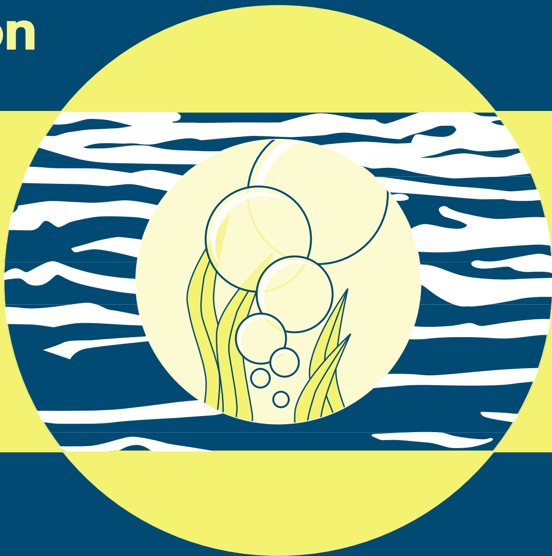
De-oxygenation

Practical self-help

for fishery owners

and managers



Environment Agency

For more copies of this booklet please contact:

National Coarse Fisheries Centre
Environment Agency
Arthur Drive
Hoo Farm Industrial Estate
Worcester Road
Kidderminster
DY11 7RA
Tel: 01562 68975
Fax: 01562 69477

De-oxygenation: practical self-help for fishery owners and managers

Introduction

This booklet is intended as a simple guide for angling clubs, fishery owners and managers on the most common causes of de-oxygenation in fisheries and ways to avoid and overcome the problems caused.

Oxygen is essential for life. Fish obtain the oxygen they need from that dissolved in the surrounding water, absorbing it through their gills. Oxygen is also consumed by other aquatic animals, respiring plants and by bacterial and fungal activity. Dissolved oxygen levels are replenished by the process of photosynthesis, in which plants produce oxygen during daylight, and by contact between the water surface and air.

Under certain circumstances the dissolved oxygen content of water can become seriously depleted, hence the term "de-oxygenation". This can mean stress or even death for plants and animals, including fish. Serious fish mortalities caused by de-oxygenation can result in severe losses in terms of finance and amenity value. De-oxygenation can also have an undesirable impact on other plants and animals that live nearby but rely on the aquatic environment.

Many de-oxygenation events occur as a result of natural processes, but the harmful effects can be made worse by inappropriate management. On the other hand, good management practice can help avoid or reduce many of the potential problems.

General principles

Water can hold much less oxygen than air - roughly a fifth of air is composed of oxygen whereas water will hold at best only approximately one part of oxygen in 100,000 parts of water. The quantity of oxygen held in solution depends on several factors, the most important of which is temperature.

As water becomes warmer the maximum amount of oxygen it can hold reduces. For example, water at 5˚C can hold a maximum of 12 milligrams of oxygen per litre (mg/1 or 12 parts per million), whereas water at 20˚C can hold a maximum of only 9.1mg/1. Consequently, less oxygen is available to organisms at a higher water temperature. This is very important because all species of fish actually require *more* oxygen at higher temperatures than at low because they are poikilothermic (more active when warm, less active when cold).

At any given temperature, if water contains the maximum possible concentration of dissolved oxygen, it is said to be "saturated" or "at saturation". The amount of oxygen dissolved in water is frequently described as a percentage of the saturation value. Hence the readout of an oxygen meter may be given as xx percent. It is important to remember that 75 percent saturation at 5˚C represents a higher level of oxygen in real terms than 75 percent at 20˚C.

Under some circumstances, water may temporarily contain more oxygen than should theoretically dissolve within it, a condition known as super-saturation. This can arise during bright, hot, calm weather in the presence of abundant plant or algal growth, which can generate oxygen by photosynthesis at a high rate.

Sources of dissolved oxygen

There are several mechanisms for entry of oxygen into water.

PHYSICAL MECHANISMS

Wind and wave action

This is one of the most significant physical influences on oxygen levels in stillwater fisheries. Choppy water conditions help increase the quantity of dissolved oxygen, as does the action of waves on the shores of banks and islands. In addition, strong wave action can help mix oxygen-rich water to considerable depths in a lake. Conversely, there will be less wave-induced oxygenation in fisheries sheltered from winds by trees, natural features, buildings or other artificial structures.

Direct rainfall

As rain falls, the water droplets absorb oxygen and other gases from the air. When the rain hits the water surface, further oxygenation occurs as the droplets “pull” more air beneath the water surface. Steady drizzle (small droplets) will contain more oxygen than torrential rain (large droplets), however very heavy rain may result in turbulence at the water surface, which can raise dissolved oxygen levels.

Surface or sub-surface drainage

Although the water entering a fishery from surface drains may be well-oxygenated, this may not be the case with sub-surface drainage or supplies derived from the underlying water table. Because such water is not in direct contact with the air, it may contain relatively little dissolved oxygen. This may also be true of spring water.

Riffles, waterfalls and weirs

In rivers, and in canals and lakes fed by flowing water, the oxygen content will be enhanced by any features that break up the water surface. These include shallow areas (riffles) and rock-strewn stretches - especially where the gradient is steep - as well as weirs, locks and natural waterfalls.

BIOLOGICAL MECHANISMS

One of the most important sources of oxygen dissolved in water is from photosynthesis in aquatic plants. In common with other living organisms, plants use oxygen and produce carbon dioxide continuously during respiration. In the presence of sunlight, aquatic plants photosynthesise and absorb more carbon dioxide from the water than they produce by respiration, and release oxygen in surplus. In darkness, plants cannot photosynthesise and become consumers of oxygen and producers of carbon dioxide, just like fish.

Only plants with submerged leaves will oxygenate the water. They include Canadian Pondweed, Hornwort, Water-milfoil, Water-crowfoot and Starwort. Algae also oxygenate water, whether they be in filamentous form ("blanket weed", "silkweed" and "cott") or suspended, single-celled forms that cause the water to turn green or green/brown. In contrast, plants with floating leaves such as water lilies, or those with leaves held above the water surface - most marginal species - do not contribute to the oxygen content of water.

Causes of de-oxygenation

Many factors can cause or contribute to the loss of oxygen from a fishery. They can be divided into two main categories - bacterial action and weather-related causes.

BACTERIAL ACTION

Bacteria are very simple organisms that occur in every type of habitat and on most living and dead matter. In water bodies, the bacteria that most influence oxygen concentration are those responsible for the process of decomposition (rotting). Bacteria can multiply extremely rapidly in warm conditions, but they are much less active in cold conditions.

Like the majority of other living things, most kinds of bacteria need oxygen to survive. As the number of bacteria increases, there is a corresponding increase in the amount of oxygen they consume. If sufficient food is available, bacteria can quickly reproduce to the point where they use up practically all the oxygen dissolved in water, leaving none for the other plants and animals, including fish. Events or activities that introduce plentiful food supplies for bacteria can often lead to de-oxygenation.

(Technical note: the demand for oxygen by bacteria in water is the Biochemical Oxygen Demand (BOD) and is expressed as the amount of oxygen in a standard volume sample of water that is consumed during a period of five days at 20˚C. As a guide, a BOD of 5mg/l or less is suitable to support coarse fish and 3mg/l or less is suitable for trout.)

Organic loading and pollution

Normally, organic material in water is broken down quickly by bacteria and used in the natural processes of the aquatic environment. If the amount of organic matter entering water is greater than the amount that can be broken down, it will accumulate on the lake, river or canal bed, forming deep layers of organic silt.

The silt can provide bacteria with ample supplies of food and bacterial action can be significant during the summer months. Ordinarily, this process will cause only slight changes to the amount of dissolved oxygen in the water, though this may be more pronounced in autumn when leaf-fall and die-back of water plants contribute towards the organic load, and photosynthesis is reduced. However, the rapid introduction of more organic matter at any time can result in severe de-oxygenation.

The lower layers of silt on the bed of the water-body may become anoxic (contain no oxygen) due to bacterial action, appearing black in colour and having a characteristic foul smell, and large-scale disturbance of this deep silt can result in sudden and catastrophic de-oxygenation.

Organic matter can enter the water in many forms. Considerable quantities of leaves (leaf litter) can enter the water from deciduous trees and shrubs growing around the banks. Leaves can also be blown in from the adjoining land or swept in through a feeder stream. Excessive use of anglers' bait and groundbait, waterfowl droppings and livestock faeces can also introduce organic matter into the water. Several common pollutants can cause deoxygenation problems when they enter fisheries. The most common are those containing a high concentration of animal and plant wastes, including sewage and agricultural wastes, which can fuel the bacteria activity described above.

Sewage

Discharges from sewage treatment works are rich in bacteria and organic matter that can deplete the oxygen content in the receiving water. The volume and chemical composition of sewage discharges are subject to legally enforceable consents designed to protect receiving water bodies. However, accidents or equipment failure can lead to pollution, as can discharges from combined sewer overflows (CSOs), broken sewers and septic tanks.

Agricultural wastes

The escape of slurry or silage liquor into watercourses represents a common form of pollution of rural fisheries. Both agricultural products are rich in organic compounds and contain prolific bacterial populations and thus are among the most potent causes of rapid deoxygenation. Typical incidents are caused by leaking slurry lagoons and silage clamps, which are often exacerbated by heavy rainfall that washes these liquors into rivers and lake feeder streams.

Other common agricultural wastes that can cause deoxygenation include by-products or accidental leakages of final products from sugar beet factories, dairies, canneries and meat-processing companies.

Industrial pollutants

A huge range of industrial pollutants can cause deoxygenation, and they are often also directly toxic to fish. Of particular note are oils, which float on the water surface and thereby prevent air interchange. Oils also smother plant life and curtail re-oxygenation through photosynthesis.

Aquatic plant management

A common cause of de-oxygenation is poorly planned and executed management of fisheries affected by "weed" problems. Excessive growth of aquatic plants usually peaks during the summer months, when it is tempting to manage large areas with weed killers or by cutting and raking.

Such management of problem plants can be highly effective, but if it is not carried out carefully the resultant rotting plant matter may cause a population “explosion” of bacteria. The consequent sudden de-oxygenation may have grave implications for the fish community.

Natural die-back of algae or of rooted water plants may also cause de-oxygenation (this is especially common in autumn as these plants die back and begin to decay due to bacterial action.

The management of “weed” problems is covered in another booklet in this series: *Water Plants: Their Functions and Management*. Applications of herbicides to most water bodies, and some other plant management techniques, require consent from the Environment Agency; you should always check first. Herbicides should only be applied by qualified personnel.

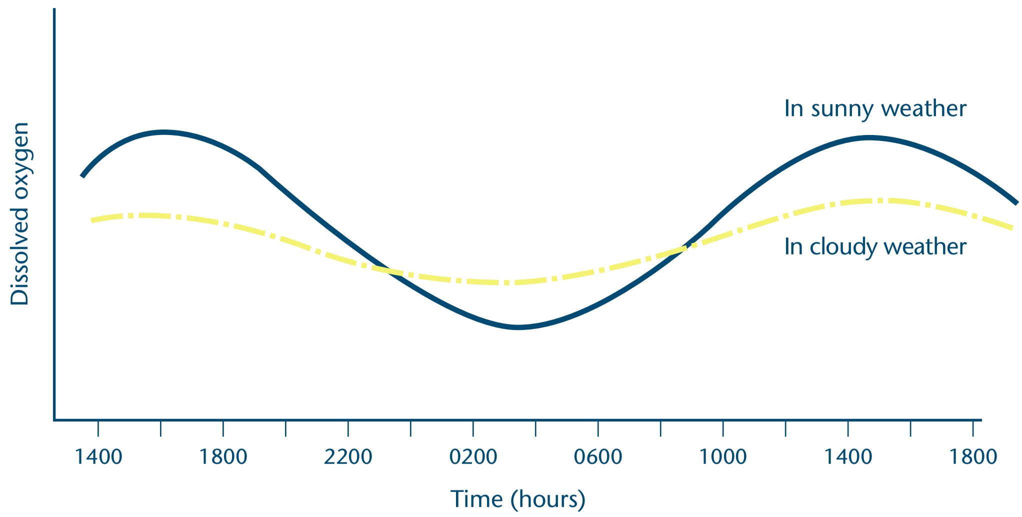
WEATHER -RELATED CAUSES

Water plants and algae

The release and absorption of carbon dioxide and oxygen by water plants and algae have been described earlier.
The day-to-night (or diurnal) variations can be significant. Because photosynthesis is more vigorous during strong sunlight, the diurnal effect is more pronounced in sunny conditions than during cloudy weather see (Figure 1). During very hot weather, super-saturation of the water with oxygen can occur in the late afternoon, but after nightfall the concentration of dissolved oxygen falls rapidly and can become so depleted by dawn that fish survival is jeopardised. This phenomenon is particularly pronounced in fisheries that are affected by intense growths - or “blooms” - of suspended algae.

Diurnal variation in dissolved oxygen concentration

Fig. 1



Thunderstorms

Thunderstorms present particular problems for fisheries during hot summer conditions. In fisheries where prolific algal blooms are present, the combination of lower atmospheric pressure associated with thunderstorms and the sudden influx of cooler rainwater can cause the suspended algae to sink to the bed. Now deprived of sunlight, the algae stop photosynthesising and may begin to die, thereby causing rapid proliferation in the number of bacteria and swift deoxygenation.

Moreover, because warmer water will rise above colder water, there may also be an “over-turning” of the water column during or following thunderstorms. This can release anoxic organic matter previously trapped in the bottom sediment, often causing the water to become dark brown or black and to deoxygenate rapidly. This release of sediment may also stimulate additional de-oxygenation through increased bacterial activity.

Additional hazards of thunderstorms are the rapid influx of surface water from surrounding areas that may contain materials and substances promoting deoxygenation, and the discharge of combined sewer overflows.

Ice-cover

When fisheries become completely covered with ice, interchange of oxygen at the water/air interface is prevented. However, those animals, including fish, that are trapped beneath the ice still require oxygen. If the ice cover lasts for a long time, the dissolved oxygen concentration can fall low enough to cause fish mortality.

The deoxygenation effect is even more pronounced if the ice becomes covered in a layer of snow. The snow stops light passing through the ice, thereby preventing any photosynthesis by the plants.

“Winter-kill” of fish is common in parts of the USA, Canada and mainland Europe, but in Britain it is rare unless the winter is severe and prolonged.

OTHER FACTORS INFLUENCING OXYGEN EXCHANGE

It is important to remember that processes consuming dissolved oxygen (and which can potentially cause de-oxygenation) and processes replenishing dissolved oxygen levels (oxygenation) are proceeding simultaneously to some extent. Whether de-oxygenation and fish mortality occurs depends on the balance between the two processes. If oxygen is being removed from the water faster than it can be replenished, de-oxygenation will eventually occur.

In circumstances where the biological productivity of a water is running at its maximum (for instance, where there are lots of fish, lots of algae and/or rooted plants and large quantities of organic matter in combination with high temperature) it is important to realise that only a small change in the balance between consumption and replenishment of oxygen can trigger a catastrophe. Such a change could be a further rise in temperature a decrease in light levels due to a period of cloudy weather, an increase in the availability of organic matter or the introduction of extra fish.

The effectiveness with which oxygen enters water depends on the surface area of the water in relation to its volume. This means that a small but deep lake is more likely to become de-oxygenated than an otherwise similar shallow one.

Very deep lakes can become ***thermally stratified*** during the summer months. This is the result of the upper layers of water becoming warmer and hence less dense due to the sun's warmth, whilst the cooler, heavier water stays on the bottom. The two layers do not mix readily due to the difference in density; biological activity on the lake bed begins to deplete oxygen in the lower, cooler layers, with little opportunity for replenishment from the well-oxygenated surface layers. In autumn, as the surface layers cool and autumnal winds stir the water, the de-oxygenated bottom water may come to the surface and cause fish kills.

In any water body, excessive cover of floating-leaved plants such as duckweed will further reduce the surface area available for gas-exchange and make de-oxygenation more likely.

Avoiding de-oxygenation through effective management

It is far more sensible to prevent problems caused by low oxygen in fisheries than to rely on emergency action once the problems have become manifest. By identifying the potential causes of de-oxygenation and, where necessary, rectifying them, it should never be necessary to take last-minute action.

REDUCING ORGANIC LOADING

De-silting

If the fishery has more than one metre of silt, that when disturbed, gives off a rotten-egg smell, there may be potential problems. Solutions include removing the accumulated silt (de-silting) and helping to prevent excessive input of organic matter from other sources.

De-silting will help to reduce bacterial activity and prevent associated de-oxygenation. It will also deepen the fishery, increase the volume of water and reduce the impact of extreme weather conditions. Lake de-silting is an expensive and disruptive process that is usually best accomplished after removing the fish and draining the fishery.

Legal consent is normally required from the Environment Agency before de-silting work is carried out. The local Agency office should be contacted for advice and further information (the telephone numbers are on the back, inside cover of this booklet). In addition, another booklet in this series *(De-silting Stillwaters)* provides further reading.

REDUCING LEAF LITTER

Careful management of bankside trees and shrubs can help control the build-up of organic silt. Bankside trees and shrubs can provide vital habitat for animals and other plants that are integral to a healthy aquatic environment. Therefore, only light, careful trimming of selected overhanging branches should be considered.

The annual removal of floating leaves before they sink to the bed is an extremely effective method of reducing silt accumulation. The simplest means of gathering the leaves to the water's edge is to use some form of floating boom - for example, a thick, floating rope or flexible chain of inter-linked, elongated buoys. This can be used to encircle the leaves when they have been blown to one end or one corner, then they can be drawn to the bank for removal.

Fishery owners have found that gardening rakes with long, closely spaced tines (such as "Springboks") are particularly effective for leaf-removal purposes if they are used upside down. The leaves should be disposed of in such a way that they cannot be blown back into the water.

POLLUTION PREVENTION

Excessive input of organic matter from any surface water flow into a fishery may result in problems as described above. More effective management of the input of organic material, often originating some distance from the fishery, may be required (local Environment Agency staff can advise and facilitate action in such cases).

If you suspect that pollution is entering a fishery, you should report it immediately by telephoning the Environment Agency 24-hour hotline Tel: 0800 807060. Qualified and experienced staff will be able to identify whether or not a problem exists and, if it does, take the necessary action to control it.

CONTROL OF ALGAE

A fishery that is always coloured, ranging from brown to light green, has a rich and abundant algal community. This does not automatically mean that de-oxygenation problems will result. Some enrichment is beneficial to coarse fisheries, particularly for very young fish, and algae are a vital component of a healthy aquatic environment. De-oxygenation problems caused by algae are often initiated by a sudden reduction in the algal community (known as a "crash"). This is usually associated with a sudden change in the water colour - overnight, for example.

Barley straw has been shown to control excessive proliferation of algae in some water bodies, but it is not always effective and its mode of action is not yet fully understood. Using too much straw may itself result in de-oxygenation, so the recommended dosage rates should always be used. The straw works most successfully if it is loosely bagged and floated in the water, with the bags being replaced with new material every autumn and spring. New bags should be added prior to the old ones being removed in order to allow new material to take effect. Straw-filled "sausages", constructed from the tubular netting used to wrap Christmas trees, are particularly useful. It has been discovered that an effective, initial dosage rate is about 500 kilograms of straw per hectare (kg/ha) (equivalent to 445lbs per acre (of water surface. This should be reduced in the subsequent year to 250kg/ha. Thereafter, a maintenance dose of 100kg/ha is appropriate. (Note: a standard-sized straw bale weighs approximately 20kg.) In stillwaters the straw may need to be placed around the margins rather than offshore - where it could interfere with angling; the same effect can be achieved if straw is applied across the channel of any feeder stream(s). It is advisable to use organically grown straw in all treatments.
The Centre for Aquatic Plant Management (see address at the end of this booklet) provides a detailed information sheet on this topic.

OTHER MEASURES

Other sources of organic enrichment can be controlled and managed by prohibiting excessive use of anglers' bait and groundbait, discouraging people from feeding waterfowl and controlling access of livestock to the water, for example by building cattle drinks. Local Environment Agency Fisheries and Ecology officers will be able to provide more detailed advice on these and other solutions.

ADJUSTING THE FISH COMMUNITY

Fisheries containing unnaturally large populations of fish are particularly vulnerable to de-oxygenation problems because of the oxygen demands of the fish. Moreover, the feeding activities of fish, particularly bream and carp, can help eradicate submerged plants and stimulate the development of algal blooms.

It would be sensible to consider reducing the size of the fish stock in heavily populated fisheries with de-oxygenation problems. The species composition could also be adjusted to establish fish that are better able to withstand periods of low oxygen concentrations. For example, common carp and tench are more robust than perch or roach.

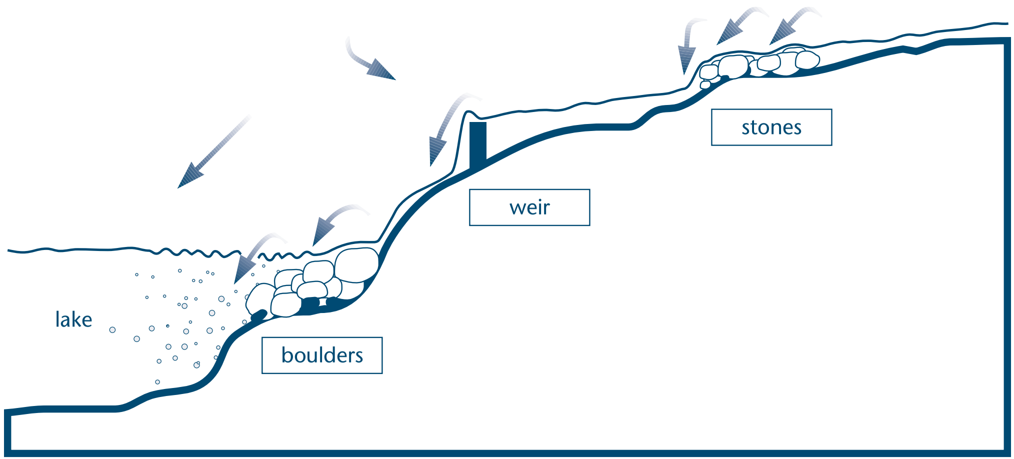
(Note: Environment Agency consent is required (i) to use seine nets, traps and electric fishing to capture fish, and (ii) to introduce fish.)

INCREASING WATER OXYGENATION

On stillwater fisheries supplied with water via feeder streams or piped supplies, it may be possible to enhance the oxygen content of the inflowing water see (Figure 2).

Aeration features on a stream-fed lake

Fig. 2



Boulders and weirs

If there is a suitable gradient on the stream, the placement of large boulders across sections of the bed should enhance turbulence and aerate the water; the erection of a low weir will serve a similar purpose. In both cases care should be taken to ensure that (i) the devices become “flooded out” during high flows, thereby preventing flooding of the adjoining land, and (ii) they do not cause undesirable scour of the stream bed or erosion of the banks. (Consent should always be sought from the Environment Agency before water channels are modified in this way.)

“Splashing”

At a fishery fed by a piped supply or by land drainage pipes that outfall above the water level, measures could be taken to “chop up” the flow and increase the splashing effect. One effective method is simply to place a pile of stones or boulders - projecting above the water surface - where the water falls into the fishery; another option is to fit a horizontal plate on the underside of the end of the pipe, thereby creating a cascade of water, rather than a single jet.

PROVIDING MECHANICAL AERATION

The routine installation of aeration devices on coarse fisheries was unusual until the 1990s, when increasing numbers of heavily stocked commercial coarse fisheries were developed. The very high fish biomass present in such waters, and the high input of anglers’ baits, predispose such waters to de-oxygenation during the summer and during periods of ice cover.

To prevent costly fish losses, various aeration devices have been installed. Most (but not all) require a convenient supply of electricity, and this renders them unsuitable for the majority of non-commercial fisheries that are owned or controlled by angling clubs, syndicates and associations. However, special propane-fuelled generators can be employed with some devices to enable them to run for many hours without refuelling.

Some of the devices are designed to operate for all or much of the year, but most fisheries` owners and occupiers deploy them in the summer and autumn months, or during “danger periods”. The better designs are cost-effective and reliable, requiring little maintenance.

In every case, however, the aerating effect is localised and it decreases away from the device. On large bodies of water it may be necessary to install and deploy several devices in different locations to achieve good aeration throughout the fishery.

The three main types of aeration device (air-injection, surface agitators and diffusers) are shown diagrammatically in Figure 3

Air-injection devices
Essentially, floating, air-injection devices mix together air (or oxygen) and water under pressure. Air is drawn into the pump, mixed with water to produce fine bubbles and delivered beneath the fishery surface as a powerful jet. The upper layers of water can be aerated quite rapidly, but deeper layers may remain unaffected. This is significant only in fisheries deeper than about two or three metres.

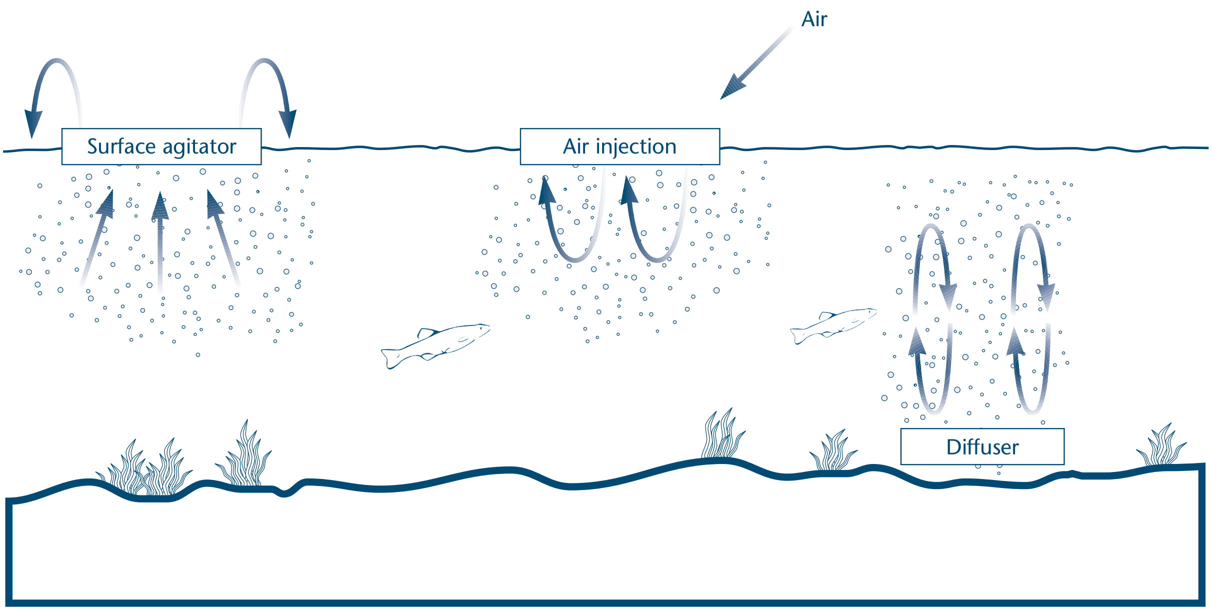
Air-injection devices can be virtually silent in operation, which can be advantageous in some situations. Some devices can be fitted with an oxygen feed via a floating pipe. Oxygen is mixed with recirculated water and injected beneath the water surface.

Most surface agitators lift or spray water into the air, causing oxygenation as the water falls back into the fishery. Whilst standard floating aerators draw water from up to 1.5 meters deep, counter-currents flowing back to the aerator can be important to circulate deeper water.

Surface agitators
As a rule of thumb, surface agitators are 50 per cent more efficient than either air-injection devices or air-diffusion methods. Furthermore, throwing water above the water surface will cool it due to loss of the latent heat of vaporisation. This can be beneficial when the water is warm, and its oxygen capacity is reduced.

Common aeration devices

Fig. 3



Surface agitators can be controlled with a time switch. As soon as they are switched on they work at 100 per cent efficiency. This is a major benefit as they can be used between dusk and dawn, the period of lowest oxygen concentrations, thereby preventing seasonal oxygen collapses.

Paddle-wheel aerators resemble miniature versions of the paddle wheels normally associated with steamers on the River Mississippi. When operational, each partly-submerged wheel turns through a vertical plane, causing the water to become aerated as the blades "chop" into the water. Water raised by the paddle then falls back into the fishery, increasing the aeration effect.

Paddle-wheel aerators can be especially beneficial for creating a wake. On larger, more efficient machines, this can be as long as 100 meters and can create discernible water movement in as much as three hectares of water. Thus, this type of machine is particularly useful in long fisheries.

Some machines are readily portable, and they can be deployed easily as and when they are required.

A floating aerator acts rather like a surface waterfall, causing the upwelling of water above the surface and its return into the fishery. In some designs (mushroom aerators) a fountain ring is formed; in others, a jet of water is created. The water deflectors around the surface-mounted or submersible motor helps break up the water jet, thereby improving oxygenation. A screen around the motor prevents fish, plants and debris being drawn into the pump. Mushroom aerators are best suited to fisheries that are approximately round or square in shape; those that create a water jet are better in long fisheries.

In fisheries that thermally stratify, fish will avoid the cooler water with low oxygen content, rendering the deeper parts of the fishery devoid of fish. There are specialised aerators that can prevent or remedy this situation. Essentially, the pump can be separated from the floating aeration mechanism by a pipe up to five meters long, so bringing cooler water to the surface. This may have an overall cooling effect on the fishery, which can be beneficial because the cooler water has a greater capacity to absorb oxygen. Nevertheless, it is better to prevent thermal stratification than cure it; there is a risk that the cooler bottom water may contain putrefaction toxins, which could harm the fish in the warmer layer. Therefore a heavily stocked fishery that is likely to thermally stratify should undergo regular artificial water circulation during spring, summer and early autumn.

Air diffusers

Compressed air, diffused through some perforated or porous membrane, can sometimes be a useful option. Most diffused aeration systems comprise a blower, which delivers air via a reinforced hose to submerged diffusers. These consist of honeycombed, ceramic stones or microporous, perforated tubes. Those made from perforated rubber are usually self-sealing when the compressed air source is switched off, but produce coarser bubbles than ceramic diffusers. If the "bubbler" is located on the bed of the fishery, oxygenation will occur as the bubbles rise to the surface. This movement stimulates the vertical circulation of water, thereby ensuring that the entire water column becomes re-oxygenated, and helps by moving water around and exposing more water to the air.

The greater the water depth, the better oxygen will be dissolved. However, greater depth requires more energy to overcome the hydrostatic head. This means that a bigger air blower, using more electricity, will be needed.

Fine bubbles provide far more efficient oxygenation than large bubbles because of their relatively greater overall surface area. Furthermore, small bubbles take longer to rise to the surface, thereby increasing the time during which oxygen can transfer to the water.

However, more energy is required to force the air through fine apertures, which also become blocked more easily. Blocking of most diffusers is inevitable through microbial overgrowth, fine particles and limescale. This process is accelerated if the diffusers remain under water and are used intermittently (for example, with a time switch). The diffusers can be cleaned in some cases, but they will need to be replaced routinely to maintain diffusion efficiency.

Self-sealing, perforated rubber membrane diffusers block less easily and are more maintenance-free, but they produce coarser bubbles, which transfer oxygen less effectively.

In remote locations, it can be easier and cheaper to run an air supply pipe than a mains electricity cable. Furthermore, diffused aeration is virtually silent in operation.

However, it is not very practical to operate diffused aerators via a time switch; when the compressor is switched off, dirty water floods the diffusers until it is driven out when the blower is re-started. With each successive flood/cycle, the diffuser becomes progressively blocked.

Emergency action

If fish are stressed due to low oxygen, they can be observed swimming close to the surface, with the tops of their mouths out of the water, continuously gulping at the water surface. Unless a pollution incident has occurred, this behaviour is most likely at or just before dawn.

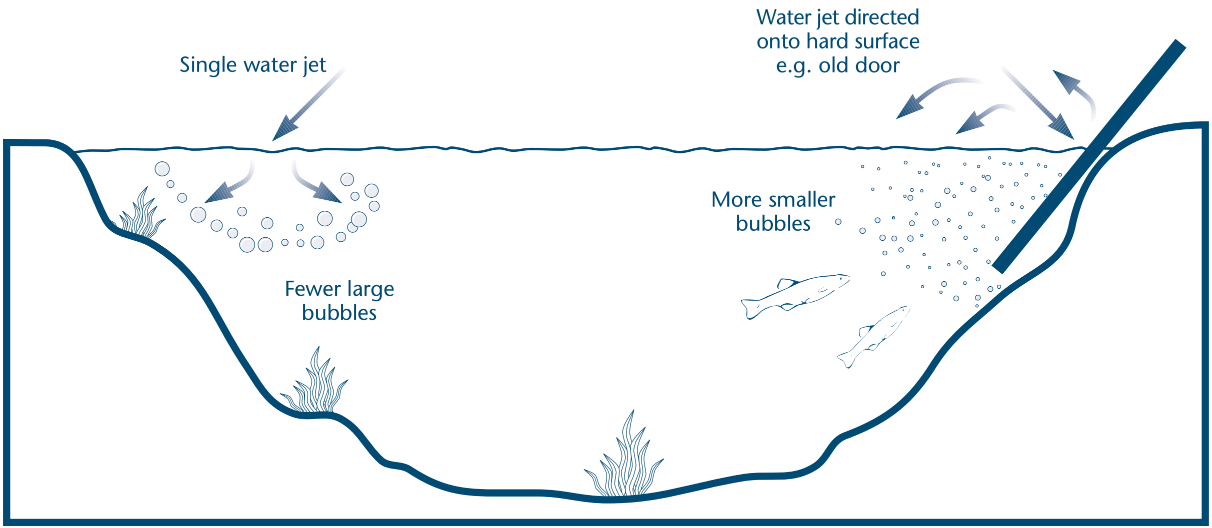
In this case, immediate action is necessary to save the fish. Contact the Environment Agency immediately on the 24-hour hotline number (see inside back cover). The Agency will provide advice and usually give practical assistance. However, in particularly busy periods (for example, during very hot, dry summers) emergency aeration equipment may already be deployed elsewhere. It is valuable to have a contingency plan in case such emergencies occur, and if specialised aeration equipment is not available, other systems may have to be deployed.

Water pumps

It may be possible to borrow or hire a water pump to help aerate fisheries affected by de-oxygenation, by re-circulating or agitating the water. Indeed, some fishery owners have purchased such pumps and suitable generators and they are retained on a stand-by basis for use in emergencies. Generally, the greater the water output, the more useful the device. Due to the inherent inefficiency of this approach, however, it may not be effective enough to deal with an oxygen collapse.

Effect of directing water jet onto a hard surface

Fig. 4



Decommissioned fire brigade pumps and generators are especially useful, though they are usually large, heavy and difficult to manoeuvre into position. Agricultural pumps are usually smaller and more portable, but the rate of water delivery will be reduced pro rata. In both cases, it will be necessary to undertake periodic re-filling of the pumps and/or generators with fuel, and 24-hour supervision may have to be maintained. Irrespective of the type and output of the pump, it is important to create small water droplets, thereby enhancing the aeration effect. Rather than simply delivering a single jet of water into the fishery, oxygenation will be far more effective if the jet is broken-up, for example, by "firing" it against an old door or sheet of corrugated iron set in the fishery margins, thereby creating a "curtain" of fine water droplets see (Figure 4).

Compressors

Air compressors are available for hire from commercial outlets, and they can help provide immediate aeration of de-oxygenated fisheries. However, because they are not usually supplied with suitable air pipes and diffusers, their effectiveness will be greatly reduced.

Unless a convenient electrical supply is available, it will be necessary to keep the generator topped up with fuel and to provide 24-hour manning when the machine is in use.

Suppliers

(Note: inclusion in this list does not imply a recommendation by the Environment Agency.)

Straw "Sausages"

The principal supplier of Christmas-tree packing and the machine that enables the straw "sausages" to be filled is:

Contemex, PO Box 94, Eastbourne Road, Uckfield,
East Sussex TN22 5Y2.
Tel: 01825 766135.

Aeration devices

Suppliers of aeration devices include: -

Aquaculture Engineering Ltd., 9 Hollowfield, Norden, Rochdale OL11 5NY.
Tel: 01706 359944/715550.
Fax: 01706 658130.

Aqua-Med Ltd., 14 Boxhill Way, Strood Green, Brockham, Betchworth RH3 7HY.
Tel: 01737 842921.
Fax 01737 842062.

Dryden Aquaculture Ltd., Butlerfield (Newtongrange), Bonnyrigg, Edingburgh EH19 3JO.
Tel: 0187 582 2222.
Fax: 0187 582 2229.

Spirex Aquatec, Bradley Green, Redditch B96 6TE.
Tel: 01527 821601.
Fax: 01527 821704.

Further reading

Aquatic weed Control, by C. Seagrave. Published by Fishing News Books Ltd, 1988.

Control of algae using Straw (Information Sheet 3). Available free from: Jonathan Newman, IACR Centre for Aquatic Plant Management, Broadmoor Lane, Sonning, Reading RG4 6 TH.
Tel: 0118 969 0072.
Fax: 0118 944 1730.

Desilting stillwaters. Published by the Environment Agency. Free from EA Fishing News Books Ltd, 1995.

Water plants - their function and management'. Published by the Environment Agency. Free from EA regional offices.

CONTACTS:

THE ENVIRONMENT AGENCY HEAD OFFICE

Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol BS32 4UD.
Tel: 01454 624 400 Fax: 01454 624 409

www.environment-agency.gov.uk
www.environment-agency.wales.gov.uk

ENVIRONMENT AGENCY REGIONAL OFFICES

ANGLIAN
Kingfisher House
Goldhay Way
Orton Goldhay
Peterborough PE2 5ZR
Tel: 01733 371 811
Fax: 01733 231 840

MIDLANDS
Sapphire East
550 Streetsbrook Road
Solihull B91 1QT
Tel: 0121 711 2324
Fax: 0121 711 5824

NORTH EAST
Rivers House
21 Park Square South
Leeds LS1 2QG
Tel: 0113 244 0191
Fax: 0113 246 1889

NORTH WEST
Richard Fairclough House
Knutsford Road
Warrington WA4 1HG
Tel: 01925 653 999
Fax: 01925 415 961

SOUTHERN
Guildbourne House
Chatsworth Road
Worthing
West Sussex BN11 1LD
Tel: 01903 832 000
Fax: 01903 821 832

SOUTH WEST
Manley House
Kestrel Way
Exeter EX2 7LQ
Tel: 01392 444 000
Fax: 01392 444 238

THAMES
Kings Meadow House
Kings Meadow Road
Reading RG1 8DQ
Tel: 0118 953 5000
Fax: 0118 950 0388

WALES
Rivers House/Plas-yr-Afon
St Mellons Business Park
St Mellons
Cardiff CF3 0EY
Tel: 029 2077 0088
Fax: 029 2079 8555

ENVIRONMENT AGENCY GENERAL ENQUIRY LINE

0845 933 3111

ENVIRONMENT AGENCY FLOODLINE

0845 988 1188

ENVIRONMENT AGENCY EMERGENCY HOTLINE

0800 80 70 60

ENVIRONMENT AGENCY

HO-3/2000-10k-CI-BFCK Printed on Cyclus Print