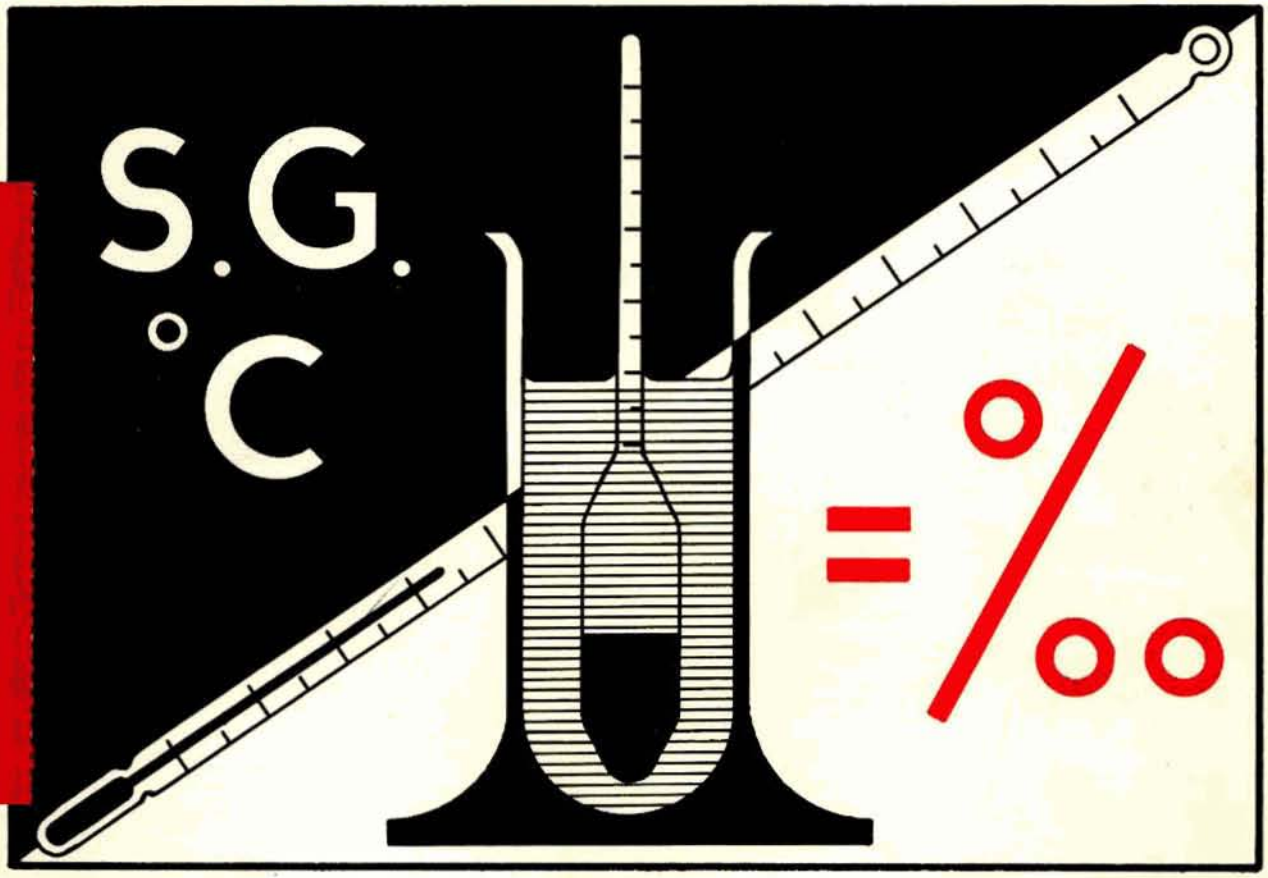
MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

LOBSTER STORAGE AND SHELLFISH PURIFICATION



NOTES ON THE SALINITY OF SEAWATER AND THE USE OF ARTIFICIAL SEAWATER IN COMMERCIAL INSTALLATIONS

LABORATORY LEAFLET (NEW SERIES) No.13
FISHERIES LABORATORY
BURNHAM ON CROUCH, ESSEX
AUGUST 1966

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INTRODUCTION

Within recent years there has been a steady increase in the number of shore installations where lobsters are stored or oysters are purified. The water used in these tanks is usually pumped from the sea, but in some cases an artificial seawater is made up from a mixture of simple salts. Where water is taken from an estuary there is a risk that the salinity may at times be too low to permit the normal activities of the shellfish. The object of this leaflet is to describe how the salt content of seawater can be measured, and how salts may be used to increase the salinity of natural seawater, or for the manufacture of artificial seawater for use in lobster storage and shellfish purification tanks.

1. WHAT IS SALINITY AND HOW DOES IT VARY?

The salt content or salinity of seawater is usually expressed as the number of parts by weight of salt in one thousand parts by weight of water. The unit "parts per thousand" is usually indicated by the symbol $^{o}/_{oo}$. Thus water having a salinity of $35^{o}/_{oo}$ contains 35 lb of salt in 1000 lb of water. Since a gallon of water weighs 10 lb, water of salinity $35^{o}/_{oo}$ contains 35 lb of salt in 100 gallons. For those wishing to use metric units, water of salinity $35^{o}/_{oo}$ contains 35 g of salt in 1 litre of water, or 35 kg in 1 cubic metre (m^3).

The salinity of seawater usually decreases as one moves from the open sea into an estuary, as a result of the increased quantity of fresh water present. In the open sea around the British Isles salinities of $34^{o}/_{oo}$ or more are usual, with only small changes during the seasons. However, in tidal estuaries salinities are generally lower and subject to considerable variation. Salinities are usually lower in winter than in summer, lower at low tide than at high tide, and lower at neap than at spring tides. At the seaward end of a typical east coast oyster-producing estuary the maximum range of salinity during the year may be from $26\text{-}34^{o}/_{oo}$, whilst at the upper limit of oyster cultivation the salinity in winter may vary from $10\text{-}25^{o}/_{oo}$ during a tidal cycle. In addition to these changes, 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, for there is a tendency for fresh water, or seawater containing a large proportion of fresh water, to remain on

the surface. For this reason, intakes to seawater installations should be placed on or near the bottom in as deep water as possible.

2. THE MEASUREMENT OF SALINITY

It is difficult to measure the salt content of seawater by direct means, but a good estimate of the water quality can be obtained by measuring its specific gravity with a hydrometer. 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 salinity can be obtained by reference to a table or a graph. Distilled water has a specific gravity of about 1.000 and "full" seawater of about 1.026, but these values vary a little according to the water temperature. It is important to distinguish clearly between salinity and specific gravity when describing seawater, for the specific gravity is often referred to by the last two numbers only. For the tank operator there are a number of hydrometers available for the measurement of specific gravity, but one which is particularly useful is listed as:- Soil testing hydrometer, long stem, to B.S. 1377, range 0.995-1.030 S.G. at 20°C. If other instruments are used, care should be taken to ensure that the graduations are sufficiently wide apart to permit accurate reading, and that the instrument, if used with the tables and graph appended to this leaflet, is calibrated between 17.5 and 20°C. When ordering a hydrometer, it is advisable to ask for a glass hydrometer jar of suitable size to go with it.

To determine the specific gravity, a sample of water should be taken from the tanks or from the incoming seawater in a clean vessel, free from oil or grease. The bulb and stem of the hydrometer should be cleaned and freed from adhering particles, salt crystals, pieces of cotton wool, grease, etc., and immersed in water in the hydrometer jar. Only the very top of the stem should be handled, for grease from the hand may affect readings. Any bubbles of air seen on the side of the hydrometer bulb should be removed by gentle agitation of the instrument, or by wiping with a clean cloth. The hydrometer should then be allowed to settle, and the reading of the hydrometer taken with the eye level with the water surface. This is why it is important to place the hydrometer in a glass jar when the reading is taken; accurate readings cannot be made in a tank where the hydrometer is viewed from above. The readings shown on the hydrometer are for specific gravity but only the last two numbers are shown, i.e. 1.020 is usually marked as "20" on the scale.

3. SALINITY REQUIREMENTS FOR SHELLFISH TANKS

Lobsters are typically coastal animals found in waters having a salinity of 33°/oo or more. They cannot tolerate low salinities, or rapid changes of salinity, and do not occur in large numbers in estuaries or other areas subject to low salinities. It is possible to store lobsters in water having a salinity down to 25°/oo, and even less when water temperatures are below 50°F (10°C), but the minimum value usually

considered acceptable in commercial storage units is 27°/oo. Lobsters exposed to low salinity may weaken and die, with a characteristic swelling in the middle of the body, between the head and the tail region.

Native and Portuguese oysters and hard clams are typically estuarine shellfish which can tolerate relatively low and rapid changes of the salinity. Although these shellfish may become gradually adjusted to the very low salinities which often result from the increasing quantities of fresh water entering an estuary in autumn and winter, the minimum salinity normally considered acceptable in purification plants is 25°/oo for native oysters, 20.5°/oo for Portuguese oysters and 20°/oo for hard clams. In comparison, the minimum salinity for mussel purification is 19°/oo. Shellfish held in water of too low a salinity will not open, and purification cannot take place; prolonged exposure to low salinity may ultimately lead to death.

For normal purposes a measurement of specific gravity is adequate for ensuring that water has a salinity equal to or greater than the minimum values shown above. The minimum specific gravities of seawater recommended are as follows:-

Shellfish	Minimum specific gravity
For storage	
Lobsters	1.023
For purification	
Native oysters	1.022
Portuguese oysters	1.018
Hard clams	1.017
Mussels	1.016

Seawater at any temperature having a specific gravity equal to or greater than the values shown is suitable for use in tanks for the purpose indicated.

If water taken into a tank has a specific gravity near to or below that recommended (say 1.021 for Native oysters) it is well worth making a more accurate estimate of the salt content by taking the water temperature and converting the values to salinity. This can be done by reference to the graph enclosed within this leaflet. Starting at the observed temperature, move the finger vertically until it reaches the line for the observed specific gravity. At this point move the finger horizontally to either side of the graph, until it cuts the scale where the salinity is shown. Thus water having an S.G. of 1.020 at 41°F (5°C) indicates a salinity of 24°/oo, which is suitable for the purification of portuguese oysters, clams and mussels, but not Native oysters, nor for the storage of lobsters. The minimum salinities normally accepted in tanks holding the various shellfish are shown on the graph by the thick

horizontal lines. If the observed salinity is below the minimum, then a salt mixture as described later should be added. For those not wishing to use the graph, Table 1 has been prepared, showing the minimum specific gravity of seawater at several temperature ranges in various types of installation. It can be seen from the table that as the water temperature rises, the minimum acceptable specific gravity falls below that given in the rough guide. Thus when the specific gravity is less than that recommended in the rough guide, and particularly where large volumes of water are involved, the accurate measurement of salinity using a temperature correction may indicate that water of adequate salinity is present, and so save the additional cost and time involved in adding salts.

Table 1 Minimum specific gravity of water for use in shellfish installations

Water temperature		Storage of lobsters	Purification of			
^{o}F	^{o}C		Native oysters	Portuguese oysters	Hard clams	Mussels
Up to 50	Up to 10	1.023	1.022	1.018	1.017	1.016
51-59	10.1-15	1.022	1.021	1.017	1.017	1.016
60-68	15.1-20	1.021	1.020	1.016	1.016	1.015
69 and above	20.1 and above	1.020	1.019	1.015	1.015	1.014

In this leaflet, detailed attention is given only to those British species stored or purified commercially, although within recent years there has been increased interest in the live storage of other shellfish.* The American lobster (Homarus americanus) is known to tolerate salinities suitable for the storage of British lobsters. The crawfish (Palinurus vulgaris), otherwise known as the spiny lobster or langouste, is stored in tanks in the south-west of England, where salinities are relatively high, and being an offshore animal is probably intolerant of very low salinities. Recent experiments at the Burnham laboratory indicated that a salinity of 28°/oo was too low, whilst 32°/oo (approximately S.G. 1.025-26) was satisfactory. The Norway lobster (Nephrops norvegicus), known as Dublin Bay prawn, langoustine, or scampi, is an offshore animal, and in the absence of more detailed information it is recommended that water for its storage should have a salinity of at least 34°/oo (approximately S.G. 1.027-28). When artificial seawater is used the weight of salts should be increased, above that shown for lobsters in Table 3, by

*The Latin names of the species of shellfish at present stored or purified commercially in this country are as follows:- Lobster (Homarus vulgaris); Native oyster (Ostrea edulis); Portuguese oyster (Crassostrea angulata; mussel (Mytilus edulis); hard clam (Venus mercenaria).

approximately 7 per cent for crawfish and 13 per cent for Norway lobsters. The edible crab (Cancer pagurus) should be held in water containing at least 30°/oo of salt (S.G. 1.024-1.025).

Of the remaining commercial species of shellfish, winkles (Littorina littorea) are often stored in seawater prior to dispatch to market. These shellfish are estuarine animals able to tolerate a wide range of salinities, at least down to 20°/oo (approximately S.G. 1.016-17), and probably lower. Escallops (Pecten maximus), although not normally stored commercially, can be held in tanks of seawater of good salinity. In the absence of any more precise information, it is recommended that escallops should not be held in water of salinity less than about 34°/oo (approximately S.G. 1.027-28).

4. THE USE OF SALTS FOR MAKING ARTIFICIAL SEAWATER

Seawater consists of a complex mixture of salts, many of which are present in very small quantities, but for lobster storage and shellfish purification water containing a mixture of five simple salts is adequate. The mixture recommended in this leaflet was devised by Dr. Wilder in Canada for the storage of lobsters, and has been successfully used in Britain in several commercial storage units. The salt mixture may be used for making up an artificial seawater from tapwater, or for increasing the salinity of natural seawater. Water for use in lobster storage and shellfish purification plants contains the same basic mixture of salts, but, for shellfish purification, lower concentrations are employed in order to reduce cost. When more than one type of shellfish is present in an installation the water should be suitable for the shellfish requiring the highest salinity.

The quantities of each of the five salts required for making up amounts of between 50 and 1000 lb of the salt mixture are shown in Table 2. In Table 3 are shown the individual weights of each salt and the weights of the salt mixture required for making up between 50 and 1000 gallons* of artificial seawater suitable for lobsters, Native oysters, and Portuguese oysters and hard clams respectively. At the time of writing it has not been found economic to make up artificial seawater for the purification of mussels, although there is no practical reason why this should not be done.

The cost of making up artificial seawater may vary widely, depending on the supplier, the area of purchase and the quantity of each salt purchased. Commercial or agricultural grades, obtained through industrial chemists, are suitable and are usually much cheaper than salts to B.P. (British Pharmacopeia) or analytical reagent quality, which are unnecessary and too expensive. It is therefore well worth making a number of enquiries before buying. One hundredweight lots are always considerably

*All volumes of water are expressed in imperial gallons

Table 2 Composition and cost of artificial salt mixture

Common names of salts	Chemical composition	Range of costs at 1966 prices (per cwt)	Weight of each salt needed to make up the following weights of salt mixture				
			50 lb	100 lb	250 lb	500 lb	1000 lb
			lb oz	lb oz	lb oz	lb	lb
Sodium chloride (common salt)	NaCl	12s. 0d.-15s. 0d.	32 14	66 0	165 0	330	660
Magnesium sulphate (Epsom salt)	$MgSO_4$ $7H_2O$	26s. 6d.-39s. 9d.	8 2	16 4	41 0	82	164
Magnesium chloride	$MgCl_2$ $6H_2O$	25s. 6d.-46s. 0d.	6 8	13 0	33 0	66	132
Flake calcium chloride	Ca Cl_2 $2H_2O$	34s. 6d.-80s. 6d.	1 12	3 8	9 0	18	36
Potassium chloride	KCl	46s. 6d.-87s. 6d.	14	1 12	4 8	9	18

Notes:- (a) Always specify both the name and the chemical composition when ordering, for there are several compounds having the same name but different chemical composition.

(b) Common salt should be of "pure vacuum dried" or cooking quality. Rock salt is not satisfactory.

(c) If flake calcium chloride is not available, hydrated calcium chloride (Ca Cl_2 $6H_2O$) may be used, but the weight should be increased by 50 per cent, i.e. for 50 lb of salt mixture 2 lb 10 oz are required. Do not use anhydrous calcium chloride.

Tables 3a, b and c Composition of artificial seawater for use in lobster storage and shellfish purification units (for further details see Table 2)

Common names of salts	Weight of salts required by the following volumes of water					
	50 gal	100 gal	250 gal	500 gal	1000 gal	1 litre
	lb oz	lb oz	lb oz	lb oz	lb	g
	(a) For lobster storage					
Sodium chloride	11 11½	23 8	58 8	117 0	235	23.51
Magnesium sulphate	2 14	5 12	14 8	28 8	57	5.77
Magnesium chloride	2 4½	4 9	11 8	23 0	46	4.58
Flake calcium chloride	9½	1 3	3 0	6 0	12	1.20
Potassium chloride	4½	9	1 4	3 0	6	0.57
Total	17 12	35 9	88 12	117 8	356	35.63
These mixtures will give artificial seawater having a salinity of approximately 30°/oo						
	(b) For purification of Native oysters					
Sodium chloride	10 9	21 1½	52 8	105 8	211	21.17
Magnesium sulphate	2 9½	5 3	13 0	26 0	52	5.20
Magnesium chloride	2 1	4 1½	10 4	20 8	41	4.12
Flake calcium chloride	8½	1 1	2 12	5 8	11	1.08
Potassium chloride	4	8	1 4	2 8	5	0.52
Total	16 0	31 15	79 12	160 0	320	32.09
These mixtures will give artificial seawater having a salinity of approximately 27°/oo						
	(c) For purification of Portuguese oysters and hard clams					
Sodium chloride	8 9½	17 3½	43 0	86 0	172	17.25
Magnesium sulphate	2 1½	4 3½	10 8	21 0	42	4.24
Magnesium chloride	1 11	3 5½	8 4	16 8	33	3.36
Flake calcium chloride	7	14	2 4	4 8	9	0.88
Potassium chloride	3½	6½	1 0	2 0	4	0.42
Total	13 0½	26 1	65 0	130 0	260	26.15
These mixtures will give artificial seawater having a salinity of approximately 22°/oo						

cheaper than smaller quantities. The minor salts are obtainable in quantities of less than one hundredweight, but at considerably higher prices. If salts are bought in quantity and stored before use, airtight containers of plastic or metal should be used, to prevent absorption of water; the salts may be mixed together and stored until required.

The costs of making up artificial seawater with salts purchased in the London area, based on the highest and lowest quotations, are as follows:-

Water at recommended salinity for	Cost per 100 gallons at 1966 prices
Lobster storage	6s. 9d.-23s. 6d.
Purification of:-	
Native oysters	6s. 1d.-21s. 2d.
Portuguese oysters) Hard clams)	5s. 0d.-17s. 4d.

Similar salt mixtures, suitable for direct addition to fresh water, are available from several commercial suppliers, but the cost of these mixtures is almost the same as the highest costs shown above.

5. HOW TO MAKE UP ARTIFICIAL SEAWATER

The volume of the tank should be checked by making measurements of the length, breadth and average depth of the water, taking into account any irregularities of the internal shape and also water in channels, pipes, etc. The volume in gallons may be obtained by multiplying the total volume in cubic feet by $6\frac{1}{4}$. Where small prefabricated tanks are used it is important to check their volume, for the nominal capacity, i.e. that given by the manufacturer, is often very different from the actual working capacity. It is also inadvisable to estimate the volume of an installation from the time taken to fill it with a pump whose flow is not accurately known; the actual pumping rate seldom coincides with that given by the manufacturer, on account of the method of installation and a general reduction in the efficiency of pumps with age. Having determined the water volume, the weight of salts required in the tank is obtained from the weights given in the appropriate table. Thus for 800 gallons of water for use in lobster storage tanks, the weight of salts may be obtained by adding together the weights shown under the columns for 500, 250 and 50 gallons in Table 3(a).

The salts may be weighed out in a quantity suitable for one filling, or for several fillings, but, in the latter case, care must be taken to ensure that the minor salts are evenly distributed throughout the mixture. This difficulty can be overcome by keeping down the bulk and mixing together all the salts except the common salt, which is then added to the tank in the appropriate amount at the same time as the mixture. Salt mixture not used immediately should be stored in clean, dry containers. Before, during or after filling the tanks with water, the salts should be distributed throughout the tanks in a thin layer, beneath the inlet or near the outlet(s) of the circulating system, in order to speed up solution. Most of the salts will pass into solution rapidly but a small quantity may remain to form a fine white precipitate which may take several hours to disappear. When the bulk of the salts has dissolved, the salinity should be checked with a hydrometer, and if satisfactory the shellfish may be immersed.

Water used for making artificial seawater should be of drinking quality. If an excessive quantity of chlorine is present, this will escape to the atmosphere during circulation. Extremely acid water, such as that from a peat catchment area or from certain mountainous areas, may be unsuitable for oyster purification, and, in cases of doubt, advice should be sought from the chemist of the local water undertaking. Artificial seawater for oyster purification should have a pH not less than 6.5.

6. THE USE OF SALTS FOR INCREASING THE SALINITY OF NATURAL SEAWATER

In estuaries and inlets which receive substantial quantities of fresh water, the salinity may at times fall below the minimum required for shellfish. Where a new installation is planned, the tank should be sited so that water of high salinity can be obtained at all times of the year, and for this purpose the proposed site should be examined during a wet spell, for water at a point which is of "full" salinity in summer may fall to 20°/oo or lower during a prolonged wet spell. Whenever possible, salinity measurements should be made on samples taken at neap and spring tides from the same position and depth as the proposed intake; visual examination of the site without reference to salinity measurements may later lead to disappointment, for there is a tendency to underestimate the effect of fresh water in the lower parts of an estuary.

At established installations, water of the highest salinity can usually be obtained during the last hour of the flood tide, and it is usually of a considerably higher salinity during the period of spring tides than on neaps. In places where the catchment area is a long way from the estuary the effect of heavy rain may not show in an estuary until several days later; after a period of heavy rain there is usually further delay before the salinity returns to normal. Where there are persistently low salinities, consideration should be given to extending the water intake to low-water mark, or even to a deep-water channel if this is not too far away.

Table 4 Approximate weights of salt mixture required to increase the salinity of natural seawater in shellfish tanks

Observed salinity (°/oo)	Observed specific gravity at temperature of			Weight of salt mixture for 100 gal, made up according to Table 2		
	Up to 50°F (10°C)	51-59°F (10.1-15°C)	60°F (15.1°C) and above	Lobsters	Native oysters	Portuguese oysters and hard clams
				lb oz	lb oz	lb oz
27	1.023	1.022	1.021			
26	1.022	1.021	-	1 3		
25	1.021	-	1.020	2 6	1 3	
24	1.020	1.020	1.019	3 9	2 6	
23	-	1.019	1.018	4 12	3 9	
22	1.019	1.018	-	5 15	4 12	
21	1.018	1.017	1.017	7 2	5 15	
20	1.017	-	1.016	8 5	7 2	1 3
19	1.016	1.016	1.015	9 8	8 5	2 6
18	-	1.015	1.014	10 11	9 8	3 9
17	1.015	1.014	-	11 14	10 11	4 12
16	1.014	-	1.013	13 1	11 14	5 15

Table 4 continued

15 14 13 12	1.013 1.012 - 1.011	1.013 1.012 1.011 -	1.012 1.011 - 1.010	14 4 15 7 16 10 17 13	13 1 14 4 15 7 16 10	7 2 8 5 9 8 10 11
11 10 9 8	1.010 1.009 1.008 -	1.010 1.009 1.008 1.007	1.009 1.008 - 1.007	19 0 20 3 21 6 22 9	17 13 19 0 20 3 21 6	11 14 13 1 14 4 15 7
7 6 5 4	1.007 1.006 1.005 -	- 1.006 1.005 1.004	1.006 1.005 1.004 -	23 12 24 15 26 2 27 5	22 9 23 12 24 15 26 2	16 10 17 13 19 0 20 3
3 2 1 0	1.004 1.003 1.002 -	- 1.003 1.002 -	1.003 1.002 1.001 -	28 8 29 11 30 14 32 1	27 5 28 8 29 11 30 14	21 6 22 9 23 12 24 15

WHEN WATER TEMPERATURE IS NOT KNOWN, USE THE COLUMN SHOWING S.G. AT THE LOWEST TEMPERATURE RANGE

When existing pipe lines are extended, the rate of pumping may be substantially reduced by the friction of the longer pipe unless the pipe is of adequate diameter. The intake should be located on or near the seabed so as to take advantage of water of the highest salinity, and as far from sewage and industrial outfalls as possible. Outfalls containing gas-works liquors can be particularly troublesome, because extremely small quantities of these effluents in water taken into shellfish tanks can lead to the development of tastes similar to those of some disinfectants.

When water of low salinity is taken into an installation, the natural salt content may be increased by the addition of the salt mixture shown in Table 2. As a quick guide to the weight of salt mixture needed for raising the salinity, the following table shows the weights of salts that must be added for every unit of salinity (1°/oo) or S.G. (0.001) that the water is below the recommended value.

To increase salt content by 1 unit of	Weight of salt mixture to be added to		
	100 gallons	1000 gallons	1 cubic metre
	lb oz	lb oz	kg
Salinity (°/oo)	1 3	12 0	1.19
Specific gravity (0.001)	1 7	14 8	1.42

To increase the salinity of water from 15°/oo to 20°/oo, (20-15 = 5) x 1 lb 3 oz = 6 lb of salt mixture must be added to every 100 gallons of water. If only the specific gravity is known, then to increase water from 1.016 to 1.020, each 100 gallons will require (1.020-1.016 = 4 units of S.G.) x 1 lb 7 oz = 5¾ lb of salt.

Further details of the quantities of salt mixture required to make up the salinity under various conditions are given in Table 4. When the salinity of the water in an installation is known, the approximate weights of salts needed in tanks holding lobsters and oysters are shown on the same horizontal line on which the observed salinity appears, i.e. a lobster tank holding water of salinity 15°/oo requires 14 lb 4 oz of salt mixture for every 100 gallons held in the tank. Alternatively, if the specific gravity and temperature are known, first the observed S.G. should be found under the appropriate temperature column, and then the weight of salts required for 100 gallons is given on the same horizontal line. For example, for Native oysters, water of S.G. 1.018 at 45°F requires 5 lb 5 oz for each 100 gallons to make it up to the desired S.G. of 1.022. If the water temperature is not known, then the observed specific gravity should be found in the second column (headed "Up to 50°F") and the weight of salts read off against this value, under the appropriate heading.

When water in lobster storage units is just below the required salinity it is possible to increase the salinity by the addition of common salt (sodium chloride) only. It is essential that the salt balance is not altered too much, and it is recommended that the use of common salt by itself be restricted to waters having an S.G. of 1.019 or more; for waters of lower salinity, the full salt mixture should be added. The salinity of water for use in oyster purification plants should be increased by the addition of the full salt mixture shown in Table 2, for it is essential that the oysters not only remain alive, but continue to function actively, so that purification can take place.

7. THE PLANNING OF NEW INSTALLATIONS OR THE EXTENSION OF EXISTING ONES

In installations which hold shellfish, the availability of water of adequate salinity at all times is of prime importance. Care taken in the selection of a site can save considerable cost later, particularly where tanks holding large volumes of water are involved. For this purpose, salinity surveys can be speeded up by the use of more advanced equipment than that described here.

For problems concerned with salinity, or with the design and construction of installations in which shellfish are stored or purified, the staff of the Ministry's Fisheries Laboratories at Conway (North Wales) and Burnham-on-Crouch (Essex) are available for consultation.

For those who need advice on how to store lobsters or purify oysters or mussels the following publications may be of assistance:-

"Lobster storage" by H. J. Thomas. Available from H.M.S.O., Edinburgh, price 1s. 6d.

"Handling lobsters and crabs" by H. J. Thomas. Available from Department of Agriculture and Fisheries for Scotland, Marine Laboratory, Aberdeen.

"Refrigerated storage of lobsters" by H. J. Thomas. Scottish Fisheries Bulletin, No. 17, pp. 16-20. Available from H.M.S.O., Edinburgh.

"Lobster storage and shipment" by D. W. McLeese and D. G. Wilder. Available from the Queen's Printer, Ottawa, Canada, price $1.75. (This publication deals with lobster storage in Canada.)

"The principles of water sterilization by ultra-violet light and their application in the purification of oysters" by P. C. Wood. Available from H.M.S.O., London, price £1.

"The purification of oysters in installations using ultra-violet light", Laboratory Leaflet No. 27. Available from the Fisheries Laboratory, Burnham-on-Crouch, Essex.

"A simplified system of mussel purification" by N. Reynolds. Available from H.M.S.O., London, price 5s. 0d.

SUMMARY OF THE IMPORTANT POINTS

1. Minimum salt content of seawater (for details see graph and Table 1)

Shellfish	Minimum salinity (°/oo)	Minimum S.G. (rough guide)
Lobsters	27.0	1.023
Native oysters	25.5	1.022
Portuguese oysters	20.5	1.018
Hard clams	20.0	1.017
Mussels	19.0	1.016

2. Artificial seawater

To make up artificial seawater (composition as in Table 2)			
Shellfish	Weight of salt mixture for		Details
	100 gal	1000 gal	
	lb oz	lb	
Lobsters	35 9	356	Table 3(a)
Native oysters	31 15	320	Table 3(b)
Portuguese oysters) Hard clams)	26 1	260	Table 3(c)

To increase salinity of natural seawater		
	Weight of salt mixture for 100 gal	Details
	lb oz	
For each unit of salinity (°/oo) that is required	1 3	Page 12
For each unit of S.G. (0.001) that is required	1 7	Page 12

3. Use of common salt instead of complete salt mixture

Add to water in lobster storage tanks when S.G. is 1.019 or more. Do not use in shellfish purification tanks.