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Fact sheet

Use of Oxygen Readings to Avoid Gas Bubble Disease in Clam Hatcheries

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The major gases in air and water are nitrogen (78%) and oxygen (21%). It is obvious that bay water contains oxygen, because if it didn't phytoplankton, shellfish and fish couldn't live there. Everyone has seen summer fish kills from insufficient oxygen, or suffocated clams under dense piles of seaweed. These organisms, like humans, need oxygen to carry on the normal functions; however, water of different temperature, salinity and pressure holds differing amounts of oxygen and other gases called air. Too high a concentration of gas or too low a concentration can cause organism to die. When the concentration of a gas, like oxygen, is the exact amount the water can hold for the pressure, temperature, and salinity; the water is considered "saturated". When there is more gas than the water can hold, it is "supersaturated", if there is less it is "undersaturated". Pressure can increase the amount of gas per unit volume water contains. Thus the deeper the water the more gas the water can contain. Water at higher temperature holds less gas per unit volume because it is less dense. The higher the salinity the less gas water can hold because the dissolved salt takes up room the gas could be using.

As a general rule of thumb, if oxygen levels in the water fall below 5 mg/L you need to aerate the water. Oxygen moderately above saturation in water is not a problem because organisms use oxygen to breathe. The gas that causes most problems is nitrogen, because nitrogen is the dominant gas in air and water, and it is not metabolized by the shellfish. Nitrogen, like oxygen, enters the organism through the gills, and then is carried to the tissues by the blood. Once distributed, nitrogen remains in the tissue while oxygen is used up. If nitrogen enters the tissue in a supersaturated condition and accumulates, it will respond by coming out of solution into the organism in the form of bubbles. Divers call these bubbles the bends, in shellfish it is called gas bubble disease.

There are two conditions that commonly cause gas supersaturation of water in aquaculture systems.

1. The suction line or the pump seals have a small leak. Because the pump is creating a suction in order to move the water, air can be sucked into the water as it passes the leak and it is forced into solution as the water is pressurized by the pump.

2. Many clam hatcheries are located near shallow bays that can change temperature rapidly. Cold water holds more gas than warm water. If temperatures rise quickly, the amount of gas the water can hold will go down (the water becomes supersaturated with gas). The problem at most aquaculture facilities is that intakes are situated near the

bay bottom in several feet (or more) of water. At these depths the gas is under pressure related to water depth, but the aquaculturist pumps the water into a shal low container, upweller, raceway etc. This release of water pressure causes additional supersaturation. This is similar to the "fizz" of bubbles that is caused by opening a soda bottle.

The simplest way to **prevent this problem** is to bounce, splash, or cascade the water through air before it reaches the animals. The bouncing allows the water to release the gas and approach equilibrium with the atmosphere. A second advantage to this process is that it also allows oxygen to enter the water if oxygen levels are below saturation. This should be a standard practice in all shellfish setting and nursery systems so that the probability of gas bubble disease is reduced.

Hard clam culturists are fortunate in that *Mercenaria* has been shown not to be susceptible to gas supersaturation up to about 109% (Bisker and Castagna, 1985). At 115% of saturation level, clams did not grow, and other clam species died at 108% and 114% of saturation. It is important to realize that these experiments were done with 5 mm or larger seed. There is no information on smaller seed so we can only presume that they behave similarly, and keep gas levels below 105%.

If you routinely measure oxygen, temperature and salinity in your system, oxygen levels can be used as a tracer of nitrogen. Oxygen can be used because all dissolved gasses behave as if no other gas was present; usually, if oxygen is low nitrogen will be low. THIS IS ONLY AN APPROXIMATION- since oxygen levels, unlike nitrogen levels, can vary due to biological activity. For instance, before sunup oxygen readings may indicate undersaturation (because all organisms including phytoplankton use oxygen at night) then, if there is a large phytoplankton bloom, in mid afternoon oxygen levels may be supersaturated (because the phytoplankton, through photosynthesis, produce more oxygen than they consume). If either undersaturation or supersatuation is common in your system, consider installing passive means of aeration and degassing.

In the few experiments that have been conducted on bivalves, the percent of saturation of nitrogen in the water was slightly higher than the percent oxygen saturation. **Table 1.** approximates the level of oxygen at saturated and 110% saturated conditions at various temperatures and a salinity of 25, 30 and 32 ppt. If you have already installed some method of degassing the water throughout your facility and your oxygen readings reach the 110% levels listed in the table, you should consider taking some additional action to degas the water. If you have dying animals and supersaturation does not appear to be the problem please contact your shellfish specialist at the University or local extension agent. They may also be able to supply a list of companies who sell oxygen testing equipment or meters.

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Literature

Bisker, R. and M. Castagna. 1985. The effect of various levels of air-supersaturated seawater on *Mercenaria mercenaria* (Linne), *Mulinia lateralis* (Say) and *Mya arenaria* Linne, with special reference to gas-bubble disease. J. Shellfish Res. 5: 97-102

Colt, J. 1984. Computation of dissolved gas concentrations in water as functions of temperature, salinity and pressure. Amer. Fish Soc. Spec. Publ. 14. 154 pp.

Table 1. Oxygen saturation at 25, 30 and 32 ppt salinity and various temperatures. The columns entitled 110% saturation provide the oxygen values for 110% oxygen saturation at 25, 30 and 32 ppt salinity. If your DO meter reads in this range at the salinity and temperature combination you should 1. Check the meter, temperature and salinity. 2. Find some way to degas the water. If oxygen levels fall below 5 mg/L you need to aerate the water.

Salinity						
Temperature Degrees C	25ppt Oxygen	30ppt Saturation	32ppt	25ppt	30ppt 110% Saturation	32ppt
5	10.82	10.47	10.33	11.90	11.52	11.36
6	10.56	10.22	10.09	11.62	11.24	11.10
7	10.31	9.98	9.85	11.34	10.98	10.84
8	10.07	9.75	9.63	11.08	0.73	10.59
9	9.84	9.53	9.41	10.82	10.48	10.35
10	9.62	9.32	9.20	10.58	10.25	10.12
11	9.41	9.12	9.00	10.35	10.03	9.90
12	9.21	8.92	8.74	10.13	9.81	9.61
13	9.01	8.74	8.63	9.91	9.61	9.49
14	8.82	8.56	8.45	9.70	9.42	9.30
15	8.64	8.38	8.28	9.51	9.22	9.11
16	8.47	8.21	8.12	9.31	9.03	8.93
17	8.30	8.05	7.96	9.13	8.86	8.76
18	8.14	7.91	7.80	8.95	8.70	8.58
19	7.98	7.75	7.66	8.78	8.53	8.43
20	7.83	7.60	7.49	8.61	8.36	8.24
21	7.69	7.46	7.38	8.45	8.21	8.12
22	7.55	7.33	7.24	8.30	8.06	7.96
23	7.41	7.20	7.12	8.15	7.92	7.83
24	7.28	7.07	6.99	8.00	7.78	7.69
25	7.15	6.95	6.87	7.87	7.65	7.56
26	7.03	6.83	6.76	7.73	7.51	7.44
27	6.91	6.72	6.64	7.60	7.39	7.30
28	6.79	6.61	6.53	7.47	7.27	7.18

Daily Environment **Month of ________________**

Date	Air Temp	Water Temp	Sal. %	D.O.	Wind Speed	Wind Direction	Observations (Rain, Tide, Etc.)

This sheet can be photocopied and used to collect environmental data for use in determining if the situation exists for gas bubble disease.

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