INSTITUTE FOR FISHERIES RESEARCH

Report No. 129

ON PENETRATION OF OXYGEN THROUGH WALLS OF "STAY-ALIVE MINNOW BUCKETS"

In September, 1930, the Institute for Fisheries Research undertook a series of experiments designed to determine the advantages of the "Stay-Alive Minnow Buckets" and "Stay-Alive Transportation Buckets" (the larger sizes are so known), and the reason for these advantages.

The experiments were undertaken in cooperation with the Shakespeare Company of Kalamazoo, manufacturers of the buckets, who kindly provided the Institute with a supply of buckets and cores for these and similar experiments.

In a considerable use of these buckets under a variety of wide conditions we have found them very satisfactory, holding fish alive very well either on standing or in transportation. Even on rather heavy overloading, we have often found the losses to be small.

A first point to test, to determine why these pulp cores contribute to the continued life of fish crowded in the buckets, was whether oxygen does or does not penetrate through the core walls. This task was first thought to be easy, but a long series of experiments was required before we discovered how to seal the surface of the water against direct oxygen absorption. Just one of these preliminary experiments is cited in illustration. Three cores were filled to the very top, covered with glass and the crack between glass and core sealed as well as possible. One core was twice painted to prevent air passing through the core; another core was heavily covered with a sealing mixture of beeswax and petrolatum; the third core was untreated. These three cores were then filled with water of low oxygen content (3.2 parts per million). The rise in the oxygen content of the water is shown in Graph 1.

Oxygen somehow penetrated into all. The untreated core gained most, indicating some penetration of oxygen through the core. But due to the increase in oxygen in all the containers, the experiment was deemed not sharply conclusive.

The difficulty of excluding oxygen from oxygen-free or oxygen-low water by any ordinary seals proved great, and required a long search to find a usable means by to this end, which was necessary to the proper carrying out of the experiment. We found oxygen would be pulled in through or around rubber gaskets. Various sorts of covers, of glass, of flexible celloidin, etc., failed.

Incidently these preliminary experiments indicate a probable solution to one query from the manufacturers, regarding the amount of ventilation around the cores. Since oxygen is so difficult to exclude from water having an oxygen deficiency, slight differences in the amount of oxygen circulating around the core probably have little affect on the amount penetrating through the core. The only way in which we would suppose that an increase in the amount of perforation of the metal bucket would be advantageous, would be in allowing the core to dry more quickly if wet.

After many unsuccessful trials with various seals - glass, celloidin, light oils, etc., it was found that about a one-inch layer of ordinary heavy machine oil was suited to the purpose of sealing the surface of the water against oxygen absorption. Unlike the lighter oils, as medicinal mineral oils, etc., the heavy machine oil allows very little oxygen to penetrate through it. And of course it rises and falls with slight changes in the volume of the water, thus not tending to pull in air as when solid covers were used.

We were now finally prepared to undertake an experiment to answer the doubtful question regarding oxygen penetration through the cores of the Stay Alive buckets. In this experiment we used 6 containers:

(1) Two battery jars shaped roughly like the Buckets, one 9" in diameter and

one 9" in diameter. These were both covered with oil, to determine how much oxygen passed through the oil cover.

(2) A 7" battery jar without oil cover, to determine how fast oxygen was absorbed through the exposed surface only.

(3) Cores of Minnow Buckets with oil covers, to determine whether oxygen penetrates through the cores. Two types of cores made by different companies, were used, one blue and one green.

(4) One core (blue) and without any treatment, to determine rate of oxygen absorption through both surface and walls. This simulates natural use, when the bucket is allowed to stand.

The results of the experiment are shown as Graph 2, and in Table 1.

PRECAUTIONS USED IN EXPERIMENTS

Before discussing these results in detail it is well to place on record the precautions which were taken to insure that the initial water should have no oxygen and should contain no oxygen-consuming substances. It is obvious that if the oxygen were being consumed in the water, we could get no easy measure of the oxygen increment. Even distilled water consumes oxygen. So the distilled water was treated with weak acid (later neutralized) and potassium permanganate to destroy the residual traces of putrescible organic matter and bacteria. To make doubly sure of sterialization the water was then made up into a 1:2000 solution of $HgCl_2$ (corrosive sublimate). Thus a water was obtained which could be relied upon to give consistent results unimpaired by bacterial action. First of all the distilled water was boiled, to remove the oxygen, then cooled to room temperature under an atmosphere of CO_2, to prevent practically all oxygen absorption during the cooling.

As further safeguards to insure comparable results, the buckets were supported slightly above the table to insure passage of air below, and all buckets and jars were rimmed with celloidin for 3½ inches down from the top on the inside.

Analyses were made by the Standard Rydell-Stuart method, with the elimination of

course of the first two steps, designed to destroy organic matter.

RESULTS

A study of Graph 2 (or Table 1; same data) will show several points of interest.

The water in the oil-covered glass battery jars (curves 1 and 2) gained only about 1.0 part per million of oxygen in two whole days, showing the surface seal adopted to be very effective.

The water in the glass battery jar without oil cover (curve 3), gained oxygen slowly: in over an hour it had less than .5 p.p.m.; in six hours, less than 2 p.p.m.; in just 12 hours, about 2.3 p.p.m.; in nearly 24 hours, about 4 p.p.m.; in 27½ hours, about 5 parts, in nearly 33 hours, about 6 parts. This water in this jar required nearly 50 hours to obtain an amount of dissolved oxygen approaching the saturation point. Clearly, surface aeration alone is not sufficient.

The water in the two cores with floating oil covers (curves 4 and 5) gained oxygen approximately twice as fast as the essentially similar glass container without oil cover. This indicates that under indoor standing conditions the oxygen penetration through the core is much greater than through the exposed surface of the water.

Naturally, the water in the untreated and uncovered core, free to absorb oxygen--both through the core and through the surface (curve 6), gained oxygen a little faster than either core with oil cover.

Our general conclusion is that the rapid penetration of oxygen through the core of the Stay-Alive Buckets is the chief reason for the success which has accompanied their use.

Of the two types of core submitted, the green core in the one test showed up slightly better than the blue core.

FURTHER EXPERIMENTS SUGGESTED

We had in mind running some additional experiments but decrease in funds and personnel, and illness, have prevented carrying these out to date.

It would appear to us desirable to learn how fast oxygen is absorbed through the exposed surface and through the core when the buckets and jars are agitated, somewhat as they would be in transportation. This experiment has been laid out in plan, but not carried out as yet.

It would also be desirable to learn how the oxygen will change when the various experiment jars are each supplied with the same weight of fish of a given species. It was planned to carry this experiment through under two temperatures, one for a pond fish (bass or sunfish) and one for brook trout.

Still further experiments to determine the importance of many holes in the metal buckets were considered at the suggestion of the Shakespeare Company. These experiments also need to be postponed.

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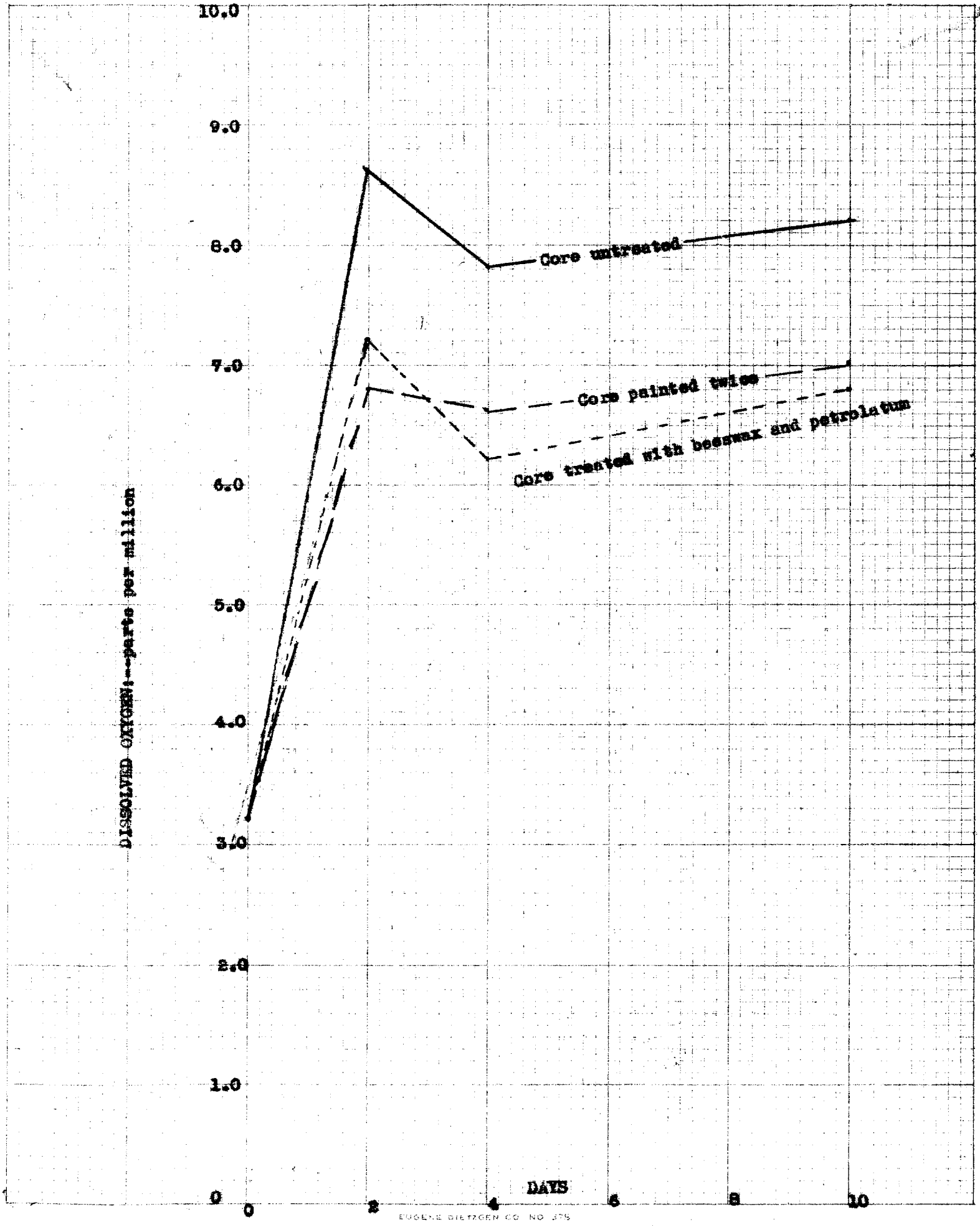
Table 1. Oxygen analyses (in parts per million) in experiment to determine whether oxygen penetrates through the walls of Stay-Alive Buckets.

Kind of jar:	battery jar	battery jar	battery jar	Blue core	Green core	Blue core
Inside diameter:	7"	9"	7"	8"	8"	8"
Kind of cover:	oil cover	oil cover	no cover	oil cover	oil cover	no cover
Corresponding curve No. on Graph 2:	1	2	3	4	5	6
Hours and Minutes after start of Exp.						
0:00	-	-	-	0.80	0.68	0.68
0:05	0.06	0.06	-	-	-	-
0:15	-	-	0.10	-	-	-
1:15	-	-	0.48	-	-	-
2:00	-	-	-	1.60	-	-
2:35	-	0.10	-	-	-	-
3:00	0.16	-	-	-	[illegible]	4.56
3:20	-	-	-	-	3.48	-
6:05	-	-	1.96	-	-	-
6:50	-	-	-	4.36	-	-
8:10	-	-	-	-	-	8.10
8:30	-	-	-	-	6.00	-
12:00	-	-	2.32	-	-	-
12:45	-	-	-	6.88	-	-
23:15	-	-	4.04	-	-	-
23:55	-	0.80	-	-	-	-
24:00	-	-	-	8.28	-	-
24:20	0.60	-	-	-	-	-
25:10	-	-	-	-	-	9.60
25:30	-	-	-	-	8.86	-
27:35	-	-	5.04	-	-	-
28:20	-	-	-	8.86	-	-
30:00	-	0.68	-	-	-	-
30:25	0.44	-	-	-	-	-
32:45	-	-	5.94	-	-	-
33:30	-	-	-	8.70	-	-
47:15	-	1.20	-	-	-	-
47:40	0.96	-	-	-	-	-
49:45	-	-	8:86	-	-	-
50:30	-	-	-	9.60	-	-

Graph 1. Increase in dissolved oxygen in experimental buckets and jars: preliminary experiment, with imperfect surface seal, etc.



Graph 2. Increase in dissolved oxygen in experimental buckets and jars: final experiment.