THE DISTRIBUTION OF TUNA IN RELATION TO OCEANOGRAPHIC CONDITIONS

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TUNA SPECIES OCCURRING ROUND NEW ZEALAND

Four species commonly occur—yellowfin tuna, *Thunnus (Neothunnus) albacares;* skipjack, *Katsuwonus pelamis;* albacore, *Thunnus germo;* and southern bluefin tuna, *Thunnus thynnus maccoyii.*

All these are pelagic oceanic species which occur, within their specific temperature ranges, mainly in the tropical and sub-tropical belts. Their presence is also dependent on suitable salinities and water clarity, and their greatest concentrations are generally near current convergences and upwellings where there is usually abundant food. Below the surface layer is the sharp temperature gradient of the oceanic thermocline which acts as a depth barrier to these fish. Water clarity is important, because the tuna largely depend on their keen sight when hunting for food. Thus the clear blue oceanic water is more favourable to them than opaque inshore water.

Their food consists mainly of small fish, crustaceans and squids. Albacore and skipjack prefer small silvery fish such as anchovies, while the larger species take fish up to about 12 inches in length. Crustacean swarms will sometimes attract them even into coastal waters.

Further specific observations, mainly from overseas sources, may usefully be mentioned here:—

(1) *Yellowfin tuna* occur most abundantly in tropical waters, the 20°C isotherm forming roughly the northern and southern limits of their distribution. The waters off the North Island of New Zealand come within their range during the summer. Near the 20°C isotherm, temperature and availability of food appear to be of greater importance than salinity in determining their distribution. They usually remain offshore, and are sometimes found under floating debris and with porpoises. Exploitation overseas is by means of purse seines (the fishermen using the oceanic thermocline as a barrier to the vertical escape route), live-bait pole fishing for near-surface schools, and mid-water long-lines which are adaptable to varying depths.

(2) *Skipjack* are found within the ocean belt of 40°N and S latitudes. Their optimum temperature range is 20°-22°C, but they are commonly found in cooler water, with minimum salinity of about 33‰. The whole of New Zealand comes seasonally within their range. They are typically surface fish, sometimes associated with yellowfin schools, but also invading the shelf water if it is clear. Exploitation is by purse seining, live-bait pole fishing and trolling. A limited quantity has been caught by pole fishing around New Zealand.

(3) *Albacore* are more temperate in distribution, occurring within the temperature limits of 14.5°-20°C for small sizes and about 3°-4°C higher for large sizes. Their northern and southern limits are roughly between 45°N and 45°S latitude, excluding the very warm tropical water. They are most abundant in small pockets of water of optimum temperatures. In New Zealand, they may be associated with southern bluefin and skipjack. Exploitation overseas is mainly by live-bait pole-fishing, but the larger sizes may be taken on long-lines.

(4) *Southern bluefin tuna* occur as far south as 46°S latitude in the Indo-Pacific oceans, tolerating a temperature range of 10.9°-21°C and salinity range of 34.9‰-35.7‰. In Australia, fish smaller than 60 lb. generally occur nearer the coast than larger sizes, and usually near convergences and current boundaries. Their distribution round New Zealand is to the south in summer and further north along both coasts during the cooler seasons. Exploitation offshore from New Zealand is by Japanese long-lines from 40°S (to the south of Hawke Bay and Wanganui) in May to about 34°S (off the extreme north) during July. In Australia, they are taken mainly by pole and line fishing.

Oceanographic Conditions and Tuna Distribution Around New Zealand

New Zealand lies between 34°S and 47°S latitude in an area influenced by both warm and cool currents, formed, according to Brodie (1960), through the influence of the Trade Wind Drift, the Tasman Current and the West Wind Drift (Fig. 1). The East Auckland, West Auckland and East Cape currents all originate from sub-tropical water of the Trade Wind Drift; the Westland, D'Urville and Southland currents arise from the warm Tasman Current; the Canterbury current results from an extension of the cool water of the West Wind Drift. The positions of the convergences which are formed from these current systems on the west, east and south coasts change seasonally.

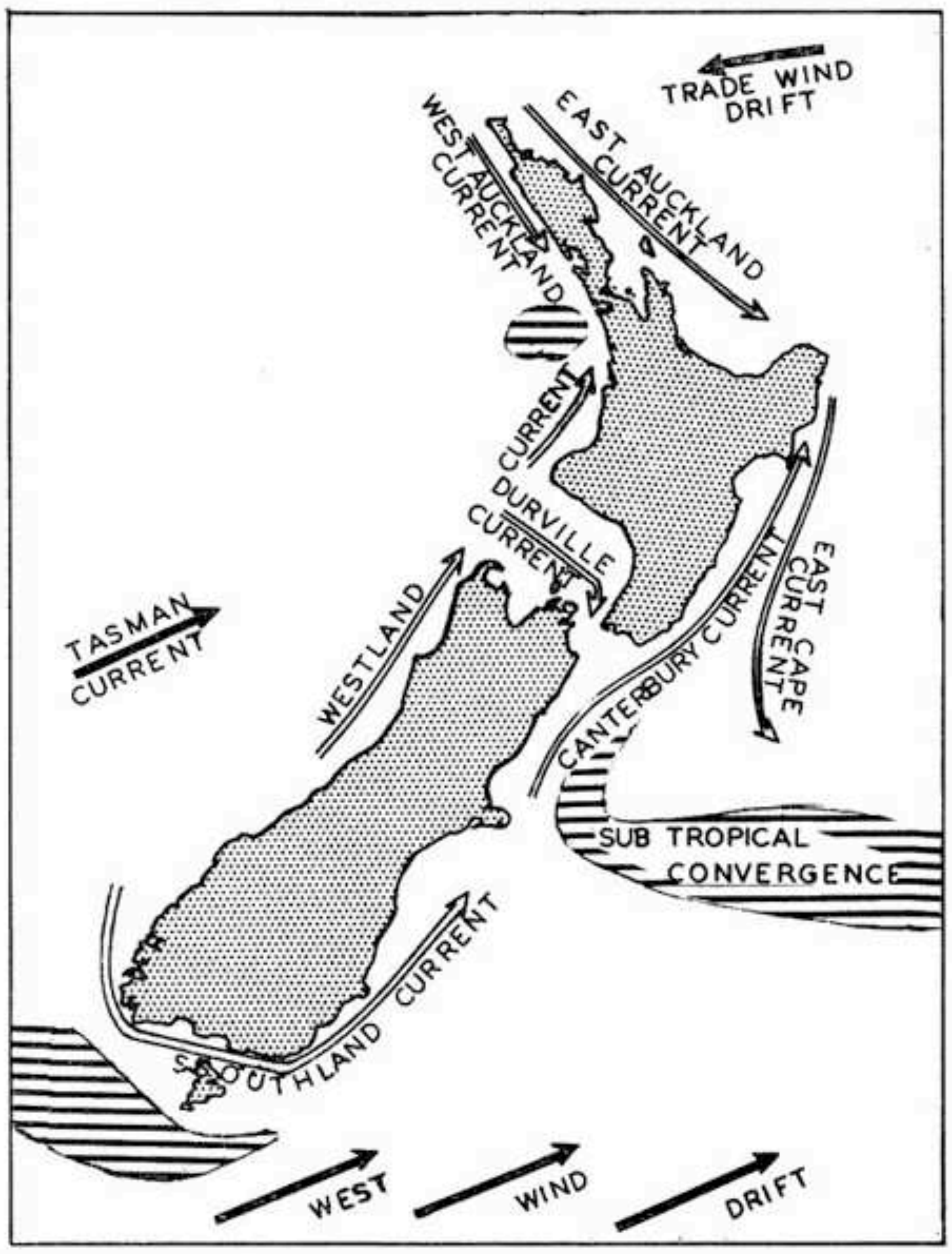

Figure 1. *Surface currents and convergences round New Zealand, and their sources of origin (after Brodie* 1960*).*

Between March 1962 and March 1963, bathythermograph records were taken off the north-eastern coast of the North Island. Surface and near-surface isotherms are shown in Figures 2, 3 and 4. The results are as follows:—

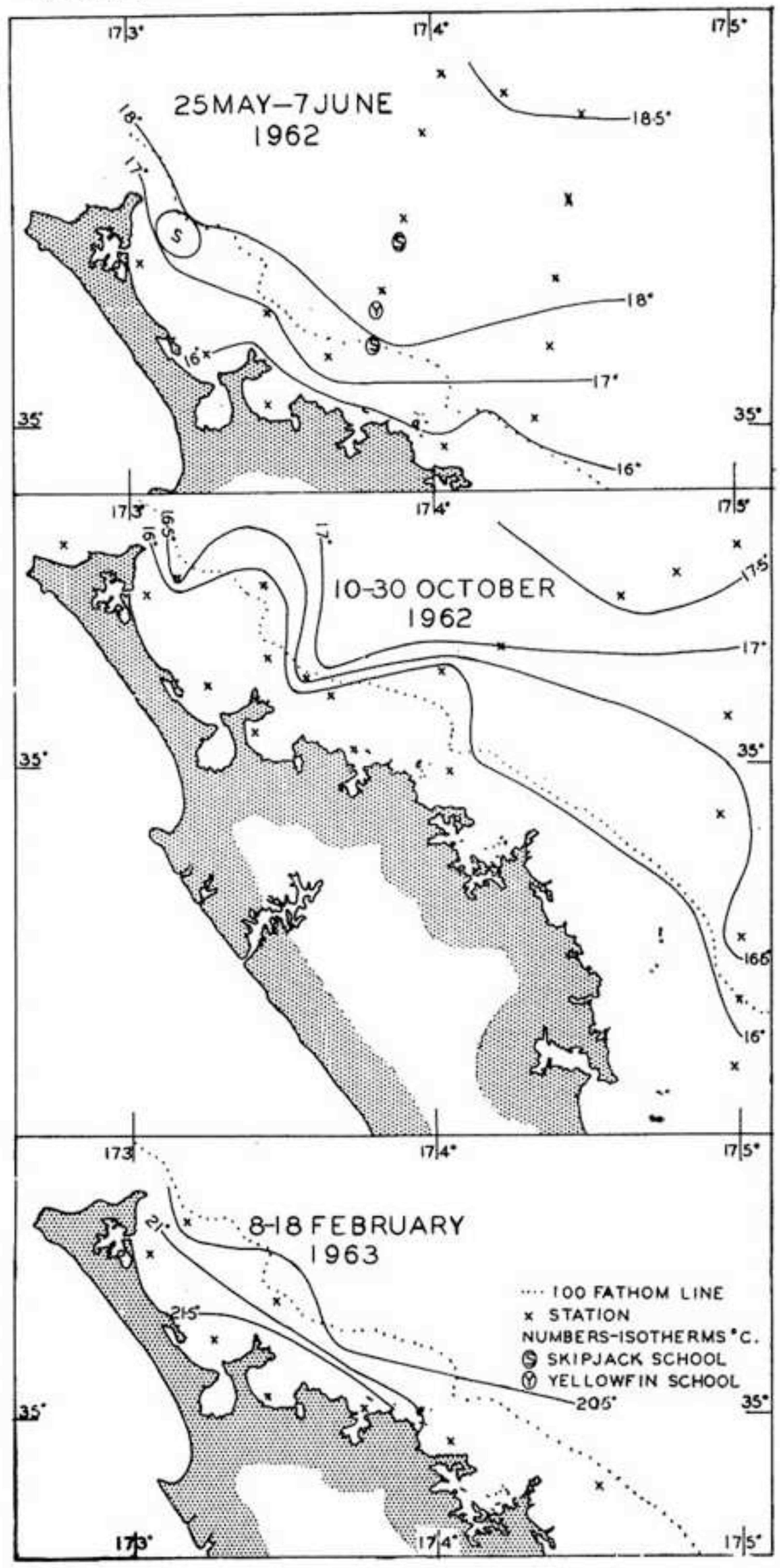

Figure 2. *Northern extremity of New Zealand: bathythermograph stations, surface isotherms and tuna schools, May* 1962—*February* 1963.

(1) North Cape to Bay of Islands:

May/June 1962: Surface temperatures increased with distance offshire to about 50 miles (the maximum distance under observation). A distinct thermocline existed about 150 to 200 feet below the surface, the gradual fall in temperature to this level being about 0.5°C.

A large school of skipjack was encountered near North Cape in very clear blue water close to the 100-fathom line in temperatures of 17-18°C. Yellowfin and skipjack were also taken on trolling lines beyond the shelf in a temperature of 18.3°C. However, another apparently favourable area for skipjack, immediately east of 174°E longitude between the 16° and 17°C isotherms, was non-productive.

October 1962: Temperatures increased from coastal to offshore water, the 16°C isotherm coinciding closely with the 100-fathom line. The isotherm pattern was almost identical throughout all depths down to the thermocline at about 200 feet. No tuna were seen. The temperature near the 100-fathom line was rather cool, but the isotherm pattern otherwise was fairly favourable for skipjack between 173° and 174°E longitude, and again near 175°E. However, beyond the 100-fathom line surface conditions of the sea were too confused for accurate observation.

February 1963: The temperature pattern was reversed. Isotherm conditions were stable down to a shallow, well-marked thermocline. No tuna were seen, in spite of favourable temperature gradients and good sea conditions near North Cape and about 40 miles further south.

(2) BAY OF ISLANDS TO HAURAKI GULF, APRIL 1962:

Marked temperature gradients were found near the 100-fathom line in the northern area, with a well-formed thermocline at a depth of about 150 feet. The sea was very clear and the surface calm.

Large schools of skipjack were found near the edge of the continental shelf in temperatures of 17.5-18°C.

(3) BAY OF PLENTY:

March 1962: Fairly uniform temperatures existed over the continental shelf, but the area of cooler inshore surface water was more extensive at the thermocline depth of 100 feet.

Although optimum conditions were not apparent, skipjack and albacore were taken in clear blue water near the 100-fathom

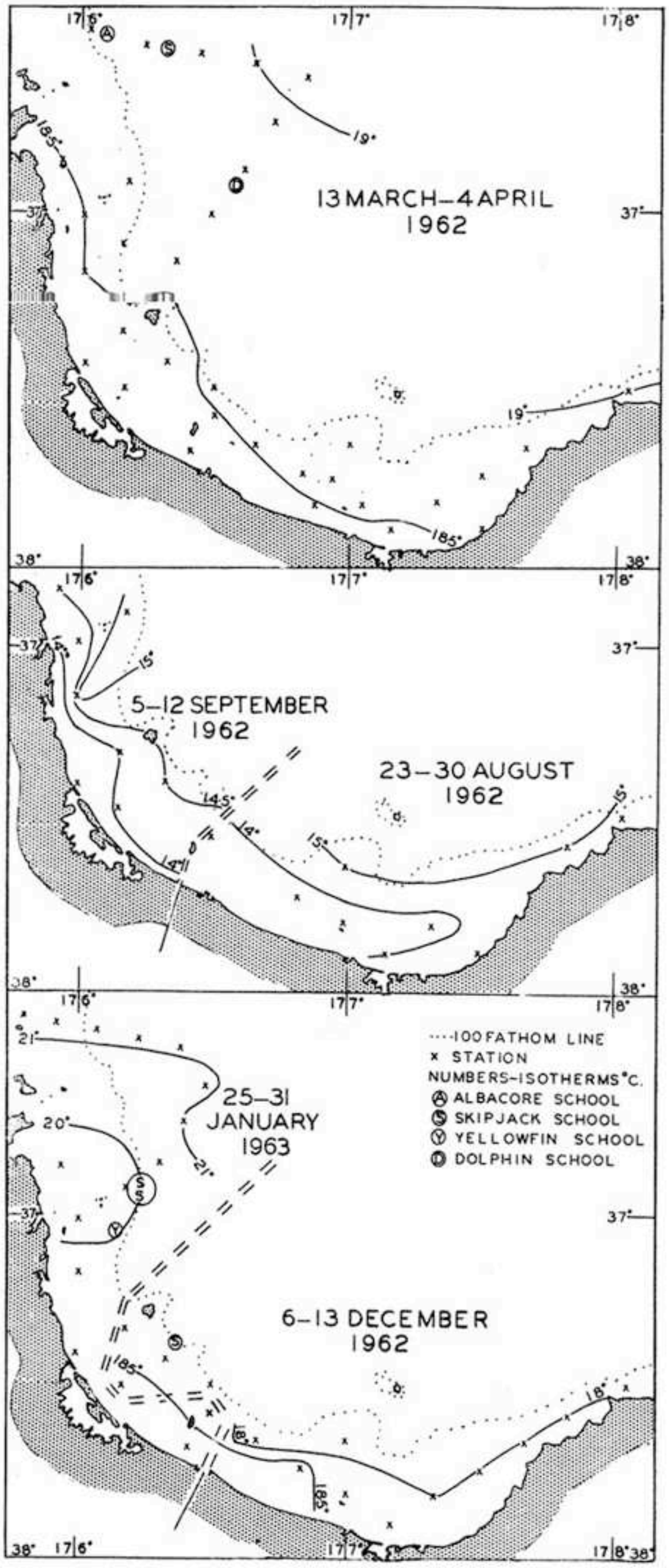

FIGURE 3. *Bay of Plenty: bathythermograph stations, surface isotherms and tuna schools, March* 1962—*January* 1963.

line in the western area of the Bay, and dolphin *(Coryphaena hippurus)*, some associated with tuna, were also caught.
August/September 1962: No thermocline was found within a depth of 450 feet, and the surface temperatures were mainly between 14.5° and 15°C. Thermal conditions were below requirements, and the water too cloudy for tuna, and none were seen.

December 1962: Only the eastern half of the Bay was covered. Temperatures were generally uniform at about 18°C on the surface and about ½°C lower about 30 to 40 feet below the surface.
Skipjack were seen near the 100-fathom line in the middle of the Bay in a temperature of about 18.3°C.
January 1963: Work was confined to the western half of the Bay about 6 weeks after the December work. Temperatures

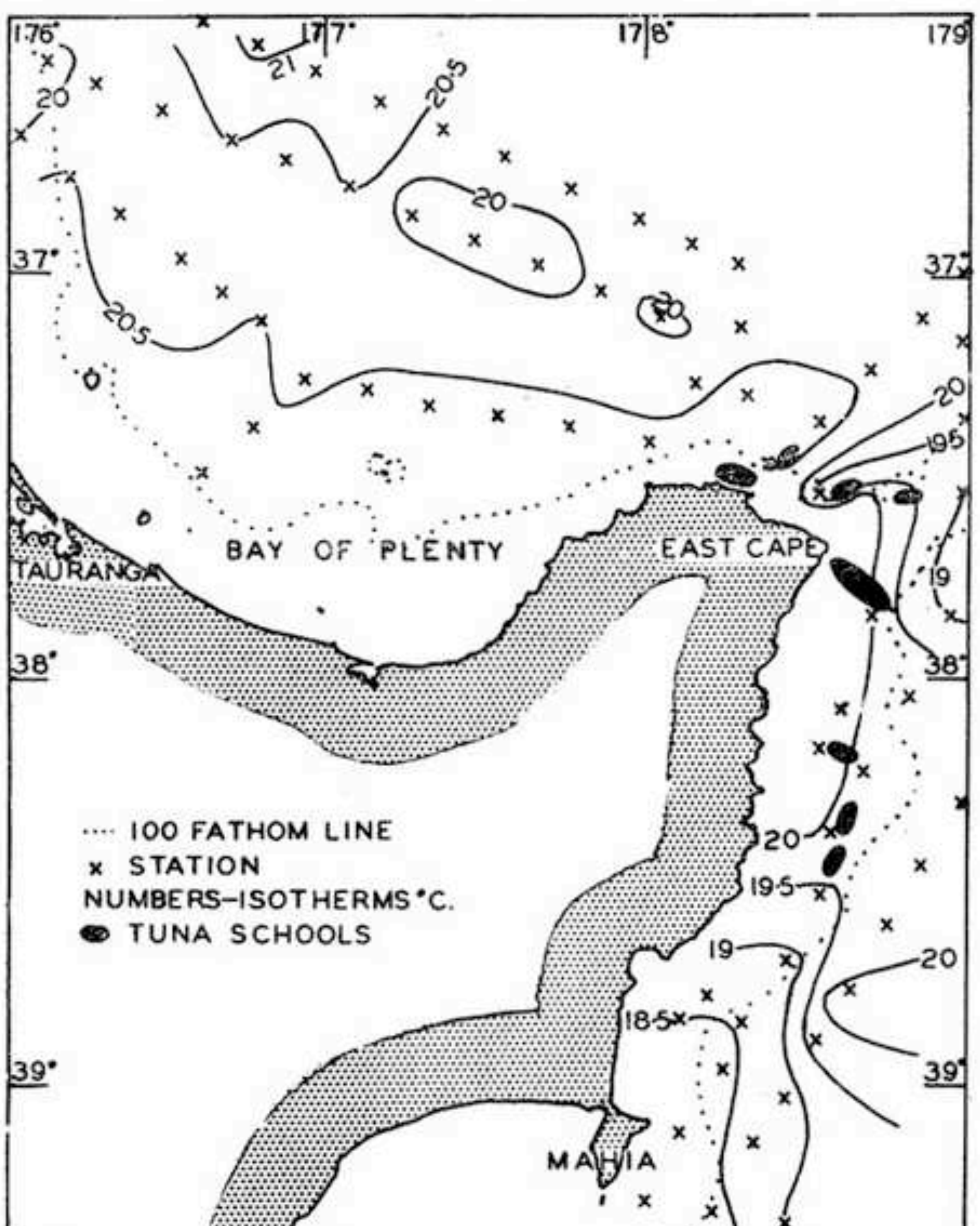

FIGURE 4. *Bay of Plenty-Mahia Peninsula: bathythermograph stations, isotherms at 30 feet below the surface and tuna schools, March 1963.*

were considerably higher, but fairly uniform. The water was mainly clear blue but the surface rather choppy.
In spite of these conditions, yellowfish and skipjack were caught on the 100-fathom line.

(4) BAY OF PLENTY TO THE MAHIA PENINSULA, MARCH, 1963:
A comprehensive offshore trolling cruise was undertaken. Temperatures down to the thermocline were generally very stable, but where a combination of bright sunshine and calm seas existed, the upper 30 feet were distinctly warmer than the steady conditions prevailing from below this depth to the thermocline. Thus, in order to show the stable temperature pattern, Figure 4 was compiled from data at 30 feet below the surface.
The interesting points observed in the Bay were:—

(a) The deepening but distinct thermocline,
(b) The receding warm water in the west, and
(c) The near-surface islands of cool water offshore in the east. This cool water extended considerably westward at the level of the thermocline in the region of the 100-fathom line. A similar patch of cool water existed below the surface over the continental shelf in the eastern portion of the Bay in December, and this apparently moved offshore during the intervening period.

The water was clear blue, but in the main choppy.
Although temperatures were sufficiently high, no tuna were observed.
From East Cape southwards, the isotherm pattern was far more complex, due to the conflicting warm and cool currents. The thermal pattern was constant down to the top of the distinct thermocline level. The water was clear blue with a light to moderate swell.
Several skipjack schools were seen near the 100-fathom line near East Cape in temperatures between 19.5° and 20.5°C. Others were located some 30 to 45 miles further south. Commercial fishermen had also reported large schools in both areas at the time, and a considerable catch of albacore had been taken near East Cape.

GENERAL REMARKS

Catches reported here have been made almost exclusively by trolling—a method which is more effective for skipjack than for the other species. These results are thus probably indicative of the distribution only of skipjack. This species has been found mainly near the 100-fathom line between 18° and 20°C, especially in areas of temperature fluctuations. However, apparently favourable localities need not necessarily harbour surface schools of the species—a conclusion also supported overseas.

REFERENCES

BRODIE, J. W., 1960. Coastal Surface Currents around New Zealand. *N.Z.J. Geol. Geophys.* 3: 235–252.

The following contributions to the F.A.O. World Scientific Meeting on the Biology of Tunas and Related Species, 1962, provided data on the biology and distribution of the various species:—

ANON. Species identification and distribution: Adults. *Report of Section 1/A.*

JONES, S., and SILAS, E. G. Synopsis of biological data on skipjack, *Katsuwonus pelamis* (Linnaeus) 1758 (Indian Ocean). *Special synopsis No.* 21.

LAEVASTU, T., and ROSA, H. Jr. Distribution and relative abundance of tunas in relation to their environment. *Information Paper No.* 2.

ROBINS, J. P. Synopsis of biological data on bluefin tuna, *Thunnus thynnus maccoyii* (Castelnau) 1872. Species Synopsis No. 17.

SCHAEFER, M. B., BROADHEAD, G. C., and ORANGE, C. J. Synopsis on the biology of yellowfine tuna *Thunnus (Neothunnus) albacares* (Bonnaterre) 1788 (Pacific Ocean). *Special Synopsis No.* 16.

WALDRON, K. D. A synopsis of biological data on skipjack, *Katsuwonus pelamis* (Linnaeus) 1758 (Pacific Ocean). *Species Synopsis No.* 22.

YOSHIDA, H. O., and OTSU, T. Synopsis of biological data on albacore, *Thunnus germo* (Lacépède) 1800 (Pacific and Indian Oceans). *Special Synopsis No.* 9.

BROWN TROUT *(SALMO TRUTTA)* IN THE HINDS RIVER

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This paper deals with data on the ecology of the brown trout collected during two visits to the Hinds River in 1962. Electric fishing and gill netting were used to capture 2,325 brown trout. Brook trout *(Salvelinus fontinalis)*, quinnat salmon *(Oncorhynchus tschawytcha)*, Eleotridae, Galaxiidae, Retropinnidae, torrent fish *(Cheimarrichthys)*, and eels were also captured.

THE RIVER

The Hinds River is a small stream rising as two branches in the foothills at the western edge of the Canterbury Plains. These branches converge at Mayfield and from there the river flows south west across the plains to the sea 12 miles south of Ashburton. At the mouth there is a small lagoon. From the confluence at Mayfield to the mouth the gradient is even and slight (Table 1). There are pools, runs and flats in approximately equal proportions, but no falls, stickles or cascades. (Definitions from Allen, 1951.) Both the branches are similar to the main river but with a steeper gradient and a few cascades; in the South Branch there is one man-made fall of 3 feet. The small tributary streams and ditches contain all the types of water listed above, although no falls are higher than 15 feet. The gradient of the tributary streams and ditches is often quite steep.

TABLE 1. *Summary of the river and tributary gradients.*

	A *Fall* (ft.)	*B* *Length* (miles)	*Ratio A:B* *(slope)*
Main River	900	27	1:160
North Br.	1100	17	1: 80
South Br.	1100	12	1: 60
Limestone Cr.	800	8	1: 50
Cravendale Cr.	600	4½	1: 40

All the tributary streams examined, the North Branch, and the main river, flow throughout the year. The South Branch has periodic dry periods, except at its headwaters and immediately below the entrance of Limestone Creek.

The bed of the main river and of both branches is shingle throughout, with small areas of boulders and. in the pools, sand. Mud is common along the banks. The bed of Limestone Creek is of similar composition to that of the main stream. The other small tributaries have large amounts of mud and little shingle.

The channel in the lower portion of the main river has been straightened by the Catchment Board. Bulldozing for shingle has modified areas of the main stream and the North and South Branches.

Cover consists almost totally of bank cover. There is one small backwater where filamentous green algae provide cover for the trout and some areas have sunken snags and willows along the bank affording underwater cover. The bank cover is summarized in Table 2.