At East and West Wallabis many tammar were seen. These little wallabies appeared to be in very good condition and were fairly tame, suggesting that there has been very little, if any, interference with them. As these tammar are an insular sub-species, it is most important that they should be left undisturbed for scientific study.

Three different varieties of lizards, and a carpet snake over six feet long, were also seen on West Wallabi.

ABNORMAL FISH MORTALITY IN SWAN RIVER BASIN IN APRIL, 1955

by Athol Middleton, B.Sc.*

(1) Introduction

During April 1955 three separate outbreaks of fish mortality in the upper reaches of the Swan River were reported. The Hydrology Section of C.S.I.R.O. Division of Fisheries, Perth, was requested to investigate and, if possible, determine the cause of these phenomena.

The results of the investigation yielded fairly strong support to the hypothesis that these fish died of oxygen deficiency due to their environment becoming contaminated with oxygen-deficient water, this oxygen-deficient water being derived from the deeper parts of the basin by "upwelling", which was most likely caused by tidal pressure.

The areas affected and dates of investigation were as follows -

(1). Bull Creek (Canning River), mainly on the western side - April 1, 1955.

(2) Perth Water, from the Royal Flying Squadron to the Mill Street drain, with particular concentration in the vicinity of the P.W.D. Harbours and Rivers Jetty - April 8, 1955.

(3) Como Beach at the foot of Thelma Street - April 21, 1955.

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* An officer of the hydrological section, Division of Fisheries, C.S.I.R.O.

The fish which suffered were the same in the three cases, and consisted of such species as Flathead (Platycephalus), Whiting (Sillago), Flounder (Pseudorhombus), Goby (Glossogobius), Trumpeter (Helotes) and Cobbler (Cnidoglanis), which are mostly bottom feeding types.

Fish which were seen in difficulties in the affected areas were floating or swimming feebly head uppermost near the surface, and were constantly gulping with the gills wide open. The fish were apparently uninjured, but the gill surfaces were quite purple in colour.

An examination of specimens by a pathologist of the Animal Health and Nutrition Laboratories, and by Dr. K. Sheard of the C.S.I.R.O. Division of Fisheries, showed no discernible diseased condition or harmful organism.

Unfortunately in the cases of Bull Creek and Como Beach the hydrological investigations were, of necessity, made after the fish had died and only in the case of Perth Water were samples collected while fish were dying. Hence the following argument can be applied with a reasonable degree of certainty only to the Perth Water phenomenon. There is, however, evidence to suggest that all three occurrences were caused by similar circumstances. That is, they all occurred either immediately prior to, or during, periods of unsettled weather conditions; in other words, at times when considerable barometric changes were occurring, and as will be shown later, the barometric conditions markedly affect the tidal behaviour of the river.

(2) Hydrological Conditions

In order to be able to understand the suggested cause of the mortalities, some elementary knowledge of the hydrological conditions obtaining in the "basin" during a typical winter period is necessary. We define the term "basin" as that part of the river lying between the Narrows and the Fremantle Traffic Bridge.

After the onset of the winter rains, usually about the middle of June, a freshwater discharge commences to flow down the Swan-Avon River system. This discharge-water is usually appreciably cooler and contains much less salt than the marine water which is occupying the basin at this time. It is therefore less dense than the basin water, and it forms a layer over the surface when it reaches the basin. The depth of this freshwater layer is dependent on the severity of the runoff, being deepest when the runoff is most intense.

The contour of the basin is such that it is shallower at either end than in the middle, and consequently when the freshwater layer reaches a certain critical depth it effectively isolates the deeper basin waters from the sea. When thus isolated, the circulation in the deeper waters is impeded and they become stagnant. Their oxygen content steadily decreases, and the phosphate and nitrate content increases until, if the stagnation period is sufficiently prolonged, the oxygen content of the isolated basin waters may reach zero. In other words, there may come a time when certain volumes of basin water contain no dissolved oxygen at all and are consequently uninhabitable by aerobic organisms, i.e., organisms which need oxygen for their growth.

As the intensity of the runoff diminishes, the thickness of the surface freshwater layer also decreases until it no longer isolates the basin from the sea. At this stage dominantly marine water spills over the sill at the seaward end and penetrates the estuary along the bottom. This marine element can be identified by its high oxygen and low phosphate and nitrate content.

In the deeper waters at the seaward end of the basin this spillover is apparently quite energetic, and it mixes quite considerably with the stagnant basin waters. However, as it starts to creep up the slope* towards the upstream end of the estuary the mixing occurs to a lesser extent and pockets of the stagnant water may remain in the vicinity of Applecross for some considerable time.

Apart from the continual and constant penetration of marine water along the bottom, the whole of

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* *Vide* note on pp. 122 - 124 of July, 1955, Bulletin.

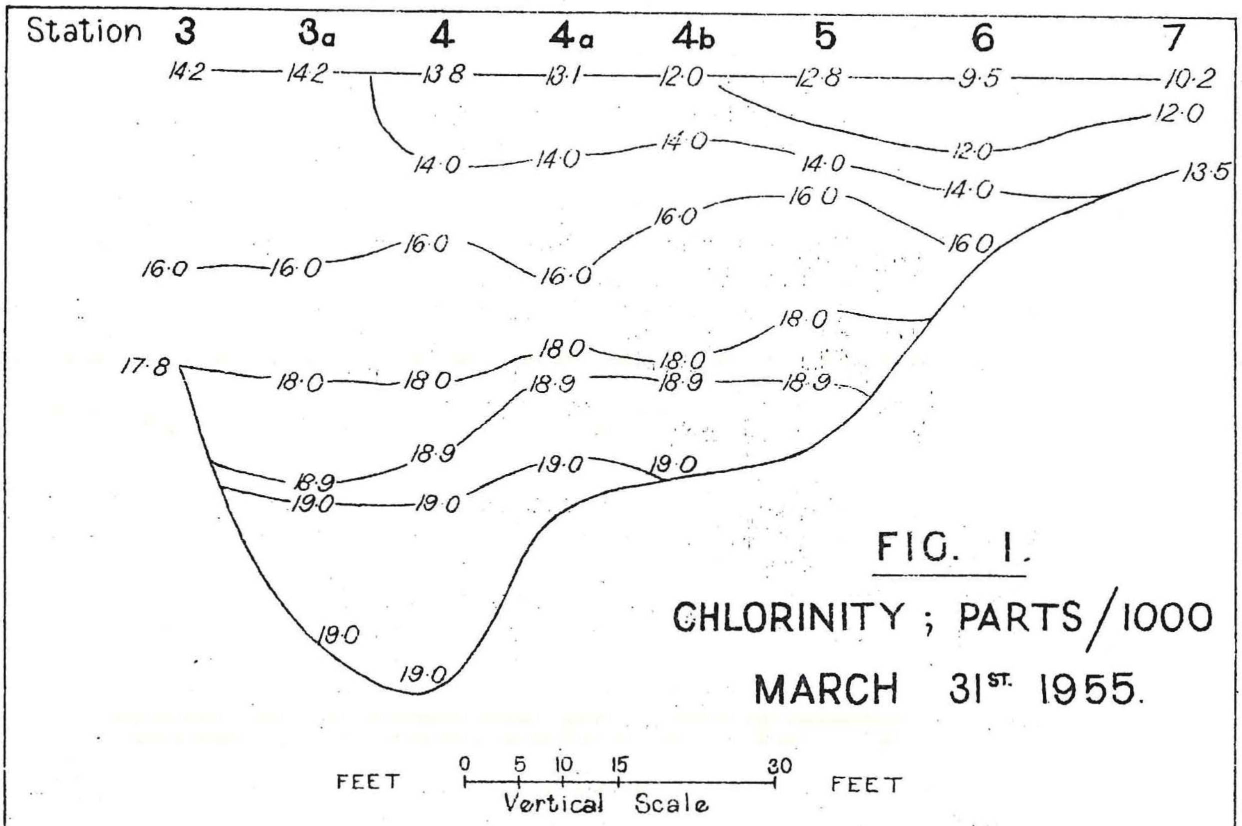


FIG. 1.

CHLORINITY ; PARTS/1000

MARCH 31ST. 1955.

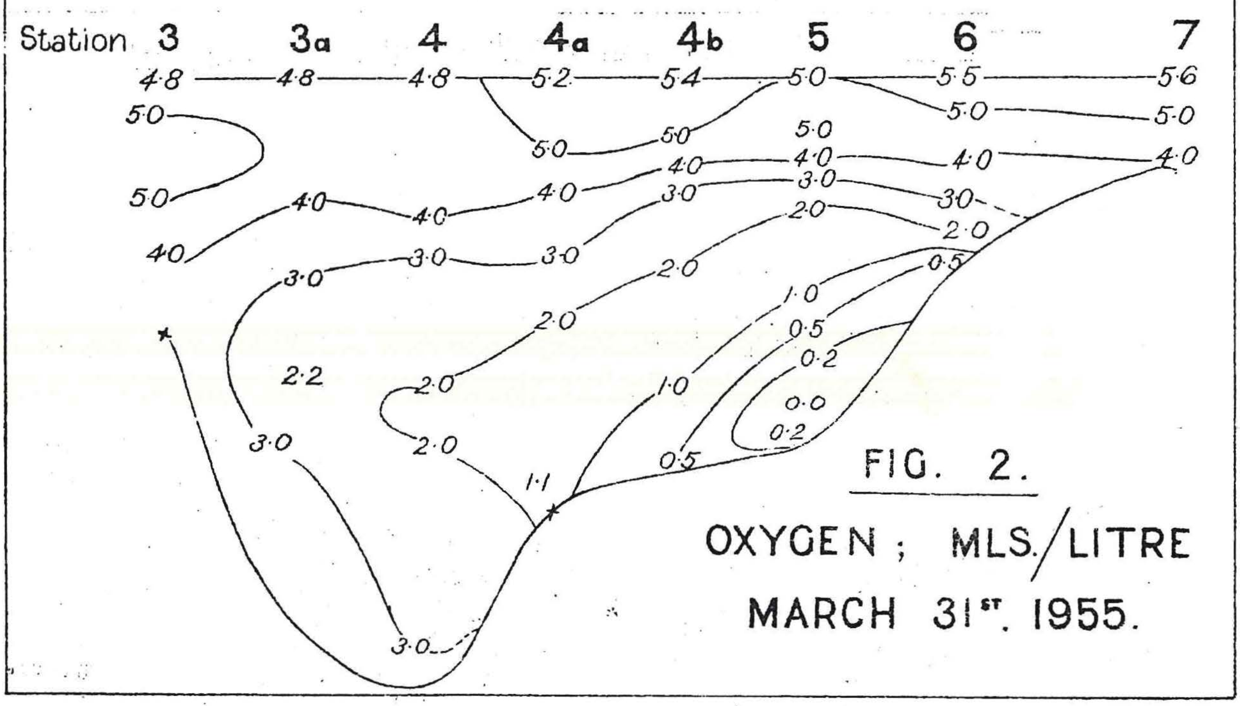


FIG. 2.

OXYGEN ; MLS./LITRE

MARCH 31ST. 1955.

the basin waters oscillate back and forth under the influence of tidal pressure. This tidal pressure under conditions of high tide will tend to force the stagnant waters farther upstream, and since the basin becomes progressively shallower they will be compelled to occupy a position at some lesser depth than their normal. That is, the stagnant or oxygen-deficient waters are forced nearer the surface in the upper reaches as the tide rises, and vice versa.

This is a highly simplified picture of the conditions obtaining in the estuary under stratified or winter conditions, but will be sufficient to illustrate the point in question.

(3) February Flood Conditions

The cyclonic depression centred off Onslow during the week beginning February 14, 1955, caused very considerable general rainfall over the southern half of the State, and resulted in a most unseasonable and intensive freshwater discharge down the Swan-Avon River system. This discharge in terms of winter flooding was of short duration, but was of sufficient length to set up a typically winter condition of stratification in the estuary.

Figures 1 and 2 show the chlorinity and oxygen distribution in the basin on March 31, 1955. From Figure 2 it can be seen that the oxygen tension is zero at a depth of approximately 35 feet at Station 5, and that until we go downstream as far as Station 3a all the water below a depth of approximately 12 feet has an oxygen tension of 3 millilitres per litre or less. An oxygen tension of 3 ml./litre represents the lower limit for the comfortable existence of most fish.

From Figure 1 it can be seen that water of chlorinity 19.0 parts per 1000 has penetrated along the bottom as far as Station 4b, and that there is no water of chlorinity 14.0 parts per 1000 above a depth of 13 feet at Station 6.

Figures 3 and 4 show the chlorinity and oxygen distribution in the basin on April 5, 1955. From Figure 4 it can be seen that the volume of water with oxygen tension below 3.0 mls/litre had

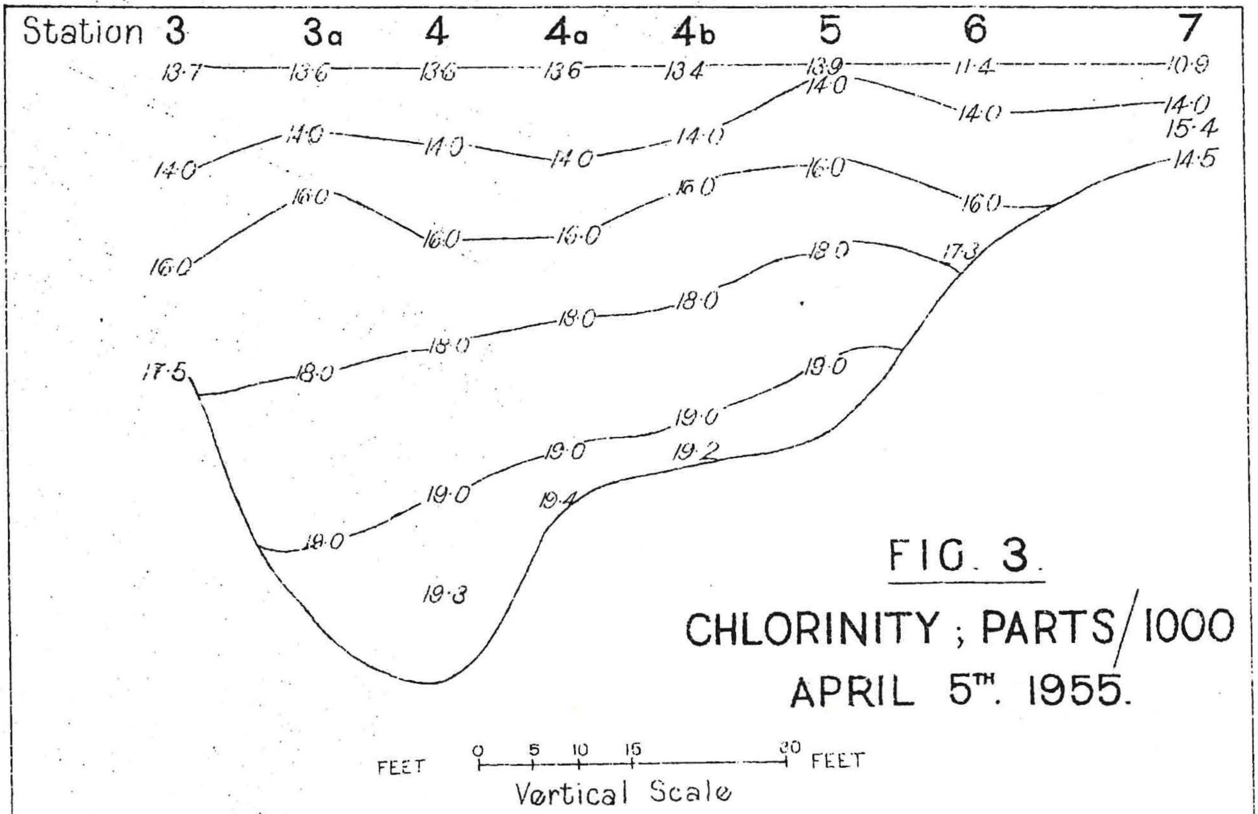


FIG. 3.

CHLORINITY ; PARTS/1000

APRIL 5TH. 1955.

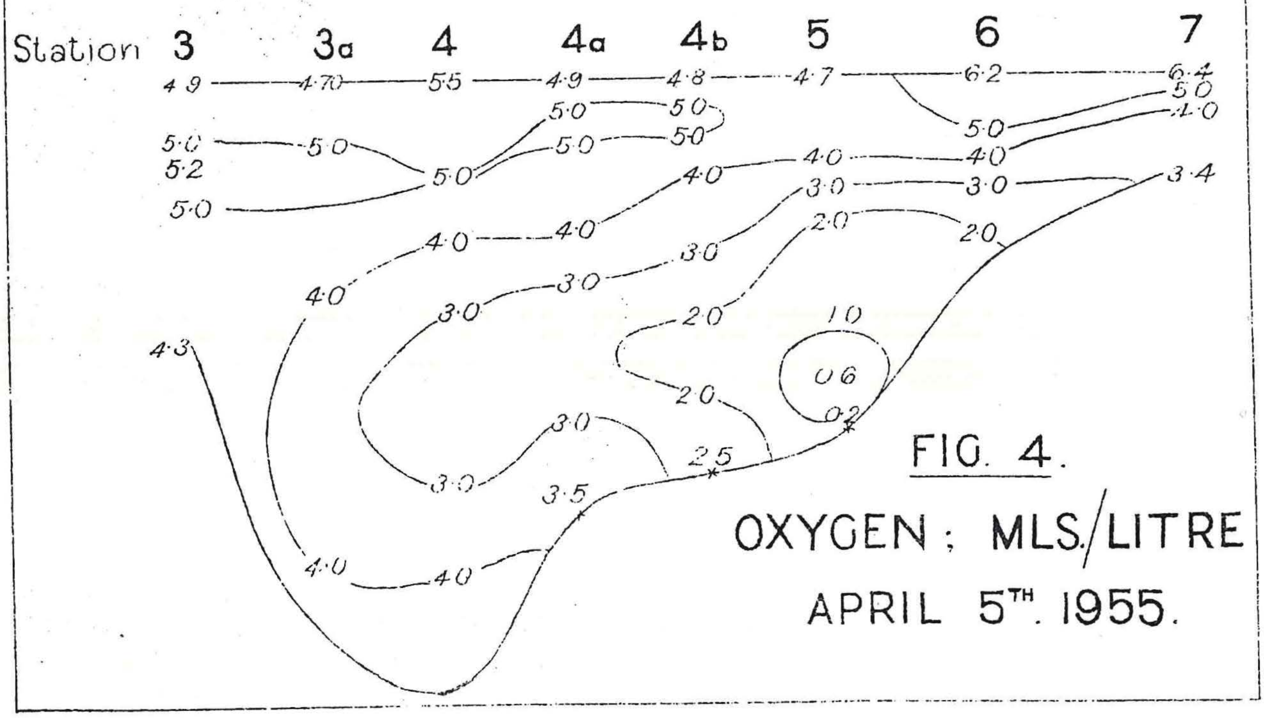


FIG. 4.

OXYGEN ; MLS./LITRE

APRIL 5TH. 1955.

decreased considerably due to mixing with the oxygen-rich marine water, and that the 3.0 and 4.0 mls/litre lines have been forced nearer to the surface at Stations 6 and 7.

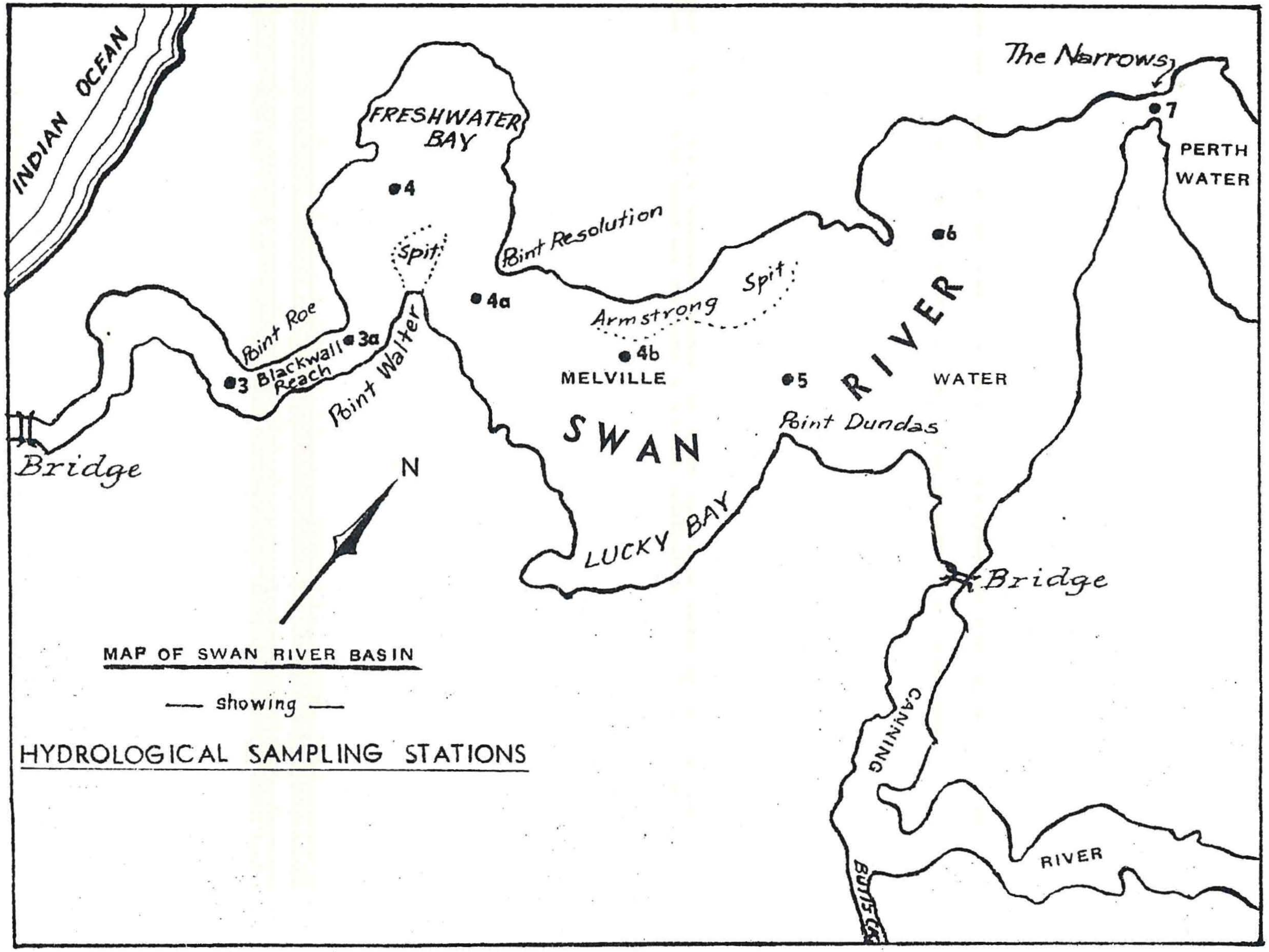
The bottom penetration of marine water is even better illustrated in Figure 3, from which it can be seen that water of chlorinity 19.0 has penetrated upstream past Station 5, and that the 14.0 chlorinity line has risen to a depth of less than 7 feet at Station 6 and is now as far upstream as Station 7. Further, there is now water of chlorinity 15.5 at Station 7, whereas 5 days previously on March 31, the highest chlorinity at Station 7 was only 13.5.

Figures 3 and 4 give a picture of the estuary as it was on April 5, 1955, three days before the major outbreak of fish mortality in Perth Water. From April 5 the tide height steadily increased due to a falling barometer, until on April 8 the tide height, as recorded by the P.W.D. tide machine at Mill Street, was the maximum for April.

As previously stated, an increase in tide height means an upstream movement of the basin waters as a whole and a consequent raising of the lower waters to nearer the surface as the water depth decreases.

With the water distribution in the basin as it was on April 5, the progressively increasing water level apparently caused some of the desaturated waters to be forced up into Perth Water where the depth is such that the low-oxygen, high-salinity waters actually appeared at the surface. Samples collected on April 7 off the P.W.D. jetty at the foot of Mill Street, where the depth is only 3½ feet, had salinities of 18.0 parts/1000 and oxygen tensions of 0.7 mls/litre.

From the diagrams it can be seen that the surface chlorinity steadily decreases and the oxygen tension steadily increases as we proceed upstream. Moreover, the surface salinity and oxygen at Station 7 on April 5 were 10.9 and 6.4 respectively. But the Perth Water figures on April 7 were 18.0 and 0.7 respectively, which means that this water must have been derived from a point downstream of Station 7.



MAP OF SWAN RIVER BASIN

— showing —

HYDROLOGICAL SAMPLING STATIONS

The salinity-oxygen ratio suggests that this water originated from a depth of about 23 feet, possibly at Station 5, and was pushed upstream by tidal pressure.

(4) Discussion

The possibility that this oxygen deficient water may have been derived from some discharge into the river was not overlooked, and as the notorious Mill Street drain was adjacent to the affected areas its discharge was analysed. The discharge was found to have an oxygen tension of zero and a salinity of 4 parts/1000. If the low oxygen tension inthe adjacent waters was due to dilution by this discharge, we would also expect the salinity to be lowered accordingly. As we have seen this is not the case; in fact the salinity is much higher than we would expect and hence the possibility of contamination from the drain must be ruled out. Furthermore, in the case of the Bull Creek and Como phenomena, no drains enter the river at or near the affected areas, and hence the effect of drain discharge must be ruled out.

(5) Conclusion

To conclude, we may say, on the basis of the somewhat limited evidence at our disposal, that the abnormal fish mortality outbreaks referred to herein were most probably caused by their environment becoming temporarily contaminated with oxygen-deficient water derived from the deeper parts of the basin, this water being forced upstream by tidal pressure most likely associated with low barometric pressures.

This report is of necessity brief and the analytical data, tidal records, etc., will not be included. A list of the hydrological sampling stations is however necessary and is included as an appendix. Their approximate locations are shown on the accompanying sketch map.

(6) Appendix

Station	Location	Depth
3	In channel off Point Roe (Billygoat Farm).	30 feet
3a	In channel at north-east end of Blackwall Reach.	60 "
4	In channel off Point Walter Spit.	66 "
4a	In channel off Point Resolution.	45 "
4b	In channel off Armstrong Spit.	43 "
5	In channel off Point Dundas.	40 "
6	In channel off Knot Spit.	20 "
7	The Narrows.	10 "