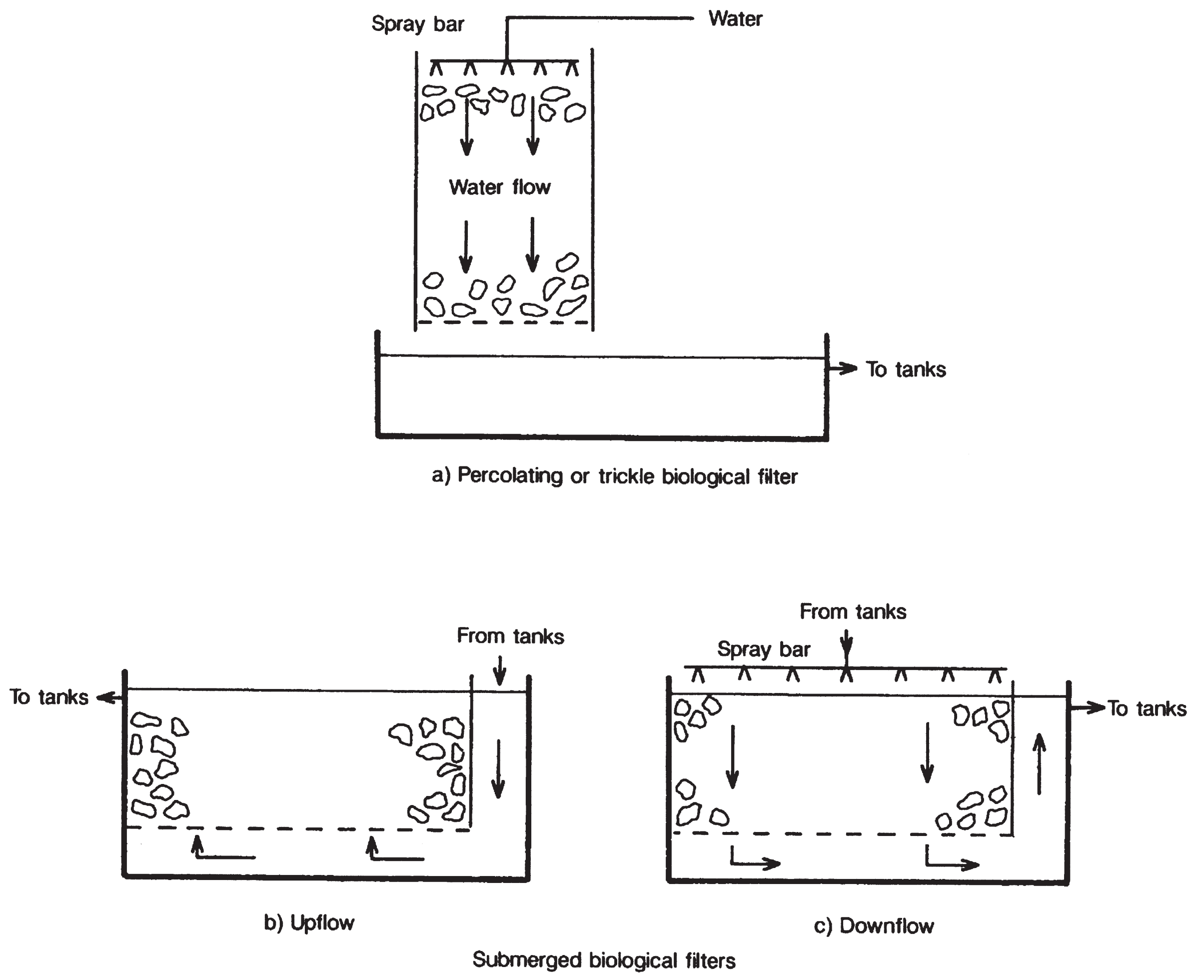


Figure 13. Examples of biological filters.

filters need to be "matured" before large numbers of lobsters can be held safely. Although the required kinds of bacteria are naturally present in sea water, they need time to multiply if they are to deal with the amount of waste products produced by a large number of lobsters.

Maturing of a new filter follows a definite sequence and a generalised pattern of the changes in levels of ammonia, nitrite and nitrate as a filter matures can be seen in Figure 14.

When animals are first introduced into a system, ammonia begins to accumulate in the water. Sufficient numbers of *Nitrosomonas* bacteria must now develop to oxidise this ammonia to nitrite. As nitrite becomes available, *Nitrobacter* can start to grow and oxidise the

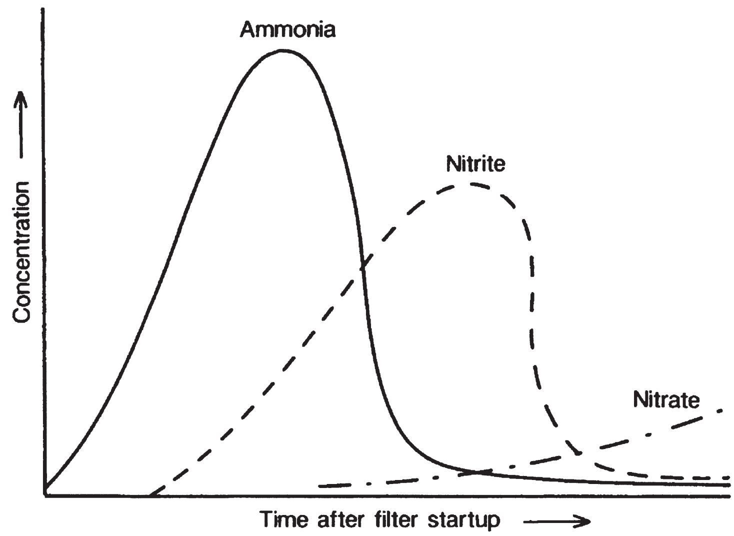


Figure 14. Typical succession of the various nitrogen forms during 'start-up' of a biological filter.

nitrite to nitrate. Nitrate will continue to accumulate and levels can be controlled by periodic changing of 10 to 20% of the water volume. The time needed for the bacterial populations to develop and the chemical changes to stabilise is very variable and dependent on temperature and food supply.

This "maturing" process may be accomplished in a number of ways. One method is to start by holding a few lobsters and then to increase their number gradually over a period of weeks. At 10°C, eight to ten weeks may be necessary for complete maturation. This time period can be reduced if a portion of an already established filter bed, complete with its coating of bacteria, is added to the new filter. This adds a large number of bacteria to the system, which includes both kinds necessary for nitrification. A second method is to add a solution of ammonium chloride to the water each day in a system without lobsters. This has the advantage of having no lobsters placed at risk by exposure to high levels of ammonia and nitrite as the filter matures. The amount of ammonium chloride which is needed each day is related to the maximum weight of lobsters which the system will eventually hold and their excretion rate. However, a useful general guide is to add 4 grams of ammonium chloride per 1000 litres of water. Once again, the maturation period will be shortened if filter material from an active filter is added.

Biological filters operate best under conditions of constant loading because their function is dependent on bacterial activity which takes time to react to changes in loading. Most lobster storage systems are operated by taking in a large quantity of animals, then selling out small quantities over the following period. This means that a filter has to deal with a sudden large influx of ammonia which decreases rapidly as the lobsters settle down and are then gradually sold out, to be followed by a sudden increase again as the next batch comes in.

Bacterial activity and regeneration are linked with temperature and their response to these large changes in stocking densities, at the low temperatures at which lobsters are usually kept, is likely to be slow. Thus, instead of the filter dealing instantly with the ammonia and nitrite, there will be a time lag as the filter oscillates between peaks of ammonia and peaks of nitrite.

The risks associated with these variations may be reduced by managing the stock more effectively by adding small batches more frequently, rather than having major swings from maximum to almost zero stock and then back again.

5.8 Carrying capacity

The weight of lobsters that a storage system will safely support is known as its carrying capacity. The most important factors used in calculating carrying capacity are oxygen content of the water, water flow rate, temperature and tank floor area, all of which interact. Other factors, such as water circulation patterns within the tanks, efficiency of the filtration system and husbandry practices will also have a strong influence, but are not easily quantifiable as they will vary from system to system.

Carrying capacity can be calculated in two ways. For instance, where the maximum weight of lobsters that are to be held is known, the minimum flow rate and tank floor area needed to hold that quantity safely can then be calculated. Alternatively, where flow rate and tank size are fixed (i.e. in an existing system) the maximum weight of lobsters that can be safely held at the different temperatures expected over the season can be calculated.

From a practical point of view, it is often more difficult to keep changing the flow rates as temperature varies than to adjust the weight of lobsters in a tank. The maximum water flow rate is almost certainly pre-determined for the system by the size of pump used and the number of outlets. Therefore, carrying capacity must generally be adjusted by removal or re-distribution of lobsters according to temperature. For example, it can be shown that a flow rate of 450 litres (100 gallons) per hour of sea water fully saturated with air will supply the oxygen requirements for approximately 77 kg of lobsters at 5°C, 48 kg at 10°C, 31.5 kg at 15°C and 21 kg at 20°C.

Although it is possible to keep lobsters in layers more than one deep, the deeper the lobsters the more difficult it will be to maintain adequate water flow rates, and hence oxygen levels, to all parts of the tank. It is not possible to give precise stocking figures, as factors such as flow patterns and water quality, which vary from system to system, will strongly influence the calculations. However, a safe starting density would be up to 30 kg/m^2 for storage over a few days, reducing to 5-10 kg/m^2 for longer-term storage. Actual measurements of flow rates, and oxygen levels in particular, will be needed to confirm the carrying capacity for each system.

It is always good practice to stock a system lightly at first and then to build up numbers slowly as experience and water quality measurements indicate that it is safe to do so. The temptation to hold that extra hundred kilograms of lobsters must be resisted. Breakdown, and the associated financial losses, invariably occurs just when such a risk has been taken and the system is overstocked.

6. GAFFKAEMIA

Most mortalities during storage can be attributed to poor handling and/or physical damage incurred prior to storage or to adverse water conditions developing during storage (e.g. build-up of toxic wastes, low oxygen levels).

Occasionally, however, heavy losses have occured which are due to a bacterial disease known as Gaffkaemia. Although outbreaks of this disease are rare in the UK, the financial loss which may result could be large.

The bacterium causing the disease is called *Aerococcus viridans* and it was first isolated in 1947 from captive American lobsters in Maine, USA. Since its first identification, it has been shown that *A. viridans* is carried by the American lobster (*H. americanus)* both on the shell and in the blood. In North America and Canada, it has been found in holding tanks and is known to persist in the natural environment, in both mud and sea water, in close proximity to places where lobsters have been stored. There is no evidence of Gaffkaemia outbreaks in stored crustaceans other than in European and American lobsters. In North America, mild infections have been induced experimentally in crabs and spiny lobsters by injection of large numbers of *A. viridans* cells. These experiments have shown that the bacterium can lie dormant and be carried for long periods. They also suggest that crabs and other crustaceans may possibly act as reservoirs of infection.

In surveys conducted between 1979 and 1981, it was demonstrated that a significant proportion of imported American lobsters were infected. However, there is no evidence to show that Gaffkaemia is established in wild stocks of the European lobster. *A. viridans* has been identified from European lobsters held in captivity, but there is further evidence that the holding tanks may have been contaminated previously by American lobsters.

It is thought that the bacterium is an opportunist pathogen, requiring that the lobster be physically damaged (loss of limb, shell damage) and heavily stressed before infection can occur and the disease can progress. The growth of *A. viridans* in the lobster host is highly dependent on temperature. At low temperatures (i.e. around 1-5°C) the disease does not develop. With temperature rise, the bacterium multiplies and death ultimately occurs. At 20°C, lobsters may die within a few days of becoming infected but, at storage temperatures between 5 and 10°C, the disease develops very slowly and deaths may occur only after long periods of storage (1-3 months).

Dead lobsters must be removed immediately. If these are infected and allowed to disintegrate, large numbers of bacteria will be released into the tank water where they may become lodged in debris, pipework, filters, etc., and form a reservoir of infection. In this situation, lobsters which have been physically damaged are especially at risk. Ensuring that claws are banded and careful handling should minimise the possibilities for infection. The primary aim at all times should be to prevent damage to the lobsters during storage.

Infected lobsters do not usually exhibit any characteristic external signs of the disease but become progressively weaker and lethargic until they die. They may also lie on their side and cast one claw, or even both claws, but such events are not necessarily indicative of disease. Under laboratory conditions, it has been shown that infected lobsters stop eating, which may possibly account for the apparent absence of infected animals among wild lobsters caught in baited traps.

When the disease was first described in American lobsters, it was observed that some infected animals had an obvious pink tint on the underside of the tail and hence the name “red tail” was often used to describe the disease. The European lobster, however, has a different colouration from its American counterpart and pinkish or red colouration of the underside is quite common in normal healthy animals. Thus, excessive colouration does not necessarily indicate the presence of Gaffkaemia.

The lobster tank operator or merchant can only suspect rather than identify the disease positively. Under commercial conditions, initial losses of up to 5% are not unusual amongst stocks which have been travelling from the fishing area. These losses may be attributed to general weakness or to the presence of newly moulted or damaged animals. However, once in the storage system, losses should decrease and stabilize at 1 or 2% over a period of weeks. If large losses suddenly occur amongst the stored stock or there is a progressive increase in mortality over a period of a few days amongst otherwise apparently healthy animals, then Gaffkaemia should be suspected. The possibility that these deaths are caused by unsatisfactory storage conditions developing (such as low concentrations of dissolved oxygen, high water temperature and low or suddenly changing salinity) should be eliminated first. Disease organisms may be present in any sediment or debris which is allowed to accumulate in a holding tank, and may also be widely distributed in pipework, on tank surfaces and on ancillary equipment such as dip nets, protective clothing and holding trays. It is, therefore, important to keep the tanks free of accumulated silt and debris and to wash and scrub the tanks each time that they are emptied. In addition, it would be wise to treat all surfaces routinely either with a solution containing 1% sodium hydroxide and 0.1% Teepol or with one containing at least 1000 ppm chlorine. These solutions should be applied directly onto the surfaces at a rate of 2.5 litres/m^2 and left in contact for 1 to 3 hours. After chemical treatment is complete, all tanks, pipework and equipment should be rinsed thoroughly before re-use. This procedure is recommended for all storage systems and equipment as a preventive measure at the start of each new season. In the event of a confirmed Gaffkaemia outbreak, further advice on cleaning and disinfection should be sought from the CEFAS Weymouth Laboratory.

The disease is not transmissible to man and the bacteria are killed when the lobsters are cooked. Providing infected animals are not spoiled, decomposing or mutilated, they may be cooked and sold for human consumption. If an outbreak of Gaffkaemia is identified, recently dead or weak animals should be cooked and sold and the remainder kept under strict quarantine. It may be possible to salvage some of the remaining live lobsters by reducing the water temperature, but in any event the survivors should be placed in an isolated tank away from possible contact with other stocks. Surviving animals are a potential source of infection and should not be sold for subsequent storage, but should be marketed so that they reach consumer outlets within a short time. Where an infection occurs in a storage facility supplying many customers, there is a high risk of transmission of the disease to other storage units, either in the UK or abroad, via infected lobsters and contaminated boxes or transport. Vivier lorries in particular run a high risk of becoming contaminated. The insides of such lorries, including all tanks, boxes and other equipment which have been used, should be sterilized and then washed well after each trip.

Fortunately, the incidence of Gaffkaemia in the UK is rare, but where the disease has occurred it has usually been associated with the introduction of American lobsters to the holding units. In North America, lobsters are often stored in very high densities and for long periods prior to shipment, in areas where Gaffkaemia is endemic. Whilst it should not be assumed that all American lobsters are infected, it is essential to store them separately from European lobsters, and to be especially careful about storage conditions. For example, they should never be held in such a way that accidents could allow animals to escape to the sea, or water from the storage system could inadvertently be discharged into the sea without treatment. It is therefore clearly in the interests of the live lobster trade that all merchants should be vigilant so that disease outbreaks can be prevented and effectively controlled if they should occur.

REMEMBER

- It makes economic sense to prevent rather than to cure!
- Don't throw weak, dying or dead animals into the sea or waters discharging to the sea. Dispose of them by land burial or incineration.
- Quarantine survivors in a separate facility.
- Do not hold consignments of *H. gammarus* and *H. americanus* together in the same storage facility.
- Consignments of *H. gammarus* should not be held in tanks which have previously held *H. americanus*, unless the tanks have been fully disinfected prior to re-use.

7. HEALTH CONTROLS

7.1 Imports

There are no restrictions on, or documentary requirements for, imports of live lobsters from other EU Member States. There are controls on importing lobsters from third countries. These controls apply to all live crustacean shellfish, their eggs and gametes. All imports need to be licensed. If you wish to apply for a licence you should contact the Fish Health Inspectorate (FHI) at the CEFAS Weymouth Laboratory (in England and Wales) or the Fisheries Research Services (FRS) at the Marine Laboratory, Aberdeen at the addresses shown in Appendix 4. The application form currently used for this purpose (DOF 7) can also be obtained on-line, at http://www.defra.gov.uk/corporate/regulat/forms/fish/Dof7.htm.

For lobsters imported for direct human consumption or storage prior to human consumption, licences are normally issued for 12 months. You must give at least one working day's notice, in writing, of the arrival of each consignment. You may use form DOF 17 for this purpose, sending it by post, fax or email to the appropriate address on the form. You can obtain form DOF 17 from the FHI or FRS or on-line at http://www.defra.gov.uk/corporate/regulat/forms/fish/Dof17.htm.

The deposit of imported lobsters may also be subject to licensing, as described below.

7.2 Controls of Deposits of Lobsters in Great Britain

The trade in lobsters within Britain poses the risk of introduction of disease, most notably the bacterial disease Gaffkaemia, in native stocks of lobsters. In order to minimise this risk there is a licensing scheme for lobster deposits. The rules cover both European lobsters (*Homarus gammarus*) and American/Canadian lobsters (*Homarus americanus*).

The licensing is administered, in England and Wales by the Fish Health Inspectorate, at the CEFAS Weymouth Laboratory and in Scotland by the Fisheries Research Services, Marine Laboratory, Aberdeen (see Appendix 4 for full contact details).

Licences are required to deposit lobsters:

- In any tidal waters or
- In any inland waters flowing into tidal waters

or

- On any land or premises within one mile of these tidal or inland waters.

If your storage system is within these designated areas then you must be licensed. A general licence may cover you.

A general licence has been issued for deposits of:

- Any European Lobsters that have not been kept in water tanks or systems that contain or have held American Lobsters.
- Any European Lobsters intended solely for consumption on the premises or canned, frozen or otherwise prepared.
- Any American lobsters intended solely for consumption on the premises or canned, frozen or otherwise prepared. This is provided that no water in which any lobsters have been held or any lobster waste is discharged into any tidal waters.

There is no need to apply for general licences for deposits in these categories.

You will need to apply for an ***individual*** licence for:
American Lobsters - Which are not intended solely for consumption on the premises or canned, frozen or otherwise prepared.
European Lobsters - Which have been kept in water tanks or systems that contain or have held American Lobsters and which are not intended solely for consumption on the premises or canned, frozen or otherwise prepared.

Individual licences usually run for a limited period and will have conditions attached to them; mainly to ensure that quarantine conditions are applied, including disinfecting the holding water prior to release.

Applications for ***individual*** licences should be made to the FHI (in England and Wales) or the FRS (in Scotland). If you are in any doubt, or if you wish to hold any other species of lobster, then please telephone us.

8. SOME DO'S AND DON'TS. A CHECK LIST FOR SUCCESSFUL LOBSTER STORAGE

DO

1 Keep water temperature as low as possible (5-10°C)
2 Check lobsters daily and remove weak or damaged animals immediately
3 Check oxygen, salinity and temperature regularly
4 Turn over stock frequently on a rota system
5 Change water frequently and fit an efficient filter
6 Keep lobsters in a single layer where possible
7 Keep tanks shaded; avoid bright lights
8 Band or tie claws securely
9 When preparing artificial sea water, use correct weight and chemical composition. Aerate for 24 hours before use

DON'T

1 Overload storage systems
2 Attempt to store soft, weak or damaged lobsters
3 Feed lobsters in tanks; this creates more problems than it solves
4 Handle lobsters roughly
5 Cause sudden changes in temperature and salinity
6 Overfill tanks with water; shallow water is adequate
7 Expose lobsters to extremes of temperature (i.e. near freezing or excessive warmth and dryness)
8 Cut or peg claws; use elastic bands to restrain claws
9 Use toxic materials in construction and operation

APPENDIX 1. Glossary of technical terms

AEROBIC - requiring free oxygen for respiration
ANAEROBIC - not requiring the presence of free oxygen
AUTOTROPHIC BACTERIA - bacteria which are able to feed on dissolved organic substances
BACK-WASH - to reverse the direction of the flow of water through the sand in a filter to remove the particulate material which has been trapped
CARAPACE LENGTH - a measurement used to define legal sized lobsters. Measured from the rear of the eye socket to the back edge of the carapace
DEAD SPOTS - areas where little or no water circulation occurs and waste material collects
EXCRETE - to get rid of waste material from the body
FAECES - solid waste material excreted by the animal
GAS EXCHANGE - the movement of gases (e.g. oxygen moving from air to water)
GILLS - feather-like structures under the carapace used for obtaining oxygen from the water
LEACH - the removal of soluble toxic substances which may be present in tanks and equipment by soaking in sea water prior to the introduction of live animals
MICROBE - a small organism such as a bacterium
NOCTURNAL - active during hours of darkness
pH - a measurement of the acidity or alkalinity of water. Acid solutions have a pH of less than 7, alkaline more than 7. Normal sea water has a pH between 8 and 8.3 (i.e. alkaline)
ROTATION OF STOCK - first in, first out. This stock movement ensures that no lobsters are held for longer than necessary
SUB-SAND EXTRACTION - removal of water from under a layer of sand or gravel which acts as a mechanical filter

APPENDIX 2. Artificial sea water

It is often necessary to hold lobsters alive at inland premises away from convenient sources of natural sea water. For short periods of time lobsters will remain alive satisfactorily in a solution of five common chemical salts, which, when made up in tap water in the correct proportions, give a salinity equivalent to that of sea water. An example of such a recipe is given in Table A2.1. The salts and tap water should be well mixed together and aerated for 24 hours before use. Mixes for artificial sea water are also available from the aquarium trade and these may be more economical and convenient to use if only small quantities of water are required or if discounts for bulk purchases can be obtained.

Table A2.1. Composition of artificial sea water for lobster storage

Chemical name	Chemical composition	Weight of salts for 450 litres (100 gallons) in kg
Sodium chloride (common salt)	NaCl	10.66
Magnesium sulphate (epsom salt)	$MgSO_4$ $7H_20$	2.61
Magnesium chloride	$MgCI_2$ $6H_20$	2.07
Flake calcium chloride	$CaC1_2$ H_2O	0.54
Potassium chloride	KC1	0.26
	Total	16.14

This will give a sea water of approximately 30‰ salinity. Salts of common industrial or agricultural grade are adequate.

APPENDIX 3. Conversion table for weights and measures

To convert:
Litres to gallons (UK) - divide by 4.55
Gallons (UK) to litres - multiply by 4.55
Pounds to kilogrammes - divide by 2.205
Kilogrammes to pounds - multiply by 2.205
Square feet to square metres - multiply by 0.0929
Square metres to square feet - divide by 0.0929
Centigrade to Fahrenheit - multiply by 9, divide by 5 and add 32
Fahrenheit to Centigrade - subtract 32, multiply by 5 and divide by 9
Cubic feet to gallons (UK) - multiply by 6.229
Cubic metres to gallons (UK) - multiply by 219.9

APPENDIX 4. Useful contacts

NOTE: Contact details can change, so you are advised to check the more up-to-date information that is published in each issue of Shellfish News, Copies can be obtained from the CEFAS Lowestoft Laboratory (see below) or they can be accessed electronically at http://www.cefas.co.uk/publications/shellfish_news.htm.

(a) Policy

Department for Environment, Food and Rural Affairs, Nobel House, 17 Smith Square, London SW1P 3JR
(Switchboard tel. 020 7238 3000)
(General fax. 020 7238 6591)
You can also visit the Defra website at http://www.defra.gov.uk

Welsh Assembly Government, Agricultural and Rural Affairs Department, New Crown Buildings, Cathays Park, Cardiff CF1 3NQ
(Tel. 029 2082 3567)
(Fax. 029 2082 3562)
(*http://www.wales.gov.uk*)

Scottish Executive Environment and Rural Affairs Department, Pentland House, 47 Robbs Loan, Edinburgh EHG14 1TW
(Tel. 0131 244 6224)
(Fax. 0131 244 6313)
(*http://www.scotland.gov.uk/who/dept_rural.asp*)

Department of Agriculture and Rural Development for Northern Ireland, Fisheries Division, Annexe 5, Castle Grounds, Stormont, Belfast, BT4 3PW
(Tel. 028 9052 3431)
(Fax. 028 9052 2394)
(*http://www.dardni.gov.uk*)

(b) Fisheries

Sea Fisheries Inspectorate, Room 13, 10 Whitehall Place East, London, SW1A 2HH
(Tel. 020 7270 8326/8160/8328)
(Fax. 020 7270 8345)
(*http://www.defra.gov.uk/corporate/contacts/sfi.htm*)
Contact information for local Coastal Fisheries Office may be obtained from the above.

Sea Fisheries Committees.
There are twelve Sea Fisheries Committees (SFCs), which regulate local sea fisheries around virtually the entire coast of England and Wales out to 6 miles. See h*ttp://www.defra.gov.uk/fish/industry.htm#sfc* for contact details for your local committee. The central contact for further information is: The Association of Sea Fisheries Committees of England and Wales, 6, Ashmeadow Road, Arnside, Via Carnforth, Lancashire, LA5 0AE (Telephone and Fax: 01524 761616; email: *asfc.office@btopenworld.com*).

(c) Scientific advice and licensing

Fish Health Inspectorate, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB
(Tel 01305 206600)
(Fax 01305 206601)
- Health regulations; disease control, including licensing (England & Wales)

CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT
(Tel 01502 562244)
(Fax 01502 513865)
- Shellfish stocks (England & Wales)
You can also visit the CEFAS website at http://www.cefas.co.uk

Fisheries Research Services, Marine Laboratory, PO Box 101, Victoria Road, Aberdeen AB9 8DB
(Tel. 01224 876544)
(Fax. 01224 295511)
(*http://www.marlab.ac.uk*)
- Shellfish stocks, health regulations; disease control, including licensing (Scotland)

(d) Technical advice

SEAFISH Technology, Seafish House, St. Andrew's Dock, Hull, HU3 4QE
(Tel 01482 327837)
(Fax 01482 223310)
(*http://www.seafish.co.uk*)

(e) Advice on commercial activities

The Shellfish Association of Great Britain, Fishmonger's Hall, London Bridge, London, EC4R 9EL
(Tel. 020 7283 8305)
(Fax. 020 7929 1389)
(*http://www.shellfish.org.uk*)

The Association of Scottish Shellfish Growers, Mountview, Ardvasar, Isle of Skye, IV45 8RU
(Tel/Fax: 01471 844324)

Appendix 5. Further reading

Bayer, R.C., Prince, D.L., Crosby, M.A., Tall, B., Fall, S. and Loughlin, M.B., 2000. Health management of the American lobster. Journal of Shellfish Research 19: 673.

Bayer, R., Riley, J., and Donahue, D., 1998. The effect of dissolved oxygen level on the weight gain and shell hardness of new-shell American lobster *Homarus americanus*. Journal of the World Aquaculture Society 29: 491-493.

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Stewart, J.E. 1975. Gaffkemia, the fatal infection of lobsters (genus *Homarus*) caused by *Aerococcus viridans* (var.) *homari*: a review. Marine Fisheries Review 37: 20-24.

Stewart, J.E., Cornick, J.W., Spears, D.I. and McLeese, D.W., 1966. Incidence of *Gaffkya homari* in natural lobster (*Homarus americanus*) populations of the Atlantic region of Canada. Journal of the Fisheries Research Board of Canada 23: 1325-1330.

Stewart, J.E., Arie, B., Zwicker, B.M. and Dingle, J.R., 1969. Gaffkemia, a bacterial disease of the lobster, *Homarus americanus*: effects of the pathogen, *Gaffkya homari*, on the physiology of the host. Canadian Journal of Microbiology 15: 925-932.

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The following Seafish publications are also available:

Crab & Lobster Live Holding Systems, Part 1 - Tanks & Buildings. *http://www.seafish.org/pdf.pl?file=seafish/Documents/datasheet_90_01_SF.pdf*

Crab & Lobster Live Holding Systems, Part II -Water Pumps, Air Pumps and Pipework. *http://www.seafish.org/pdf.pl?file=seafish/Documents/datasheet_90_02_SF.pdf*

Crab & Lobster Holding Systems, Part III - Filters & Instrumentation. *http://www.seafish.org/pdf.pl?file=seafish/Documents/datasheet_90_03_SF.pdf*

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