FISHERIES TECHNICAL REPORT 9'

LENGTH - FREQUENCIES, CATCH DATA, AND GONAD MATURITY OF PILCHARDS (*SARDINOPS NEOPILCHARDUS* (STEINDACHNER)) AND ANCHOVY (*ENGRAULIS AUSTRALIS* (WHITE)) CAUGHT TASMAN BAY AND MARLBOROUGH SOUNDS, 1969 - 1970

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CONTENTS

SUMMARY

The results from a 9 month pilchard survey from Tasman Bay and the Marlborough Sounds have been described and discussed. Catches were found to be good and the fish evenly distributed in quantity over the surveyed region. Fish caught were mainly pilchard and anchovy, with a limited quantity of kahawai. No yellow-eyed mullet (Aldrichetta forsteri Cuv. & Val.) or sprat (Sprattus antipodum (Hector)) were landed.

Length-frequencies were expressed as percentages in 0.5cm length groups owing to bias in some of the samples. There was an indication that 2 populations occurred, 1 in Tasman Bay and the other in the Marlborough Sounds. Sex ratios were also analysed.

Water temperatures were plotted for each month and showed typical seasonal fluctuation. A greater temperature range per month and all year was noted in Tasman Bay than in the Marlborough Sounds.

In Appendix 2 data from Marine Department files concerning the Picton Cannery, 1942-1950, has been tabulated and discussed. Biological data of length-frequencies and catch rates were collected by A.M. Rapson.

INTRODUCTION

Between 17 September 1969 and 29 May 1970 a purse seine survey for pilchards (Sardinops neopilchardus (Steindachner)) and anchovy (Engraulis australis (White)) was attempted by the f.v. "W.J. Scott". Apart from Tunbridge (1969) and Baker (1972) little information has been published on 'pilchard-type' shoals in New Zealand. Research projects from the Zoology Department, Victoria University, Wellington, and information on file in the Marine Department, Wellington, virtually completes the sources of available data. Recorded observations north of the South Island by the fishing vessel "Liberta" during 1947, 1948, 1949, and 1950 (data on deposit Marine Department file) indicated surface shoals all year round, differing from aerial sightings made during 1968-1969 (Webb, 1971). Appendix 2 gives a brief report on the Picton pilchard cannery venture which existed between 1942-1950 inclusive. Most of the pilchard research in New Zealand has concentrated in the area of northern South Island. The terms "pilchards" or "pilchard-type" has been used in this report to include anchovy, pilchard, sprat, and yellow-eyed mullet.

The project was conducted to assess (1) whether there existed a potential pilchard industry using the purse seine method; (2) accumulate length-frequency measurements from random samples; and (3) investigate the gonad maturity and sex ratios occurring within the shoals. Unfortunately, of the 73 purse seine shots recorded on data sheets, 40 were lost, being either mislaid or accidently rejected overboard in the absence of the author. Thus analysis of catch effort per time or per shot, was not feasible.

METHODS AND GEAR USED

Purse seining for "pilchard-type" fish was operated from the f.v. "W.J. Scott", this vessel having the following dimensions:

Registered length = 85.54ft (26.0725m)
Registered breadth = 22.33ft (6.8061m)
Registered depth = 9.69ft (2.9474m)
Maximum draft = 13.0ft (3.9624m)
Gross tonnage = 166.86 tons (nett registered = 50.42 tons)
Radar = D 202 (Decca); 24 volt inverter type 4687
Engine power = 510 b.h.p. with reduction gear 3.5:1
Propeller size = 1750m diameter, variable pitch
Engine = compression ignition, caterpillar 8 cylinder, model II 379 A
Electrical system = 24 volt

The "Scott" was constructed in 1962, of welded steel, by Ackers Ltd, Norway. Net retrieving was through a hydraulic power block system after which the net was manually re-stacked on deck. Details of the pilchard net used are as follows:

A. Mounting Details

Head rope = 1¼" (31.75mm) circumference, R & L lay nylon, 27 fathoms (493.77m) each.

Footrope = 1¼" (31.75mm) circumference, R & L nylon lay, 270 fathoms (493,77m) each.

Floatrope = 1⅛" (28.575mm) circumference, polypropylene, 345 fathoms (630.867m).

Bolsh line = ½" (12.7mm) circumference, nylon lead and float, 585 fathoms (1095.731m) total.

Breast and lug = 1¼" (31.75mm) circumference, R & L lay nylon, 24 fathoms (43.886m) each.

Bridles = 1½" (38.1mm) circumference, nylon 40 x 4¼ fathoms (7.771m), 180 fathoms (329.148m) on all.

Pursing wire = 2¼" (57.15mm) circumference, 6 x 37 construction steel wire, 300 fathoms (548.58mm) - (Later replaced with 3¼" (82.55mm) circumference wire).

Floats = 2000 oval plastic floats 6" (152.4mm) x 3½" (88.98mm) - (later added further 2000 approximate, for added flotation).

Leads = 1360 oval leads 1 kilo each (later added further 1000 to increase sinking of net).

Purse snap rings = 40, 9" (228.6mm) x 6" (152.4mm) x 4" (101.6mm), 6.6lbs (2.993kg) each (later replaced with 40 spring-clip Japanese rings 29cm x 14.5cm tapered, 4.751bs (2.1546kg): from the Marine Department kahawai purse seine net - original rings unsatisfactory).

Breast rings = 7, rounded 3½" (88.9mm).
Netting hitched and served to lead and foot ropes every 9" (228.6mm) with treated nylon twine.

B. Net Panels

Panel A = 18 S knotless, 60 x 27 fathom x ½" stretch mesh (109.716m x 49.373m x 12.7mm)

Panel B = 12 S knotless, 40 x 27 fathoms x ½" stretch mesh (73.144m x 49.373m x 12.7mm)

Panel C = 12 S knotless, 245 x 2½ fathoms x ½" stretch mesh (539.437m x 4.571m x 12.7mm)

Panel D = 9 S knotless, 245 x 22 fathoms x ½" stretch mesh (539.437m x 40.229m x 12.7mm)

Panel E = 12 S knotless, 245 x 2½ fathoms x ½" stretch mesh (539.437m x 4.571m x 12.7mm)

Panel F = 210/120 knotted, 345 fathom (630.867m) x 7 meshes x 2" (50.8mm) stretch mesh

Panel G = 210/120 knotted, 405 fathoms (740.583m) x 30 meshes x 3½" (88.9mm) stretch mesh

For detailed net construction see Marine Department file, Fisheries Laboratory, Wellington. The pilchard net was made by W. & J. Knox Ltd, Ayshire, Scotland, with 20% slack when slung, giving final dimensions of 250 x 20 fathoms x ½" stretch mesh (457.15m x 36.572m x 12.7mm).

Fish were measured while fresh using a standard 1 metre measuring board: shrinkage by freezing, drying, or age was not a problem. Sightings of shoals were made by:

(a) Visual, shoals being located on the surface by eye or 7 x 50 binoculars.

(b) Birds, using flocks or feeding birds over a distance of 2-3 nautical miles either side of the vessel; and

(c) echosounder, 2 Elac sounders horizontal and/or vertical transducers, for blind shots.

Fish samples were taken as brailing occurred, the samples being placed into plastic fish boxes ready for use. The number of fish measured per sample varied according to time available, but usually ranged from 150-300. Although a number of shoals caught were not commercial, either in quantity of quality, random samples were still taken before fish were released. Conversely, not all shoals caught were sampled. While the author, with assistance from technicians, did most of the measuring during 1969, all measurements and data collected during 1970 were by the "W.J. Scott" technicians. Factors beyond the power of the author resulted in the loss of 40 of the 73 purse seine sheets which were completed in each shot.

TABLE 1 DETAILS OF THE 33 "PILCHARD" PURSE SEINE SHOTS RETAINED DURING THE PERIOD 17 SEPTEMBER 1969 TO 29 MAY 1970. T.B. = TASMAN BAY; M.S. = MARLBOROUGH SOUNDS; A.B. = ADMIRALTY BAY

Shot Number	Location	Date	Shoal Depth (feet)	Depth to sea bottom (fathom)	Wind speed (kts)	Wind direction	Shot starts (hrs)	Remarks
23	3 miles 250°T Ragged Pt.(T.B)	13.12.69	0-5	20	calm		1740	swell 2ft (NE), water blue
29	12 miles 280°T Ragged Pt.(T.B)	8.1.70	0-5	27	calm		1128	sea smooth, water blue
31	2 miles 250°T Clay Pt.(A.B)	11.1.70	0-10	24	2	S	1058	sea smooth, water gray-green
40	3 miles 220°T Ragged Pt.(T.B)	20.2.70	0-10	26	7	NE	0947	swell 3ft (NE), water blue
41	centre Admiralty Bay	21.2.70	-	25	3	NE	1045	demonstration shot only
42	Beatrix Bay (M.S.)	25.2.70	0-20	20	calm		1057	sea smooth, water green
43	Port Ligar (M.S.)	26.2.70	0-15	17	variable 3		1937	sea smooth, water green
48	½ mile Bulwer Post Office (M.S.)	11.3.70	0-15	13	3	N	1611	sea smooth, water green
49	Maori Bay-Port Ligar (M.S.)	3.4.70	0-15	13	variable 3		1052	sea smooth, water green
50	2½ miles 260°T Pepin Is. (T.B)	14.4.70	0-96	16	calm		1340	sea smooth, water green
51	1½ miles 340°T Pepin Is. (T.B)	21.4.70	84-114	19	calm		0916	sea rippled, water green
52	1½ miles 270°T Mackay Bluff (T.B)	22.4.70	0-20	10	calm		1139	sea glassy, water green
53	4 mile 240°T Pepin Is. (T.B)	22.4.70	0-20	13	3	N	1352	sea rippled, water green
54	3½ miles 290°T Pepin Is. (T.B)	22.4.70	0-20	16	2	N	1556	sea rippled, water green
55	4¾ miles 330°T Mackay Bluff (T.B)	27.4.70	0-15	14	calm		1033	sea glassy, water green
56	3½ miles 280°T Pepin Is. (T.B)	29.4.70	0-15	14	3	S	1116	surface rippled, water green
57	1 mile 90°T Tonga Is. (T.B)	29.4.70	0-15	16	3	N	1657	sea rippled, water green
58	4¾ miles 245°T Nelson Harbour	4.5.70	0-15	9	4	SW	1006	sea rippled, water green-yellow

TABLE 1 (Contd)

Shot Number	Location	Date	Shoal Depth (feet)	Depth to sea bottom (fathom)	Wind speed (kts)	Wind direction	Shot starts (hrs)	Remarks
59	4 miles 320°T Mackays Bluff (T.B)	4.5.70	0-10	14	calm		1441	sea smooth, water green
60	5½ miles 340°T Nelson Harb. Ent.	6.5.70	24-72	12	2	S	0824	sea rippled, water green
61	5 miles 20°T Nelson Harb. Ent.	6.5.70	12-78	13	calm		1101	sea glassy, water green
62	4½ miles 250°T Okuri Light (T.B)	7.5.70	24-108	21	calm		1532	sea glassy, NW swell (2')
63	1½ miles 270°T Clay Pt. (A.B)	12.5.70	18-108	26	calm		1649	sea rippled, water green
64	5 miles 355°T Nelson Harb. Light	13.5.70	39-54	9.5	2	SW	1417	sea rippled, water green
65	3½ miles 0°T Mackays Bluff (T.B)	16.5.70	12-36	15	calm		1608	sea rippled, water green
66	3 miles 357°T Nelson Harb. Light	17.5.70	0-20	7	calm		1437	sea glassy, water green
67	Tawa Bay - Endeavour Inlet (M.S)	19.5.70	48-120	20	calm		1138	sea smooth, water green
68	Maori Bay - Port Ligar (M.S)	19.5.70	48-84	16	calm		1656	sea glassy, water green
69	5 miles 260°T Whangamoa Hd. (T.B)	25.5.70	36-84	16	10	SW	1218	swell 2' (SW), sea slight
70	4 miles 350°T Mackays Bluff (T.B)	27.5.70	0-10	17	calm		1350	sea rippled, water green
71	3½ miles 0°T Mackays Bluff (T.B)	27.5.70	0-10	16	3	N	1600	sea rippled, water green
72	1 mile 270°T Cape Soucis (T.B)	28.5.70	36-96	18	3	SW	1140	sea rippled, swell 1'(SW)
73	¼ mile 290°T Reef Pt. (A.B)	29.5.70	60-144	24	2	E	0855	sea rippled, water green

RESULTS

Between 17 September 1969 and 29 May 1970, 73 purse seine shots were set, fishing being localised between map coordinates 173° 00.0 to 174° 00.0E longitude and south of 40° 30.0S latitude, i.e., in Tasman Bay and the western areas and approaches to the Marlborough Sounds (refer N.Z. Marine Chart 61G or general map of New Zealand). As previously related 40 of the purse seine forms were lost on board ship: details of the remaining 33 shots may be seen in Table 1. Repairs to torn netting and broken lastridge were constant throughout the project: 9 of the 33 shots had damage classified as "major", i.e. large tears, broken bridles, fouled netting inside purse rings, jammed netting with purse wire. Such entanglements left areas of netting extensively damaged.

The time for each completed shot, excluding brailing, from the time the shot started until the net was re-set on deck, varied from 42 to 130 minutes. This time depended on whether net mending occurred during retrieving, or net fouled during shot. Brailing took approximately ½ hour per ton of "pilchards", although if operations went smoothly, this time could improve to 15 minutes.

As shown in Table 1 weather conditions for purse seining required wind below 15kts, and seas below 5ft (1.524m): at no time were conditions in excess of these limits. Another reason for the limitations was the sensitivity of the "pilchard" shoals to adverse weather resulting in them seeking deeper water until calmer weather prevailed. Although most of the project shots were in Tasman Bay, "pilchard" shoals were present throughout the entire area (Webb, 1971). Limitations to purse seining occurred with shoals being too close to the shoreline, rough weather (wind above 15kts open sea or 25kts in enclosed bays), or to the water depth being sufficiently great to allow fish escapement below the net before pursing. Best fishing success was in water depth between 18-36m (10-20 fathoms).

The catch success of fish landed by the "W.J. Scott" has been listed in Table 2.

TABLE 2 LANDED WEIGHT OF FISH CAUGHT BY THE "PILCHARD" PURSE SEINE NET

Date	Weight of catch (kg)	Fish Species	General area of location
1.10.69	181.4388	70% pilchard, 30% anchovy	off Cape Soucis
2.10.69	3556.2006	95% pilchard, 5% anchovy	off Cape Soucis
5.10.69	181.4388	pilchards-released	off Cape Soucis
28.11.69	12192.688	pilchards	off Greville Harbour
12.12.69	1016.0573	pilchards	off Greville Harbour
8.1.70	1016.0573	pilchards	middle Tasman Bay
9.1.70	508.0286	pilchards	west D'Urville Island
11.1.70	9144.516	pilchards	Admiralty Bay
15.1.70	3048.172	pilchards	Admiralty Bay
16.1.70	12192.688	pilchards	Admiralty Bay
24.1.70	952.5537	pilchards	Pelorus Sound
26.1.70	1016.0573	pilchards	Forsyth Bay-Pelorus Sd.
28.1.70	1016.0573	pilchard	Admiralty Bay
18.2.70	4064.2293	pilchard	Pelorus Sound
20.2.70	2032.1146	90% pilchard, 10% anchovy	Admiralty Bay
25.2.70	771.1140	pilchard	Beatrix Bay
26.2.70	17272.974	pilchard	Admiralty Bay - released
3.3.70	3048.172	anchovy	off Cape Soucis
5.3.70	249.4783	50% pilchard, 50% anchovy	off Cape Soucis
11.3.70	6604.3726	pilchard	Pelorus Sound
14.4.70	30481.72	pilchard	off Pepin Island
27.4.70	11176.63	95% kahawai, 5% pilchard	off Pepin Island
29.4.70	68.0395	50% pilchard, 50% kahawai	off Pepin Island
4.5.70	317.5179	kahawai	off Mackays Bluff
6.5.70	317.5179	50% pilchard, 50% anchovy	off Cape Soucis
6.5.70	5080.2866	pilchard	off Cape Soucis
7.5.70	7620.43	pilchard	off Cape Soucis
13.5.70	136.0791	50% pilchard, 50% anchovy	off Nelson Harb. light
16.5.70	4064.2293	95% pilchard, 5% anchovy	off Cape Soucis

TABLE 2 (CONTD)

Date	Weight of catch (kg)	Fish Species	General area of location
17.5.70	812.8458	kahawai	off Nelson Harb. Light
25.5.70	136.0791	anchovy	off Whangamoa Head
27.5.70	22.6798	anchovy	off Mackays Bluff
27.5.70	45.3597	anchovy	off Mackays Bluff

Total weights for each species over the project period were: pilchard = 124,319kg (274,073lbs); anchovy = 4,242.4925kg (9,353lbs); and kahawai = 11,782.179kg (25,974lbs), giving % catch as pilchards 88.5%, anchovy 3.02%, and kahawai 8.3%. Receipts paid for the fish landed showed all "pilchards" weighing 177,125lbs (80,343.372kg) the discrepancy between the paid catch and the pursed catch being caused by (1) the rejection of a large tonnage through lack of a market, (2) deterioration of the fish resulting in the rejected fish being used as pig food, e.g. 26 February 1970, and (3) releasing of large quantities through damage to the ship's gear, for example, on 14 April 1970, of the 30 metric tons caught only 15 metric tons were landed owing to buckling of the loading derrick.

All "pilchards" landed were either converted to fish meal or used as pig food, although 2 metric tons were used in an experimental canning trial. Fish were preserved in flake ice aboard ship, and were found to be in satisfactory condition for periods of 2-3 days. Crushing proved to be a serious problem with anchovies if stored in bulk, but was less serious for pilchards. Consequently after the first 3 trial shipments most of the fish were stored in the normal 30" x 17" x 10" plastic fish box (762mm x 431mm x 254mm). Little difference was seen in the condition of the bulk pilchards to those placed in the 100lb (45.3597kg) plastic boxes, providing a period of chilling occurred between each load of pilchard, and the shoals themselves were reasonably small. Catch success showed no relationship to time of day owing to the use of echosounder in shallow water, as well as using the visual method and bird aggregations.

In the list below may be seen the number of successful shots related to the total, from September 1969 to May 1970.

Month	Days out of port	Days fishing	Number of shots	Number of successful shots	Pilchard (kg)	Anchovy (kg)
September	10	4	6	-	-	-
October	10	6	6	3	3686.8364	232.2416
November	20	16	7	1	12192.688	-
December	17	15	9	1	1016.0573	-
January	21	14	9	8	28894.128	-
February	17	12	7	4	23937.221	203.2114
March	11	6	4	3	6729.1117	3172.9111
April	17	10	9	3	31074.57	-
May	19	18	16	10	16788.531	634.1284
Totals	142	101	73	33	124319.1	4242.4925

In the above list success means any shot that landed fish, however small. Kahawai was only caught during April and May 1970, and so was not included in the analysis. Going by the number of successful shots (45.2%) it would appear that the purse seining method as used on the "Scott" still needed modification, such as (a) a smaller net, (b) use of a smaller vessel, or (c) replacement method for the dory. Mechanical faults, weather interruptions, and training shots accountered for approximately 15% of the shots. In a previous paper (Webb, in press) the number of days suitable for purse seining in this region ranged from 70-90%: the 142 days spent at sea out of a total of 240 (59.1%) illustrated the effect the various mechanical interruptions had on the purse seining operation.

In the initial purse seine period until the end of December 1969, very few fish shoals were sighted, despite favourable sea and weather condition in December. Most shots recorded throughout this period were for practice or demonstration: only 13% of all "pilchards" caught were in 1969.

During January and February most of the purse seining was in the Admiralty Bay - Pelorus Sound area, the average time for each shot being 1 hour. "Pilchards" were seen to shoal mainly between daybreak and 1100 hours and from 1600 hours to darkness. The shoals rose intermittently at first appearing on the surface for

1-2 minutes before diving again. Gradually their periods on the surface increased allowing the "W.J. Scott" sufficient time to approach and shoot the net. Although most shots were made in the Marlborough Sounds area, distribution of "pilchards" was still widespread in Tasman Bay concentrating along the eastern coast from Pepin Island to D'Urville Island. Shoals, however, were either too close inshore or below 20 fathoms. Birds working the fish shoals were mainly gannets, fluttering shearwaters, red-billed gulls, and white-fronted terns, with numbers from 10-50 and flocks from 100-1000.

Within March and April purse seining was more evenly distributed between the Sounds and Tasman Bay. The diurnal appearance of the shoals occurred in similar fashion to January and February, although "pilchard" shoals were sighted between 1200-1400 hours in the local areas of Pepin Island, Croixelles Harbour, Waihinau Bay, and Port Ligar. Most of these mid-day sightings were in 5-15 fathom water, on clear, fine days, and with little or no wind. Purse seining occurred in these shallow waters with little difficulty (20 fathom net).

May saw the completion of the "pilchard" project with most shots being in Tasman Bay. Shoal numbers sighted diminished rapidly with shoals being seen only off Separation Point, Pepin Island, Croixelles Harbour, and Admiralty Bay. Echosounder traces were therefore followed in shooting the net, using a 12" (30cm) red, plastic buoy to mark the shoals.

The presence or absence of bird species for each recorded purse seine shot, were as follows:

Shot Number	Bird Species Present
23	-
29	-
31	-
40	-
41	-
42	-
43	2 gannets
48	-
49	-

Shot Number	Bird Species Present
50	flocks of gannets (20-30), fluttering shearwaters (100+)
51	-
52	-
53	4 black - back gulls
54	10 gannets
55	numerous black-back gulls, fluttering shearwaters, red-billed gulls, gannets, shags
56	gannets and fluttering shearwaters (40-50)
57	gannets and fluttering shearwaters (40-50)
58	gannets and fluttering shearwaters (40-50), red-billed gulls, 400+ white-fronted terns
59	white-fronted terns, black-back gulls, fluttering shearwaters
60	-
61	-
62	10 gannets
63	gannets and white-fronted terns
64	red-bill gulls, shags, fluttering shearwaters
65	-
66	black-back gulls, red-bill gulls
67	-
68	-
69	-
70	black-back gulls, shags, fluttering shearwaters, white-fronted terns (500-1000 total)
71	white-fronted terns, black-back gulls, shags, fluttering shearwaters (500-1000 total)
72	-
73	-

Of the 17 shots without birds present, 9 were by echosounder. This gave 16 shots (66.6%) of the remaining 24 which had birds present, and used as indicators for purse seining.

Length-frequency data

A. Pilchards

Length-frequency measurements were made on random samples of fish collected by bucket from a 1 ton brailer load as the fish were being stored in the fish hold. Sampling was in most cases in the absence of the author leading firstly, to insufficient shoals

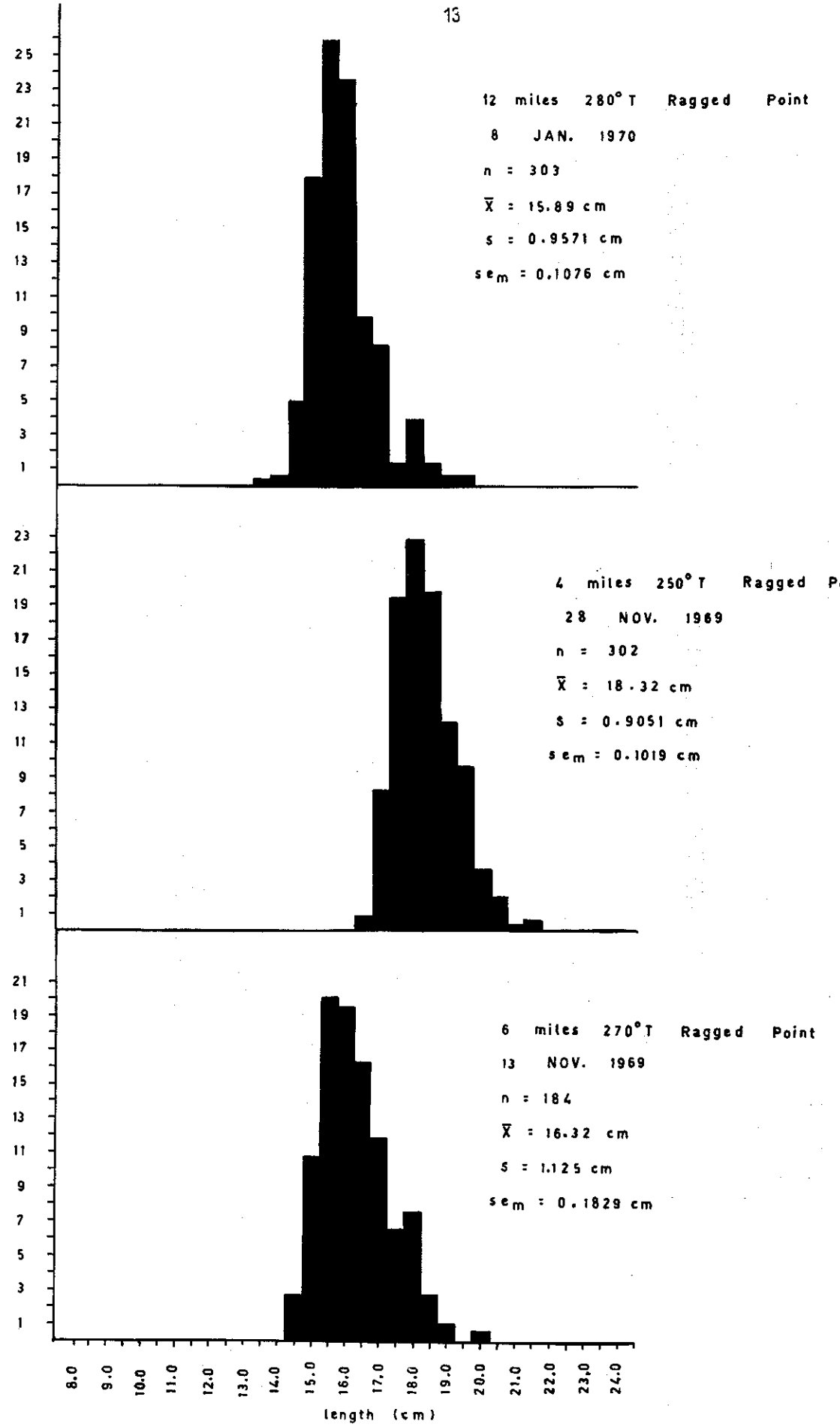

FIG. 1 Pilchard samples from upper Tasman Bay, expressed as % length-frequencies. Class interval = 0.5 cm. Capture method = purse seine.

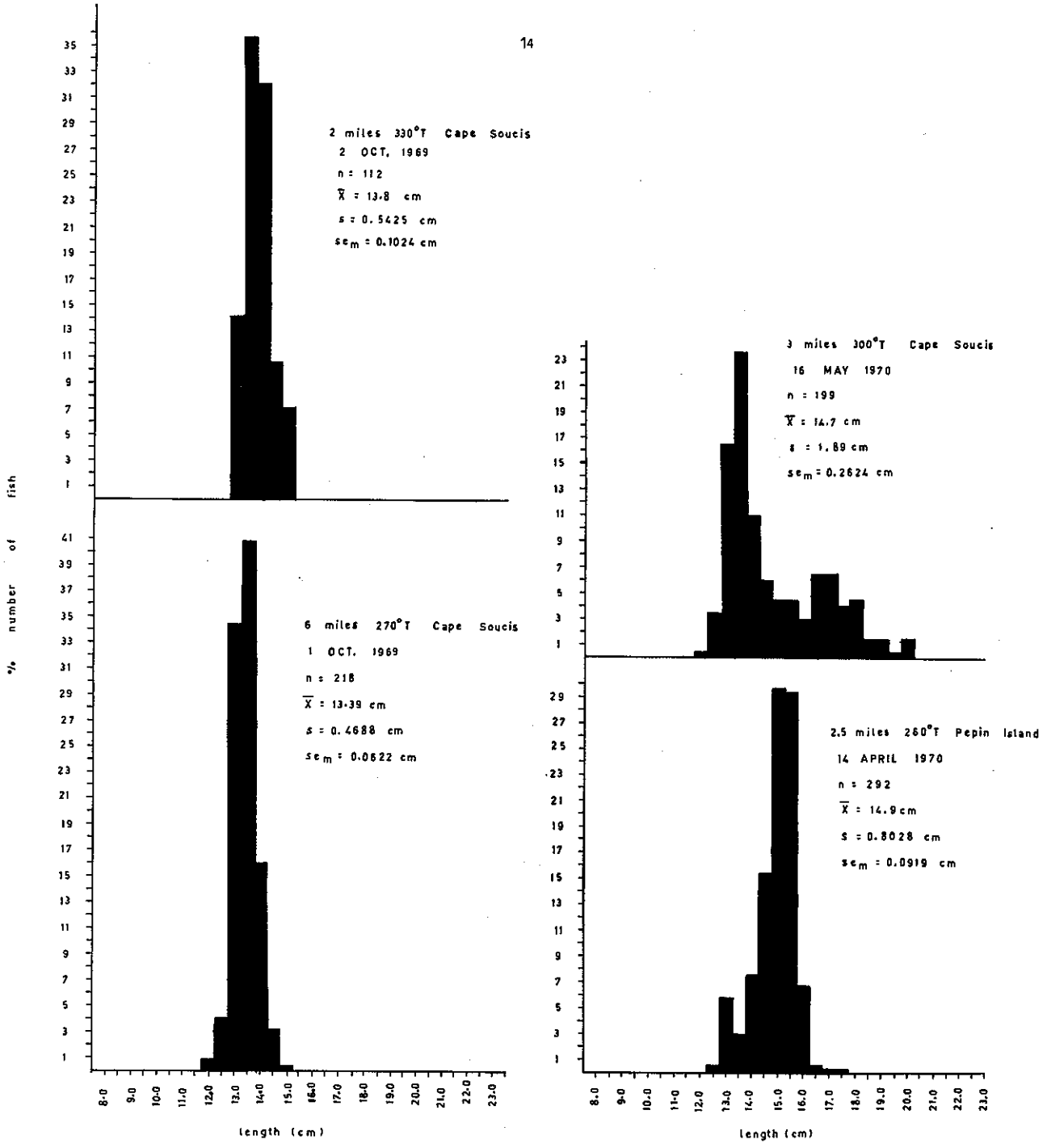

FIG. 2 Fish samples from lower Tasman Bay, as % length-frequencies. Class interval = 0.5 cm. Capture method = purse seine

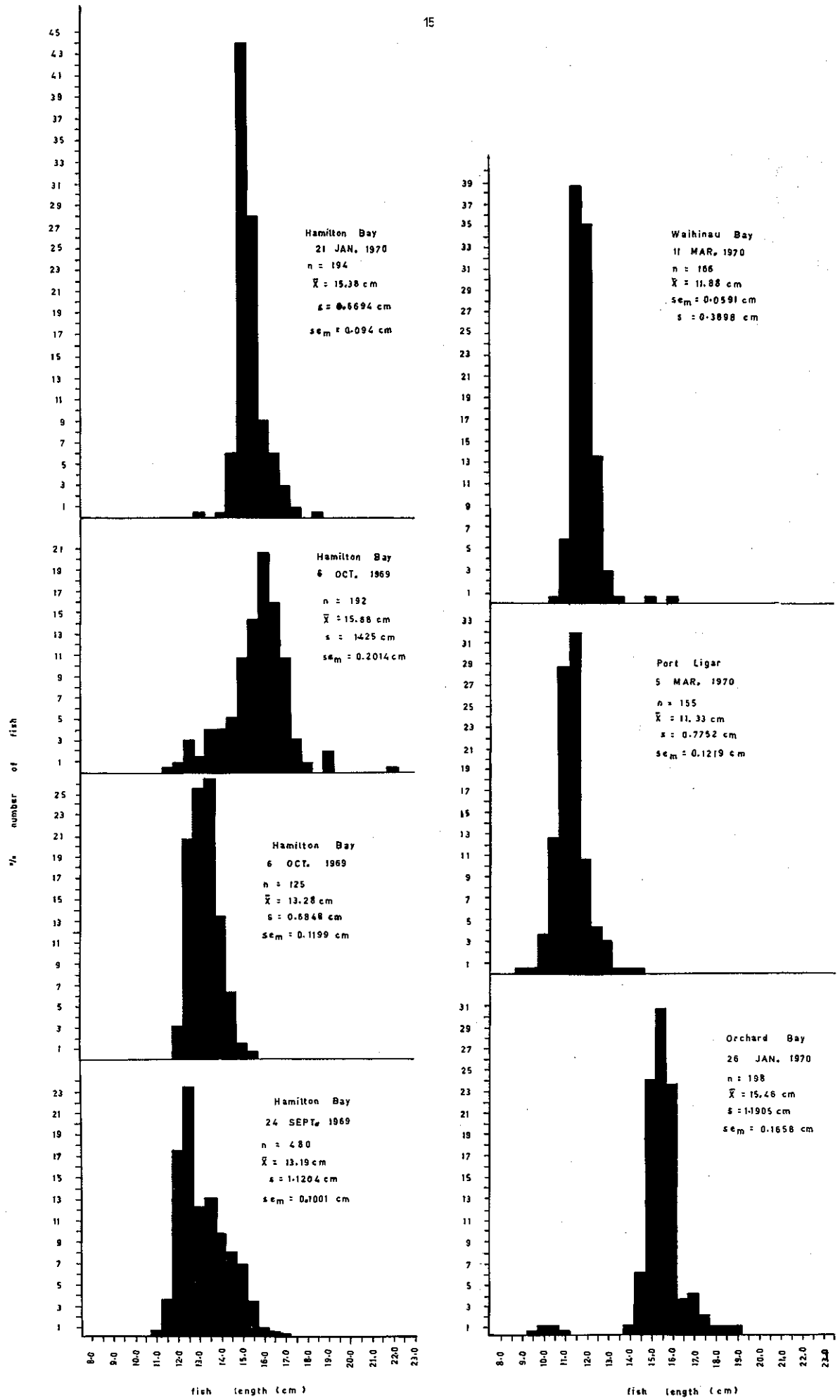

FIG. 3 Fish samples from Marlborough Sounds, as % length-frequencies. Class interval = 0.5cm. Capture method = purse seine

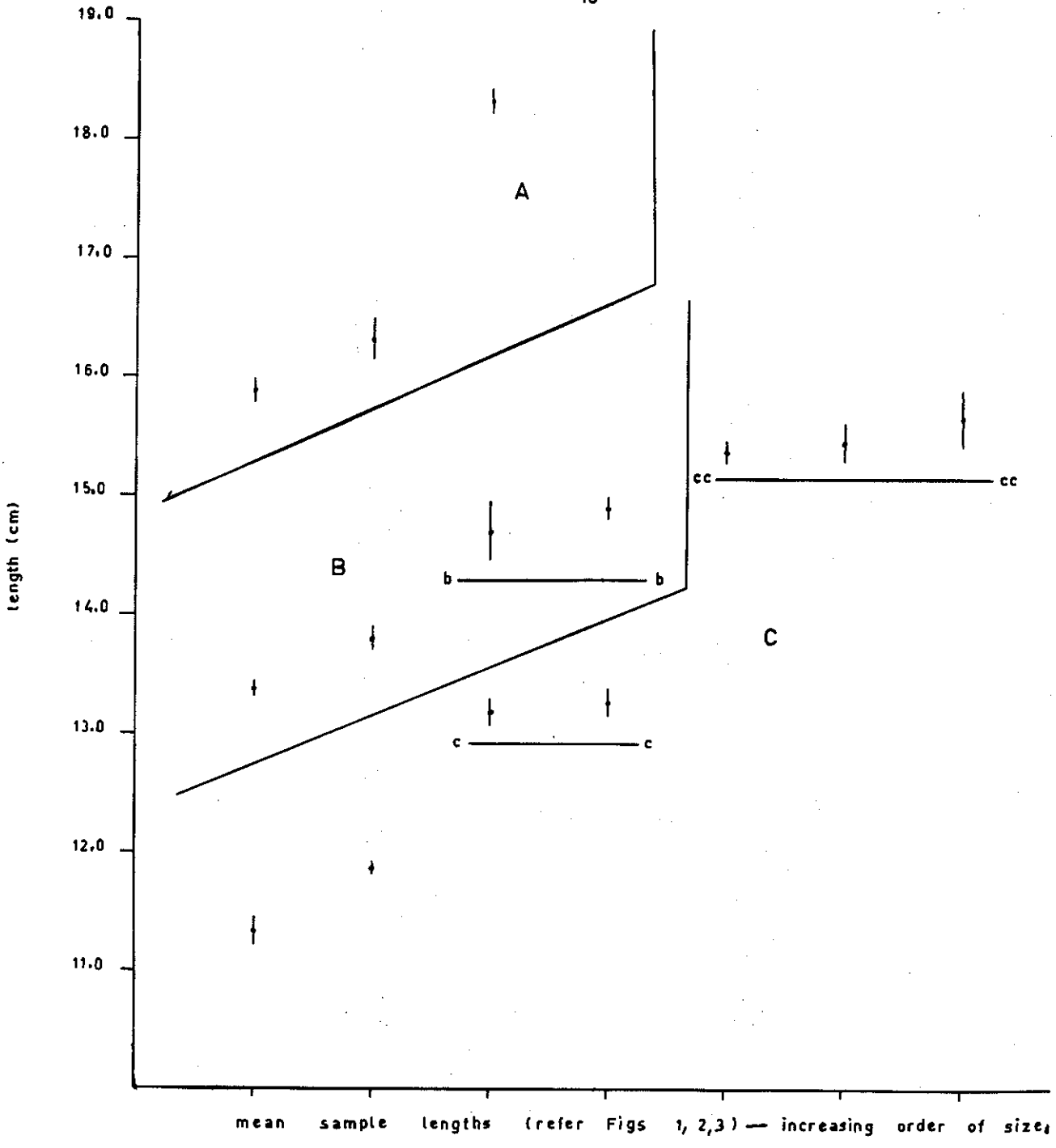

FIG. 4 Mean lengths, with their standard errors of the mean, for the 3 areas, underscored by Duncans Multiple Range Test. A = west off D'Urville Island; B = west off Cape Soucis and Pepin Island; C = Marlborough Sounds.

being sampled for analysis; secondly, to insufficient fish numbers being measured per sample, and thirdly, measurement bias was later noted for the shoals measured during April and May 1970. The latter reason necessitated converting all samples to % frequency, and lengths to 0.5cm intervals in place of the 0.1cm size ranges initially used. The % length-frequencies (Fig. 1-3) were presented as 3 localities: Fig. 1 = west of D'Urville Island (upper Tasman Bay), Fig. 2 = west of Cape Soucis and Pepin Island (lower Tasman Bay), and Fig. 3 = Marlborough Sounds.

Analysis of variance tests within each area were calculated to find if significant difference existed at the 95% confidence level, between the samples. The areas are coded A = Fig. 1, B = Fig. 2, C = Fig. 3.

	F. value	P	Remarks
A	548.35	$< .005$	significant difference
B	102.1	$< .005$	significant difference
C	101.43	$< .005$	significant difference

Since in all cases significant variation in sample length-frequency were located, the means were underscored by Duncans Multiple Range Test to show which samples had similar lengths in each area (Fig. 4).

1. There appeared to be 2 populations of pilchards located respectively in Tasman Bay and the Marlborough Sounds, as shown by the mean length, standard deviations, and standard errors of the mean. Fish sizes were generally larger in Tasman Bay having mean length ranges from 13.39cm to 18.32cm, as distinct from 11.33cm to 15.68cm in the Marlborough Sounds. Communication between the 2 populations appeared to be hindered by the 7 knot current through French Pass as well as the land-enclosed nature of the Sounds area, with only fringe mixing occurring north of D'Urville Island. To verify these 2 populations, however, would require greater intensive sampling than occurred on this present survey.

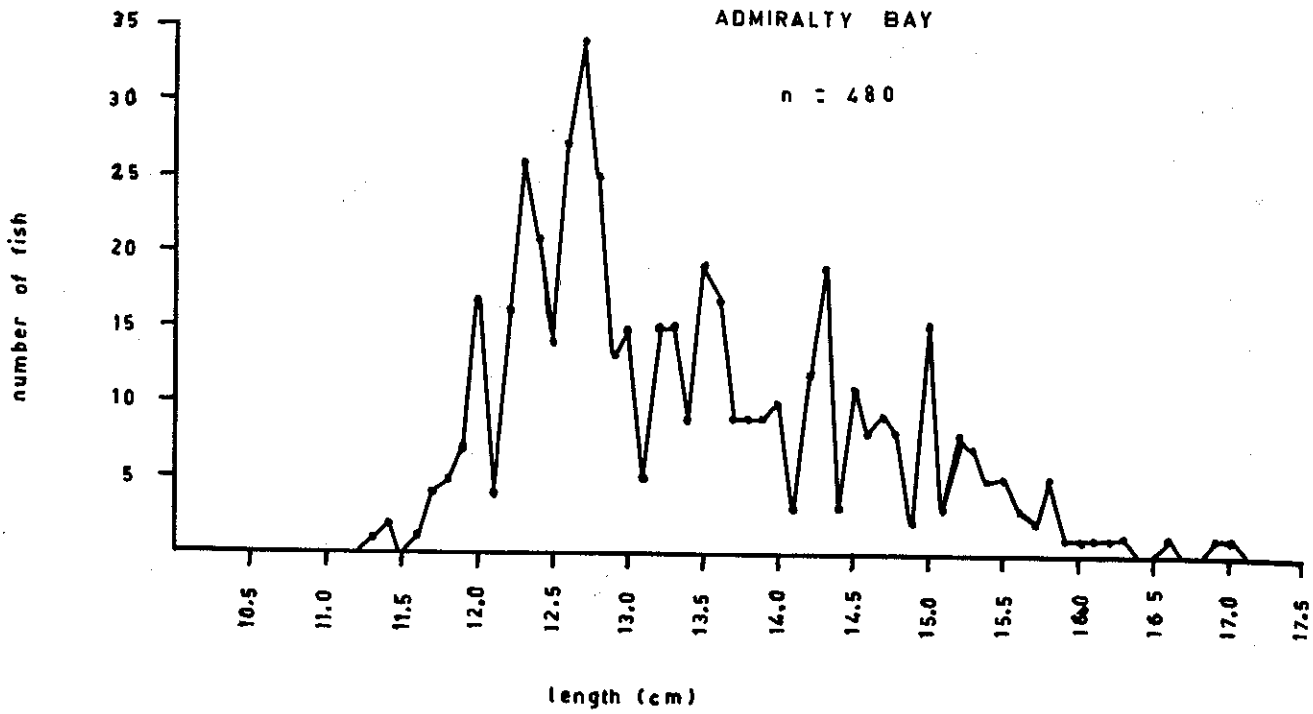

FIG. 5 Length - frequency of pilchards from 1 random sample (24/9/69) in Marlborough Sounds. Class interval : 1 mm.

2. Shoals containing different size ranges were caught in the same area within the same month (Fig. 1 and 2). Similarly, shoals were found showing no size difference between months, (Fig. 3): thus, seasonal variation in lengths was not evident.

3. The shoals were found to contain relatively narrow size ranges; the standard deviations, from 0.3898 to 1.89cm, indicated that large departures from the calculated sample means were unlikely at the 95% confidence level. It appeared that pilchard shoals throughout the year were composed of 1 or 2 age groups only. Since the principal characteristics of fish shoal organisation were to (a) stay together for feeding, breeding and escapement from predation, (b) head in the same direction, and (c) maintain even spacing, such a size limit was obviously of great importance. Fish of similar size could thus maintain the correct distance from one another by having a similar tail beat amplitude, so important for sudden movement or change of direction (van Olst and Hunter, 1970).

Although a number of shoals showed measurement bias, 1 sample collected by the author (24 September 1969) was randomly measured (Fig. 5). Analysis by probability paper was completed to separate possible age groups, the length divisions used being in millimetres. The 4 groups thus separated had the following statistics:

29 September 1969	n	$\bar{X}$ (cm)	SEm (cm)	s (cm)
	228	12.44	0.046	0.36
	98	13.42	0.046	0.23
	92	14.3	0.066	0.32
	45	15.2	0.075	0.25

According to Baker (1972) these lengths represented: 12.44cm = 2.7 years, 13.42cm = 3.5 years, 14.3cm = 4.3 years, and 15.2cm = 4.7 years. Baker found that length-frequency distributions for adult pilchards gave no indication of seasonal growth. Such a conclusion was also generally true for the 1969-70 data.

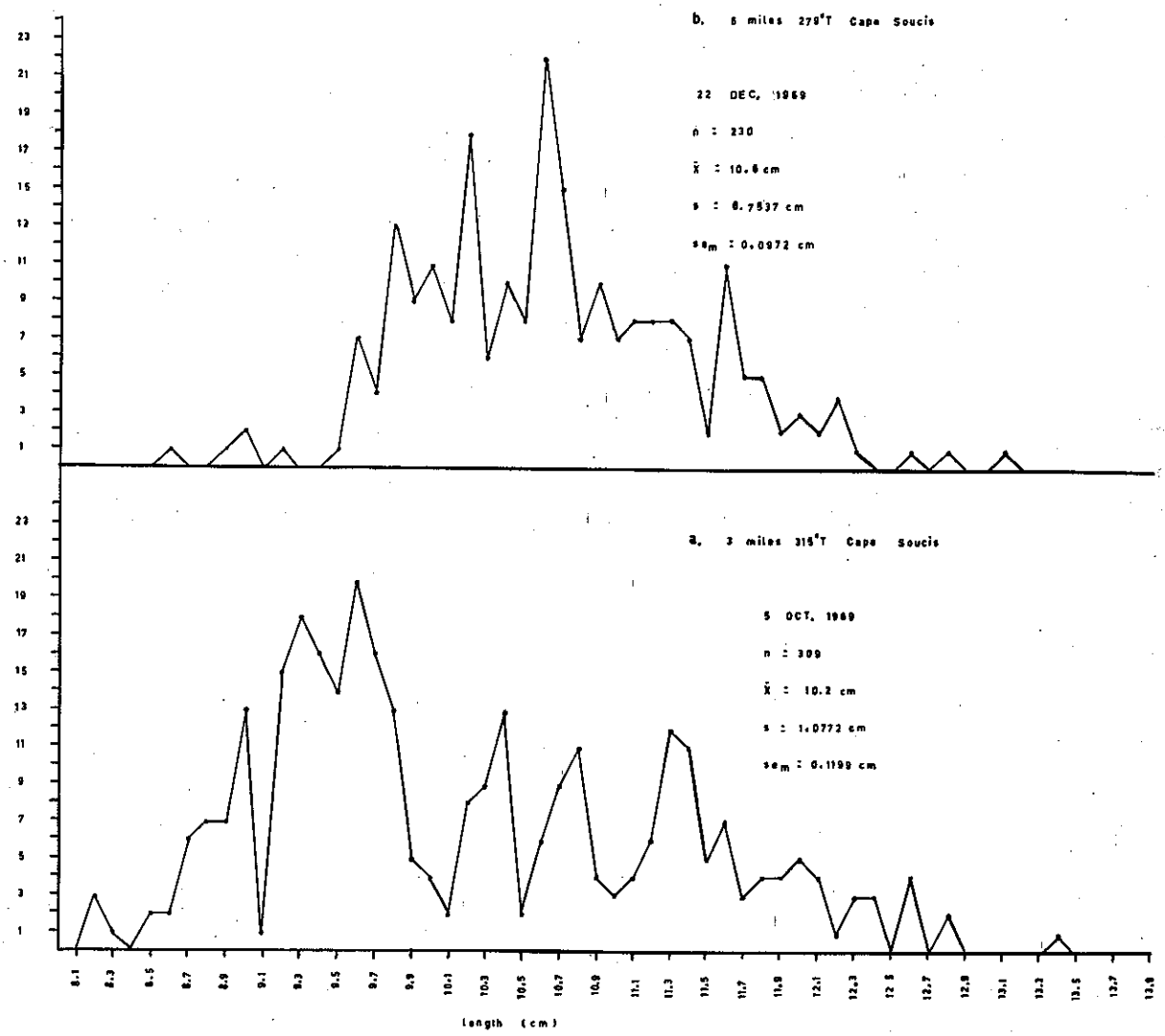

FIG. 6 Length - frequency data for the anchovy (Austranchovia australis (White) from samples taken off Cape Soucis (Tasman Bay). Class interval : 1 mm.

B. Anchovy

Only 2 shoals of anchovy (not mixed) were randomly sampled throughout the project, the data being collected by the author on 5 October 1969 and 22 December 1969. Fig. 6 shows the plotted length-frequency distribution for the 2 samples. Analysis of variance test between the samples gave F = 32.76 having P = .005, indicating difference in the size ranges of the shoals. This apparent increase in fish size with approach of summer suggested a population movement away from the shoreline areas and into the open waters for spawning. Definition of age groups was not attempted owing to insufficient data.

Gonad Maturity

A. Pilchard

In most of the samples taken all fish were examined for sex and gonad maturity, the general maturity ratings used being shown in Appendix 1. Table 3 sets out the maturity states of the fish illustrating the breeding season and size length reached for first maturity. Areas designated A, B, and C are the same as used for Fig. 1, 2 and 3 above.

First maturity for the pilchard occurred at 13.0cm for fish in Tasman Bay and 14.0cm for those in the Marlborough Sounds. However, such maturity differentiation between the 2 areas will require substantiation from additional sampling. There did not appear to be any size variation between the sexes for first maturity. Spawning occurred between November and February for both areas.

The sex ratios found for each of the above samples were as follows.

		Male	Female	Ratio (M/F)	X^2	P
A.	13.11.69	37	147	1:3.97	65.6	< .005
	28.11.69	119	183	1:1.53	13.4	< .005
	8.1.70	120	183	1:1.52	13.4	< .005

TABLE 3 GONAD MATURITY PER 0.5cm LENGTH CLASS FOR THE PILCHARD SAMPLES ANALYSED, SHOWING NUMBER OF FISH IN EACH LENGTH CLASS

A. West of D'Urville Island (upper Tasman Bay)

Date	Sex	Length class (cm)	Gonad Maturity I	II	III	IV	V	VI	VII
13.11.69	male	14.5	-	1	2	-	-	-	-
		15.0	-	-	-	3	-	-	-
		15.5	1	-	5	8	-	-	-
		16.0	-	1	-	7	-	-	-
		16.5	-	-	-	4	-	-	-
		17.0	-	-	1	-	-	-	-
		17.5	-	-	-	2	-	-	-
		18.0	-	-	-	2	-	-	-
	female	14.5	-	-	2	-	-	-	-
		15.0	-	1	6	6	2	-	-
		15.5	-	-	8	9	7	1	-
		16.0	1	-	7	14	5	2	-
		16.5	-	-	3	4	12	6	-
		17.0	-	-	5	3	10	1	-
		17.5	-	-	3	4	5	-	-
		18.0	-	-	1	3	4	4	-
		18.5	-	-	1	2	1	1	-
		19.0	-	-	-	1	-	1	-
		19.5	-	-	-	-	-	-	-
		20.0	-	-	-	1	-	-	-
28.11.69	male	16.5	-	-	1	-	-	-	-
		17.0	-	-	9	1	3	-	-
		17.5	-	-	20	4	3	-	-
		18.0	2	-	20	6	2	-	-
		18.5	-	-	11	7	6	-	-
		19.0	-	1	5	3	1	-	-
		19.5	-	-	3	2	4	-	-
		20.0	-	-	1	-	-	-	-
		20.5	-	-	1	2	1	-	-
	female	16.5	-	-	1	-	-	1	-
		17.0	-	-	1	1	2	8	-
		17.5	-	-	2	3	3	21	-
		18.0	-	-	1	2	11	20	-
		18.5	-	-	-	4	8	21	-
		19.0	-	1	1	4	4	17	-
		19.5	-	-	-	-	5	15	-
		20.0	-	-	-	-	2	18	-
		20.5	1	-	-	-	1	1	-
		21.0	-	-	-	-	-	1	-
		21.5	-	-	-	-	-	2	-

8.1.70	male	13.5	-	-	-	1	-	-	-
		14.0	-	-	-	1	-	-	-
		14.5	-	-	2	8	1	-	-
		15.0	-	-	8	24	-	-	-
		15.5	-	1	2	34	1	-	-
		16.0	-	-	4	18	1	-	-
		16.5	-	-	1	3	1	-	-
		17.0	-	-	-	6	1	-	-
		17.5	-	-	-	-	-	-	-
		18.0	-	-	-	2	-	-	-
	female	13.5	-	-	-	-	-	-	-
		14.0	1	-	-	-	-	-	-
		14.5	-	2	1	1	-	-	-
		15.0	-	4	9	4	5	-	-
		15.5	1	5	10	13	8	4	-
		16.0	2	4	10	10	18	6	-
		16.5	-	3	3	1	16	2	1
		17.0	-	-	4	1	7	5	-
		17.5	-	-	-	-	-	4	-
		18.0	-	-	1	-	3	6	-
		18.5	-	-	-	-	3	1	-
		19.0	-	-	-	-	-	2	-
		19.5	-	-	-	-	-	2	-

B. West of Cape Soucis and Pepin Island (Lower Tasman Bay)

1.10.69			NO DATA						
2.10.69			NO DATA						
14.4.70	male	12.5	-	1	-	-	-	-	-
		13.0	5	5	3	-	-	-	-
		13.5	2	7	3	-	-	-	-
		14.0	3	10	5	-	-	-	-
		14.5	3	8	13	-	-	-	-
		15.0	3	16	26	3	-	-	-
		15.5	5	17	22	11	-	-	-
		16.0	-	2	9	-	-	-	-
		16.5	-	1	1	-	-	-	-
		17.0	-	-	-	1	-	-	-
	female	12.5	1	-	-	-	-	-	-
		13.0	-	2	-	-	-	-	-
		13.5	1	5	1	-	-	-	-
		14.0	1	5	-	-	-	-	-
		14.5	5	9	4	2	-	-	-
		15.0	2	14	11	7	-	-	-
		15.5	1	15	10	2	-	-	-
		16.0	-	1	5	3	-	-	-
		16.5	-	-	-	-	-	-	-
16.5.70	male	12.0	1	-	-	-	-	-	-
		12.5	4	1	-	-	-	-	-
		13.0	9	16	-	-	-	-	-
		13.5	30	10	2	-	-	-	-
		14.0	9	8	-	-	-	-	-
		14.5	1	7	2	-	-	-	-
		15.0	3	4	1	-	-	-	-
		15.5	2	6	-	-	-	-	-
		16.0	4	2	-	-	-	-	-

		16.5	2	5	2	-	-	-	-
		17.0	2	7	4	-	-	-	-
		17.5	-	1	3	-	-	-	-
		18.0	-	2	3	-	-	-	-
		18.5	-	-	2	-	-	-	-
		19.0	-	2	2	-	-	-	-
		19.5	-	1	-	-	-	-	-
		20.0	-	-	1	-	-	-	-
	female	12.0	-	-	-	-	-	-	-
		12.5	1	-	-	-	-	-	-
		13.0	4	2	-	-	-	-	-
		13.5	6	2	-	-	-	-	-
		14.0	3	2	-	-	-	-	-
		14.5	1	-	-	-	-	-	-
		15.0	-	1	-	-	-	-	-
		15.5	1	-	-	-	-	-	-
		16.0	1	1	-	-	-	-	-
		16.5	-	2	4	-	-	-	-
		17.0	-	-	-	-	-	-	-
		17.5	1	2	2	-	-	-	-
		18.0	-	6	-	-	-	-	-
		18.5	-	2	2	-	-	-	-
		19.0	-	-	-	-	-	-	-
		19.5	-	-	-	-	-	-	-
		20.0	-	2	-	-	-	-	-

C. Marlborough Sounds

24.9.69				NO DATA				
6.10.69	male	12.0	1	-	-	-	-	-	-
		12.5	4	6	-	-	-	-	-
		13.0	3	6	-	-	-	-	-
		13.5	2	12	-	-	-	-	-
		14.0	-	10	2	-	-	-	-
		14.5	-	3	-	-	-	-	-
		15.0	-	-	1	-	-	-	-
	female	12.0	2	-	-	-	-	-	-
		12.5	8	8	-	-	-	-	-
		13.0	3	19	-	-	-	-	-
		13.5	1	19	1	-	-	-	-
		14.0	-	6	-	-	-	-	-
		14.5	-	4	2	-	-	-	-
		15.0	-	-	-	-	-	-	-
		15.5	-	1	1	-	-	-	-
6.10.69	male	11.5	-	-	-	-	-	-	-
		12.0	1	1	-	-	-	-	-
		12.5	2	-	-	-	-	-	-
		13.0	1	1	-	-	-	-	-
		13.5	2	2	-	-	-	-	-
		14.0	2	-	-	-	-	-	-
		14.5	-	6	-	-	-	-	-
		15.0	-	7	2	-	-	-	-
		15.5	-	10	5	-	-	-	-
		16.0	-	12	4	-	-	-	-
		16.5	-	5	6	-	-	-	-
		17.0	-	2	5	-	-	-	-
		17.5	-	-	1	-	-	-	-

	female	11.5	1	-	-	-	-	-	-
		12.0	1	-	-	-	-	-	-
		12.5	4	1	-	-	-	-	-
		13.0	-	-	-	-	-	-	-
		13.5	3	2	-	-	-	-	-
		14.0	1	6	-	-	-	-	-
		14.5	-	4	-	-	-	-	-
		15.0	-	13	-	-	-	-	-
		15.5	-	12	1	-	-	-	-
		16.0	-	21	2	-	-	-	-
		16.5	-	16	2	-	-	-	-
		17.0	-	10	4	-	-	-	-
		17.5	-	2	3	-	-	-	-
		18.0	-	1	1	-	-	-	-
		18.5	-	-	-	-	-	-	-
		19.0	-	2	1	-	-	-	-
		19.5	-	-	-	-	-	-	-
		20.0	-	-	-	-	-	-	-
		22.0	-	-	1	-	-	-	-
24.1.70	male	13.0	-	-	-	-	-	-	-
		13.5	-	-	-	-	-	-	-
		14.0	-	1	-	-	-	-	-
		14.5	1	3	-	-	-	-	-
		15.0	4	12	4	7	-	-	-
		15.5	1	3	2	7	-	-	-
		16.0	-	1	1	1	-	-	-
		16.5	-	-	5	1	-	-	-
		17.0	-	-	-	2	-	-	-
		17.5	-	-	-	1	-	-	-
		18.0	-	-	-	-	-	-	-
		18.5	-	-	-	-	-	-	-
	female	13.0	-	-	-	-	-	-	-
		13.5	-	-	-	-	-	-	-
		14.0	-	-	-	-	-	-	-
		14.5	-	7	-	-	-	-	-
		15.0	4	37	8	6	3	2	-
		15.5	5	27	6	2	2	3	-
		16.0	1	6	4	1	-	2	-
		16.5	-	2	3	-	-	-	-
		17.0	-	-	2	2	-	-	-
		17.5	-	-	-	-	-	1	-
		18.0	-	-	-	-	-	-	-
		18.5	-	1	-	-	-	-	-
26.1.70	male	9.5	-	-	-	-	-	-	-
		10.0	-	1	-	-	-	-	-
		10.5	-	-	-	-	-	-	-
		11.0	1	-	-	-	-	-	-
		14.0	-	-	-	-	-	-	-
		14.5	-	2	2	4	-	-	-
		15.0	1	7	8	6	-	-	-
		15.5	-	2	15	7	2	-	-
		16.0	1	4	2	6	2	-	-
		16.5	-	1	-	1	-	-	-
		17.0	-	1	1	1	1	-	-
		17.5	-	-	-	-	-	-	-
		18.0	-	-	-	-	-	-	-
		18.5	-	-	-	-	-	-	-
		19.0	-	-	-	-	1	-	-

	female	9.5	1	-	-	-	-	-	-
		10.0	-	-	-	-	-	-	-
		10.5	-	2	1	-	-	-	-
		11.0	-	-	-	-	-	-	-
		14.0	-	-	2	-	-	-	-
		14.5	-	1	2	-	-	-	-
		15.0	2	8	11	4	2	-	-
		15.5	4	10	14	2	2	-	1
		16.0	1	8	14	3	5	1	-
		16.5	1	1	4	-	-	-	-
		17.0	-	-	2	1	-	1	-
		17.5	-	1	-	-	1	1	1
		18.0	-	1	-	-	1	-	-
		18.5	-	1	-	-	-	-	-
		19.0	-	-	-	-	-	-	-
5.3.70	male	9.0	-	-	-	-	-	-	-
		9.5	-	-	-	-	-	-	-
		10.0	3	-	-	-	-	-	-
		10.5	4	3	-	-	-	-	-
		11.0	5	5	-	-	-	-	-
		11.5	9	5	4	-	-	-	-
		12.0	3	2	1	-	-	-	-
		12.5	-	1	-	-	-	-	-
		13.0	1	1	1	-	-	-	-
		13.5	-	1	-	-	-	-	-
		14.0	-	1	-	-	-	-	-
		14.5	-	1	-	-	-	-	-
	female	9.0	1	-	-	-	-	-	-
		9.5	1	-	-	-	-	-	-
		10.0	1	1	-	-	-	-	-
		10.5	5	8	-	-	-	-	-
		11.0	8	25	1	-	-	-	-
		11.5	10	20	3	-	-	-	-
		12.0	1	9	1	-	-	-	-
		12.5	1	5	-	-	-	-	-
		13.0	-	3	-	-	-	-	-
11.3.70	male	10.5	-	-	-	-	-	-	-
		11.0	2	4	-	-	-	-	-
		11.5	7	24	13	-	-	-	-
		12.0	2	19	22	-	-	-	-
		12.5	2	6	12	-	-	-	-
		13.0	-	2	-	-	-	-	-
		13.5	-	1	-	-	-	-	-
	female	10.5	1	-	-	-	-	-	-
		11.0	2	3	1	-	-	-	-
		11.5	-	17	4	-	-	-	-
		12.0	1	5	7	-	-	-	-
		12.5	1	1	2	-	-	-	-
		13.0	-	2	1	-	-	-	-
		13.5	-	-	-	-	-	-	-
		14.0	-	-	-	-	-	-	-
		14.5	-	-	-	-	-	-	-
		15.0	-	-	1	-	-	-	-
		15.5	-	-	-	-	-	-	-
		16.0	-	-	1	-	-	-	-

		male	female	Ratio (M/F)	X^2	P
B.	14.4.70	185	107	1:0.57	20.8	< .005
	16.5.70	151	48	1:0.31	53.3	< .005
C.	6.10.69	50	75	1:1.5	5	.025
	6.10.69	77	115	1:1.49	7.5	.005
	24.1.70	57	137	1:2.4	32.8	< .005
	26.1.70	80	118	1:1.47	7.2	.01-.005
	5.3.70	51	104	1:2.03	18.12	< .005
	11.3.70	116	50	1:0.43	26.24	< .005

Most of the samples in areas A and C showed a significant predominance of females with males being more abundance in area B. With the small numbers taken and only a few shoals sampled further data would be needed before definite conclusions are made on the sex compositions of the pilchard populations in Tasman Bay and Marlborough Sounds.

B. Anchovy

All fish dissected in the 2 samples were examined for sex and gonad maturity (Appendix 1). Maturity of the fish were noted, showing breeding season and size length reached at first maturity (Table 4). First maturity was reached at 10.0 cm, with no size variation between the sexes. Spawning began in October.

The sex ratios for the 2 samples were:

	male	female	Ratio (M/F)	X^2	P
3.10.69	86	223	1:2.59	60.74	< .005
22.12.69	138	92	1:0.66	9.2	< .005

Although variation in the sex ratios occurred further samples are required to find if seasonal and geographical differences exist.

TABLE 4 GONAD MATURITY PER 0.5cm LENGTH CLASS FOR THE TWO ANCHOVY SAMPLES, SHOWING NUMBER OF FISH IN EACH LENGTH AND MATURITY CLASS

1. 3 miles 315°T Cape Soucis

Date	Sex	Length Class (cm)	Gonad Maturity I	II	III	IV	V	VI	VII
5.10.69	male	8.0	1	-	-	-	-	-	-
		8.5	2	-	-	-	-	-	-
		9.0	5	5	-	-	-	-	-
		9.5	5	8	-	-	-	-	-
		10.0	-	13	1	-	-	-	-
		10.5	-	9	4	-	-	-	-
		11.0	-	5	11	-	-	-	-
		11.5	-	2	8	-	-	-	-
		12.0	-	-	5	-	-	-	-
		12.5	-	-	1	1	-	-	-
	female	8.0	2	1	-	-	-	-	-
		8.5	17	6	-	-	-	-	-
		9.0	18	35	-	-	-	-	-
		9.5	9	45	-	-	-	-	-
		10.0	2	16	4	-	-	-	-
		10.5	-	11	6	1	1	-	-
		11.0	-	5	10	3	2	-	-
		11.5	-	5	2	5	1	-	-
		12.0	-	1	-	9	1	-	-
		12.5	-	-	1	1	-	-	-
		13.0	-	-	-	3	-	-	-
22.12.69	male	8.0	-	-	-	-	-	-	-
		8.5	-	1	-	-	-	-	-
		9.0	-	1	-	-	-	-	-
		9.5	-	9	13	-	-	-	-
		10.0	-	11	14	7	1	-	-
		10.5	-	6	26	12	-	-	-
		11.0	-	3	13	4	-	-	-
		11.5	-	-	7	5	-	-	-
		12.0	-	-	-	4	-	-	-
		12.5	-	-	-	1	-	-	-
		13.0	-	-	-	-	-	-	-

female	8.0	-	-	-	-	-	-	-
	8.5	-	1	-	-	-	-	-
	9.0	-	1	1	-	-	-	-
	9.5	-	7	3	1	-	-	-
	10.0	-	5	7	8	1	-	-
	10.5	-	5	3	6	3	1	-
	11.0	-	-	8	7	1	2	-
	11.5	-	-	3	6	3	1	-
	12.0	-	-	1	1	1	3	-
	12.5	-	-	-	-	1	-	-
	13.0	-	-	-	-	-	1	-

WATER TEMPERATURES

The "W.J. Scott" kept mainly to restricted areas along the eastern and western sides of Tasman Bay, and in the Marlborough Sounds. During the fishing trips surface water temperatures (^{o}C) were recorded using a Murayama Electric Resistance Thermometer, type M-2 (dry cell batteries FM-4), having an accuracy of $\pm$ 0.1^{o}C. Temperatures were recorded per 10 minute intervals while cruising, and 30 minute intervals while fishing, or searching, for shoals in a confined area (Fig. 7-15).

1. Water temperatures were found to fluctuate between 3-5^{o}C through water turbulence, caused by wave action formed with strong winds. Most of the area fished had water depth above 63m (33 fathoms). However, a 1^{o}C fluctuation was found to be normal throughout each month with fair weather, owing to rising air temperatures (spring and summer) or falling air temperatures (autumn and winter).

2. A system of surface water temperatures was noticed in Tasman Bay where warm close-inshore water gave way to a belt of cooler water, followed by a slight temperature rise over the deeper central Tasman Bay water. Complications in surface temperatures further arose from the influx of the cool D'Urville Current (Heath, 1969), the warm tidal water from Croixelles Harbour, Delaware Bay, and southern Tasman Bay off Nelson Harbour, and to the tidal water

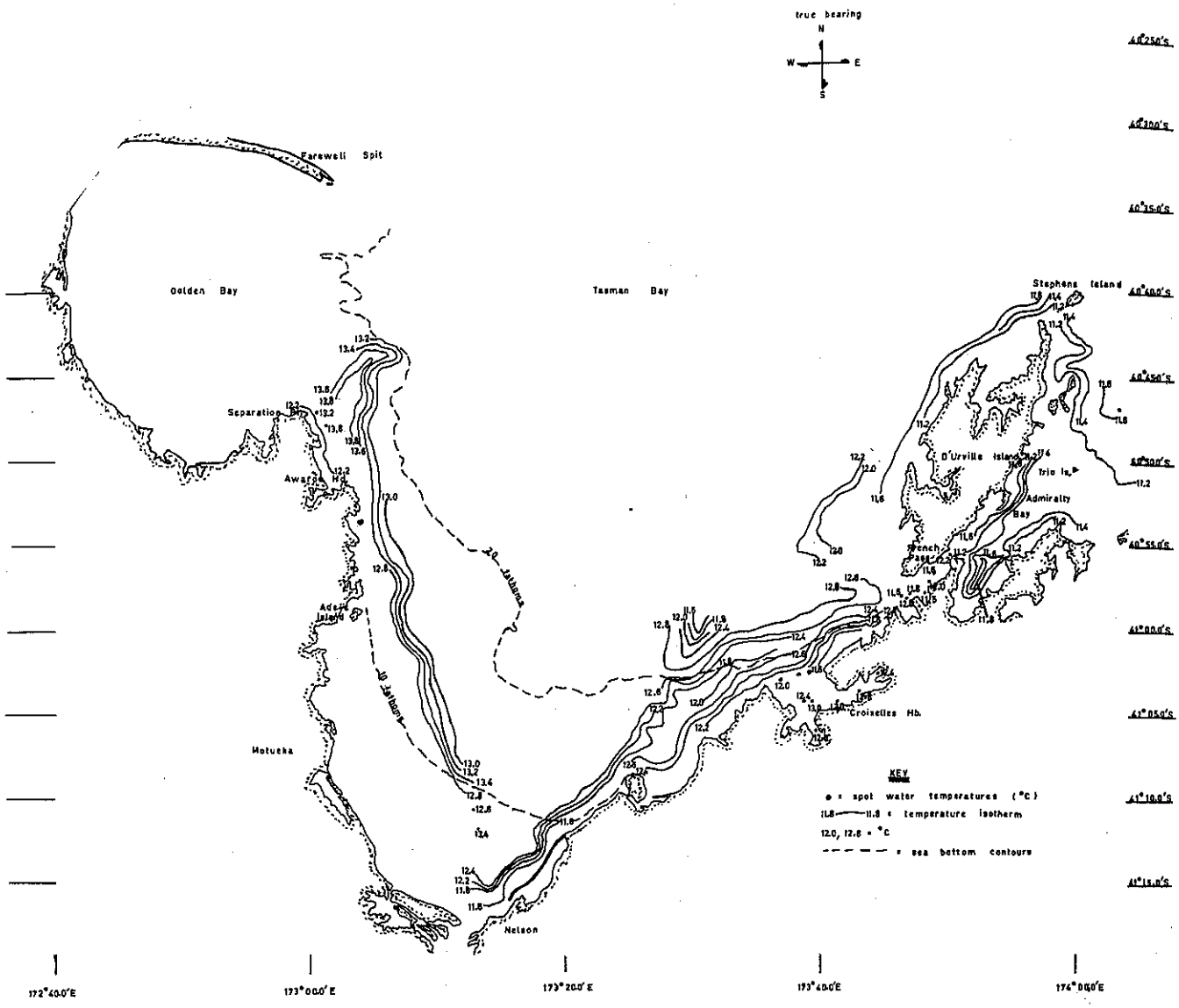

FIG. 7a Sea surface temperature isotherms (°C) plotted for Tasman Bay region, September 1969.

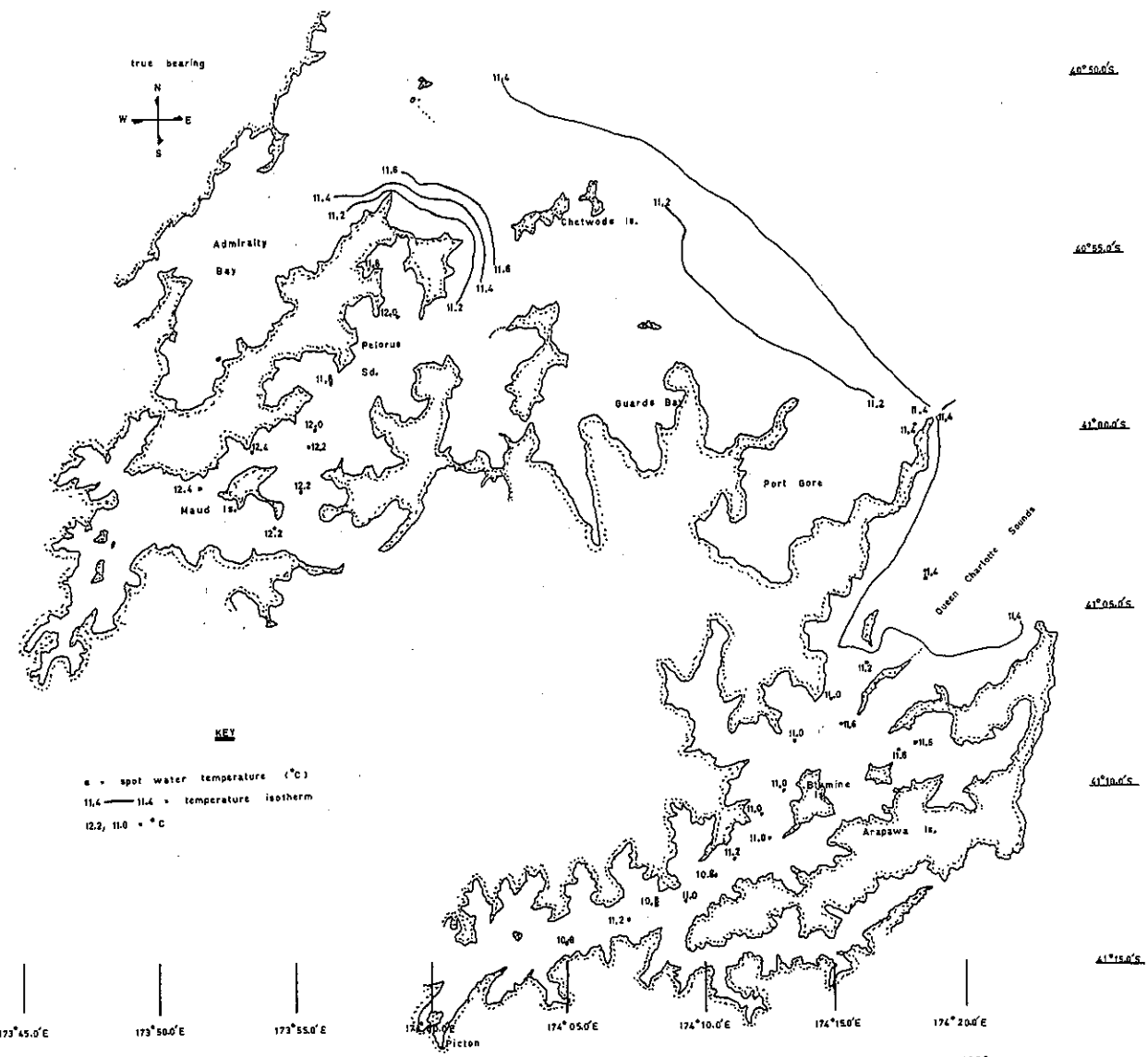

FIG. 7b Sea surface temperatures (°C) plotted for the Marlborough Sounds, September 1969.

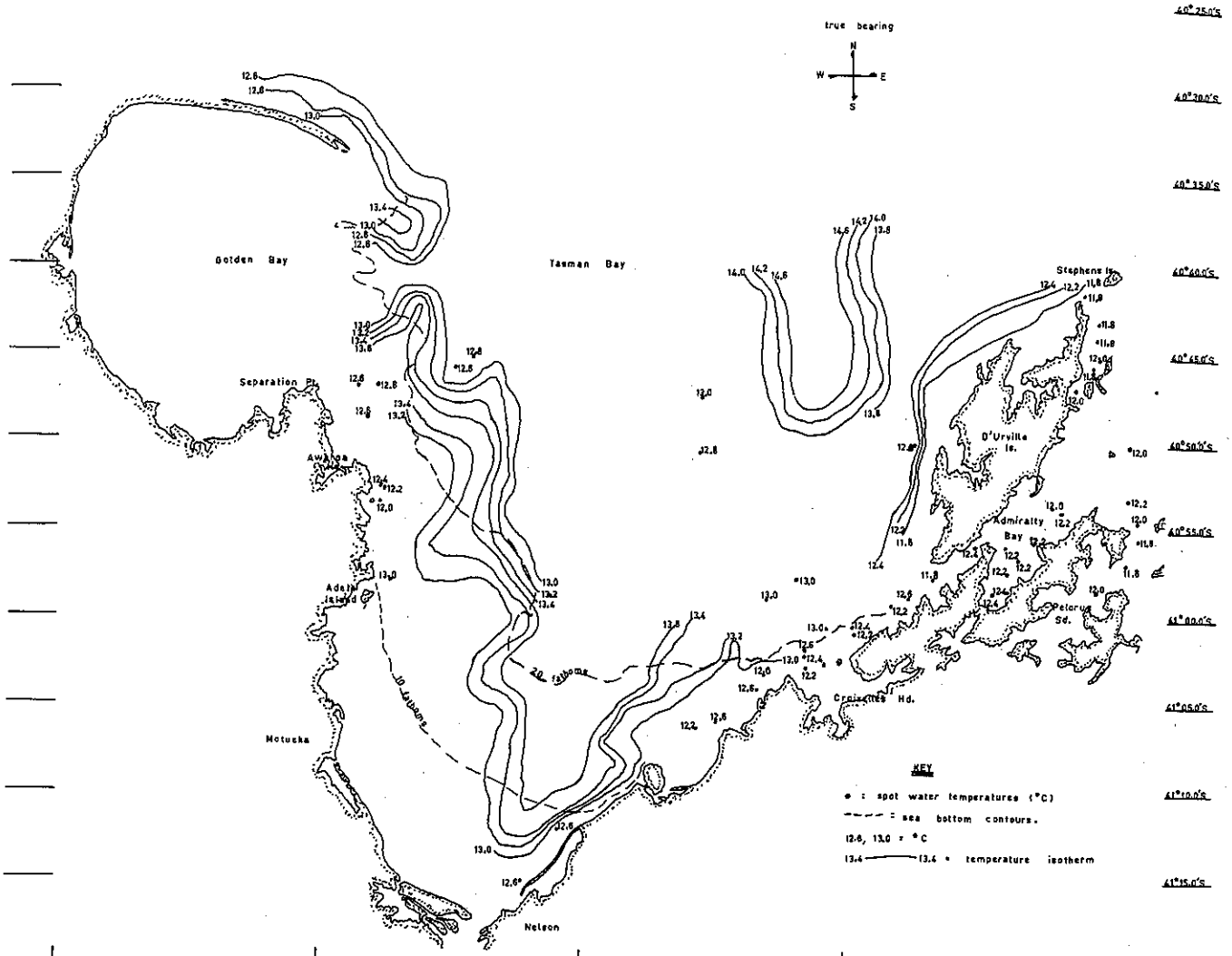

FIG. 8 Sea surface temperature isotherms (°C) plotted for Tasman Bay, October 1969.

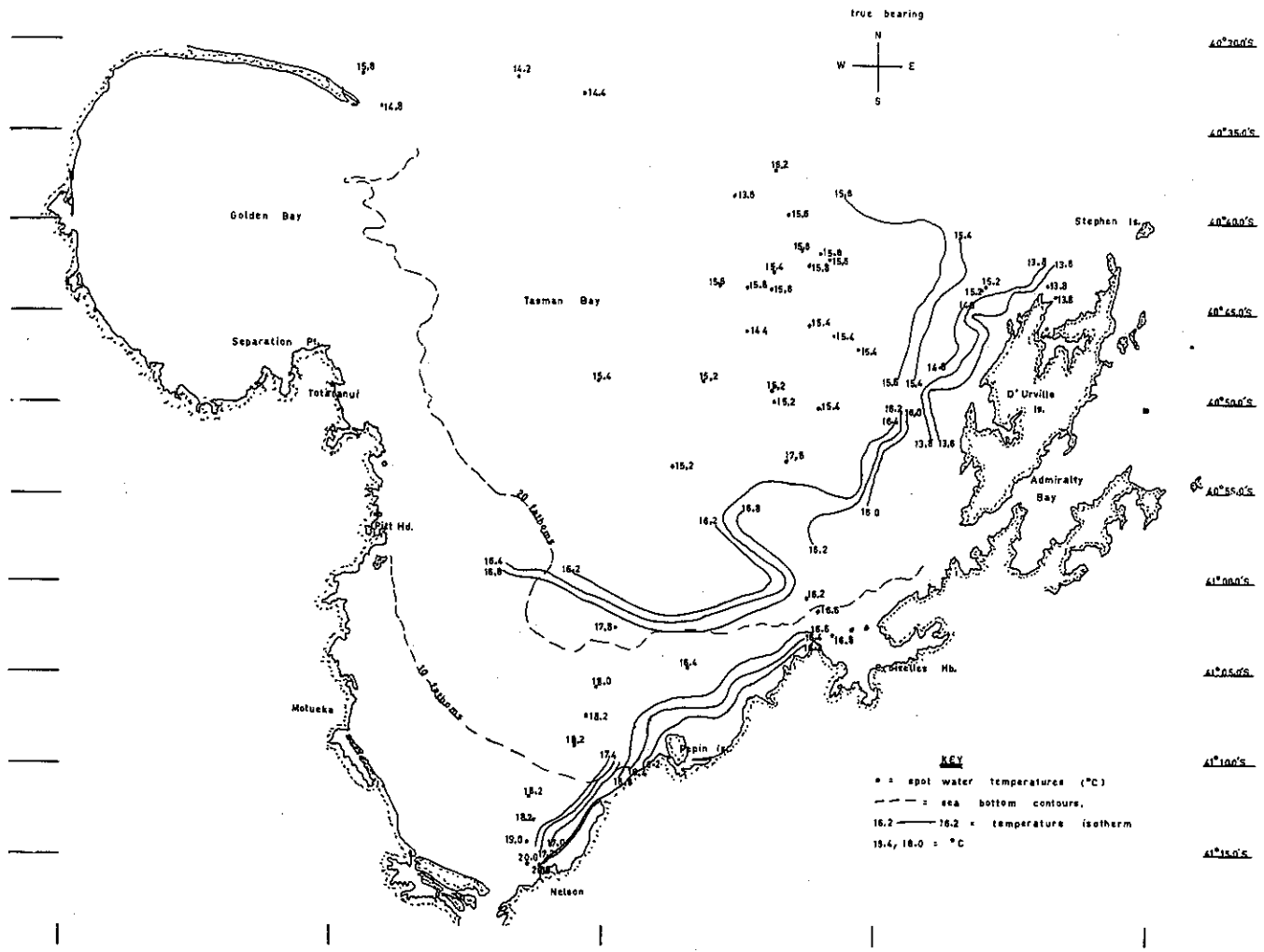

FIG. 9 Sea surface temperature isotherms (°C) plotted for Tasman Bay, November 1969.

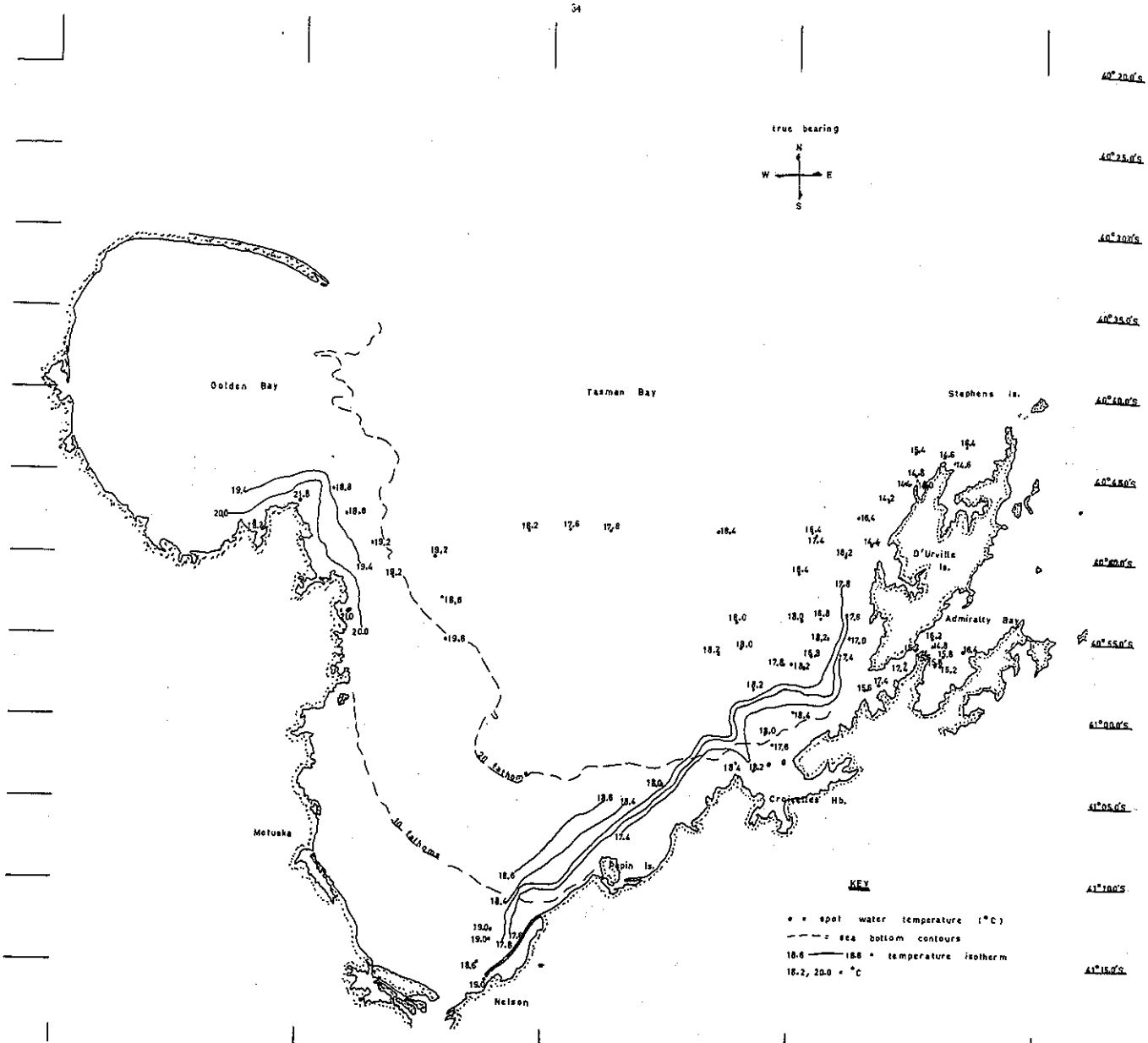

FIG. 10 Sea surface temperature isotherms (°C) plotted for Tasman Bay, December 1969.

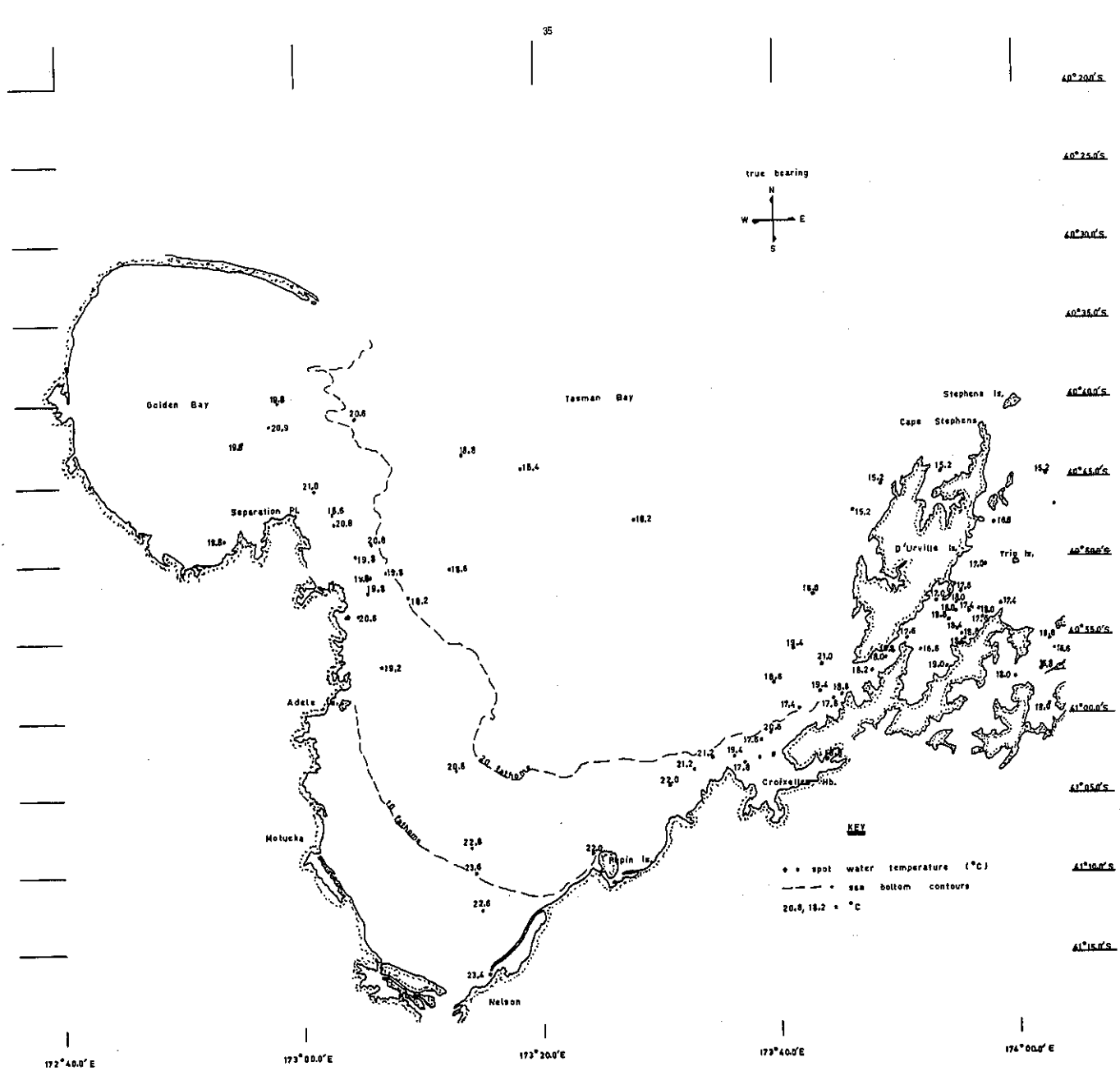

FIG. 11 Sea surface temperatures (°C) plotted for Tasman Bay, January 1970.

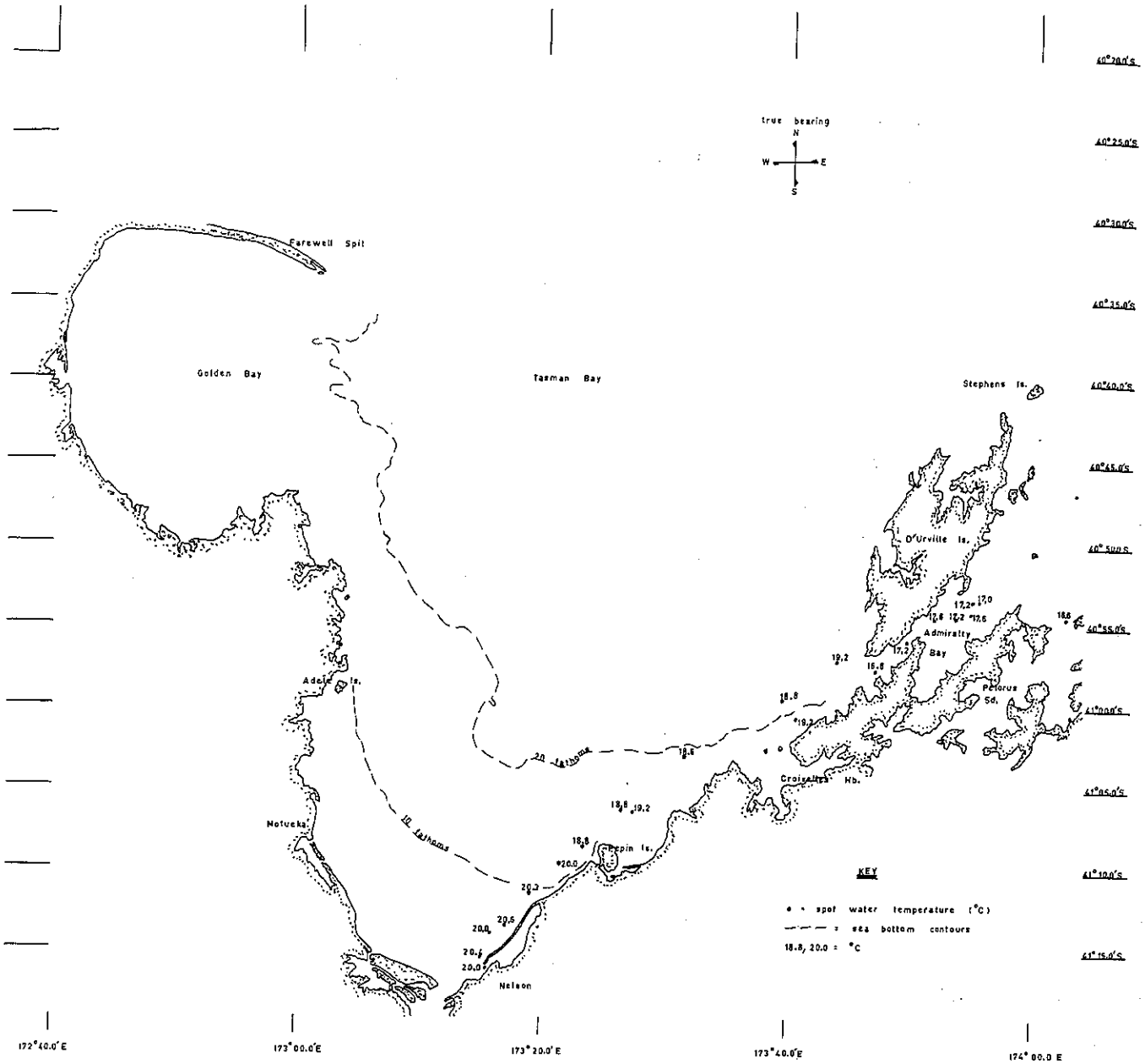

FIG. 12 Sea surface temperatures (°C) plotted for Tasman Bay area, February 1970.

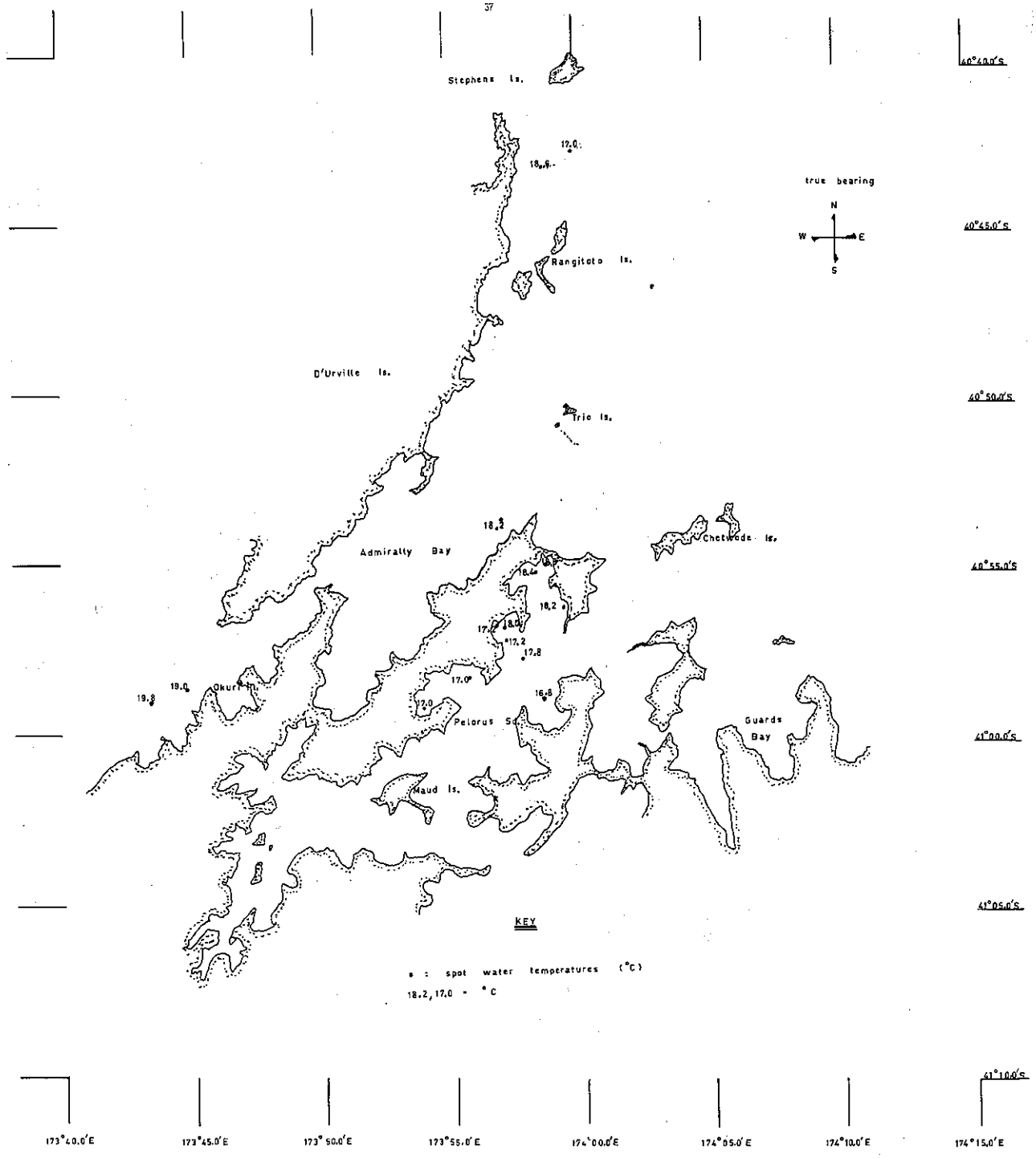

FIG. 13 Sea surface temperatures (°C) plotted for northern areas of the Marlborough Sounds, March 1970.

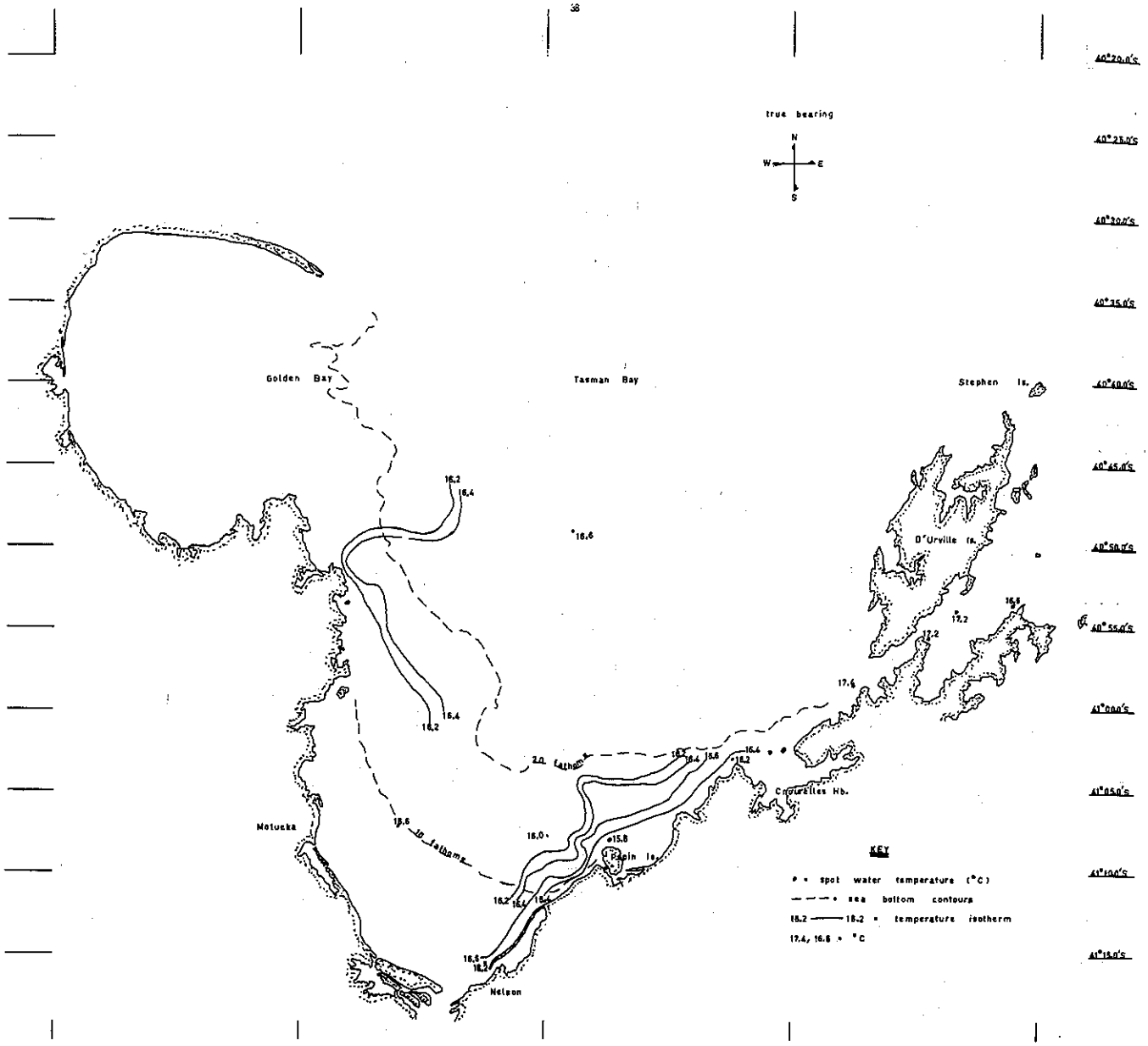

FIG. 14a Sea surface temperature isotherms (°C) plotted for Tasman Bay, April 1970.

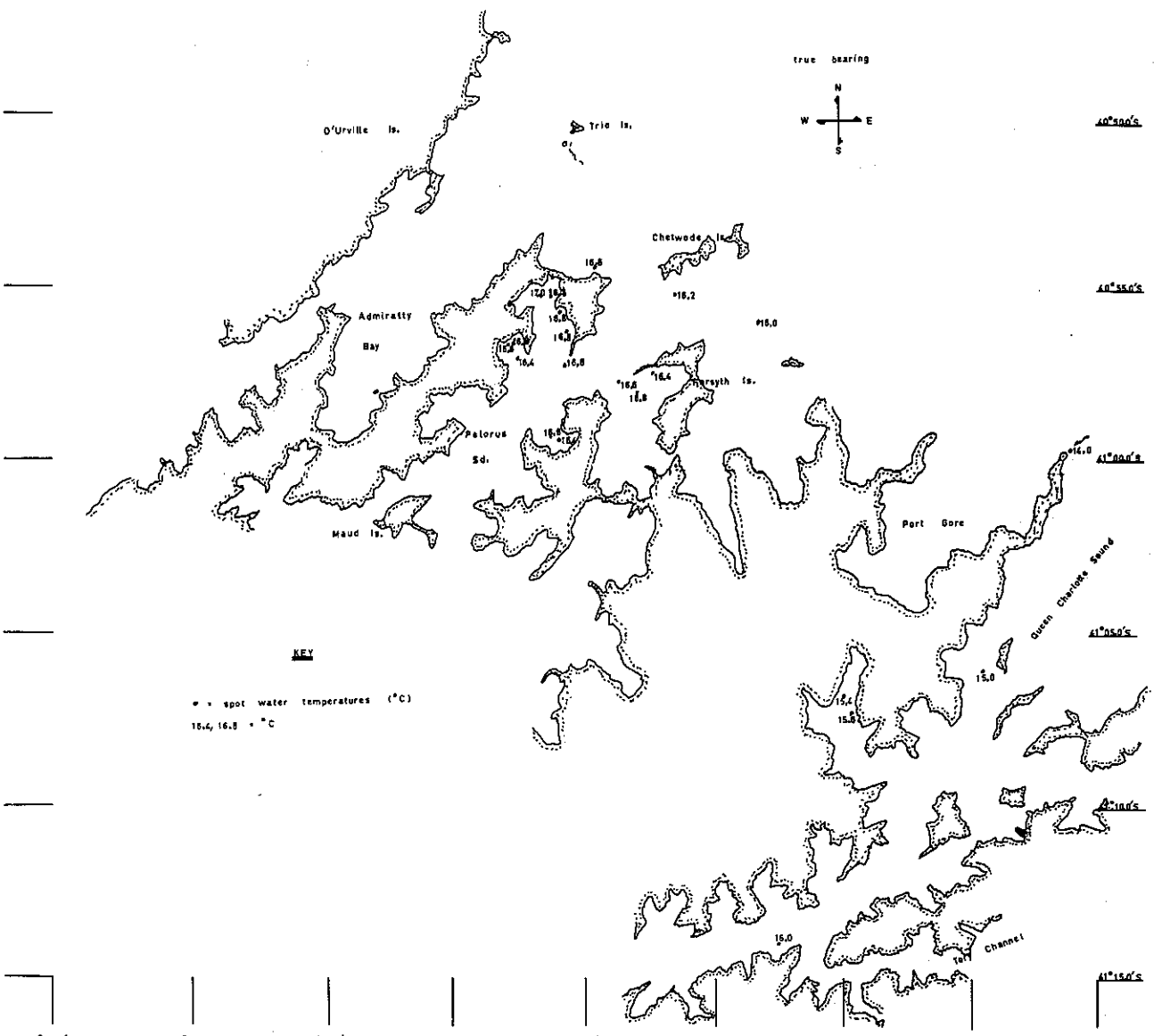

FIG. 14b Sea surface temperatures (°C) plotted for the Marlborough Sounds, April 1970.

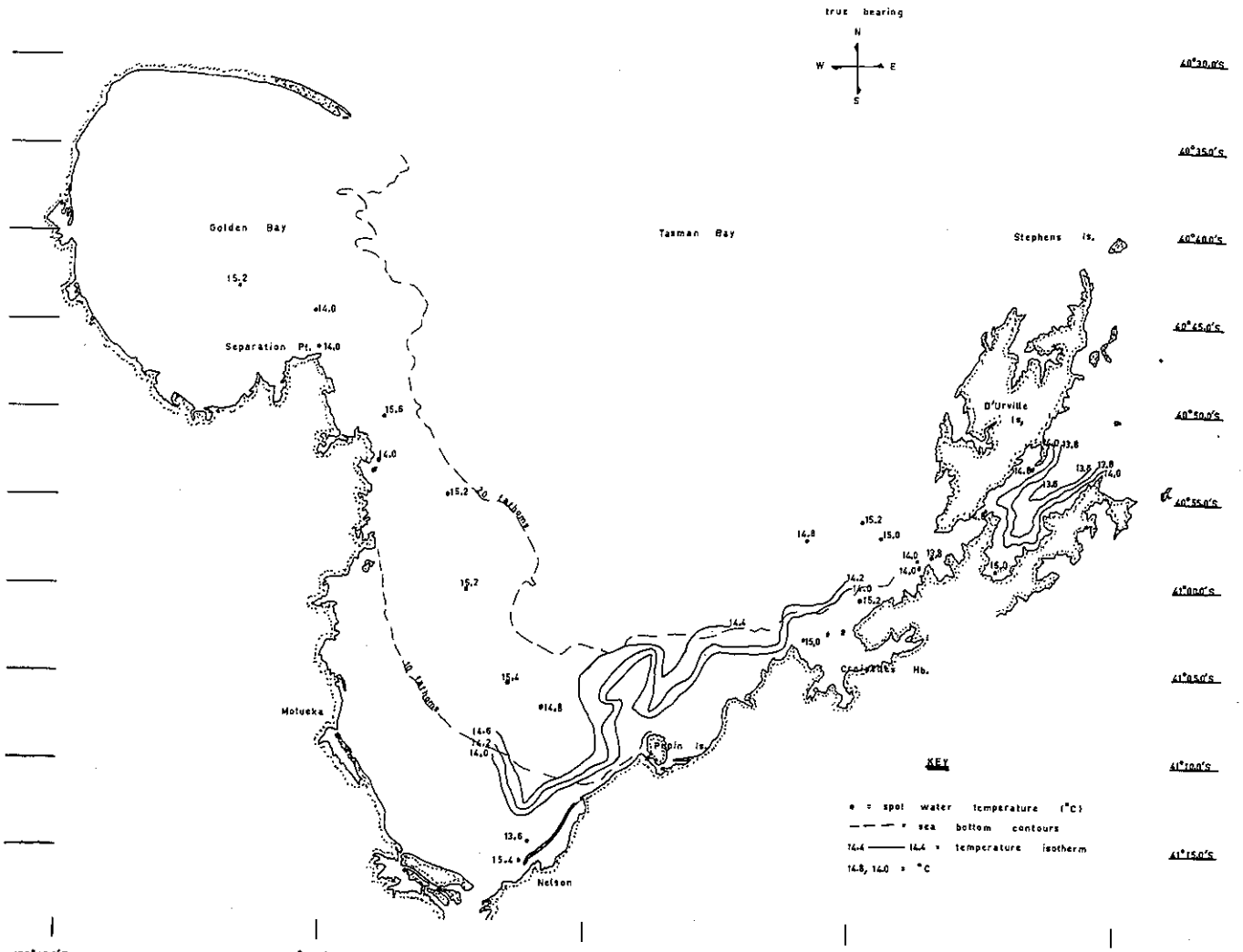

FIG. 15a Sea surface temperature isotherms (°C) plotted for Tasman Bay, May 1970.

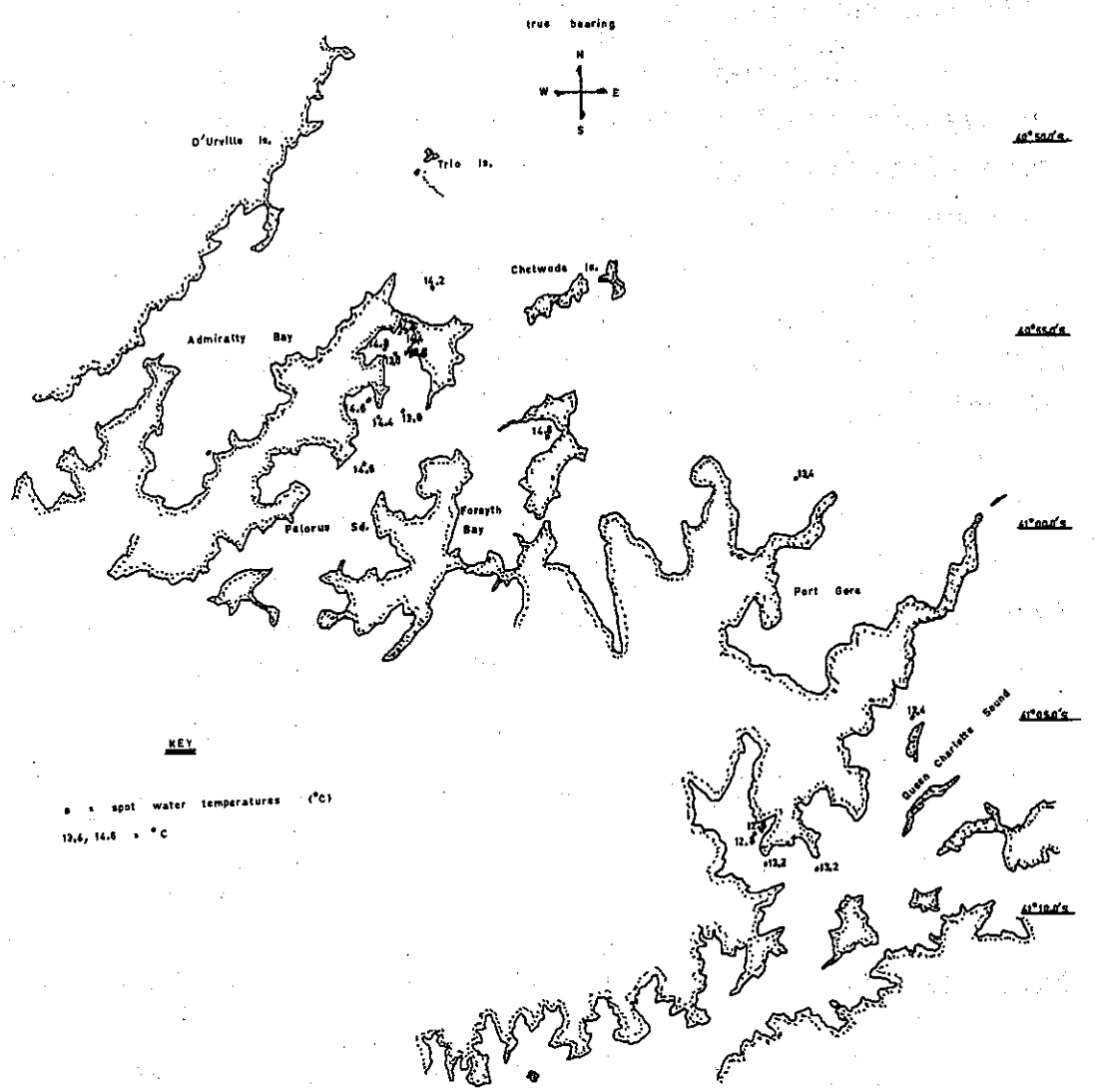

FIG. 15b Sea surface temperatures (°C) plotted for the Marlborough Sounds, May 1970.

movements from Golden Bay. Baker (1972) further found currents that ran parallel to the shore off Motueka and Pepin Island.

3. Temperatures did not vary more than 2°C in any one month throughout the Marlborough Sounds. Warmest areas for all months were Admiralty Bay and northern Pelorus Sound. Surface temperatures in each month became lower when moving from west to east and from north to south. Although tidal movements were large, from 1.853km to 9.26km (1-5kts), these did not appear to significantly affect water temperatures. Ocean currents and strong winds were not effective in altering temperatures due to the land-enclosed nature of the Sounds as well as the small fetch of water available.

The main areas fished, from September 1969 to May 1970, were in Admiralty Bay and off Pepin Island-Croixelles Harbour. Temperatures taken from these 2 areas over the 9 month period showed significant differences in the temperature ranges.

Admiralty Bay (°C)	Pepin Island-Croixelles Harbour (°C)
11.2 - 18.6	16.6 - 22.0

Fish shoals, surface and mid-water, were abundant in both areas.

DISCUSSION

Landed catches of "pilchards" from Tasman Bay and the Marlborough Sounds were: Tasman Bay = 82,228kg (22 shots) and Marlborough Sounds = 58,114kg (11 shots), giving 3737kg and 5283kg respectively as the average catch weight per successful shot. The high average for Marlborough Sounds was due principally to the shallower water and confined space when compared to the fishing areas available in Tasman Bay. Nevertheless, the total catches from the 2 regions indicated that quantities were considerable and approximately in similar concentrations. Such a conclusion was also reached by Tunbridge (1969).

Very little indication of anchovy was located throughout the survey period, in the areas off Pepin Island and Croixelles Harbour, and in Admiralty Bay and Pelorus Sound. Anchovy represented about 4% of the total "pilchard" catch.

The location of "pilchard" shoals relied mainly on the presence of bird species and use of the echosounder. The presence of these fish detection methods resulted in the "W.J. Scott" blind shooting the purse seine net, with best catches being in water depths above 36m (20 fathoms). Shoals were also encircled while on the surface with limited success, owing to "pilchard" behaviour of diving below the net or escaping around the wing ends. It was thought that ship cavitation through the drive shaft may have been one reason for the erratic fish behaviour.

As communication between Tasman Bay and the Marlborough Sounds was through either French Pass or north of D'Urville Island, intermingling between the 2 "pilchard" populations appeared to be limited. In those months with recorded water temperatures (e.g. Fig. 7a, 15a), no difference was found in temperatures through French Pass-Current Basin and in the east-west area of Cape Stephens Passage. On either side of these areas, however, water temperatures varied considerably. Water temperatures may thus have contributed to the apparent different growth rates noted in pilchards from the 2 regions.

ACKNOWLEDGEMENTS

I wish to thank Messrs T. Ure and B. Ransby, Technicians, Marine Department, Wellington, for their assistance in recording most of the data on this project; to Captain J. Hollins and the crew of the "W.J. Scott" for helpful assistance throughout the sampling programme; and to Mr M. Baker, mate of the "W.J. Scott", for his technical advice during the purse seine preparations and operations, and for his assistance in data collecting. Thanks also to the staff of the Marine Department, Nelson, for their work in keeping the "Scott" operational. Special acknowledgement goes to Mr A.M. Rapson, Marine Biologist in the Marine Department, Wellington, during the 1940's, for the pilchard data gathered during 1939-1943, and now deposited in Marine Department files, and

to Mr A.C. Kaberry, retired Director of Fisheries, for helpful advice in clarifying details in Appendix 2.

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_____ (in press) - Analysis of wind direction, wind speed, and wave height from 6 selected New Zealand meteorological stations, 1967 to 1969 inclusive. N.Z. Mar. Dept. Fish Tech. Rep.

APPENDICES

Appendix 1. General Gonad Description (modified from Bowers, 1954).

Male	I	Immature - testes small, no sperm
	II	Mature unripe - sperm extruded on cutting and squeezing.
	III	Ripe - as above, but testes enlarged and lobate.
	IV	Ripe running - as above, but milt extruded on pressure.

	V	Spent - testes crinkled and shrunken, little sperm left.
Female	I	Immature - ovaries very small, translucent, eggs microscopic.
	II	Female mature unripe or virgin maturing - ovaries small to moderate, eggs microscopic, ovaries often translucent.
	III	Mature ripening - ovaries of moderate size, eggs visible, opaque.
	IV	Nearly ripe - ovaries enlarged and distended, eggs clearly visible, opaque.
	V	Ripe - ovaries enlarged and distended, tunica bursts easily, some eggs transparent.
	VI	Ripe running - nearly all eggs transparent, eggs extruded on slight pressure to flank.
	VII	Spent - ovaries flaccid, shrunken, and with some residual eggs.

Appendix 2. Brief comments on Picton Cannery, 1942-1950

Between 1942 and 1950 a pilchard cannery was established and operated in Picton, by the Auckland firm Brown Barrett Ltd with assistance from the Marine Department, as a wartime measure. The motivation behind the venture was due principally to the pilchard quantities that had been caught for groper longline bait by fishermen in the Marlborough Sounds area over the previous 10 years. A further stimulus was provided by the outbreak of World War II and the shortage of imported canned fish into the Dominion.

At the outset, the buildings for the cannery, already in existence, were converted for the venture. Facilities were set up for canning 2500kg (5500lbs) daily, with waste material amounting to 30% of the fish weight brought in. Their weekly packing weight of fresh fish was set at 13,636 (30,000lbs): 3000kg (6600lb) weekly were salted, in 10 gallon casks and exported to Australia as "Sardella", when auto-digestion of the fish precluded the catch for canning purposes. The canned pilchards were utilised for the overseas troops, rather than sold in New Zealand.

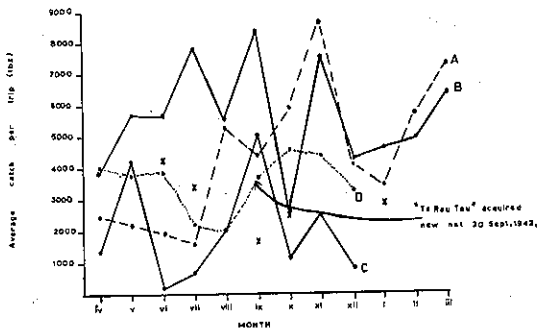

FIG. 16 Sardine (pilchard) fishery - Wellington and Picton. Average catch per landing (per trip) for each month. x = 1939-40, A = 1940-41, B = 1941-42, C = 1942-43, D = "Te Rau Tau" catches only for 1942-43, landed in Picton.

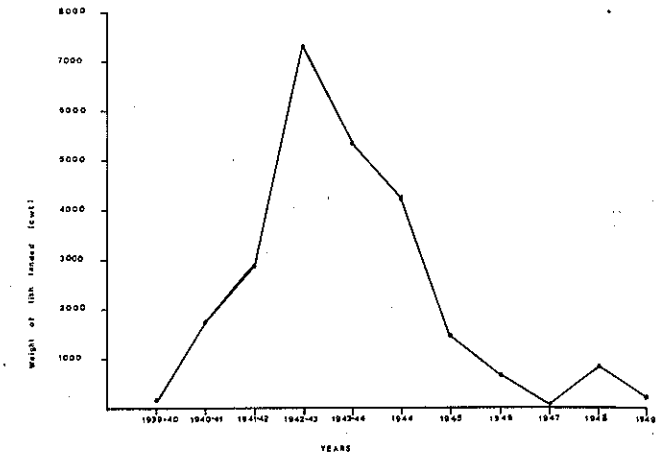

FIG. 18 Annual pilchard landings for Picton, 1939-1949 inclusive. Pilchard cannery started April 1942. Wellington landings 1939-1941 inclusive. Combined Wellington and Picton landings for 1942.

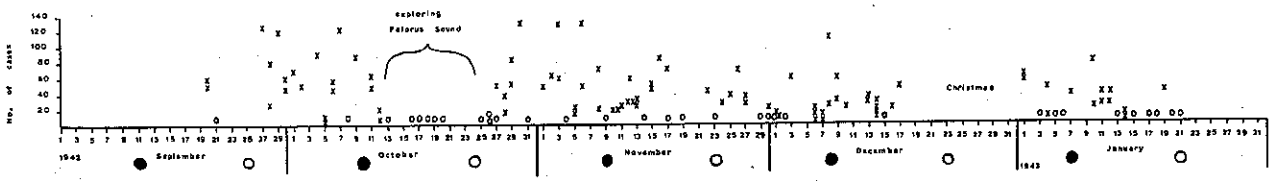

FIG. 17 Catch per haul of pilchards, expressed as number of cases. Detail records from each nightly haul with new net onboard f.v. "Te Rau Tau" - 20 September 1942 to 20 January 1943. x = successful haul, o = haul, where no fish caught. ● = new moon, ○ = full moon.

Equipment in the plant was mostly secondhand, acquisition of new equipment being handicapped by war-time conditions. Machinery included rotary scaling and washing plant, and boiler, retort, and rotary processing units; all cans used were bought. Freezer capacity was 20 metric tons, the freezing temperature possible to -28.8°C (-20°F), and storage temperature at -20.55°C (-5°F).

The staff consisted of the Manager, foreman, stoker, retort man, seaming machine hand, pre-closer, fish scaler, box washer, 12 fish cleaners, 6 can fillers, and 2 labellers.

RESULTS

The total pilchard landing (other names are "sardine", "Picton Bloater", "Picton Herring") for the years 1942 to 1949 inclusive, at Picton, have been tabulated below. Years were taken from 1 April to 31 March for 1942 to 1943, and until 31 December from 1944 to 1949. Only 1 fishing vessel, the "Te Rau Tau" operated by A.R. Pawley was contracted to catch the sardines for the cannery at £10 per ton. Catches ranged from ½ - 8 metric tons, averaged 4 metric tons, with the fish size between 4½" - 14" (11.25-35cm) with average 7" (17.5cm).

Year (12 month period)	Total Landed Catch (cwt)	Average weight per month (cwt)
1942-43	5,487 (278,739kg)	457 (23,215kg)
1943-44	5,339 (271,221kg)	444 (22,555kg)
1944 (9 months)	4,281 (217,474kg)	475 (24,130kg)
1945	1,458 (74,066kg)	121 (6,146kg)
1946	1,191 (60,502kg)	99 (5,029kg)
1947	97 (4,927kg)	8 (406kg)
1948	896 (45,516kg)	74 (3,759kg)
1949	223 (11,328kg)	18 (914kg)

Prior to these landings, Wellington fishermen procured nets similar in make to those used in Italy (lampara) and had for some years made occasional trips to Queen Charlotte Sounds to catch pilchards for groper bait. Pilchard catches in 1939-40, 1940-41, 1941-42, and 1942-43 for Wellington were as follows:

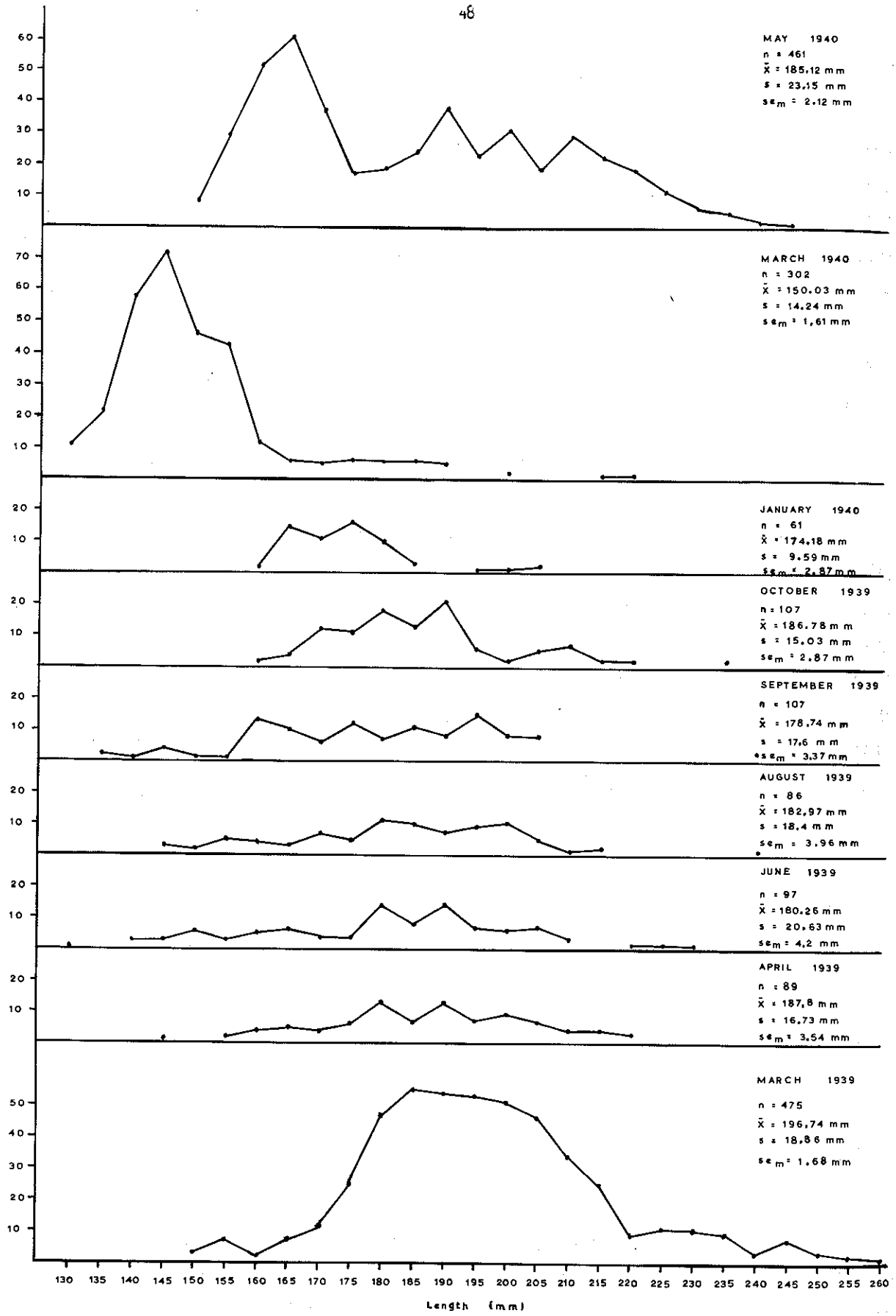

FIG. 19 Length - frequencies for pilchards from Queen Charlotte Sounds, taken March 1939 to May 1940 by A.M. Rapson.

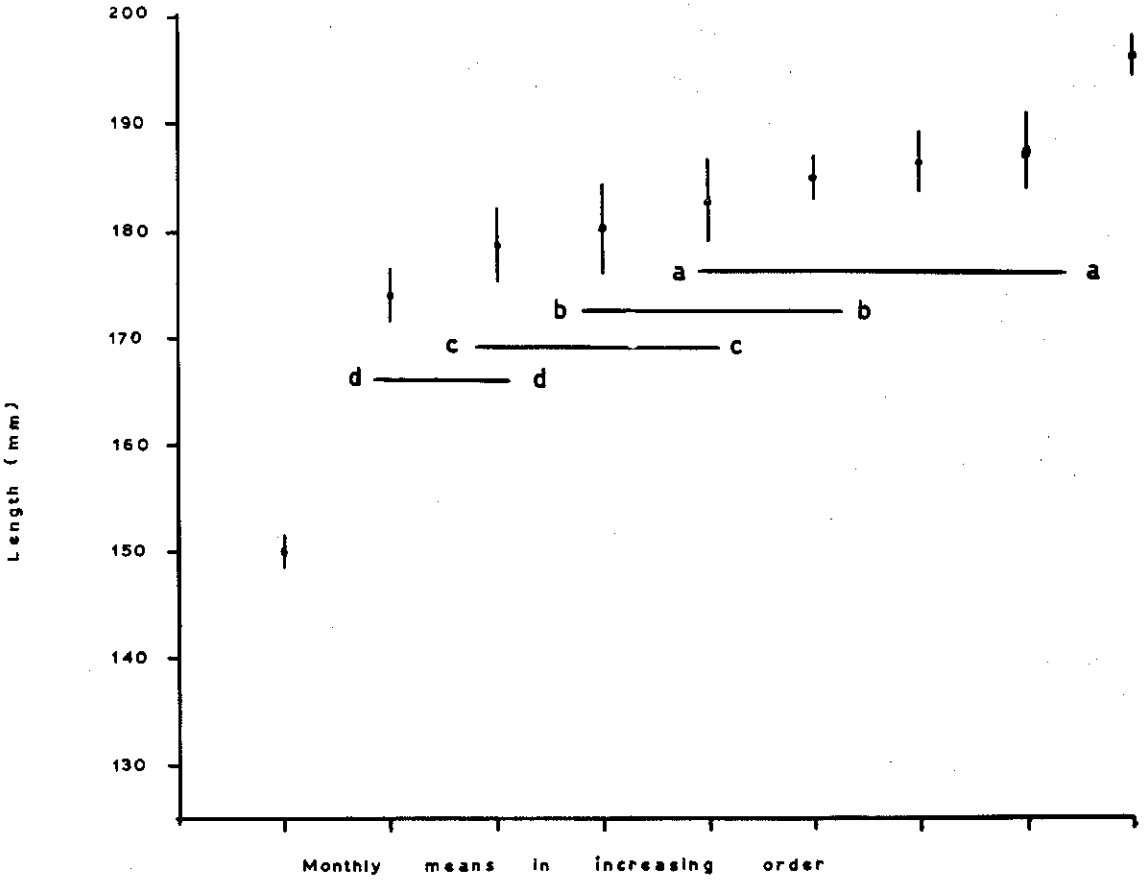

FIG. 20 Means and standard error of the means for pilchard length-frequencies underscored by Duncans Multiple Range Test.

Year	Trips	Total Weight (cwt)	Average catch per trip (cwt)
1939-40	7	192 (9,753kg)	27.42 (1,392kg)
1940-41	38	1,751 (88,950kg)	46.08 (2,340kg)
1942-42	57	2,914 (148,031kg)	51.13 (2,597kg)
1942-43*	114	1,862 (94,589kg)	16.33 (829kg)

*(April to December inclusive)

Pilchard landings for Wellington (1939-43) and Picton landings for 1942-43 from the "Te Rau Tau", have been plotted (Fig. 16). Although approximately 10% of the Picton catch was used for groper bait, the Island Bay fishermen continued to fish the Marlborough Sounds area over the war years (under the supervision of a security officer) and up to 1950 when the cannery was forced to close. Unfortunately, catch records of pilchards from the bait fishermen are unavailable owing to fire damage to records in 1951, and subsequently, to no pilchard-landing records being kept. Thus the total pilchard weights per year in Fig. 18 are those officially recorded, and must be regarded only as a conservative estimate. Reasons for the closure of the cannery are not clear, but appear to be related to (a) overfishing, (b) fluctuation or absence of fishing personnel, and therefore, inexperience, (c) the loss of the purse seine net during 1950, and (d) the imposed seasonal catching after 1944-45, from October to June.

The nets used in Queen Charlotte Sounds before September 1942 were lampara-type ($\frac{3}{4}$-$1\frac{1}{2}$" mesh) and fishing only the $1\frac{1}{2}$ week period either side of the new moon phase: attraction lights for night fishing were introduced only after 1942 when pilchard landings started to fall. Beach seines were utilised in the Admiralty Bay and Port Ligar areas with limited success. After September 1942 a new net designed and built as a purse seine was introduced on the "Te Rau Tau", and replaced the lampara net as the main pilchard fishing method: net details were not recorded (refer Fig. 16 and 17). The number of cases caught from September 1942 to January 1943 with this new net were recorded (Fig. 17) by A.M. Rapson, then Marine Biologist, Marine Department, Wellington. During this period 162,680lbs (72,945kg) of pilchards, in 4067 cases, were landed from 123 shots, each case holding 18kg (40lbs) of pilchards.

Plotting total pilchard landings for the years 1939-1949 (Fig. 18) with Wellington and Picton figures combined for 1942-43, shows the probable impact of overfishing on the pilchard population. Most fishing was in the Queen Charlotte Sound area, with limited effort in Pelorus Sounds and Admiralty Bay. No attempt was made to fish Tasman Bay. In a previous paper (Webb, 1971) it was suggested that approximately 1,000 metric tons of "pilchard-type" fish (pilchards, sprats, anchovy, yellow-eyed mullet) existed in the Tasman Bay and Marlborough Sounds area. As a very general guideline, it has been asserted by many authors that at a particular population size the surplus which produces the best sustainable yield is about half the unfished population. Assuming 1,000 metric tons, and about 200 tons removed each year by fishermen for groper bait, as well as that utilised by predators (dolphins, birds, barracouta), the fishable estimate would give an approximate maximum limit of 400 metric tons as a quantity of "pilchards" to be removed equally from Tasman Bay and the Marlborough Sounds. Such an estimate, however, can vary even within the same population depending on population structure, recruitment rates (both migration into the area as well as spawning) and natural mortality, and so must be treated with caution.

Length-frequency measurements were plotted (Fig. 19) from figures recorded by Rapson during 1939 and 1940. Analysis of variance test between the samples gave $F = 149.72$ having $p = .005$. Sample means were underscored by Duncans Multiple Range Test (Fig. 20) grouping the samples which showed similarity in their mean lengths. Hauls with large numbers of small fish were released (March 1940), it being considered that fish smaller than 6 inches (15cm) were not suitable for longline bait. A marked difference in fish size occurred (Fig. 19 and 20) probably caused by more than one shoal caught on each occasion, or on different fishing nets being used. Unfortunately, Rapson did not indicate which of the 9 samples analysed were taken by lampara or purse seine, although he does mention that the lampara net caught smaller numbers of the larger pilchards than the purse seine. Anchovy were caught in very small quantities (approximately 5% of total catch) and so were not considered important to warrant separate catch figures or mention in the cannery output.

For a brief history of the North Island pilchard fishery refer Baker (1972).