adults have been caught several times. As a result we can say that the number of feathers is twelve or ten. The outer two feathers are always white but there may be up to ten coloured feathers. There are often variegated feathers (one or two each side) separating the whites from the all-blacks. The 4-4-4 arrangement does not indicate a very mature bird; birds showing this pattern one season have been found to revert to ten feathers the next with all three types of feather showing.

We have not yet enough records to venture an estimate as to how long a gannet may live. We have several ringed birds that we know are at least twelve years old. The mortality rate among chicks is so high, and breeding seems to begin so late, that it seems likely that a pair may be twenty years old before they have succeeded in raising two breeding adults to replace themselves. Our most complete record is of a pair which raised a chick the first season, had a sturdy chick the second (but it had its neck broken in a landing accident), and did not occupy the nest the third. The fourth season the hen turned up alone and laid an egg in the same nest. After she had sat on it for over three months I found it was infertile. The fifth season she brought a new husband to the same nest and they hatched an egg but the chick died after a few weeks. Last season they succeeded in raising a chick but this season, at our last visit, the nest site was still vacant. The female must now be at least 12 years old. In six years, she and her mates have succeeded in raising two chicks to a stage where they could depart for Australia. We have no news of either returning to Horuhoru.* In spite of all this, our colonies are slowly increasing in size. Very long life of breeding pairs must be making up for the high mortality among their chicks.

Hydrology of Hauraki Gulf

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Most of the published data concerning the Hauraki Gulf are confined to surface temperatures (Cassie, 1956; Dellow, 1955; Marine Department, 1938; Skerman, 1958).

The only records of salinity are by Fuller (1953) and of subsurface temperature by Cassie (1957). I have collated the published data with unpublished data from various sources and it is possible to present a reasonably representative picture of conditions in the Gulf both for summer and winter. While my interpretation may seem rather a drastic oversimplification to the hydrologist, I feel that some interpretation is better than none, and that it will be quite adequate for the purposes of the ecologist. I will consider only the outer Gulf (north of an east-west line passing through the northern extremity of Waiheke). The inner Gulf, Firth of Thames and Waitemata Harbour will obviously be more heterogeneous in character, depending on the influence of various freshwater sources. In general, salinities will be lower, particularly in winter, and temperatures will be several degrees higher in summer and lower in winter.

Surface temperatures tend to follow the trend of air temperature fairly closely, though with a lag of 2-4 weeks. Maximum temperature is in January-February. and minimum in July-August. Particularly in summer, surface temperatures alone are a poor index of underlying water temperatures owing to the tendency for a surface layer of a few feet depth to be heated by the sun to a temperature several degrees higher than the main body of water. Apart from abnormal temperatures in harbour or very shallow water, the maximum recorded annual range of surface temperature is from 9°C. to 23°C. An average range would be from 13°C. to 22°C., although these figures

* The nest site remained empty throughout the season. On 15 Jan. 1960 the female (No. 19860) was found sick at Warkworth, 40 miles north-west of Horuhoru—she died the following day.

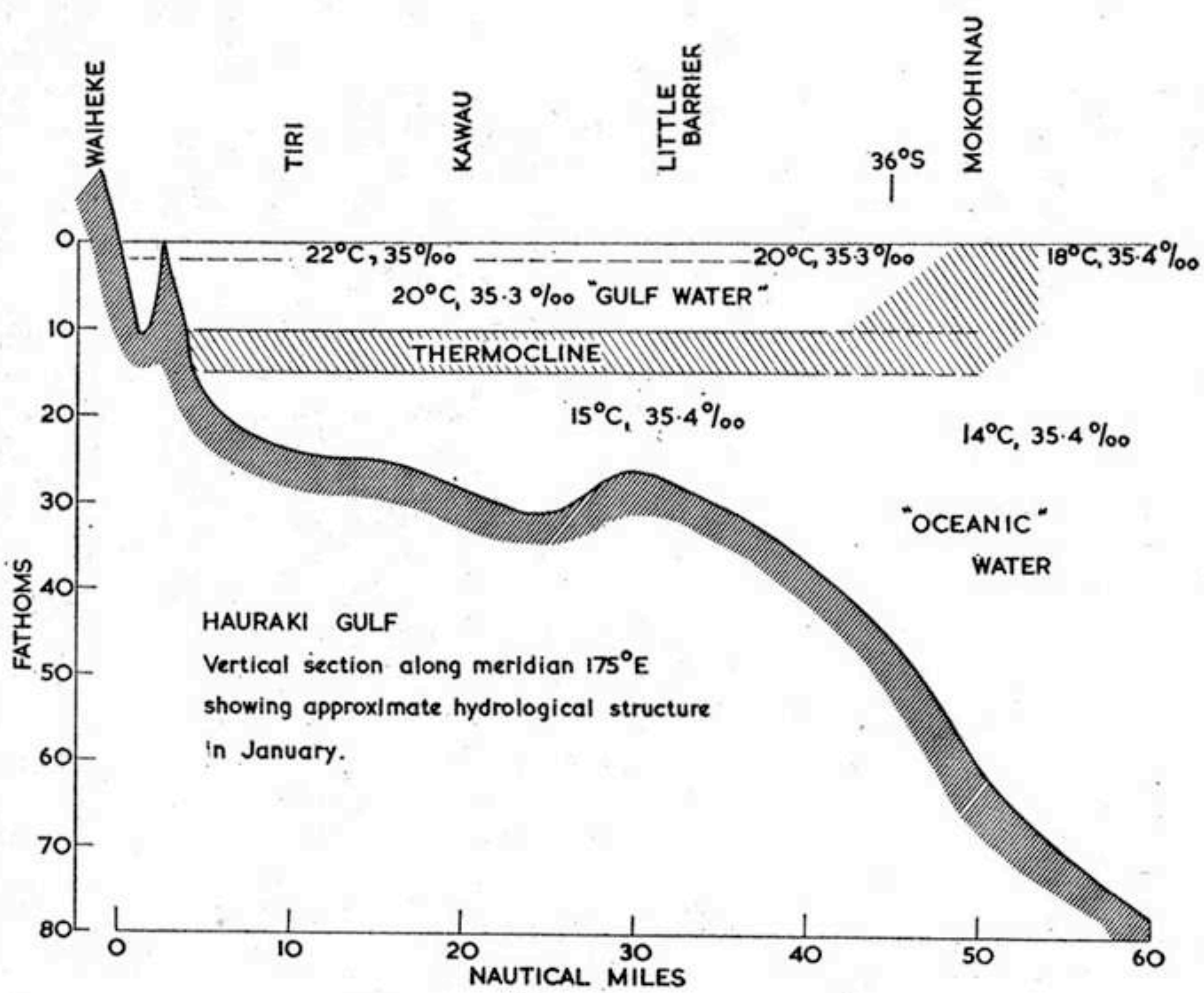

FIGURE 1.

from 13°C. to 22°C., although these figures may vary one or two degrees in either direction from year to year. Thus, the annual temperature range is about 9°C.

However, the more significant hydrological features are to be found below the surface. Figs. 1 and 2 are diagrammatic cross-sections along the 175°E. meridian, and give a representative picture of the outer Gulf except perhaps for the shoal region toward the western shore. Fig. 1 shows average conditions in January. The outer Gulf is a relatively flat basin 25 - 30 fathoms deep, falling off into deeper water north of Little Barrier, and rising to less than 10 fathom water near Waiheke. A thermocline forms between 15 and 20 fathoms, with a fall in temperature of up to 5°C. between the upper and lower layers of water. A thermocline is, of course, a common feature of many bodies of water, both marine and fresh water, in summer and is due to the influence of solar radiation plus the transference of heat down to a limited depth by turbulence. In a partly enclosed body of water such as the Gulf this

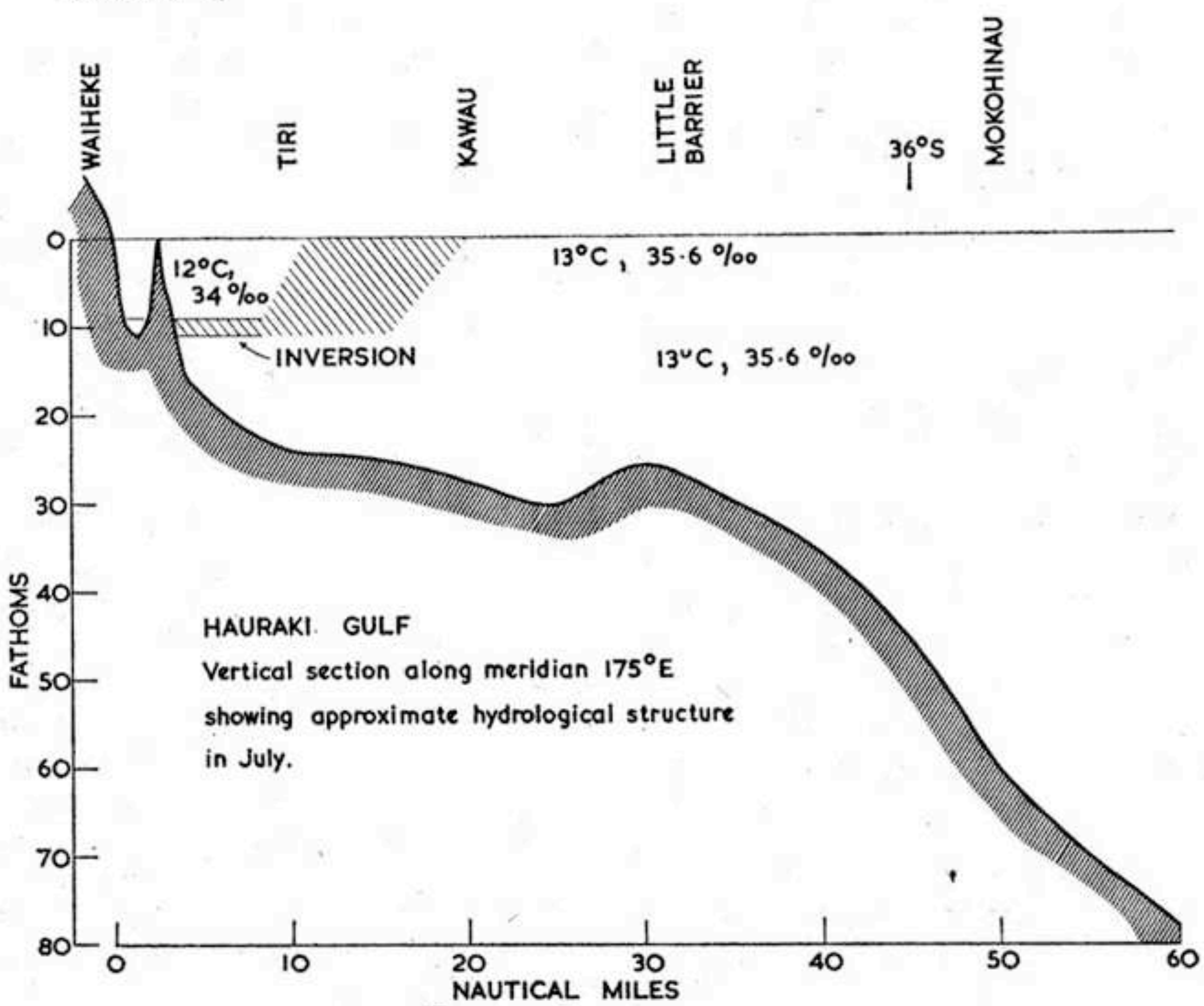

FIGURE 2.

effect is intensified by the run-off of fresh water from the land which tends to accentuate the lower density of the upper layer by lowering its salinity. In the open ocean this upper layer would tend to have a higher salinity owing to evaporation, whereas in the Gulf it is very slightly lower than the deeper layer. I have called the two layers above and below the thermocline "gulf" and "oceanic" waters respectively, although these two terms should not be taken as too literal a definition of their hydrological relationships. The oceanic water in January is continuous with the outside ocean and is practically identical in properties, with a temperature of about 15°C. and a salinity of 35.4‰. Like the ocean proper it is relatively transparent and free of suspended matter. The gulf water is about 20°C. and 35.5‰ salinity and has the turbid appearance typical of most inshore waters, which is due largely to suspended dead organic matter. This turbidity extends to the bottom of the thermocline (15 fathoms) and ceases abruptly at this level, so that it seems reasonable to assume that the thermocline water has more affinity with the Gulf than the oceanic water. The northward extent of the thermocline is variable but it can usually be found well beyond the Gulf limits, north of Little Barrier and in the Colville Passage, and may merge with the oceanic thermocline when one is present. Frequently two or more thermoclines will form at different depths, but the principal discontinuity is usually approximately as shown in Fig. 1. The surface layer which tends to become several degrees warmer than the remaining Gulf water is indicated in Fig. 1, though its depth has been somewhat exaggerated for convenience of labelling. A further illustration of the summer stratification is given by Cassie (1957, Fig. 1) in connection with the spawning of the snapper.

Fig. 2 shows the corresponding situation in July. The thermocline has disappeared, and most of the Gulf is isothermal, isohaline, and virtually homogeneous with the outside ocean water. The temperature is 13°C, only 2°C. colder than the summer oceanic water, and the salinity is 35.6‰, slightly higher than in summer. "Gulf" water is not nearly so conspicuous in winter, but it does appear as a layer of colder water between the surface and 10 fathoms at the southern extremity of the outer Gulf. Although colder, it is also considerably less saline, so that the density is still lower than that of the oceanic water over which it floats, forming a temperature inversion at about 10 fathoms. The northern extremity of this layer is variable in position, but at times it may extend as far as Kawau Island.

The ecological significance of this information will depend on the group of organisms being studied. Benthic species will have a fairly constant environment, varying by only 2-3°C. and 0.1-0.3‰ salinity. Pelagic species above the thermocline will experience an annual range of about 7-8°C. and up to 1.4‰ salinity, while for surface pelagic and intertidal fauna temperature may vary by up to 10°C.

Apart from the effect *in situ* of the range of physical properties, the oceanic plankton of the outer Gulf varies in composition as different water masses from outside are transported into the area. Fuller (1953) found that the inshore portion of the Gulf had a fairly constant species composition of resident copepods, plus two species of Cladocera which appeared in the summer. The more exposed portion of the Gulf was dominated in summer by a salp, *Thalia democratica*, and in winter by three chaetognaths, of the genus *Sagitta*. There were also different copepod species characteristic of summer and winter. Although the associated oceanic water movements are not yet fully understood, Fuller found that salps were correlated with low salinity and chaetognaths with high salinity, and he suggested that the two plankton groups were indicators of two different oceanic water masses which invade the Gulf in summer and winter respectively.

While I have presented an "average" picture of hydrological conditions, it should be emphasised that these may vary appreciably from year to year. It has been shown (Cassie 1956) that surface temperatures in November and December 1951, were 1-2°C. lower than in the previous year, and other unpublished data indicate that late 1951 was in fact particularly cold and that subsurface temperatures were also at least 1°C. lower. While one degree does not sound very significant, when the difference occurs about a temperature level which is critical for a particular species, the effect may be considerable, and in this year it seems that spawning of the snapper was delayed for about a month by the lower temperature. To speculate further, it is possible that such a delay might have a very serious effect on the survival of that year's brood of young snapper.

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The Marine Algal Ecology of Some Islands of the Hauraki Gulf

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INTRODUCTION

I would like to present a brief picture of the algal zonation patterns that can be observed at various stations in the Hauraki Gulf. I will mention animal species to some extent in addition to the algal dominants as it is impossible to consider the plants by themselves. With respect to nomenclature, the terms of Stephenson and Stephenson (1949) will be used, except for the substitution of the prefix sub- for infra- in the case of infralittoral and infralittoral fringe.

I also wish to point out that much of the data that I will talk about are the results of the work of Dr. Cassie, and my own contribution is mainly limited to the observation of the sublittoral communities that I will describe (Dellow, 1955).

THE MARINE BIOTIC COMMUNITIES

1. LITTLE BARRIER

The entire shore of this island is composed of boulders forming beaches at the bases of high cliffs, with only occasional rocky headlands. The shore is subject to frequent vigorous wave action. We may divide the seemingly meaningless jumble of plants and animals into the surface pattern zonation and the between boulders zonation. These zonation patterns are listed in Table 1.

	SURFACE PATTERN ZONATION	BETWEEN BOULDERS ZONATION
UML	*Nerita melanotragus* *Apophloea sinclairii*	
ML	*Nemastoma oligarthra* *Haplospongidion saxigenum* *Ralfsia verrucosa*	*Lithothamnion-Basal Corallina* *Petrolisthes elongatus* *Heterozius rotundifrons* *Ozius truncatus*
LML	*Basal Corallina officinalis* *Ulva lactuca* *Gelidium caulacanthum* *(Halopteris spicigera)*	*Hildenbrandtia* sp. *Caulacanthus spinellus* *Chamaesipho columna*
SBLF	*Lithothamnion + Corallina crusts* *Xiphophora chondrophylla* *Cystophora retroflexa*	*Erect Corallina turf* *Xiphophora chondrophylla* *Pterocladia lucida* *Champia laingii*
USBL	*Carpophyllum plumosum* *Carpophyllum maschalocarpum* *Melanthalia-Vidalia-Pterocladia*	
MSBL	*Ecklonia radiata* *Cystophora torulosa* *Carpophyllum maschalocarpum* *Spatoglossum chapmanii*	

TABLE 1.—*Schematic pattern of zonation at Little Barrier. Brackets around the names of plants or animals indicate localised dominance.**

* The following abbreviations are used in the tables:—UML—upper midlittoral; ML—midlittoral; LML—lower midlittoral; SBLF—sublittoral fringe; SBL—sublittoral; USBL—upper sublittoral; MSBL—midsublittoral.