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Aerial Survey of Pelagic Fish Resources Off South East Australia 1973–1977

Kevin Williams

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AERIAL SURVEY OF PELAGIC FISH RESOURCES OFF SOUTH EAST AUSTRALIA 1973 - 1977

Kevin Williams

CSIRO Division of Fisheries and Oceanography
P.O. Box 21, Cronulla, NSW 2230

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Abstract

Waters of south eastern Australia were surveyed over a four year period for concentrations of pelagic fish. The most abundant species sighted was jack mackerel *(Trachurus declivis)* with an overall sighting rate of a high 93.4 tonnes/hr. A range of 64.1 tonnes/hr to 141.3 tonnes/hr over four years was evident indicating a substantial resource at times. The greatest amounts were sighted during the new moon phase and during the earlier morning and late afternoon/evening. Skipjack tuna *(Katsuwonus pelamis)* was also prominent at 11.1 tonnes/hr indicating a large resource at least at times. Distribution patterns with respect to season, sea surface temperature, area etc. are discussed. Sightings of each of these two species and also sightings of Australian 'salmon' *(Arripis trutta)* and southern bluefin tuna (*Thunnus maccoyii)* are mapped month by month for the four years of the survey period.

INTRODUCTION

In 1973 CSIRO (Division of Fisheries and Oceanography) was granted finance from the Fishing Industry Research Trust Account for an aerial survey of pelagic fish resources off S.E. Australia. The objectives of this survey were (i) to provide routine spotting to determine seasonal distribution, resource size and behaviour in relation to environmental factors of jack mackerel *(Trachurus declivis)* (and other pelagic fish), (ii) provide close support for fishing activities by the exploratory fishing vessel *FV Laurus* (see Anon 1975) and (iii) provide isotherm maps of sea surface temperature for environmental studies and supply the southern bluefin tuna fleet with isotherm maps.

In 1974 the survey was extended, the aims then being to (i) assess pelagic fish seasonal abundance and distribution (ii) support present and future research and exploratory fishing vessel operations (iii) provide data on fish sightings and other information to commercial fishing operations and (iv) ensure the continuance of the provision of sea surface temperature maps as a service to the southern bluefin industry.

In 1975-76, 1976-77 the survey was continued to assist *FV Courageous,* a CSIRO charter research vessel. These operations consisted of routine spotting flights over the whole area and when needed closer support for the vessel. It was thought that this would provide useful background to the boat work in the entire program i.e. the biological survey of south eastern pelagic resources.

Aerial spotting has been used

extensively both in Australia (Robins 1975, Hynd 1968, Hynd and Robins 1967) and overseas (Squire 1972) for (i) detection of pelagic fish schools and (ii) evaluation of stock abundance. Fish spotting aircraft are also an integral part of the Australian southern bluefin tuna fishery. Most of the Australian research surveys have been of limited duration and area but this present report covers a survey over a four year period and a large area of south east Australia. As such it supplies information on seasonality, variation within and between years and allows comparison of the effect of environmental factors.

AREA OF OPERATIONS

The survey area was mainly the inner coastal and continental shelf areas between Sydney and the Victoria/ South Australia border around the Australian mainland and the area around the Tasmanian coast and including Bass Strait.

SURVEY METHODS

The spotting was carried out by an experienced spotter with expertise in survey work for fisheries research. He was particularly familiar with the area surveyed and did not have any trouble with species identification.

The spotting took several forms:

(a) Spotting by flying predetermined tracks and not varying these tracks at all (or as little as possible) - this allowed the collection of sea surface temperatures and hence production of isotherm maps.

(b) Spotting by flying along the coast of the entire area on a regular basis. This was to duplicate what was done on many occasions during the first year so as to allow any comparisons of results between years.

(c) Spotting in direct support of a surface vessel (*Laurus* or *Courageous*).

(d) Spotting for fish in a different area to the surface vessels but in support of them.

(e) Prolonged spotting in an area of high fish abundance.

The aircraft type used throughout the survey was an Aero-Commander Shrike 500S fitted with long range fuel tanks. This is a twin-engined, high winged aircraft very similar to the type used by Hynd (1968) and the most suitable fish spotting aircraft available in Australia.

Sea surface temperatures were measured using a Barnes PRT5 infra-red radiation thermometer (see Williams 1977).

Flights were usually carried out at about 500m and at a speed of 135 kts although these were varied sometimes, depending on weather conditions, visibility, Department of Transport requirements etc. Logging of sighting positions was done by the spotter at the time of sighting on special grid charts. Description of schools (size, behaviour, etc.) was on an accompanying sheet. Ground truths (verification of species identification and tonnage estimates) were obtained whenever possible, i.e. when fishing and/or research vessels were in the area.

Different species are identified by studying (i) colour of the school of fish, (ii) behaviour of the fish, (iii) size of individual fish. The ability to assess these indicators is built by years of feedback from ground truth checks, i.e. commercial fishing fleets. When perfected professional fish spotters seldom (if ever) make mistakes in species identification and are extremely accurate in tonnage estimates of individual schools.

GROUND TRUTHS FOR SPECIES IDENTIFICATION AND TONNAGE ESTIMATES

On many occasions during the survey it was possible to check with surface craft the identity of the fish sighted from the air. Wherever the opportunity arose checks were carried out by getting the vessel to catch some of the fish. This method proves species identifications but unless the boats can catch the whole school tonnage estimates cannot be confirmed definitely. This requires a purse seiner to shoot in and catch the entire school - usually they can see if fish escape and it is possible to watch the set from the air anyway. This was achieved only on a few occasions and in each case the spotters estimate agreed with the tonnage weighed in almost exactly. On some other occasions part of the school escaped during the setting of the net or over the top of the net during pursing and on these occasions the spotters estimates were compared with the catch plus the skipper's estimate of fish lost. The other way checks can be made is by comparing estimates between professional spotters and as we were surveying in areas where tuna spotters were working comparison checks were made on an opportunistic basis. All methods gave extremely satisfactory results. The only time variation between spotter's estimates and actual tonnages can be expected is when very large schools (> 200 tonnes) are encountered and in these cases the spotter will tend to underestimate particularly if the school is very deep.

During the survey we had one unique chance to test the spotter's knowledge of species identification. Following one survey off the Tasmanian east coast the spotter reported in his logs some schools as 'unidentified fish - almost certainly tuna'. He discussed with me the behaviour of the fish, school size etc., but said while he was almost certain they were tuna he did not think they were anything he had seen previously. In the next few weeks after these sightings two purse seiners operating in the area caught over 200 tonnes of a species known as slender tuna, *Allothunnus fallai*. (See Webb and Wolfe 1974.) Previously this species was known in Australian waters from a few single specimens and those catches were apparently the world's first by purse seining. The size of fish caught corresponded with the spotter's estimation of fish size - approximately 10 kg fish.

These feedbacks from surface vessels particularly the latter example confirm the ability of these professional spotters to both positively identify the schools and estimate tonnage of the schools and sizes of fish in the schools.

The survey area was divided into four sub-areas (Fig. 1) and total tonnages of each species and hours flown were calculated for each sub-area.

RESULTS AND DISCUSSION

The aim of this report is to summarize the total spotting effort and results. The sightings for each calendar month have been totalled and plotted on to one chart together with any available sea surface temperatures (Figs 2-48). The species plotted in these summaries are the three most abundant species encountered over the survey period i.e. jack mackerel, skipjack tuna and Australian salmon. Southern bluefin tuna sightings, whilst not very common, were plotted also because of their commercial interest. Many other species were seen but in very small quantities and sporadic in appearance and thus are not plotted on these summaries. Most of these other species are of no commercial interest. These included yellowfin tuna, mackerel tuna, frigate tuna, blue mackerel, kingfish, mullet, snoek, tailor, stingrays, anchovy/pilchard, jewfish, blackfish, sunfish, sharks and whales.

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Tables 1-16 summarize the jack mackerel sightings for each month of the survey and for each sub-area. The numbers of hours flown are total spotting times and are not adjusted to allow for reduced effectiveness in poor weather conditions. Robins (1975) used a graph of spotting efficiency vs wind speed to reduce total flying time to effective searching time. While definitely giving a more accurate estimate of effective search time than the method used here, because of the duration of our survey (4 years) and the fact that the use of wind speed alone as a determinant of effective search time does not give exact search time it was decided to remain with total searching hours. Other factors, such as cloud cover, haze, smog, mist, sun position, rain, sea swells etc., affect spotting efficiency and as these cannot be quantified as easily as wind speed total search time was not reduced to effective search time. Also it was reasoned that as the survey was over four years with a total flying time of 2770 hours, the influences of poor spotting conditions would be levelled out over the period. In a survey similar to the one described here, Squire (1972) did not find it necessary to reduce total time to effective time. However he was using data gathered from a number of professional fish spotters engaged in normal commercial operations and as such they would be doing as little flying as possible in windy or adverse conditions. Sometimes in general survey operations the avoidance of such conditions is not always possible e.g. it is sometimes necessary to suffer some period of poor spotting conditions whilst en route to an area of known good conditions.

Total sightings, hours etc., are given in Tables 18-21 . Total flying hours during the survey were 2770 for a total tonnage of 258,759 tonnes giving a sighting rate of 93.4 tonnes/hr flown. Because of the regularity of the survey the tonnes/hr figure probably gives a good indicator of abundance. Robins (1975) used tonnes/effective spotting hour as an indication of abundance and Squire (1972) used a system of small grid squares to give an indicator of abundance as tonnes sighted/number of grid area flights, a grid area flight being designated as one pass of the aircraft's track over a section of the grid area. He then manipulated these figures to give indices of apparent abundance for each species by area and by day and night. In this report the indicator of abundance used is simply: total tonnes of one species sighted during the defined period in the defined area divided by total spotting hours flown in the period in the area. This index is suitable for survey operations when regular (unbiased) flights are the norm and flights are not generally restricted to areas of known fish abundance. The index then really means total amount of fish sighted for a given distance travelled over the water. This is also the basis of the Squire (1972) method. Neither method, however, gives an accurate measure of total abundance, but Squire's indices of apparent abundance during his survey years. There are as yet no estimates of total abundance for jack mackerel in Australian waters by any methods. The overall indices of apparent abundance are interesting to analyse by years (Table 17), by areas (Table 18), and by years within each sub-area (Tables 19 and 20). While 93.4 tonnes/hr is the average figure over the four years a huge variability is obvious from a low of 2.9 (Area B, 1976-77) to a high of 515.9 (Area D, 1976-77). Naturally even greater variability exists in the monthly

This sort of variability would be expected in short term figures just by the nature of the fishes behaviour itself, i.e. a surface schooling species forming dense schools and sometimes great aggregations of schools. Such behaviour would lead to wide fluctuations over small time periods but this should be reasonably averaged over one and four year periods.

There is no direct indication of what relationship there is between the index of apparent abundance used here and total abundance (or real abundance). But it is well worth noting that for a very similar species, the Pacific mackerel *(Trachurus symmetricus)* Squire's (1972) work gave an approximate value of 38 tonnes/hr. During the time of the survey the United States catch (of Pacific mackerel) in this area fluctuated between 25,000 and 50,000 tonnes. These figures could be slightly biased in the sense intended here in that his was a survey using commercial spotting data and the spotting influenced the fishing operations i.e. the spotters having located an area abundant in *T. symmetricus*, directed fishing operations there. This was probably the case to some extent but a counter-balancing influence was the effect of market pressure on the catching of certain less desirable species like mackerel i.e. even though the fish is available to the fishery no attempt is made to catch it because of a depressed market. So probably the figures give a good guide to the relation between apparent abundance and possible catch.

Variation in the index value between years could be cause by local conditions e.g. oceanographic conditions not suitable for the appearance of the fish on the surface. This may not preclude the possibility of the fish being present lower in the water column. But for the purpose of this survey non appearance on the surface leads to a conclusion of no fish being in the area. Thus apparent abundance could be underestimated if conditions in an area were not conducive to surface schooling for a period.

This variation within an area between years is seen in Area C, e.g. between 1973/74 and 1974/75. During these years sufficient sea surface temperature data was gathered to indicate that jack mackerel are seldom seen above temperatures of 17°C. In 1973/74 temperatures on the east coast of Tasmania increased to higher than this and no further sightings were made. The fish either migrate further south, migrate offshore or are simply not surface schooling. In any case the aerial sightings are zero and apparent abundance for the year is consequently down. In the following year temperatures did not rise as high and conditions were presumably suitable for the surface schooling of the fish for a longer period and hence the index of abundance was greater. This phenomenon falls under the definition of apparent abundance - 'fish accessible to a fishery' - and if the fish are accessible only when on the surface this is consistent. Another way of calculating apparent abundance is by including the sub-areas where fish do not occur in the season they do not occur. The index of apparent abundance is then much higher and in some ways more relevant to a potential fishery but is not comparable to other survey figures where this elimination has not been carried out and therefore no handle can be placed on the actual stock size or possible catch.

The relationship between the surface sightings of jack mackerel and sea surface temperature can be seen through all the charts (Figs 2-48) and in Anon (1975) which uses some of the same data, and Fig. 49.

The migration of jack mackerel (or at least the surface appearance) is from north (New South Wales coast) to south (Tasmanian coast) in the winter to summer period and a reverse process during autumn to winter (Table 21). The fish appearing in western Victoria in March-April are presumably a different stock (or at least not the same fish that appear in Tasmania). It is possible that these fish are part of the same stock that appears in New South Wales but lack of sightings in western Bass Strait tends to negate this. If the fish were migrating west through Bass Strait more sightings would be expected there for the amount of effort expended. The fish appear in western Victoria at the same time as some fish in Tasmania therefore are not the same body of fish.

The idea of a north-south-north migration on the east coast and a migration in and out of western Victoria (in whatever direction) are not the only possibilities. It is reasonable to suggest different bodies of fish are migrating onshore at these times in response to particularly favourable conditions or perhaps the fish are demersal for the remainder of the year and only surface school at the times we saw them. More work will be needed to definitely establish what pattern is followed - this work would be mainly from a surface vessel. The preliminary evidence (from CSIRO research cruises) would tend to favour a north-south migration pattern.

School size

The average weights of jack mackerel schools for all areas and years are given in Tables 17-20. The variation over four years is from 15.6 tonnes/school with the overall mean of all sightings being 18.5 tonnes/school.

Moon phase

The total tonnages of jack mackerel sighted during each moon phase are given in Table 22. More than double the amount of fish are sighted during the new moon phase than the full moon phase with about equal amounts on the quarters. Phases here are defined as being from the day one phase began until the day before the following phase began. Catch rates in some overseas pelagic fisheries show tendencies to be greater during new moon periods, e.g. in the New Zealand skipjack fishery (Habib *et al.* 1980).

Sightings and time of day

Sightings of jack mackerel plotted as tonnes/hour are plotted against each two hourly time period in Figure 49. There is a tendency for larger sightings to occur in the earlier morning and late afternoon/evening.

Night spotting for phosphorescent glow caused by fish movement was attempted on several occasions but was severely restricted each time for logistic reasons and flying regulations. Also for night spotting operations an efficient surface catcher/sampler vessel is required to verify any sightings and circumstances never allowed the cooperation of plane and boat. In the short flights carried out at night the spotter did not consider night spotting an advantage over daytime spotting - perhaps because of the relative low productivity of the waters and hence very low phosphoresence.

Sightings and distance from the coast

Positions of all sightings can be seen in Figures 2 - 48. No sightings of jack mackerel made off the continental shelf. The furthest distance from land sightings were made was in Bass Strait. In fact sightings were not only restricted to the shelf area, they were more concentrated on the inner half of the shelf and in Tasmania on many occasions, schools were congregated about the rocky foreshore and inshore rocks. This behaviour was peculiar to Tasmanian waters but presumably only because there is deep water right to the cliffs whereas in most of the area shallow beaches prevented close inshore congregation.

Skipjack tuna

Another abundant species sighted during the survey was skipjack tuna *Katsuwonus pelamis*. The total tonnages of skipjack sighted are summarized by years and areas in Table 23. The sightings are plotted on charts in Figures 2 - 48.

The most obvious feature of the skipjack sightings is their extreme variability - a high of 10,985 tonnes in area B 1974/75 is followed by a value of 21 tonnes the following year. The overall average sighting of skipjack was 11.1 tonnes/hr yet for 1974/75 it was 21.2 tonnes/hr. This was the year the largest Australian catches were made off the southern NSW coast (including eastern Victoria). During the period of highest sightings November-March about 2400 tonnes of skipjack were landed at Eden (New South Wales). The following year only about 450 tonnes were caught even though more effort was expended.

The great variability in skipjack abundance was evidenced during some surveys between Sydney and the Queensland border. In 1974 this aerial survey was extended northward to cover the New South Wales north coast. In the period August to January no skipjack were sighted at all in this area despite two flights (8 hours) per fortnight being carried out in the area. In a later survey by a surface vessel in 1977-78 many schools were seen off the New South Wales north coast (FIRTA funded commercial skipjack survey). In a still later survey by the South Pacific Commission research vessel *Hatsutori maru* despite great success catching and tagging skipjack south of Sydney and in Queensland waters very few sightings were made in the Port Stephens - Queensland border area (Kearney and Gillette 1979).

Nevertheless the overall figure of 11.1 tonnes/hr indicates at least a substantial resource at some times, particularly considering the survey structure was largely biased against skipjack. Area D was not considered (from previous knowledge) likely to produce large sightings, if any. This proved to be the case and hence the total hours spent in Area D help to bias the overall spotter's figure downwards. Also, because the survey was developed primarily for jack mackerel, inshore spotting was more prevalent than offshore and knowing what we know now this would be biased heavily against skipjack sightings. So in fact the figures of 11.1 tonnes/hr could realistically be a lot larger and represent a large stock.

In order to achieve a fuller understanding of the skipjack sightings it is necessary to look at total sightings of southern bluefin tuna that might be made during one year. In south eastern Australia, the survey area, southern bluefin tuna form a substantial fishery - approximately 4000 tonnes average. All catches are taken within our surveyed area (A, B and C), although more recently catches are being made further seaward than in earlier years. The area of southern bluefin tuna catches therefore almost exactly overlaps the area of skipjack tuna sightings for this aerial survey i.e. from Sydney to the Tasmanian east coast and areas of Bass Strait to about Wilson's Promontory. Skipjack of course are known to be far more wide ranging to the north than southern bluefin but for the purposes of comparison nearly all our skipjack sightings occur within the southern bluefin fishing areas.

Three spotters working in the southern bluefin tuna fishery were consulted about the total tonnage of of fish they spot each season (approx. August to February). A general consensus was reached that in an average season they would expect to sight 7000 tonnes of southern bluefin tuna. This figure is their rough estimate - it should be noted that accurate records are not available. This estimate is based on one spotter or one pilot/spotter using one aircraft flying in all the fair to good conditions throughout the season - total flying time about 300 or more hours. Because he is operating in a commercial fishery, effort is concentrated almost soley on southern bluefin and is therefore biased when compared to general survey type operations. For example only areas with a suitable sea surface water temperature would be searched - rippling schools of southern bluefin are restricted to water with temperatures of about 17-20°C. Also multiple sightings of the same fish are very common in commercial operations. Spotters having found fish one day direct boats to the area and fly in the same area looking for the same fish the next day to position the fleet. This can occur for several days running.

Comparison of the southern bluefin tuna expected sightings figure and our sightings of skipjack tuna gives some appreciation of the skipjack stock size when consideration is given to the size of the southern bluefin tuna fishery (Table 24). Sightings in an average southern bluefin tuna season total approximately 7000 tonnes in a fishery that produces about 4000 tonnes/season. This certainly points to the skipjack reource being substantial - at least at times - despite the obvious restrictions in efficiency of closer inshore survey spotting operations for skipjack tuna. This type of operation covers only about one third of their known local distribution area compared with the bluefin spotting planes covering the entire bluefin range.

The bluefin spotters considered that they would fly an average of about 300 or more hours in good productive conditions giving a figure of about 20 tonnes/hour. This is virtually tonnes/effective hour and does not include hours flown when bad weather forces the plane to turn back or otherwise abort the flight. Our figure of 11.1 tonnes/hr becomes 13.4 tonnes/hr if area D is omitted (an area which is thought to be unsuitable for skipjack). This figure compares very favourably with the bluefin figure of about 20 tonnes/hr when consideration is given to the facts that (i) all bluefin spotting is done during the 'bluefin season' - our spotting is spread through the year and not confined to the more 'favourable' times, (ii) all our flying hours are included not just favourable or effective flying time (iii) our flights were not designed to cover the known skipjack distributional range as is the case in the bluefin commercial fishery and (iv) because of the survey nature of our operations obvious multiple sightings of the same fish were avoided which is not the case in the commercial fishery.

In fact if only the hours for each month in which skipjack are sighted are totalled for areas A, B and C, a figure of 1514.8 flying hours is obtained. This, to some degree, eliminates objection (i) above. Total skipjack sighted in areas A, B and C is 30,143 tonnes. This gives an abundance figure of approximately 20 tonnes/hr which is similar to the bluefin commercial spotters' figure despite the restrictions of ii, iii and iv above. If the figures could be adjusted for the other factors the spotting rate would be still higher.

The sporadic appearance and occasional sighting of huge numbers of schools makes further analysis of the data into time periods, moon phases etc. impossible. Migration patterns can be seen on the charts of the sightings, particularly in 1974-1975. Fish are first sighted in the Sydney to Jervis Bay area in October to December 1974 then progressively further south each month until large quantities are seen off Tasmania in March. The main sighting area then retracts to the north into southern New South Wales. Fish are not seen again until October-November of the next season in the Jervis Bay area when a similar (although less obvious migration south appears to take place.

Australian Salmon

The sightings of Australian salmon are included in the maps because of this commercial interest. No effort has been made to quantify the data because of some obvious biases involved and the fact that they are already subject to a fairly intensive commercial fishery. The biases are (i) the fish are seen only on sandy beaches therefore sightings are restricted to times when the aircraft was flying close inshore e.g. near airports or when bad weather prevented offshore flying, (ii) salmon schools have been known to remain in the same place for up to weeks at a time therefore multiple sightings are a problem of some magnitude unless survey flights are carefully structured and regular to keep biases constant.

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Table 1:

Jack Mackerel Sightings 1973-1974

Area A

Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours flown (Number)	3.6	17.8	51.0	18.5	20.9	3.4	12.0	15.8	8.8	3.0	5.1	21.0	180.9
No. of schools sighted	10	20	309	325	-	-	-	-	-	-	-	-	664
No. of tonnes sighted	20	120	3286	3248	-	-	-	-	-	-	-	-	6674
Tonnes/School	2	6	10.6	10.0	-	-	-	-	-	-	-	-	10.1
No. of days flown	2	9	17	6	11	8	11	11	10	9	4	13	111
No. of days on which fish sighted	1	1	6	4	-	-	-	-	-	-	-	-	12
No. of schools/hr	2.8	1.1	6.1	17.6	-	-	-	-	-	-	-	-	3.7
No. of tonnes/hr	5.6	6.7	64.4	175.6	-	-	-	-	-	-	-	-	36.9

Table 2:

Jack Mackerel Sightings 1973-1974

Area B

Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours flown (Number)	5.3	5.8	2.5	3.5	20.2	25.7	27.3	23.4	21.5	19.2	9.0	18.9	182.3
No. of schools sighted	-	-	1	-	376	-	1	30	12	3	6	-	429
No. of tonnes sighted	-	-	5	-	6080	-	20	350	85	4	80	-	6624
Tonnes/School	-	-	5	-	16.2	-	20	11.7	7.1	1.3	13.3	-	15.4
No. of days flown	2	4	2	2	9	8	11	11	11	8	4	11	83.
No. of days on which fish sighted	-	-	1	-	2	-	1	1	1	1	1	-	8
No. of schools/hr	-	-	0.4	-	18.6	-	<0.1	1.3	0.6	0.2	0.7	-	2.4
No. of tonnes/hr	-	-	2.0	-	3.01	-	0.7	15.0	4.0	0.2	8.9	-	36.3

Table 3:

Jack Mackerel Sightings 1973-1974

Area C

Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	-	2.4	1.0	-	4.0	17.3	27.4	34.9	9.9	5.3	0.8	12.9	115.9
No. of schools sighted	-	-	-	-	124	160	525	7	60	-	-	-	876
No. of tonnes sighted	-	-	-	-	2873	2305	13802	190	1200	-	-	-	20370
Tonnes/School	-	-	-	-	23.2	14.4	26.3	27.1	20.0	-	-	-	23.3
No. of days flown	-	1	1	-	4	7	13	12	9	5	1	8	61
No. of days on which fish sighted	-	-	-	-	2	5	8	2	1	-	-	-	18
No. of schools/hr	-	-	-	-	23.2	9.4	19.2	0.2	6.1	-	-	-	7.6
No. of tonnes/hr	-	-	-	-	718.2	133	503.7	5.4	121	-	-	-	175.8

Table 4:

Jack Mackerel Sightings 1973-1974

Area D

	Month												
	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	-	-	-	-	2.7	6.9	6.0	11.7	32.1	43.9	21.6	9.3	134.2
No. of schools sighted	-	-	-	-	-	-	-	-	81	439	53	-	573
No. of tonnes sighted	-	-	-	-	-	-	-	-	1514	9310	844	-	11668
Tonnes/School	-	-	-	-	-	-	-	-	18.7	21.2	15.9	-	20.4
No. of days flown	-	-	-	-	1	2	3	5	11	14	7	3	46
No. of days on which fish sighted	-	-	-	-	-	-	-	-	3	11	2	-	16
No. of schools/hr	-	-	-	-	-	-	-	-	2.5	10.0	2.5	-	4.3
No. of tonnes/hr	-	-	-	-	-	-	-	-	47.2	212.1	39.1	-	86.9

Table 5:

Jack Mackerel Sightings — 1974-1975

Area A — Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	11.9	28.7	35.6	25.7	31.8	24.6	56.9	17.8	15.9	3.2	17.1	11.2	280.4
No. of schools sighted	-	-	-	40	5	270	-	-	-	-	-	2	315
No. of tonnes sighted	-	-	-	80	120	4435	-	-	-	-	-	80	4635
Tonnes/School	-	-	-	2.0	24.0	16.4	-	-	-	-	-	40	14.7
No. of days flown	10	10	13	12	14	11	15	11	12	9	12	10	139
No. of days on which fish sighted	-	-	-	1	1	3	-	-	-	-	-	1	6
No. of schools/hr	-	-	-	1.6	0.2	11.0	-	-	-	-	-	0.1	1.1
No. of tonnes/hr	-	-	-	3.1	3.8	180.3	-	-	-	-	-	7.1	16.5

Table 6:

Jack Mackerel Sightings 1974-1975

Area B

	Month												
	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	14.7	12.2	25.9	25.7	25.2	21.0	28.3	29.3	31.1	31.4	34.4	29.1	308.3
No. of schools sighted	-	-	-	-	50	1	-	-	-	84	313	76	524
No. of tonnes sighted	-	-	-	-	1000	6	-	-	-	1258	6750	1131	10145
Tonnes/School	-	-	-	-	20	6.0	-	-	-	15.0	21.6	14.9	19.4
No. of days flown	7	5	9	10	10	9	11	12	13	12	16	12	126
No. of days on which fish sightd	-	-	-	-	1	2	-	-	-	5	3	7	18
No. of schools/hr	-	-	-	-	2.0	<0.1	-	-	-	2.7	9.1	2.6	1.7
No. of tonnes/hr	-	-	-	-	39.7	0.3	-	-	-	40.1	196.2	38.9	32/9

Table 7:

Jack Mackerel Sightings 1974-1975

Area C

Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	8.7	3.8	15.0	13.8	15.9	13.3	15.8	15.8	19.4	21.6	17.9	16.3	177.3
No. of schools sighted	-	-	-	-	-	242	355	198	310	889	626	451	3071
No. of tonnes sighted	-	-	-	-	-	2654	6400	4350	6919	30060	7782	5093	63258
Tonnes/School	-	-	-	-	-	11.0	18.0	22.0	22.3	41.2	12.4	11.3	20.6
No. of days flown	6	5	10	9	10	8	10	10	10	13	10	10	111
No. of days on which fish sightd	-	-	-	-	-	2	3	3	4	2	4	5	23
No. of schools/hr	-	-	-	-	-	18.2	22.5	12.5	16.0	33.8	35.0	27.7	17.3
No. of tonnes/hr	-	-	-	-	-	199.5	405	275	356.6	1391.7	434.7	312.5	356.8

Table 8:

Jack Mackerel Sightings — 1974-1975

Area D — Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	8.4	15.4	15.8	16.3	15.4	5.0	11.0	15.6	10.5	19.4	23.8	2.9	159.5
No. of schools sighted	-	-	-	-	-	-	5	150	468	597	2	-	1222
No. of tonnes sighted	-	-	-	-	-	-	30	2500	3009	6086	4	-	11622
Tonnes/School	-	-	-	-	-	-	6.0	16.7	6.4	10.2	2	-	9.5
No. of days flown	4	6	5	6	6	2	4	5	4	6	8	2	58
No. of days on which fish sighted	-	-	-	-	-	-	1	1	2	4	1	-	10
No. of schools/hr	-	-	-	-	-	-	0.5	1.0	44.6	30.8	0.1	-	6.5
No. of tonnes/hr	-	-	-	-	-	-	2.7	160	285.9	313.7	0.2	-	72.9

Table 9:

Jack Mackerel Sightings 1975/1976

Area A

Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	26.8	40.2	37.9	30.7	4.8	6.8	2.0	9.0	9.8	8.5	1.3	13.6	191.4
No. of schools sighted	-	320	-	8	-	-	-	-	-	-	-	1	328
No. of tonnes sighted	-	13467	-	164	-	-	-	-	-	-	-	30	13661
Tonnes/School	-	40.1	-	20.5	-	-	-	-	-	-	-	30	41.7
No. of days flown	15	13	7	12	4	6	6	4	8	6	4	7	92
No. of days on which fish sighted	-	6	-	3	-	-	-	-	-	-	-	1	10
No. of schools/hr	-	8.0	-	0.3	-	-	-	-	-	-	-	<.1	1.7
No. of tonnes/hr	-	335.0	-	5.3	-	-	-	-	-	-	-	-	2.2

Table 10:

Jack Mackerel Sightings 1975-76

Area B

	Month												
	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	36.1	15.8	-	20.8	11.3	21.1	21.8	7.9	29.4	13.1	10.1	10.5	197.9
No. of schools sighted	-	-	-	59	21	976	-	-	-	-	10	3	1069
No. of tonnes sighted	-	-	-	224	256	7551	-	-	-	-	20	32	8083
Tonnes/School	-	-	-	3.8	12.2	7.7	-	-	-	-	2.0	10.7	7.6
No. of days flown	17	9	-	7	6	9	11	2	11	6	5	5	88
No. of days on which fish sighted	-	-	-	1	1	3	-	-	-	-	1	1	7
No. of schools/hr	-	-	-	2.8	1.9	46.3	-	-	-	-	1.0	0.3	5.4
No. of tonnes/hr	-	-	-	10.8	22.7	35.7	-	-	-	-	2.0	3.0	40.8

Table 11:

Jack Mackerel Sightings 1975-1976

Area C

Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	20.8	7.9	-	5.9	9.0	20.2	27.6	-	18.4	17.9	9.8	-	137.5
No. of schools sighted	10	-	-	-	-	131	154	-	-	793	21	-	1109
No. of tonnes sighted	40	-	-	-	-	1783	1750	-	-	12304	383	-	16260
Tonnes/School	40	-	-	-	-	13.6	11.4	-	-	15.5	18.2	-	14.7
No. of days flown	13	5	-	4	5	10	10	-	8	7	5	-	67
No. of days on which fish sighted	1	-	-	-	-	4	4	-	-	3	2	-	13
No. of schools/hr	0.5	-	-	-	-	6.5	5.6	-	-	44.3	2.1	-	8.1
No. of tonnes/hr	1.9	-	-	-	-	88.3	63.4	-	-	687	39.1	-	118.3

Table 12:

Jack Mackerel Sightings 1975-1976

Area D

Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	12.5	3.7	-	-	7.4	2.2	12.7	23.8	15.1	1.5	25.7	17.3	122.9
No. of schools sighted	-	-	-	-	-	-	94	-	40	30	-	-	164
No. of tonnes sighted	-	-	-	-	-	-	2585	-	800	235	-	-	3620
Tonnes/School	-	-	-	-	-	-	27.5	-	20.0	7.8	-	-	22.1
No. of days flown	4	2	-	-	3	1	3	4	5	1	6	5	34
No. of days on which fish sighted	-	-	-	-	-	-	1	-	1	1	-	-	3
No. of schools/hr	-	-	-	-	-	-	7.4	-	2.6	12.0	-	-	1.3
No. of tonnes/hr	-	-	-	-	-	-	203.5	-	53.0	94.0	-	-	29.5

Table 13:

Jack Mackerel Sightings — 1976-1977

Area A — Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	9.0	12.3	27.3	5.6	13.5	26.2	6.2	1.67	2.0	4.33	5.41	18.33	131.84
No. of schools sighted	12	-	138	-	69	1	-	-	-	-	-	21	241
No. of tonnes sighted	52	-	1902	-	230	50	-	-	-	-	-	680	2914
Tonnes/School	4.3	-	13.8	-	3.3	50	-	-	-	-	-	32.4	12.1
No. of days flown	8	5	15	7	7	14	7	5	6	5	6	11	96
No. of days on which fish sighted	1	-	8	-	3	1	-	-	-	-	-	3	16
No. of schools/hr	1.3	-	5.1	-	5.1	<0.1	-	-	-	-	-	1.1	1.8
No. of tonnes/hr	5.8	-	69.7	-	17.0	1.9	-	-	-	-	-	37.1	22.1

Table 14:

Jack Mackerel Sightings

1976-1977

Area B

Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	38.3	12.4	24.8	15.4	12.4	24.8	25.5	14.8	14.1	10.5	16.6	24.1	233.7
No. of schools sighted	1	-	-	-	-	60	83	2	6	-	-	-	152
No. of tonnes sighted	30	-	-	-	-	380	145	18	105	-	-	-	678
Tonnes/School	30.0	-	-	-	-	6.3	1.7	9.0	17.5	-	-	-	4.5
No. of days flown	12	6	11	5	6	11	10	7	6	4	9	8	95
No. of days on which fish sighted	1	-	-	-	-	2	3	2	1	-	-	-	9
No. of schools/hr	<0.1	-	-	-	-	2.4	3.3	0.1	0.4	-	-	-	0.7
No. of tonnes/hr	0.8	-	-	-	-	15.3	5.7	1.2	7.5	-	-	-	2.9

Table 15:

Jack Mackerel Sightings 1976-1977

Area C

Month

	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	8.3	3.1	4.8	3.3	6.0	7.5	15.4	16.9	12.6	11.7	17.3	2.3	109.2
No. of schools sighted	-	4	-	-	-	-	316	923	8	40	134	-	1425
No. of tonnes sighted	-	40	-	-	-	-	5759	11192	100	220	6136	-	23447
Tonnes/School	-	10	-	-	-	-	18.2	12.1	12.5	5.5	45.8	-	16.5
No. of days flown	4	2	4	4	5	5	8	9	7	5	6	2	61
No. of days on which fish sighted	-	1	-	-	-	-	6	7	1	1	3	-	19
No. of schools/hr	-	13	-	-	-	-	20.5	54.6	0.6	3.4	7.7	-	13.0
No. of tonnes/hr	-	12.9	-	-	-	-	374.0	662.2	7.9	18.8	354.7	-	214.7

Table 16:

Jack Mackerel Sightings 1976-1977

Area D

	Month												
	7	8	9	10	11	12	1	2	3	4	5	6	Totals
Hours Flown (Number)	8.8	1.7	11.3	11.4	12.9	4.9	6.0	6.3	18.3	4.8	3.2	17.2	106.8
No. of schools sighted	12	-	-	-	-	-	6	33	1776	-	-	-	1827
No. of tonnes sighted	135	-	-	-	-	-	12	177	54776	-	-	-	55100
Tonnes/School	10.4	-	-	-	-	-	2	5.4	30.8	-	-	-	30.2
No. of days flown	5	1	4	4	5	3	2	4	6	2	1	6	43
No. of days on which fish sighted	1	-	-	-	-	-	1	1	6	-	-	-	9
No. of schools/hr	104	-	-	-	-	-	1.0	5.2	97.0	-	-	-	17.1
No. of tonnes/hr	15.3	-	-	-	-	-	2.0	28.1	2993.2	-	-	-	515.9

Table 17:

Jack Mackerel Sightings - Totals by Years

	Tonnes	Hours	Schools	Tonnes/School	Tonnes/hour
1973-74	45,336	613.3	2,542	17.8	73.9
1974-75	89,660	925.5	5,132	17.5	96.9
1975-76	41,624	649.7	2,670	15.6	64.1
1976-77	82,139	581.5	3,645	22.5	141.3
TOTAL	258,759	2770	13,989	18.5	93.4

Table 18:

Jack Mackerel Sightings - All years - By areas

	Tonnes	Hours	Schools	Tonnes/School	Tonnes/hour
Area A	27,884	784.5	1,548	18.0	35.5
Area B	25,530	922.2	2,174	11.7	27.7
Area C	123,335	539.9	6,481	19.0	228.4
Area D	82,010	523.4	3,786	21.7	156.7

Table 19:

Jack Mackerel Sightings - Areas by Year

		AREA A		
	1973-74	1974-75	1975-76	1976-77
Tonnes	6,674	4,635	13,661	2,914
Hours	180.9	280.4	191.4	131.8
Schools	664	315	328	241
Tonnes/ school	10.1	14.7	41.7	12.1
Tonnes/ hour	36.9	16.5	71.4	22.1

		AREA B		
	1973-74	1974-75	1975-76	1976-77
Tonnes	6,624	10,145	8,083	678
Hours	182.3	308.3	197.9	233.7
Schools	429	524	1,069	152
Tonnes/ school	15.4	19.4	7.6	4.5
Tonnes/ hour	36.3	32.9	40.8	2.9

Table 20:

Jack Mackerel Sightings - Area by Year

AREA C	1973-74	1974-75	1975-76	1976-77
Tonnes	20,370	63,258	16,260	23,447
Hours	115.9	177.3	137.5	109.2
Schools	876	3,071	1,109	1,425
Tonnes/ school	23.3	20.6	14.7	16.5
Tonnes/ hour	175.8	356.8	118.3	213.4

AREA D	1973-74	1974-75	1975-76	1976-77
Tonnes	11,668	11,622	3,620	55,100
Hours	134.2	159.5	122.9	106.8
Schools	573	1,222	164	1,827
Tonnes/ school	20.4	9.5	22.1	30.2
Tonnes/ hour	86.9	72.9	29.5	515.9

Table 21. Jack Mackerel (tonnes/hr) figures for areas A, B and C, illustrating north - south - north migration patterns

	North ⟶		South
	Area A	Area B	Area C
July 1974	3.1	-	-
A	3.8	-	-
S	180.3	-	-
O	-	-	-
N	-	39.7	-
D	-	0.3	199.5
Jan 1975	-	-	405.1
F	-	-	275.3
M	-	-	356.6
A	-	40.1	1391.7
M	-	196.2	434.7
J	7.1	38.9	312.5
J	-	1.1	1.9
A	335.0	-	-

Table 22:

Jack mackerel sightings/moon phase
Sightings in thousands of tonnes

Days after start of moon phase	Moon phase: New	First Quarter	Full	Last Quarter
0	8.4	2.5	1.4	3.6
1	5.9	1.3	6.2	11.2
2	2.2	4.8	8.1	15.4
3	0.8	0.9	5.1	8.4
4	33.8	4.8	3.9	6.2
5	2.8	50.6	10.0	6.1
6	25.2	2.7	4.9	7.7
7	11.4	1.2	0	1.2
Totals	90.5	68.8	39.6	59.8
% of Total	35.0	26.6	15.3	23.1
Ratio to full moon	2.29	1.74	1	1.51

Table 23:

Skipjack Tuna Sightings

	1973-74	1974-75	1975-76	1976-77
		AREA A		
Tonnes	1,454	7,165	299	401
Hours	180.9	280.4	191.4	131.8
Schools	115	155	14	67
Tonnes/ school	12.6	46.2	21.4	6.0
Tonnes/ hour	8.0	25.6	1.6	3.0
		AREA B		
Tonnes	427	10,985	21	1,557
Hours	182.3	308.3	197.9	233.7
Schools	99	360	2	87
Tonnes/ school	4.3	30.5	10.5	17.9
Tonnes/ hour	2.3	35.6	0.1	6.7
		AREA C		
Tonnes	2,426	1,451	66	3,891
Hours	115.9	177.3	137.5	109.2
Schools	287	104	21	208
Tonnes/ school	8.5	14.8	3.1	18.7
Tonnes/ hour	20.9	8.7	0.5	35.6
		AREA D		
Tonnes	88	10	180	243
Hours	134.2	159.5	122.9	106.8
Schools	19	1	7	81
Tonnes/ school	4.6	10	25.7	3.0
Tonnes/ hour	0.66	0.06	1.5	2.3

TOTALS: Tonnage 30,664 Tonnes/hr 11.1

Table 24: Skipjack Tuna Sightings Compared with Southern Bluefin Tuna Expected Average Sightings

	Skipjack tuna sightings in southern bluefin tuna fishery area (tonnes)	Southern bluefin tuna expected sightings (one spotter-one season)	Southern bluefin tuna catch (tonnes)
1973/74	4,307		1,811
1974/75	19,601		5,186
1975/76	386	Average approximately	2,465
1976/77	5,849	7,000 tonnes or	308
1977/78	-	approximately	4,814
1978/79	-	20 tonnes/effective hr	4,350
1979/80	-		3.610

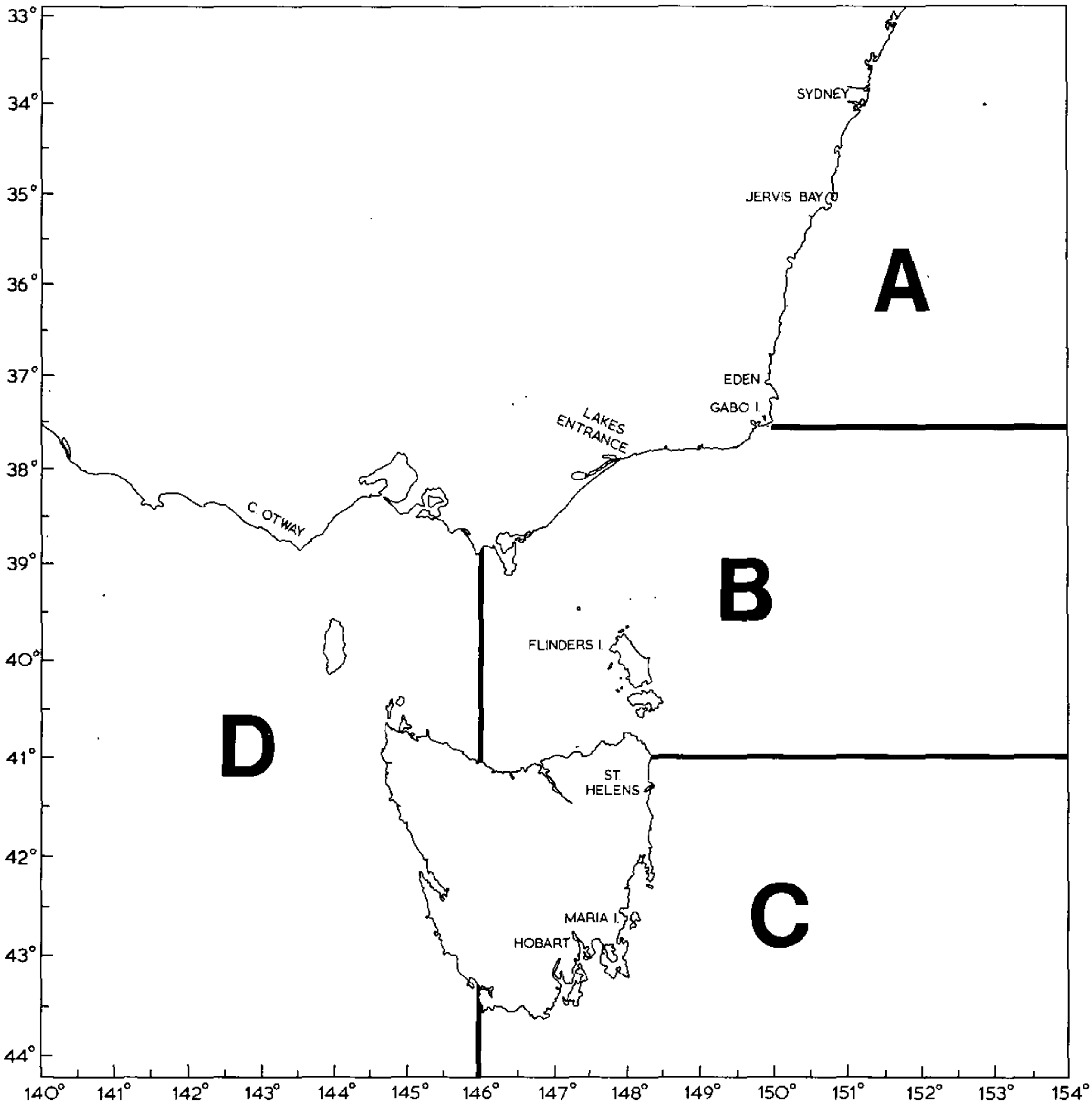
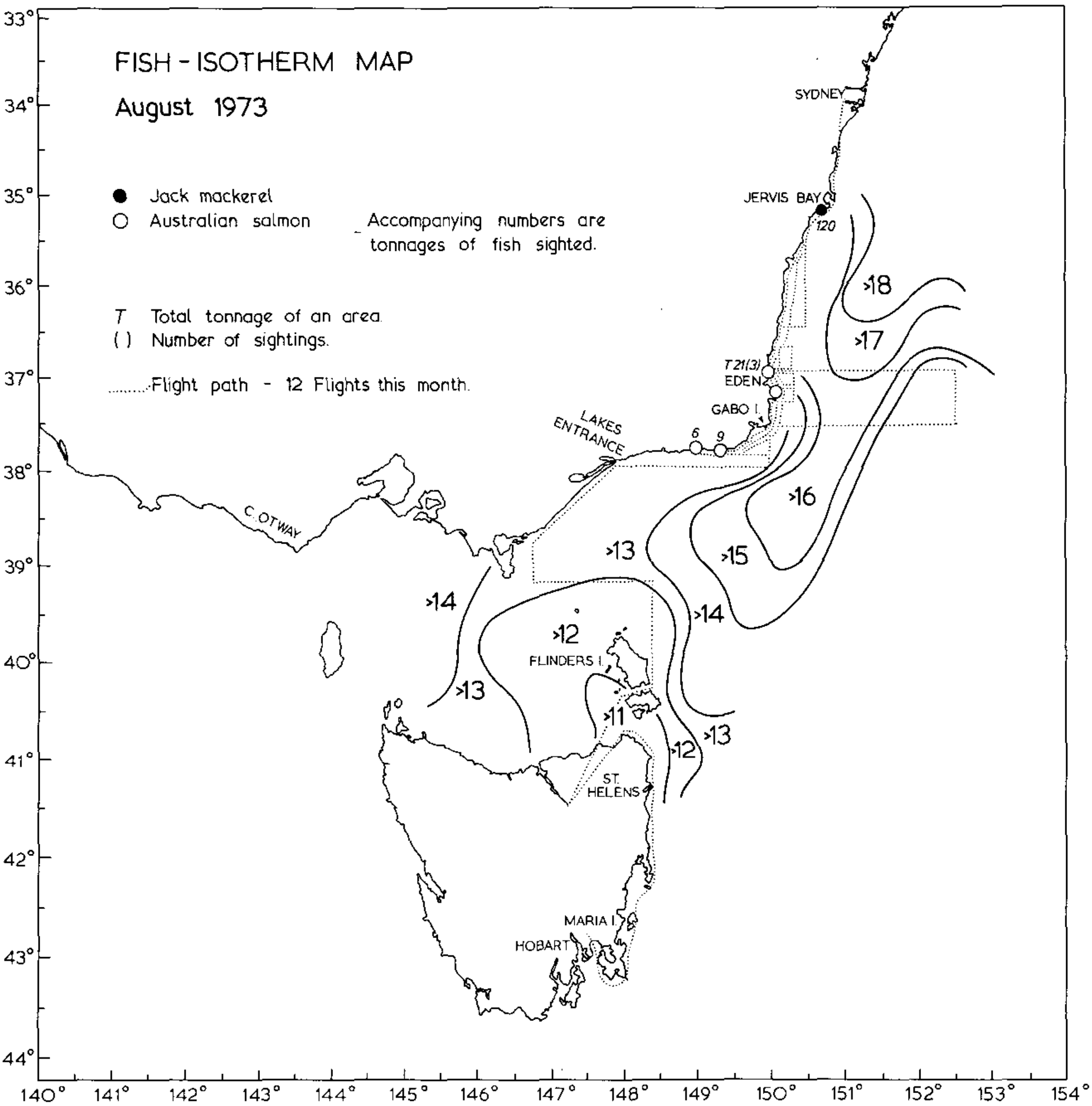


Fig. 1. Survey area showing sub-areas A-D used for data analysis.

Figs 2-48. Monthly fish sighting positions and tonnages and number of sightings for jack mackerel, skipjack tuna, Australian salmon and southern bluefin tuna. Sea surface temperatures (°C) are also shown.


FISH - ISOTHERM MAP
August 1973
Jack mackerel
Australian salmon
Accompanying numbers are tonnages of fish sighted.
T Total tonnage of an area.
( ) Number of sightings.
Flight path - 12 Flights this month.
SYDNEY
JERVIS BAY
120
T21(3)
EDEN
GABO I.
6
9
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
>18
>17
>16
>15
>14
>13
>12
>11
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
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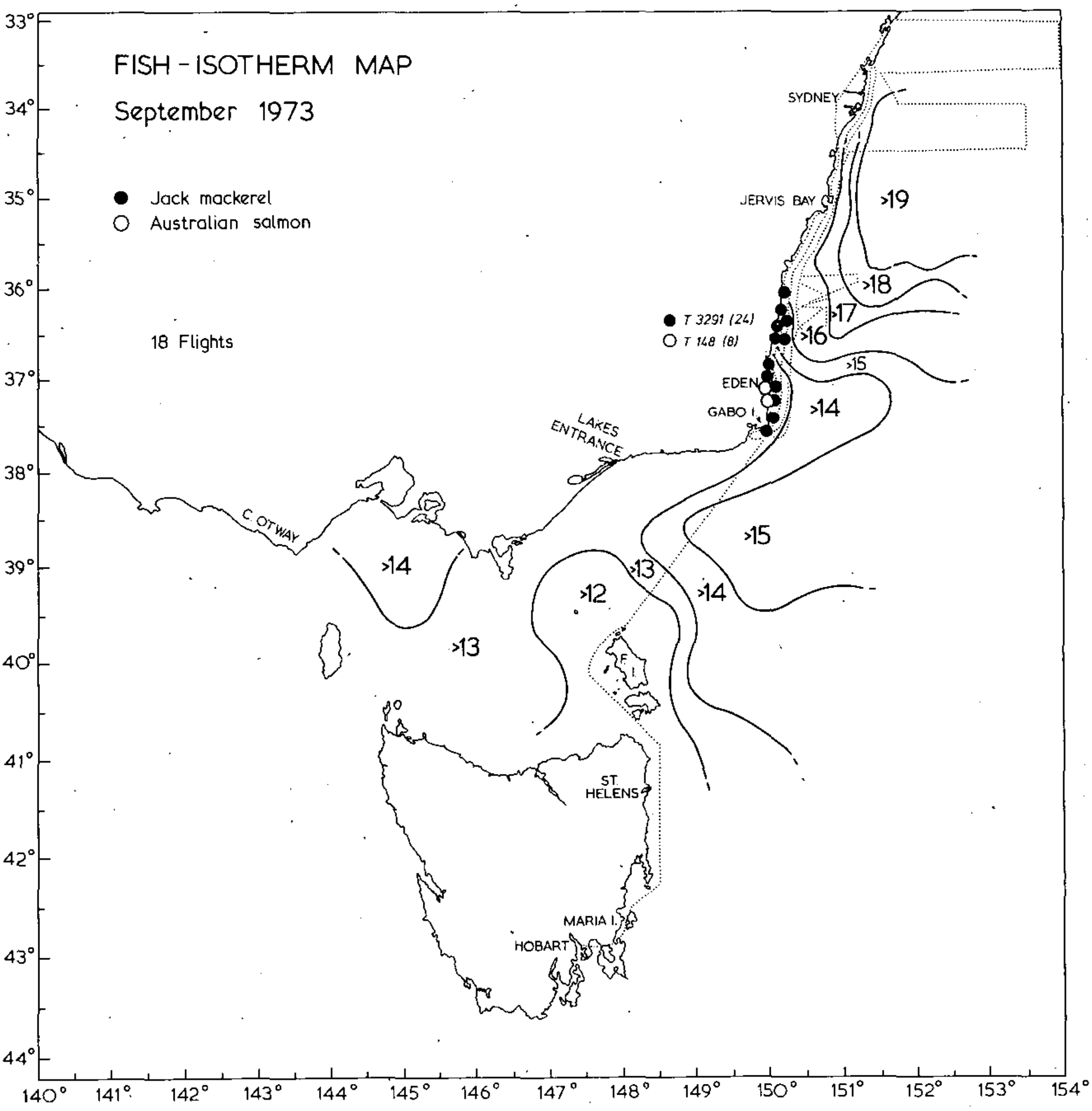
148°
149°
150°
151°
152°
153°
154°

Fig. 2.



FISH - ISOTHERM MAP
September 1973
Jack mackerel
Australian salmon
18 Flights
T 3291 (24)
T 148 (8)
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
ST. HELENS
MARIA I.
HOBART
F. I.
>19
>18
>17
>16
>15
>14
>13
>12
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
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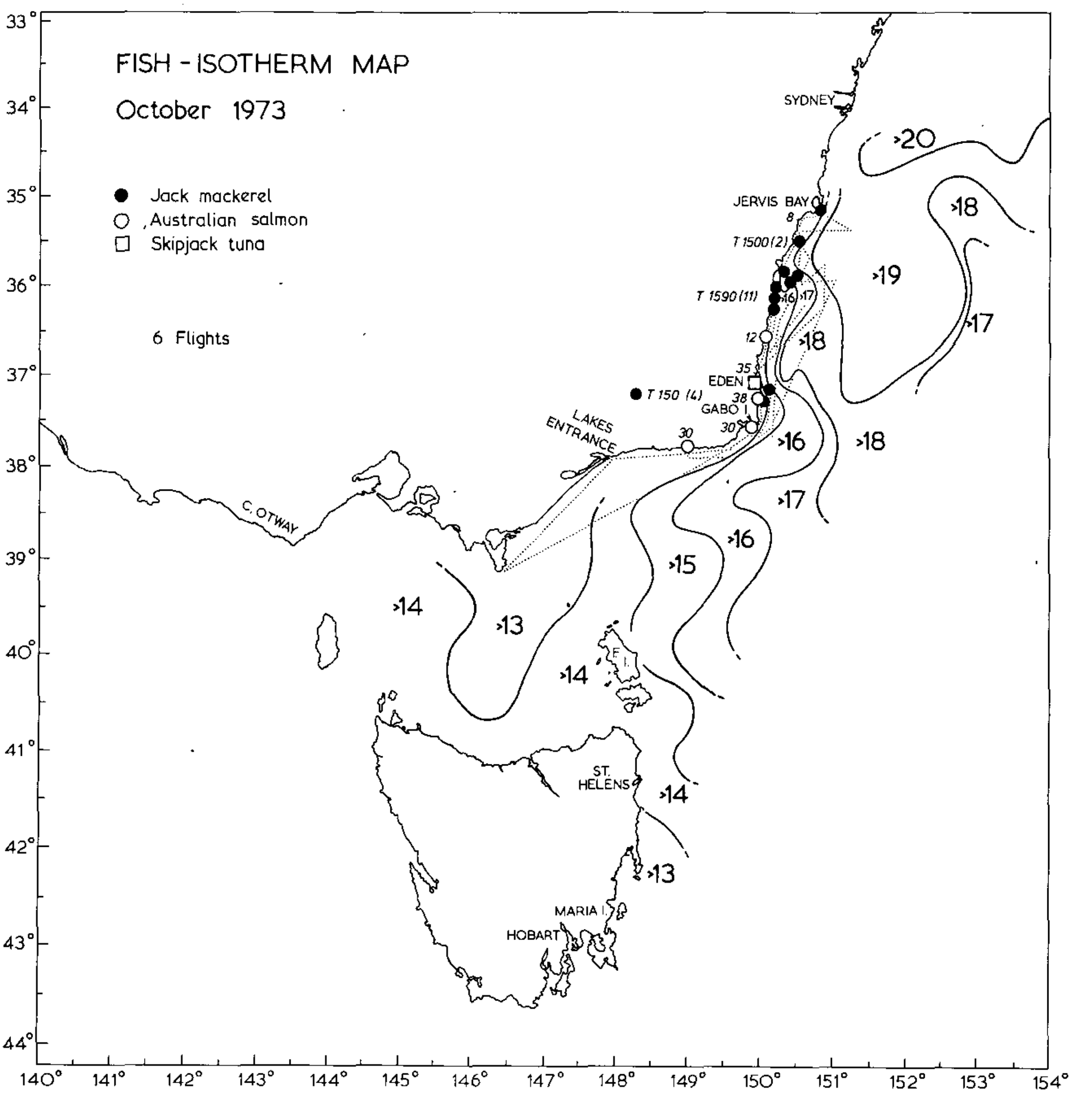
148°
149°
150°
151°
152°
153°
154°

Fig. 3.


FISH - ISOTHERM MAP
October 1973
Jack mackerel
Australian salmon
Skipjack tuna
6 Flights
SYDNEY
JERVIS BAY
T 1500 (2)
T 1590 (11)
EDEN
GABO I.
T 150 (4)
LAKES ENTRANCE
C. OTWAY
F. I.
ST. HELENS
MARIA I.
HOBART
>20
>19
>18
>17
>16
>15
>14
>13
33°
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154°

Fig. 4.

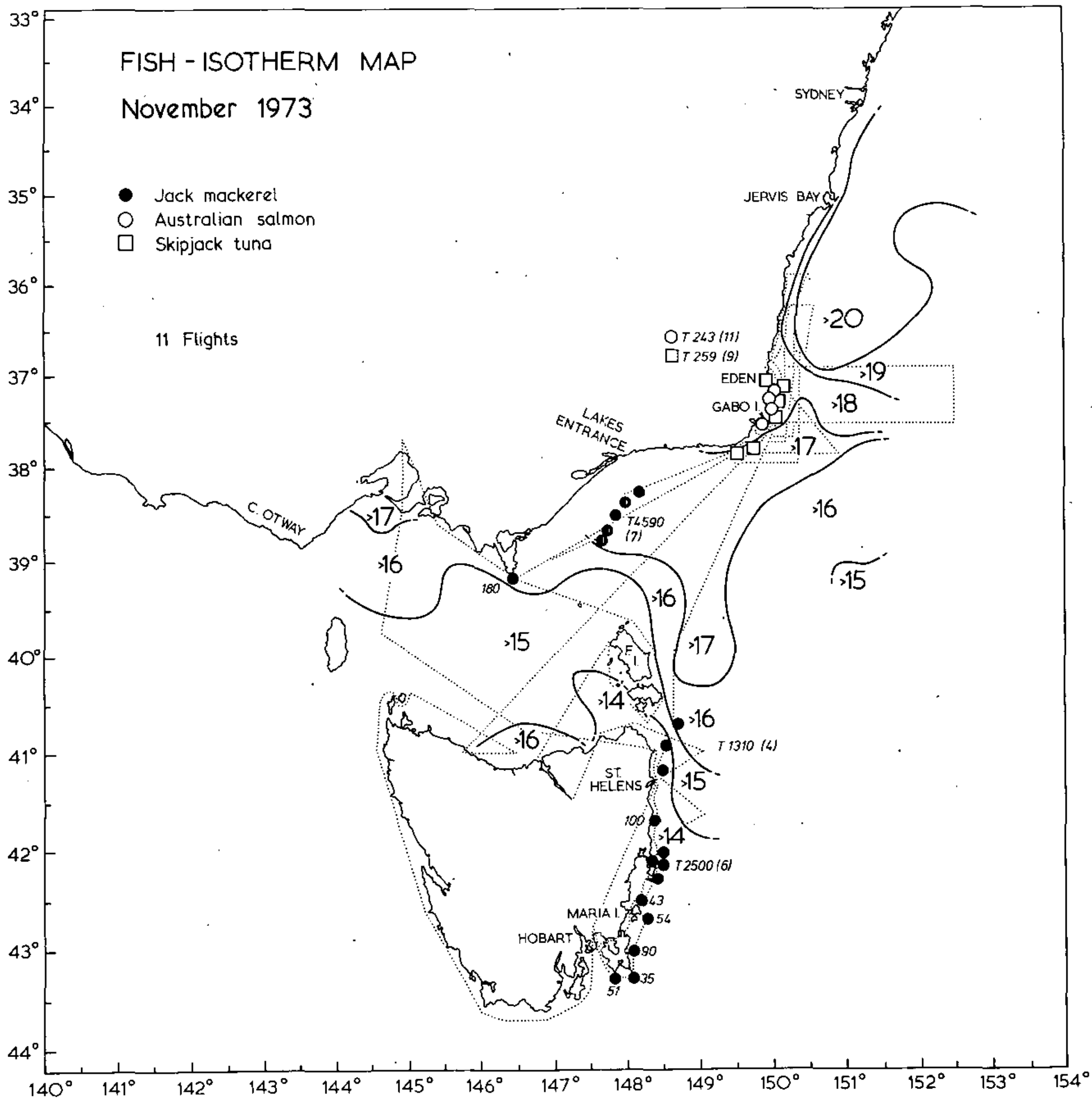
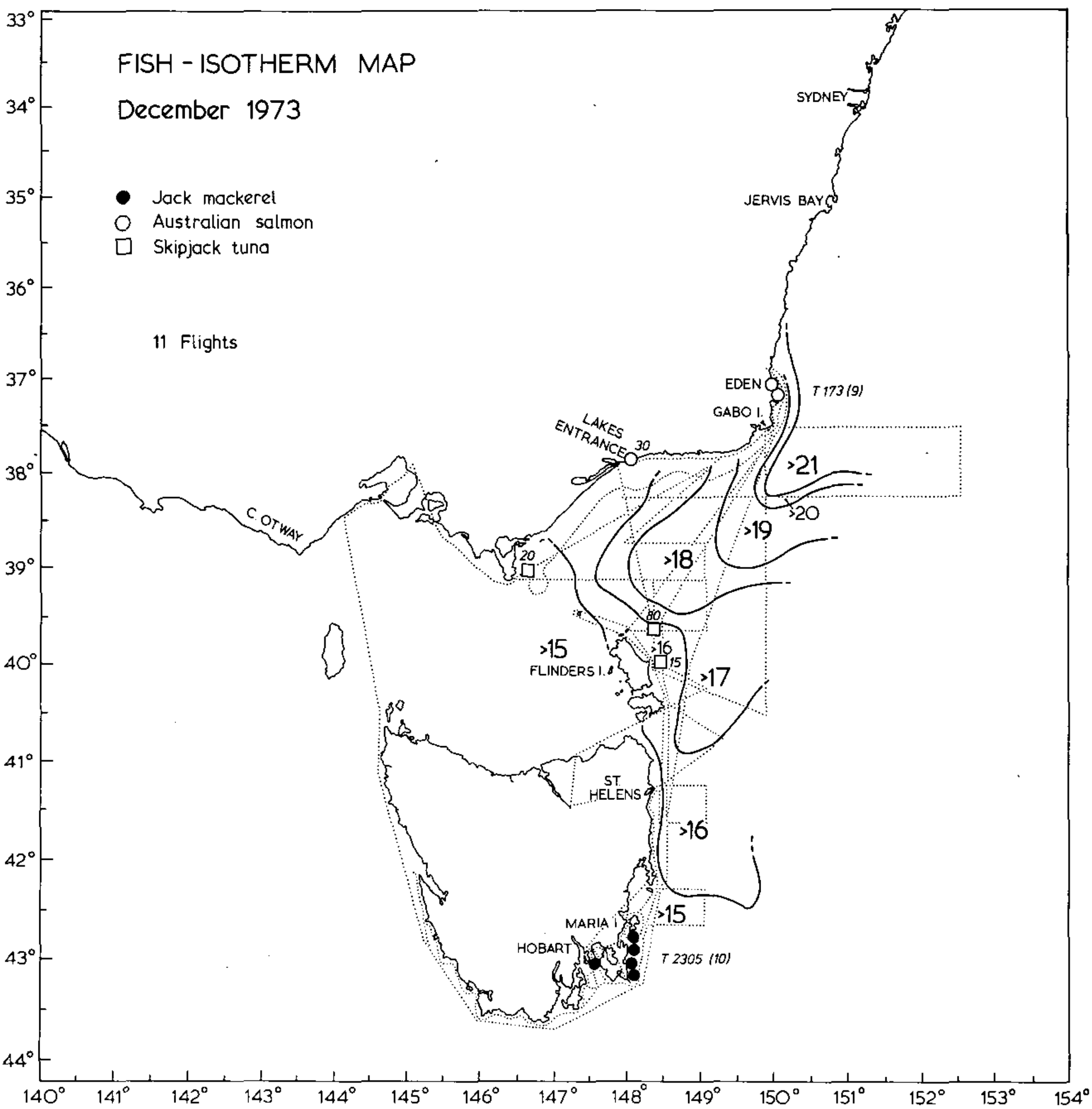
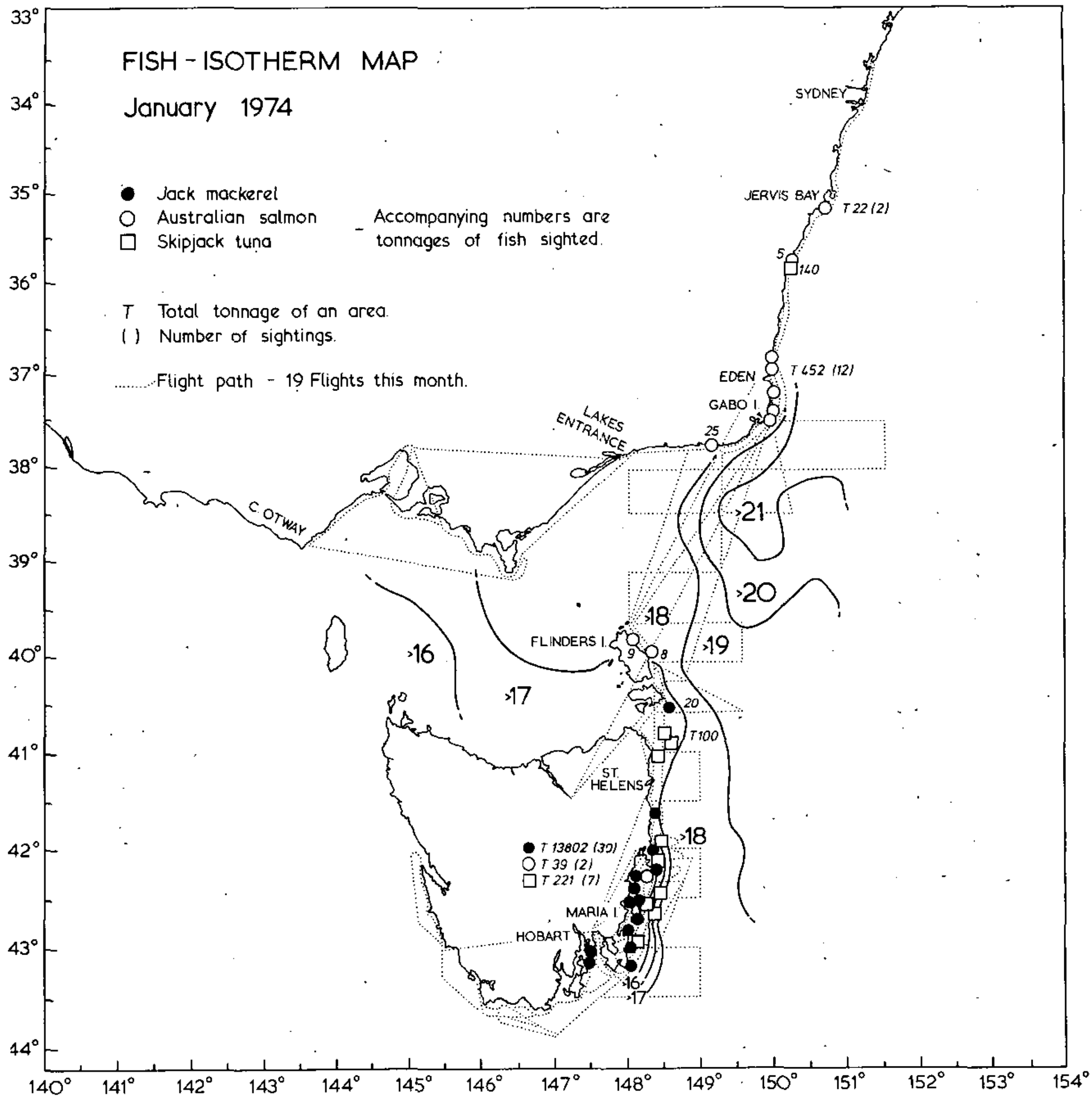

FISH - ISOTHERM MAP
November 1973
Jack mackerel
Australian salmon
Skipjack tuna
11 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
T 243 (11)
T 259 (9)
T4590 (7)
T 1310 (4)
T 2500 (6)
F. I.
ST. HELENS
MARIA I.
HOBART
>20
>19
>18
>17
>16
>15
>14
180
100
43
54
90
35
51
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 5.



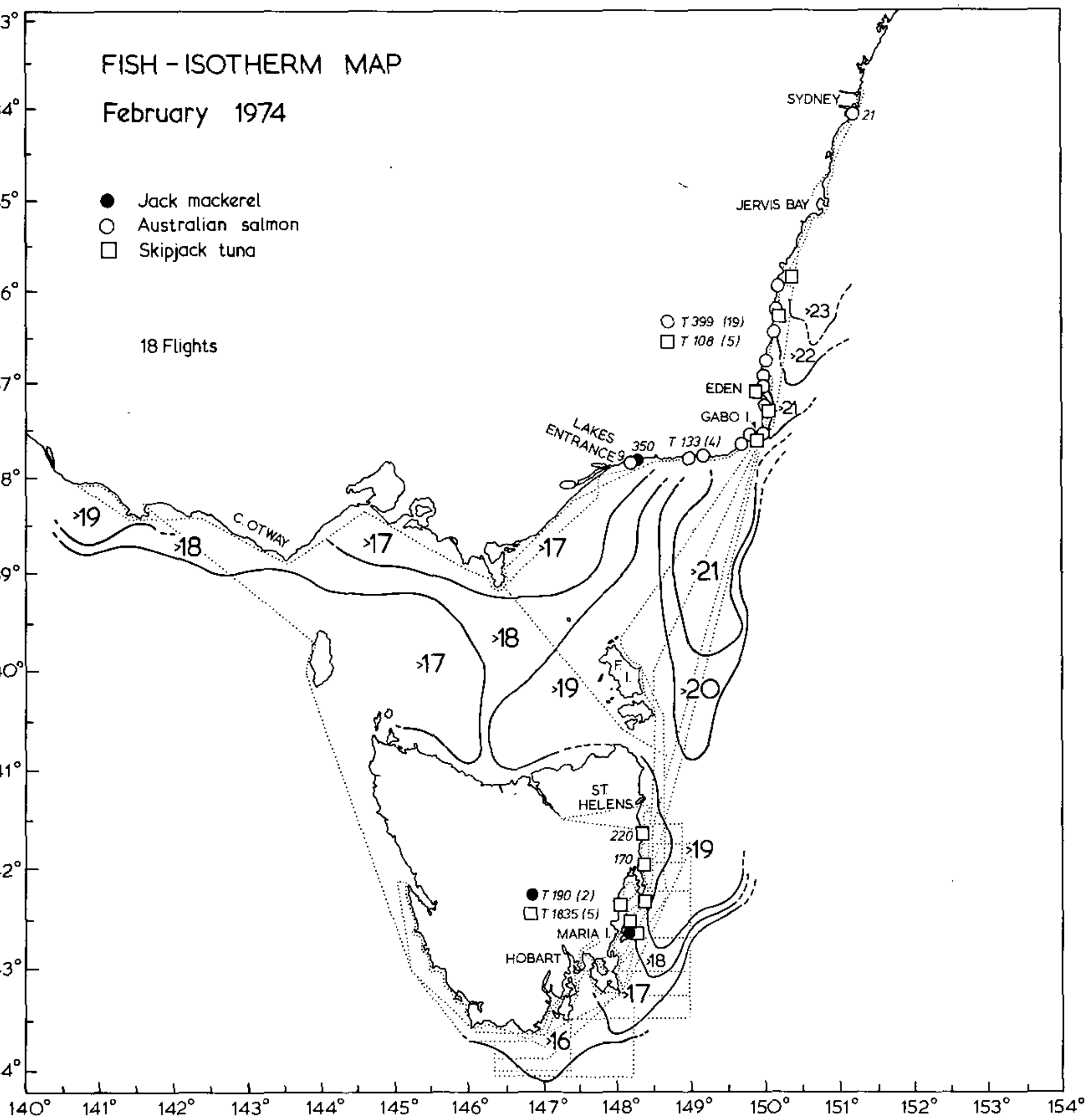
FISH - ISOTHERM MAP
December 1973
Jack mackerel
Australian salmon
Skipjack tuna
11 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
T 173 (9)
LAKES ENTRANCE
30
C. OTWAY
>21
>20
>19
>18
20
80
>15
>16
15
FLINDERS I.
>17
ST. HELENS
>16
>15
MARIA I.
HOBART
T 2305 (10)
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 6.



FISH - ISOTHERM MAP
January 1974
Jack mackerel
Australian salmon
Skipjack tuna
Accompanying numbers are tonnages of fish sighted.
T Total tonnage of an area.
( ) Number of sightings.
Flight path - 19 Flights this month.
SYDNEY
JERVIS BAY
T 22 (2)
5
140
EDEN
T 452 (12)
GABO I.
25
LAKES ENTRANCE
C. OTWAY
>21
>20
>19
>18
>16
>17
FLINDERS I.
9
8
20
T100
ST. HELENS
T 13802 (30)
T 39 (2)
T 221 (7)
MARIA I.
HOBART
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 7.



FISH - ISOTHERM MAP
February 1974
Jack mackerel
Australian salmon
Skipjack tuna
18 Flights
SYDNEY
21
JERVIS BAY
T 399 (19)
T 108 (5)
EDEN
GABO I.
LAKES ENTRANCE
350
T 133 (4)
C. OTWAY
>23
>22
>21
>19
>18
>17
>17
>17
>18
>19
>21
>20
F. I.
ST HELENS
220
170
>19
T 190 (2)
T 1835 (5)
MARIA I.
HOBART
>18
>17
>16
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 8.

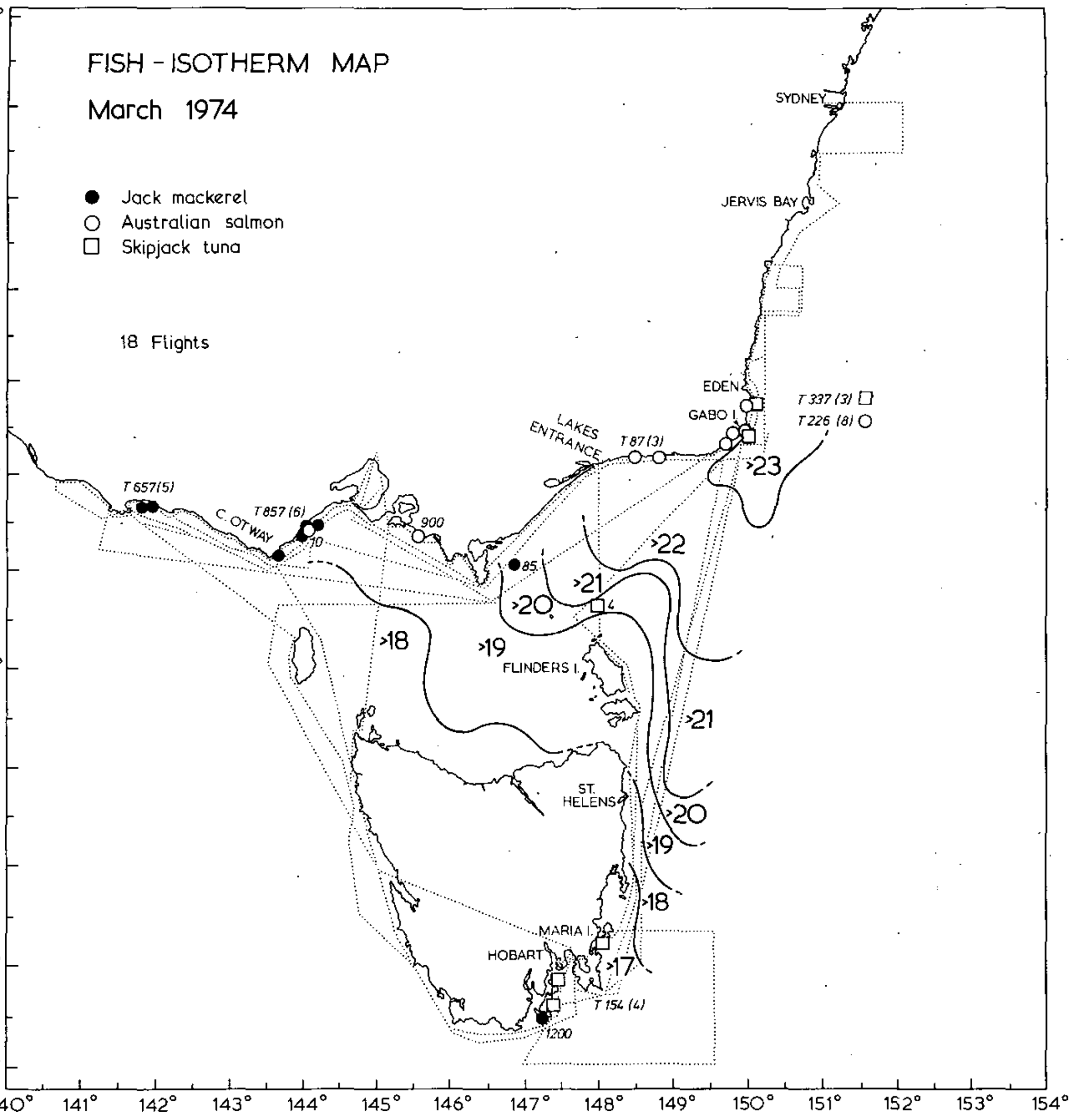
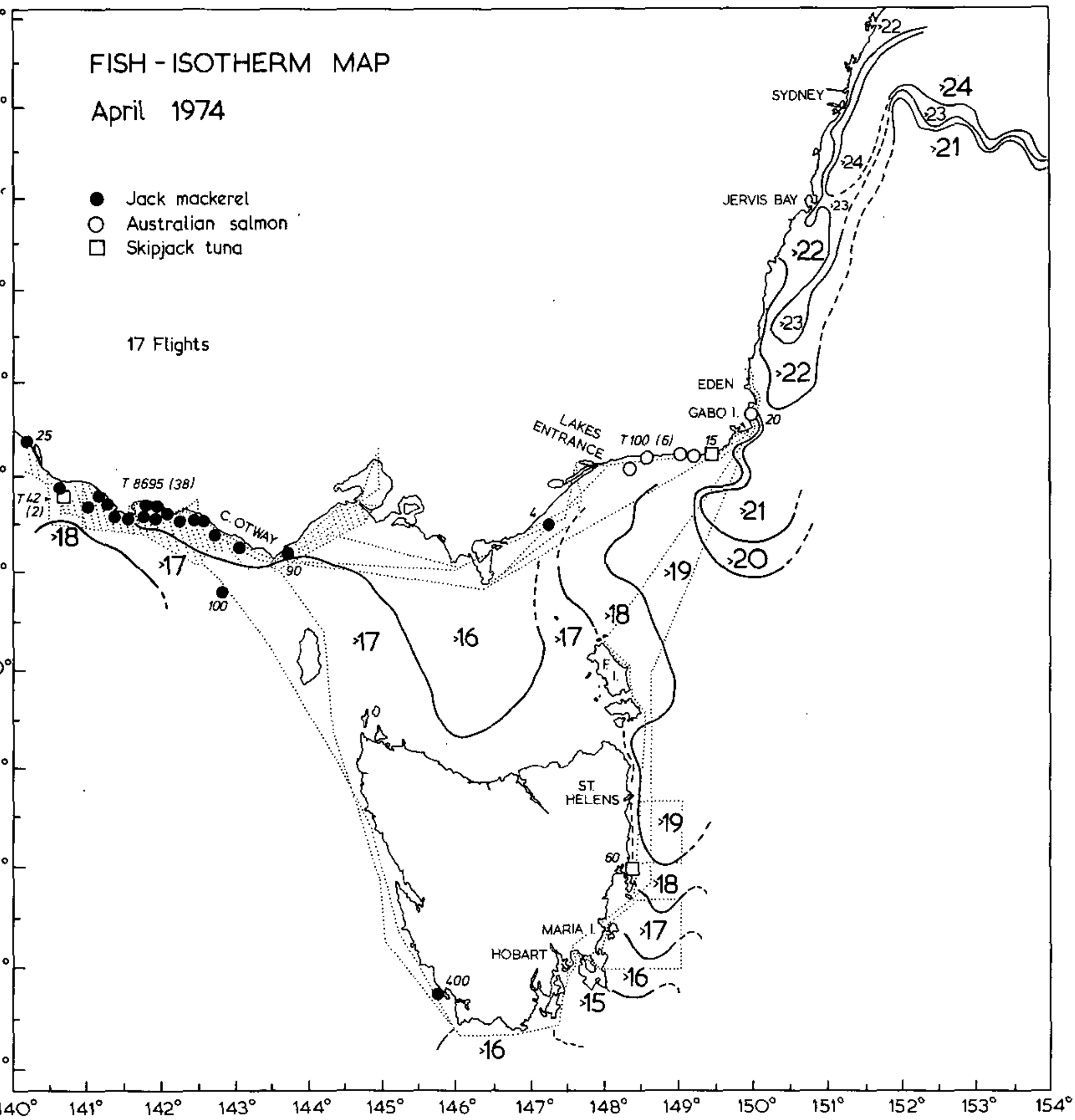

FISH - ISOTHERM MAP
March 1974
Jack mackerel
Australian salmon
Skipjack tuna
18 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
T 337 (3)
T 226 (8)
T 87 (3)
T 657 (5)
T 857 (6)
C. OTWAY
10
900
85
>23
>22
>21
>20
>19
>18
>17
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 154 (4)
1200
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 9.



FISH - ISOTHERM MAP
April 1974
Jack mackerel
Australian salmon
Skipjack tuna
17 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
T100 (6)
T 8695 (38)
T42 (2)
C. OTWAY
F. I.
ST. HELENS
MARIA I.
HOBART
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 10.

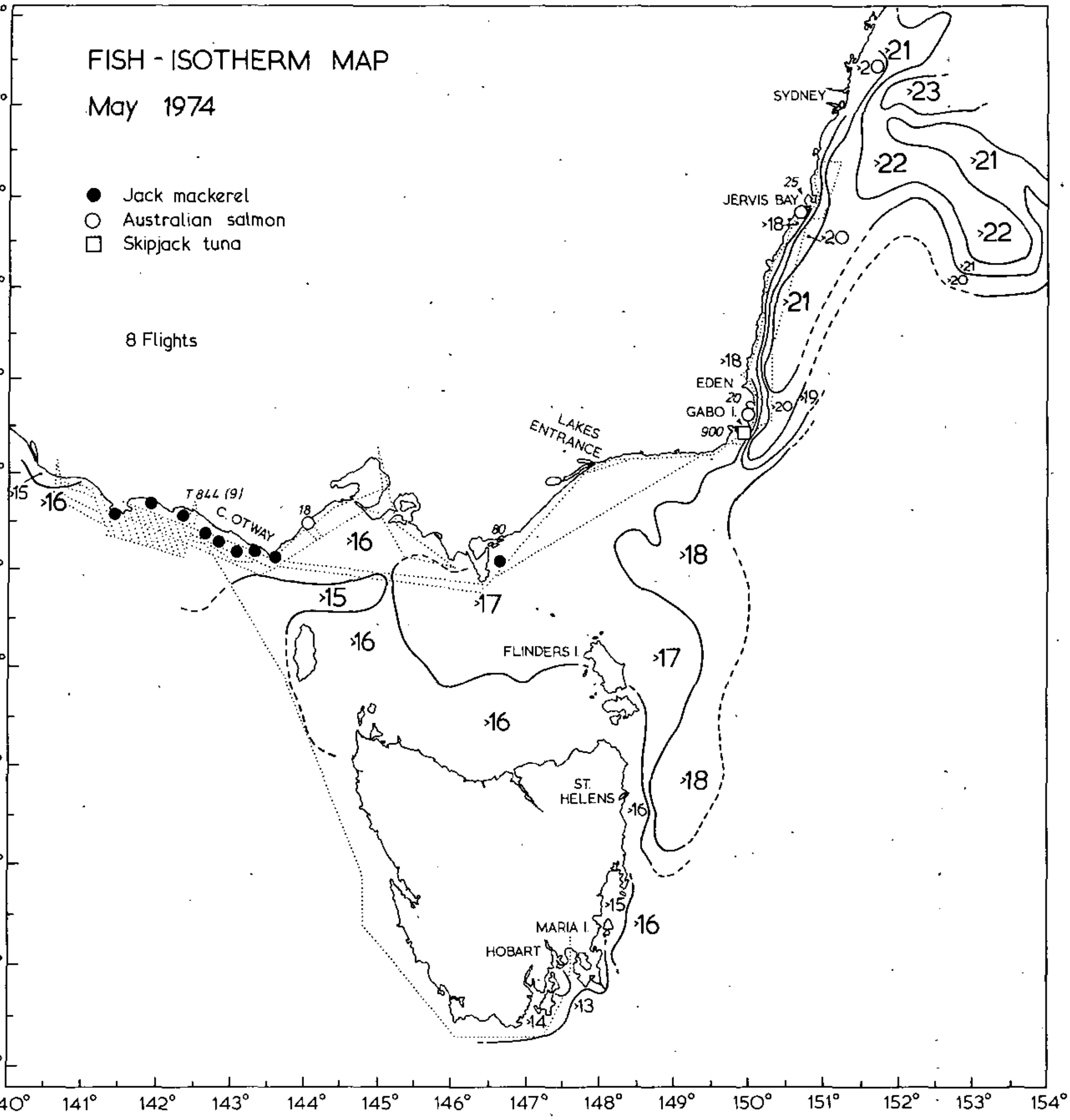
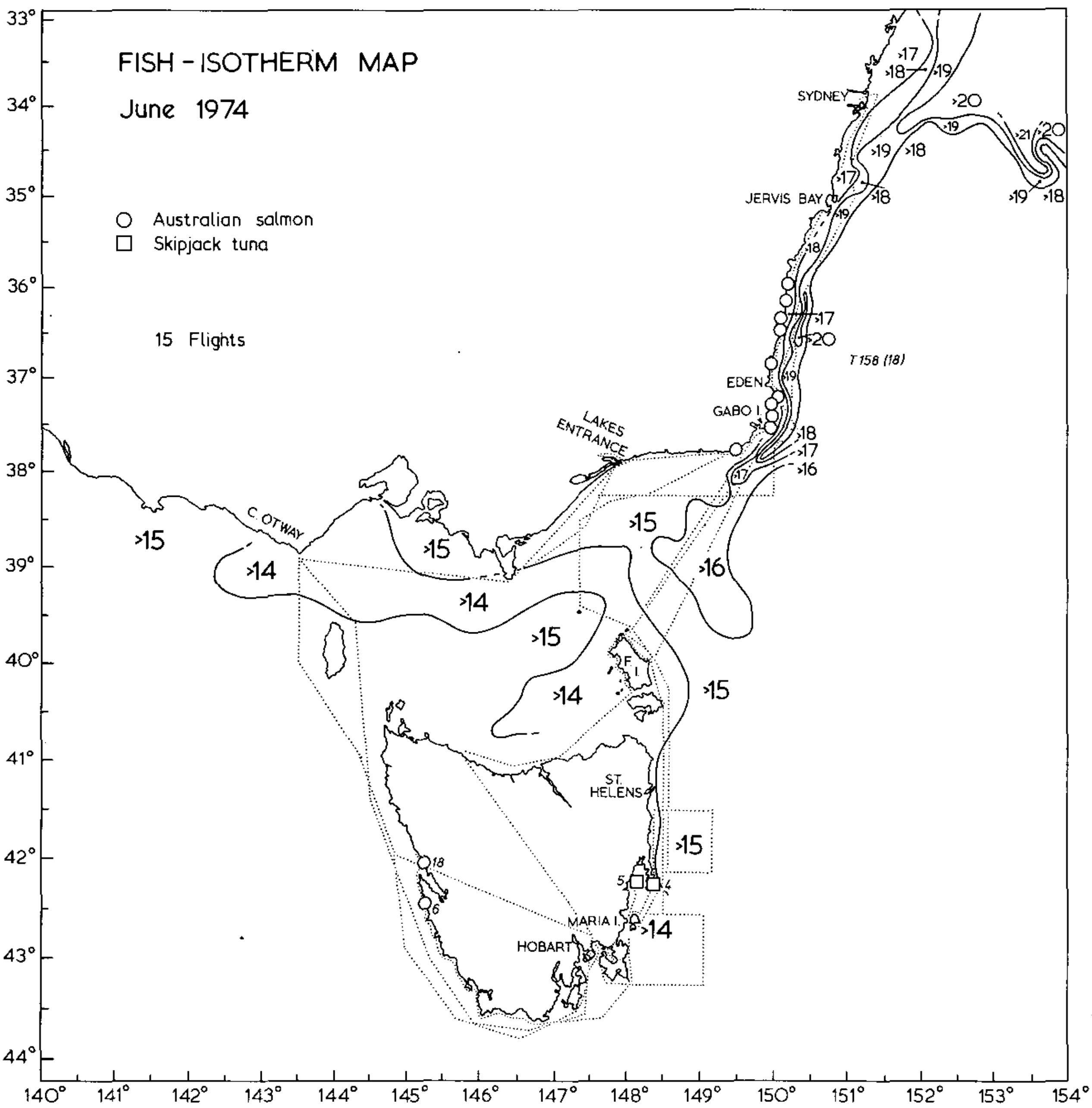

FISH - ISOTHERM MAP
May 1974
Jack mackerel
Australian salmon
Skipjack tuna
8 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
T 844 (9)
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 11.



FISH - ISOTHERM MAP
June 1974
Australian salmon
Skipjack tuna
15 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
F. I.
ST. HELENS
MARIA I.
HOBART
T 158 (18)
>15
>14
>16
>17
>18
>19
>20
>21
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 12.

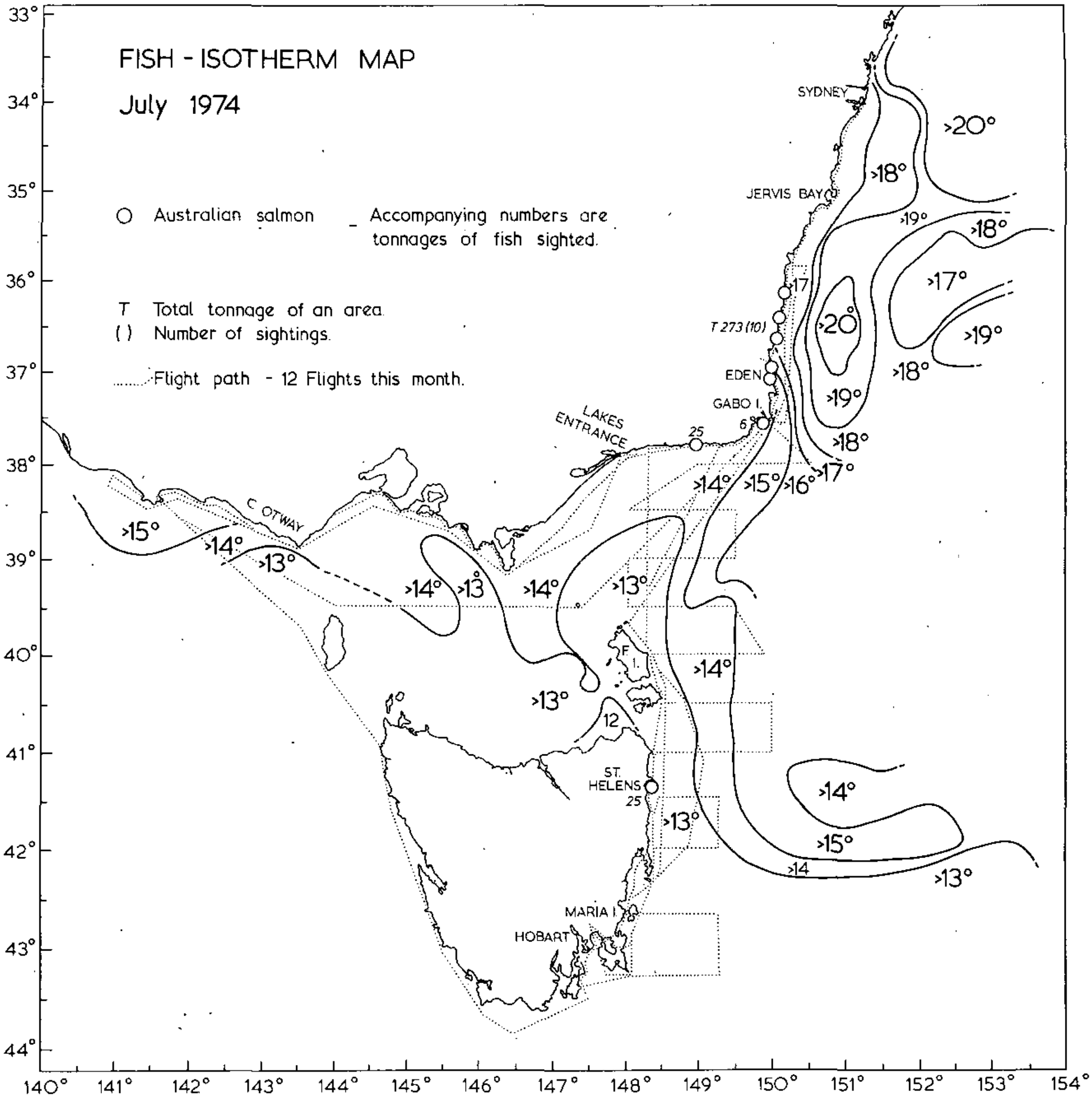
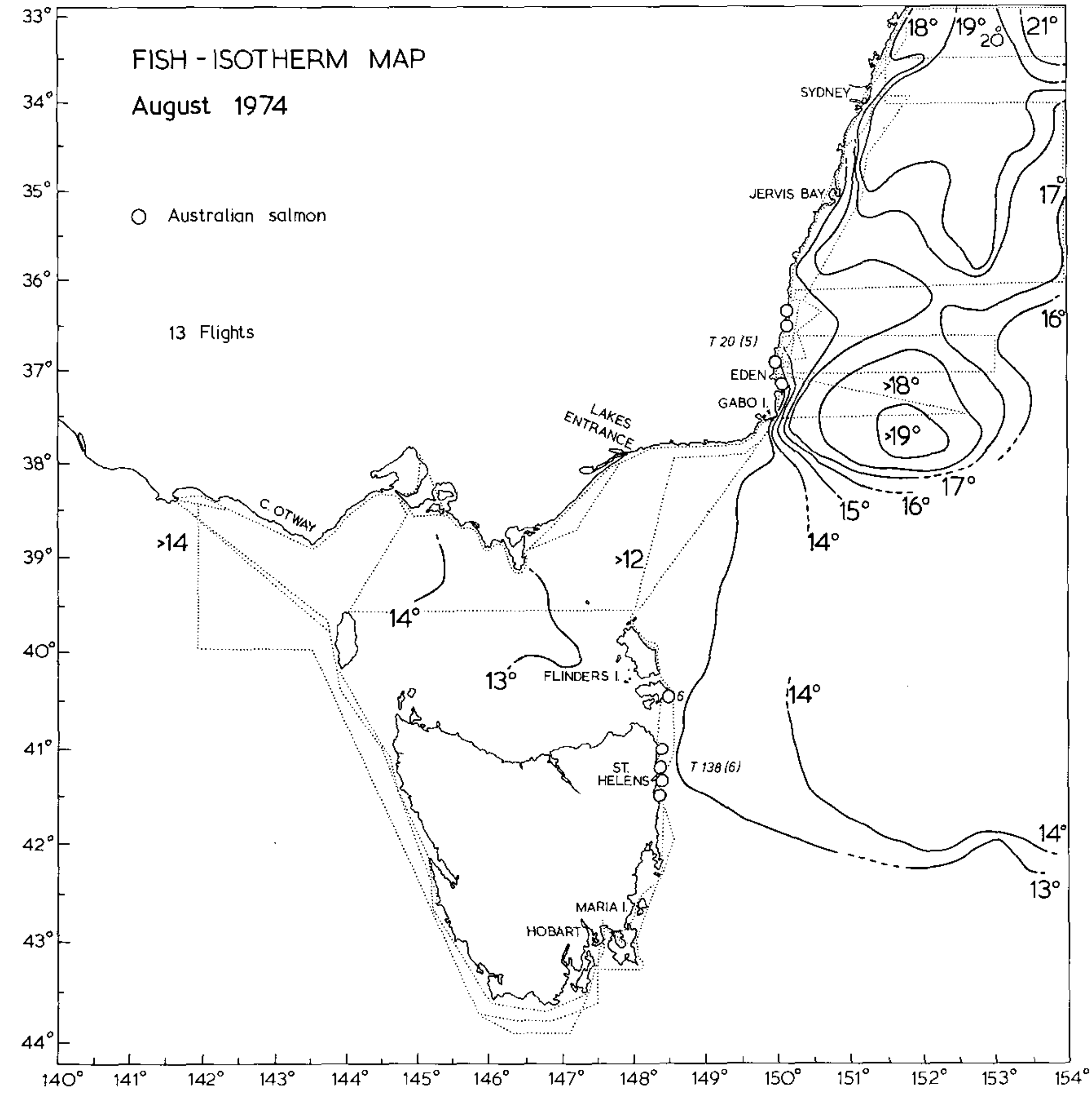

FISH - ISOTHERM MAP
July 1974
Australian salmon
Accompanying numbers are tonnages of fish sighted.
T Total tonnage of an area
( ) Number of sightings.
Flight path - 12 Flights this month.
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
F. I.
ST. HELENS
MARIA I.
HOBART
T 273 (10)
>20°
>18°
>19°
>17°
>16°
>15°
>14°
>13°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 13.



FISH - ISOTHERM MAP
August 1974
Australian salmon
13 Flights
SYDNEY
JERVIS BAY
T 20 (5)
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
T 138 (6)
MARIA I.
HOBART
>14
>12
14°
13°
>18°
>19°
15°
16°
17°
18°
19°
20°
21°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 14.

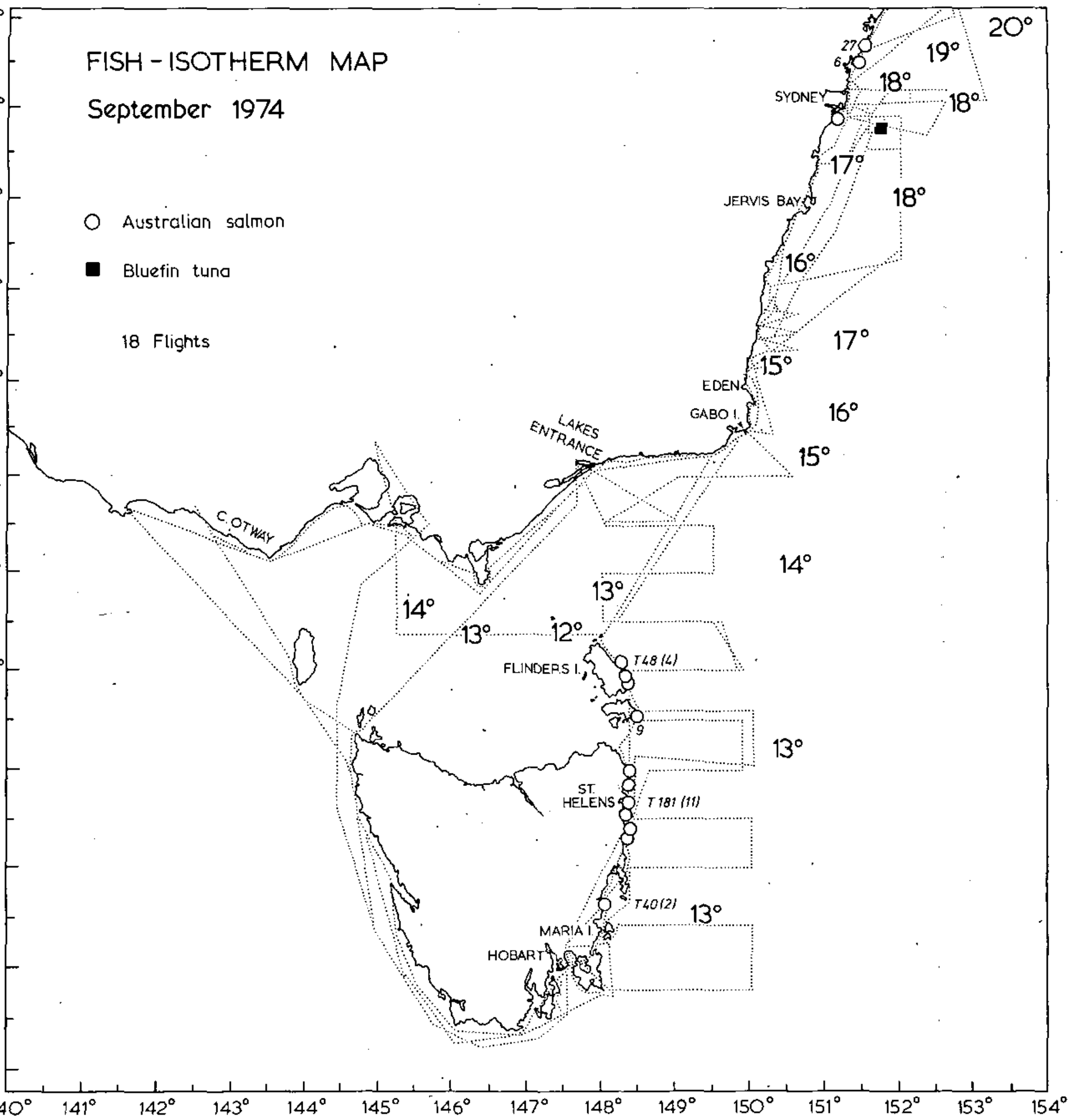

FISH - ISOTHERM MAP
September 1974
Australian salmon
Bluefin tuna
18 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T48 (4)
T181 (11)
T40 (2)
20°
19°
18°
17°
16°
15°
14°
13°
12°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 15.

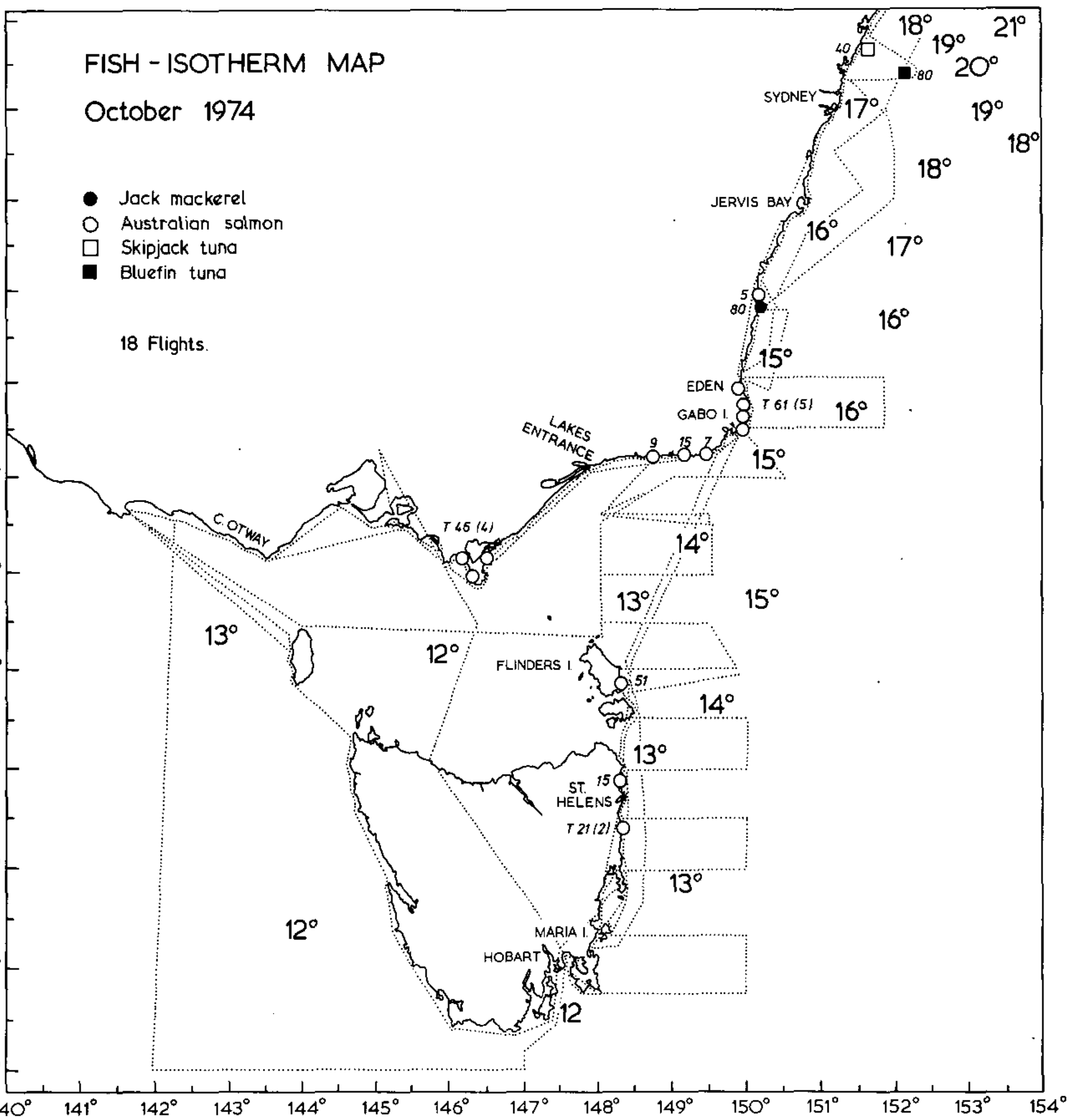
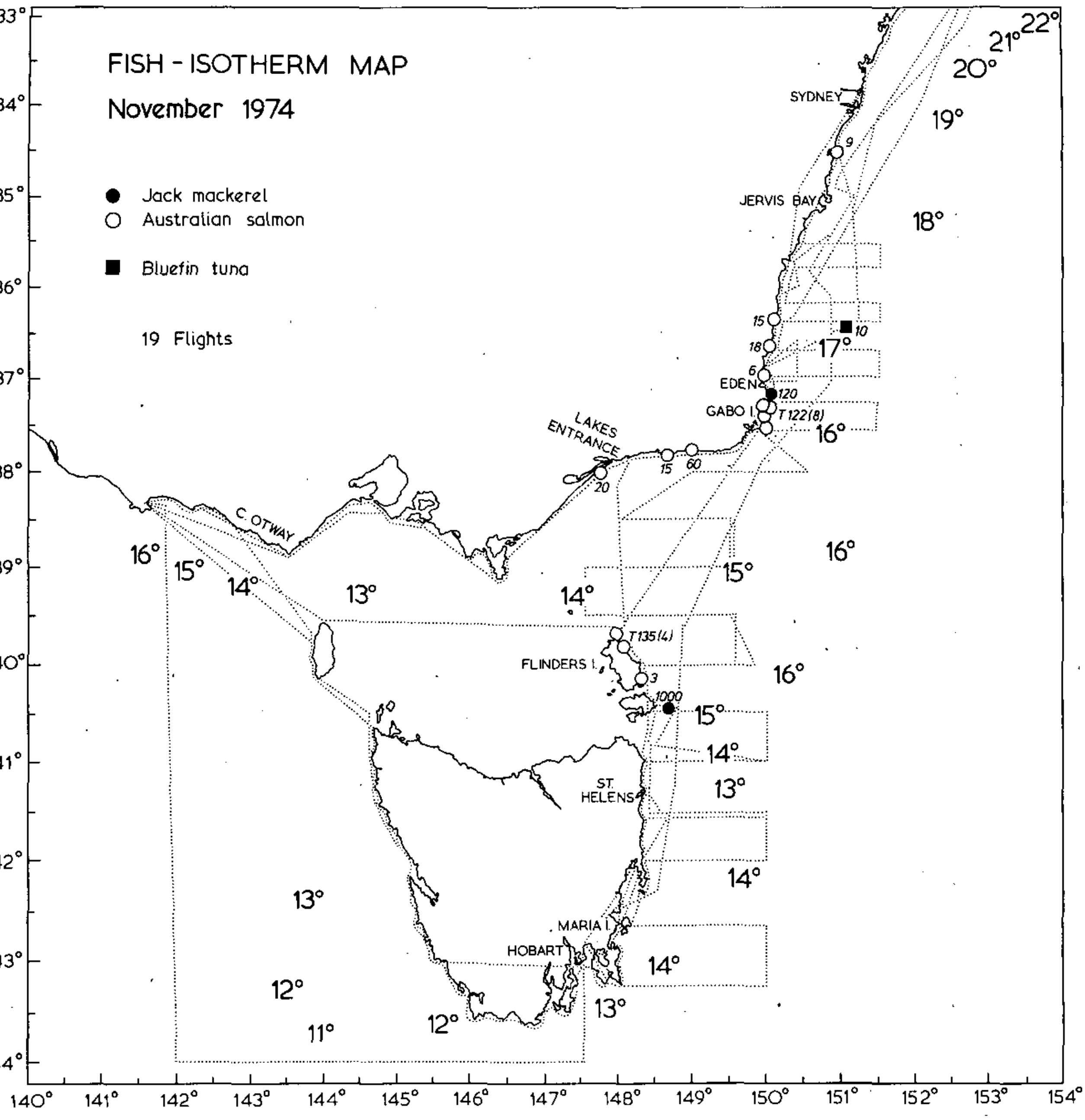

FISH - ISOTHERM MAP
October 1974
Jack mackerel
Australian salmon
Skipjack tuna
Bluefin tuna
18 Flights.
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 61 (5)
T 46 (4)
T 21 (2)
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 16.



FISH - ISOTHERM MAP
November 1974
Jack mackerel
Australian salmon
Bluefin tuna
19 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T135(4)
T122(8)
1000
120

Fig. 17.

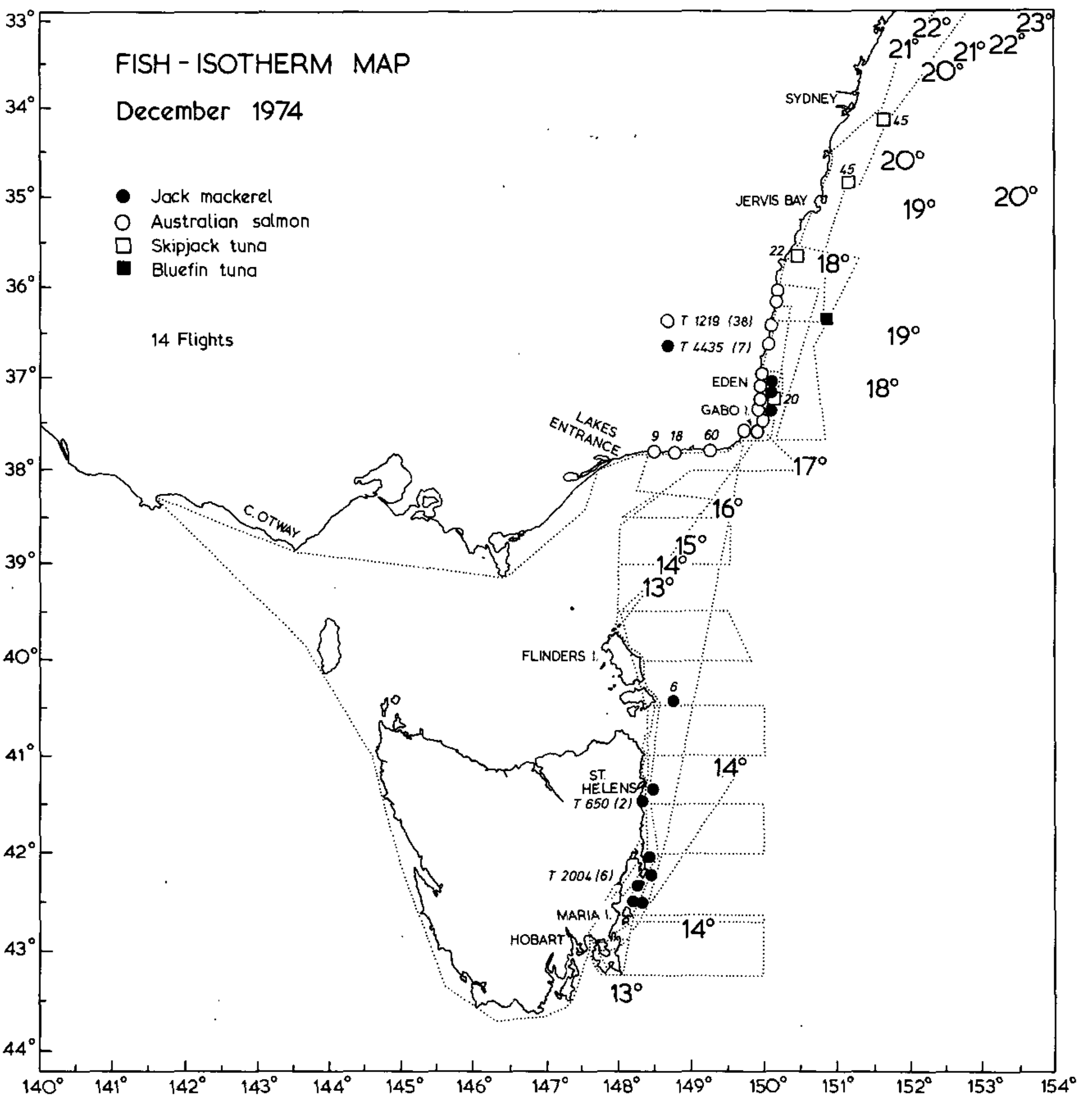

FISH - ISOTHERM MAP
December 1974
Jack mackerel
Australian salmon
Skipjack tuna
Bluefin tuna
14 Flights
T 1219 (38)
T 4435 (7)
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
T 650 (2)
T 2004 (6)
MARIA I.
HOBART
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 18.

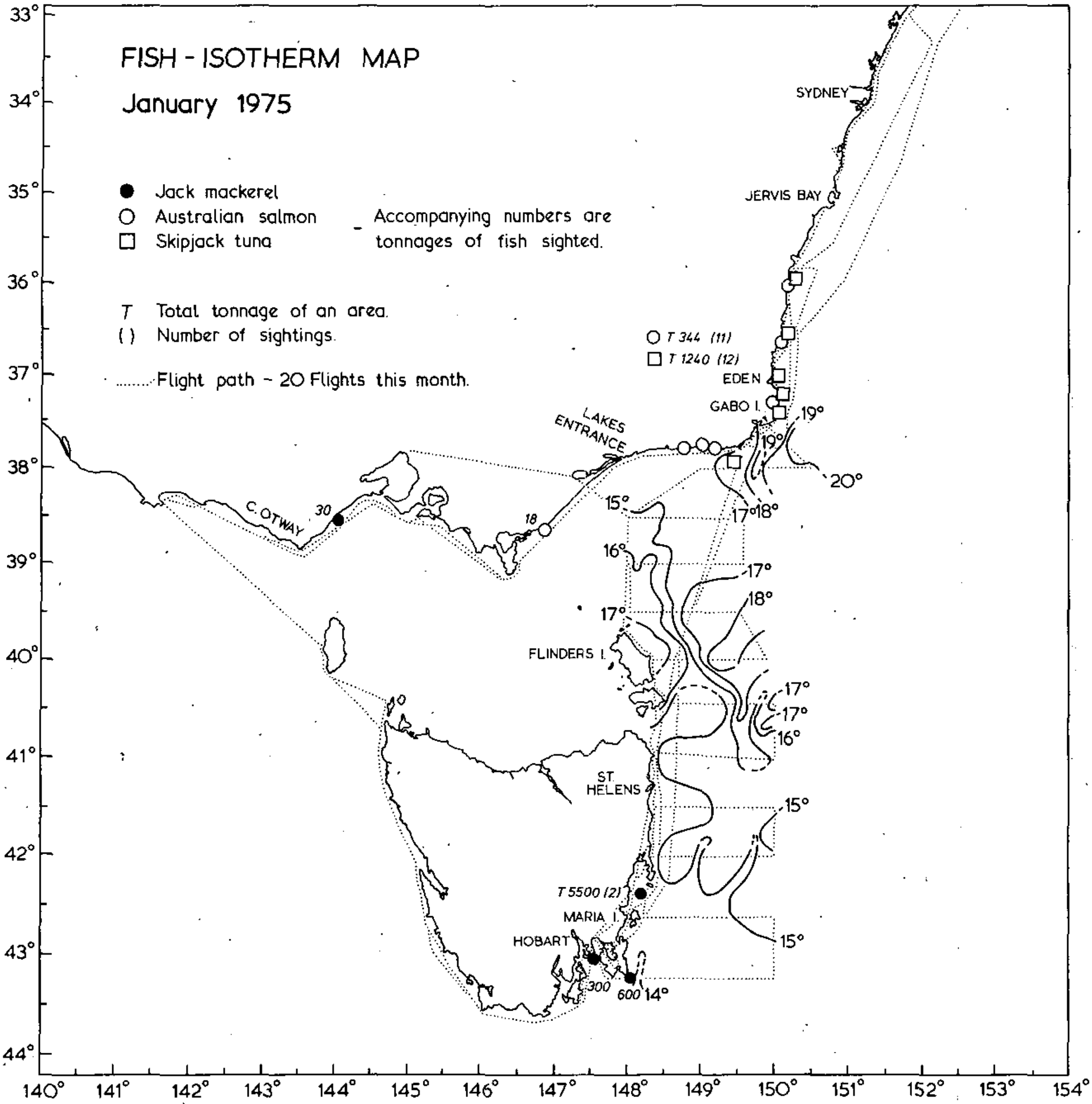
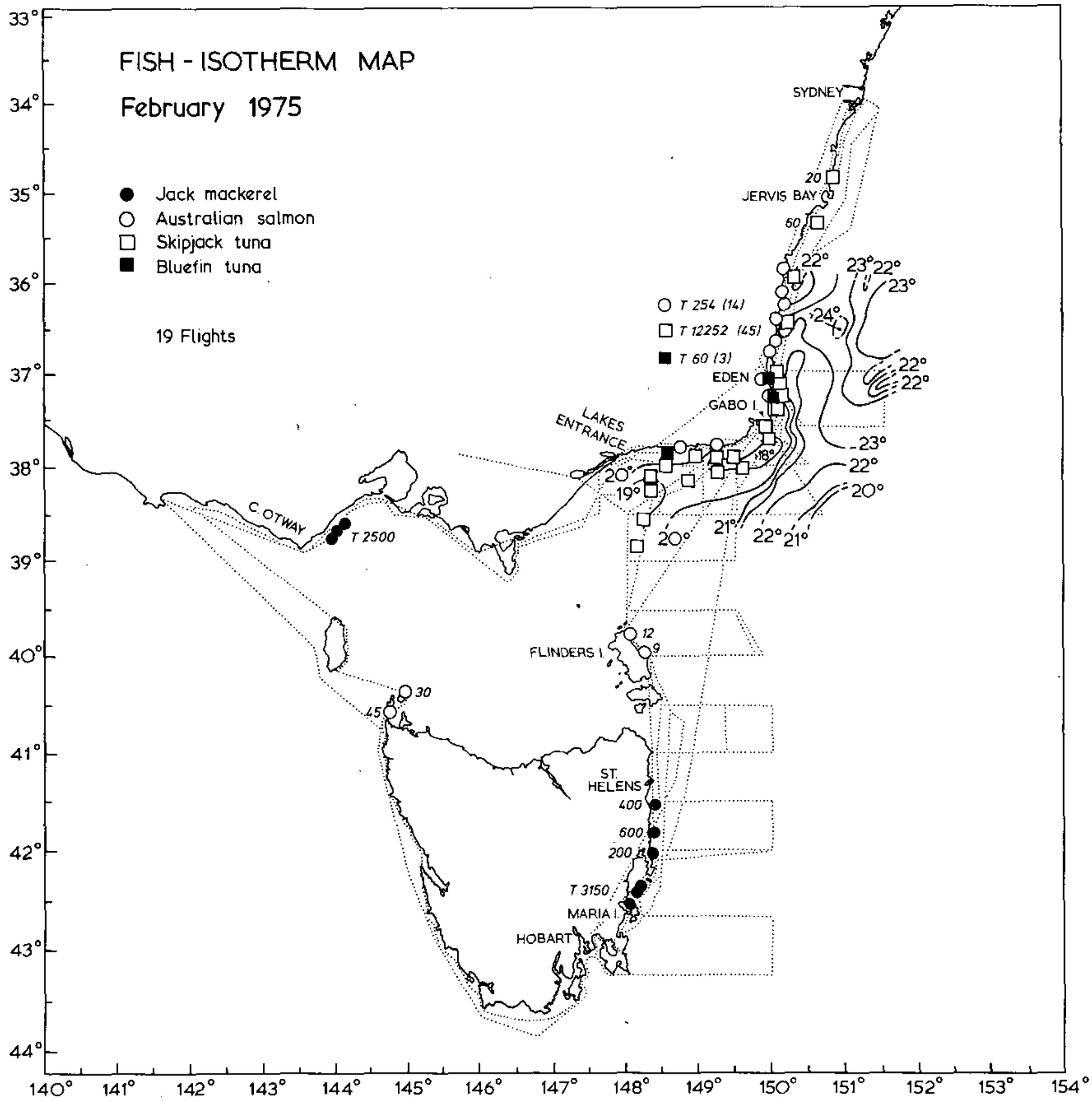

FISH - ISOTHERM MAP
January 1975
Jack mackerel
Australian salmon
Skipjack tuna
Accompanying numbers are tonnages of fish sighted.
T Total tonnage of an area.
( ) Number of sightings.
Flight path - 20 Flights this month.
SYDNEY
JERVIS BAY
T 344 (11)
T 1240 (12)
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
30
18
FLINDERS I.
ST. HELENS
T 5500 (2)
MARIA I.
HOBART
300
600
14°
15°
16°
17°
18°
19°
20°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 19.



FISH - ISOTHERM MAP
February 1975
Jack mackerel
Australian salmon
Skipjack tuna
Bluefin tuna
19 Flights
T 254 (14)
T 12252 (45)
T 60 (3)
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
T 2500
FLINDERS I.
ST. HELENS
T 3150
MARIA I.
HOBART

Fig. 20.

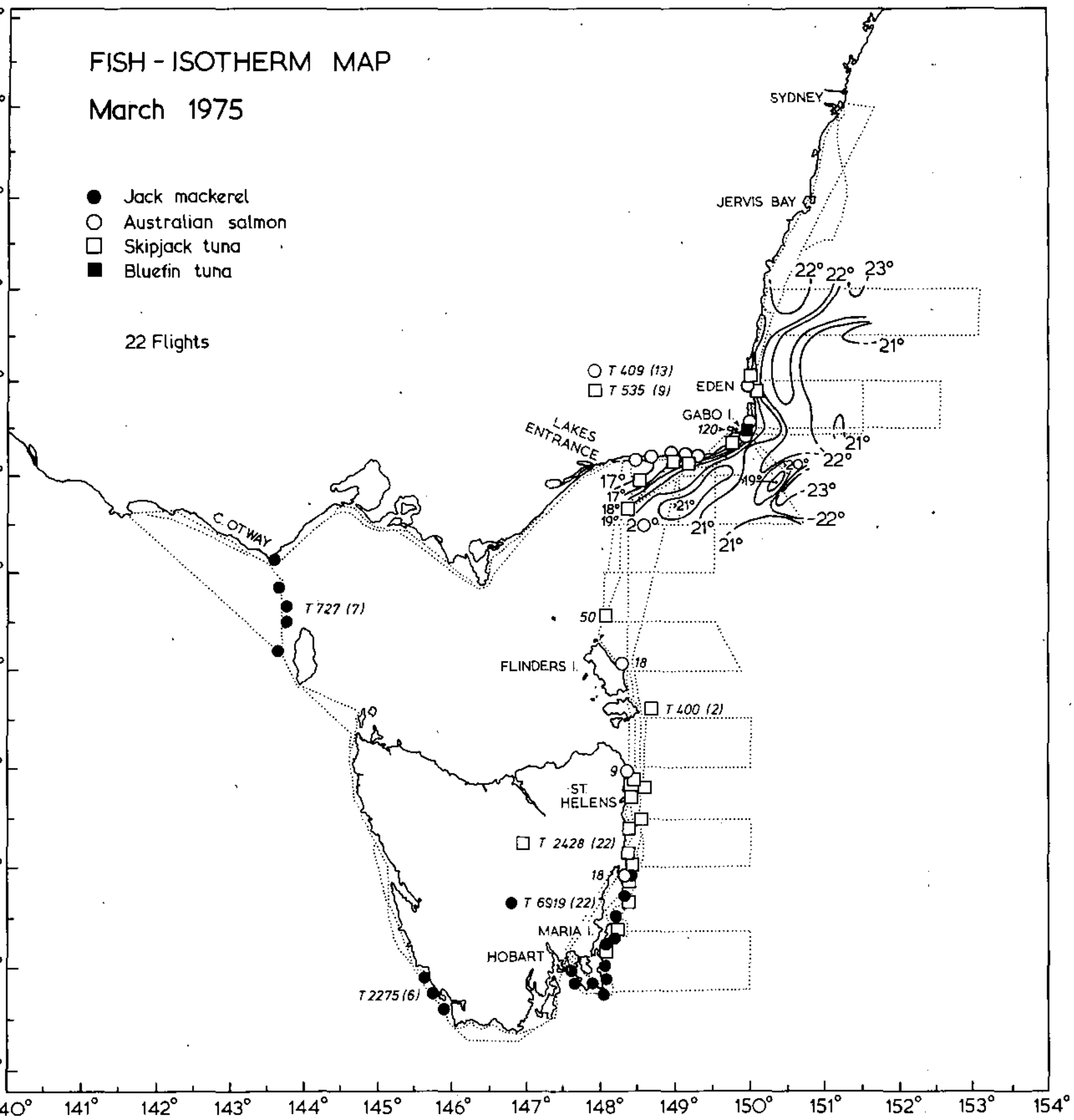
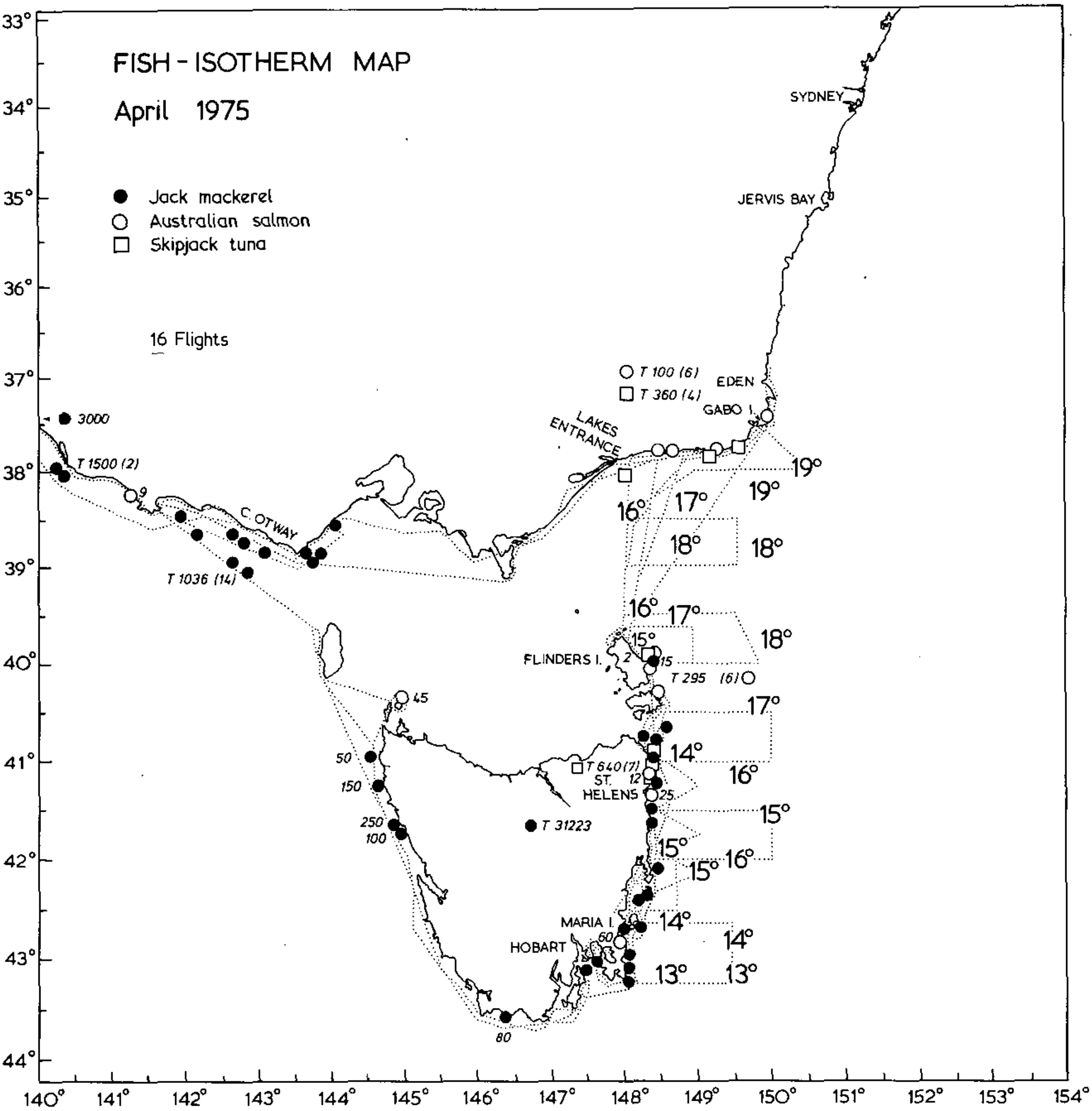

FISH - ISOTHERM MAP
March 1975
Jack mackerel
Australian salmon
Skipjack tuna
Bluefin tuna
22 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 409 (13)
T 535 (9)
T 727 (7)
T 400 (2)
T 2428 (22)
T 6919 (22)
T 2275 (6)
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 21.



FISH - ISOTHERM MAP
April 1975
Jack mackerel
Australian salmon
Skipjack tuna
16 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 100 (6)
T 360 (4)
T 1500 (2)
T 1036 (14)
T 295 (6)
T 640 (7)
T 31223
3000

Fig. 22.

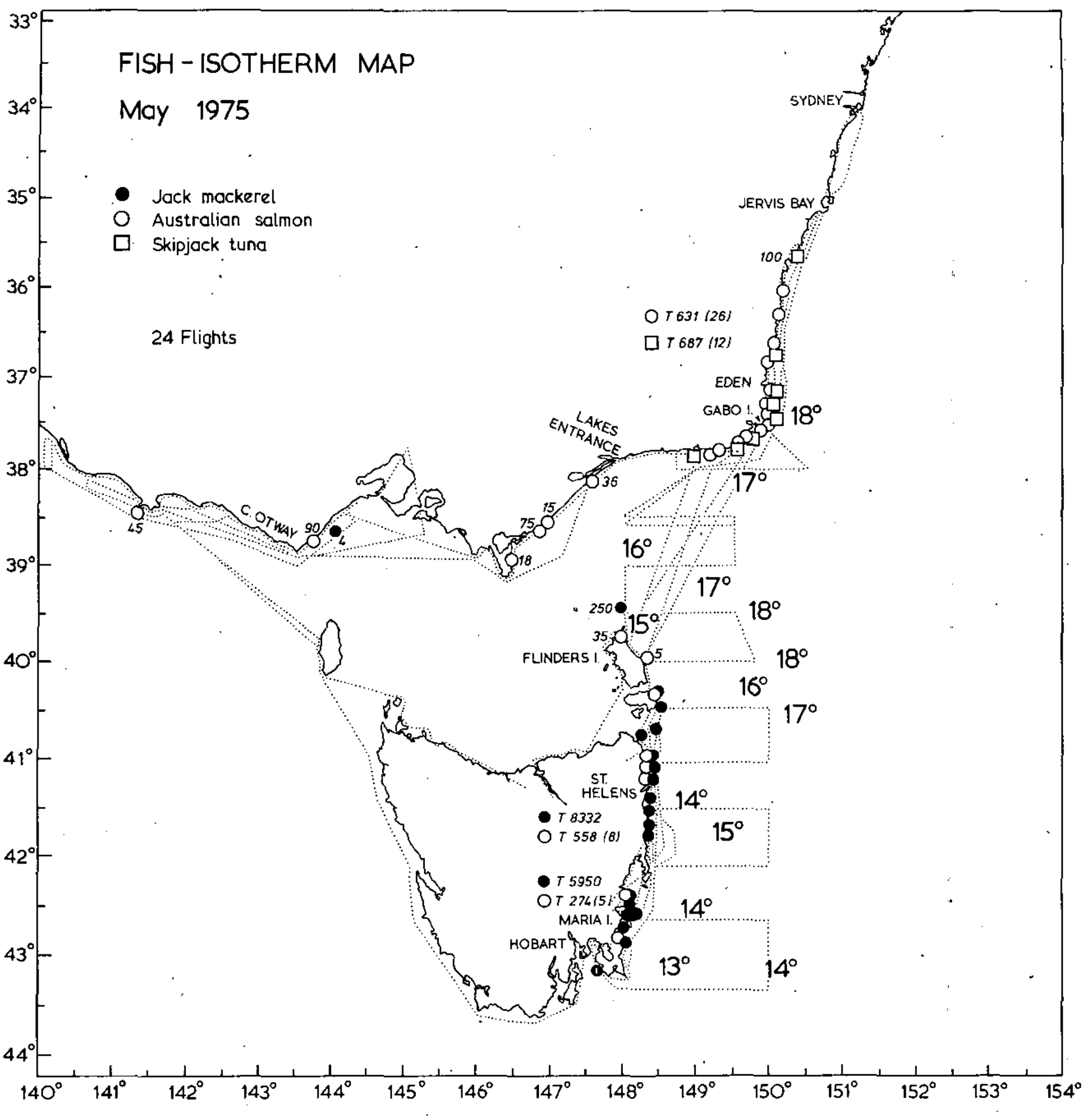

FISH - ISOTHERM MAP
May 1975
Jack mackerel
Australian salmon
Skipjack tuna
24 Flights
SYDNEY
JERVIS BAY
100
T 631 (26)
T 687 (12)
EDEN
GABO I.
18°
LAKES ENTRANCE
17°
C. OTWAY
45
90
4
36
15
75
18
16°
17°
18°
250
15°
35
5
FLINDERS I.
18°
16°
17°
ST. HELENS
14°
15°
T 8332
T 558 (8)
T 5950
T 274 (5)
14°
MARIA I.
HOBART
13°
14°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 23.

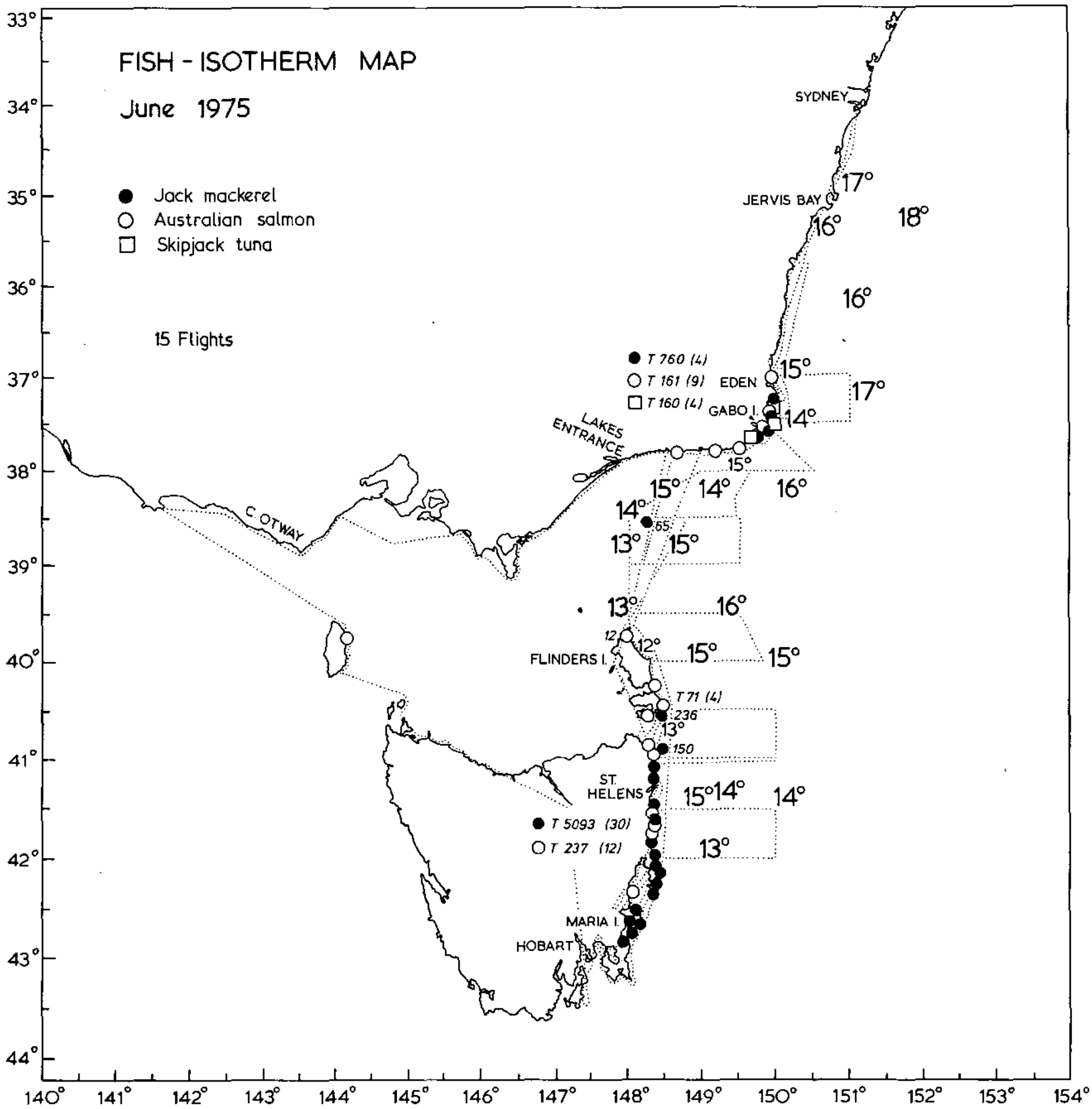

FISH - ISOTHERM MAP
June 1975
Jack mackerel
Australian salmon
Skipjack tuna
15 Flights
T 760 (4)
T 161 (9)
T 160 (4)
T 5093 (30)
T 237 (12)
T 71 (4)
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
17°
18°
16°
16°
15°
17°
14°
15°
15°
14°
16°
14°
13°
15°
13°
16°
12°
15°
15°
13°
15°14°
14°
13°
65
12
236
150
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 24.

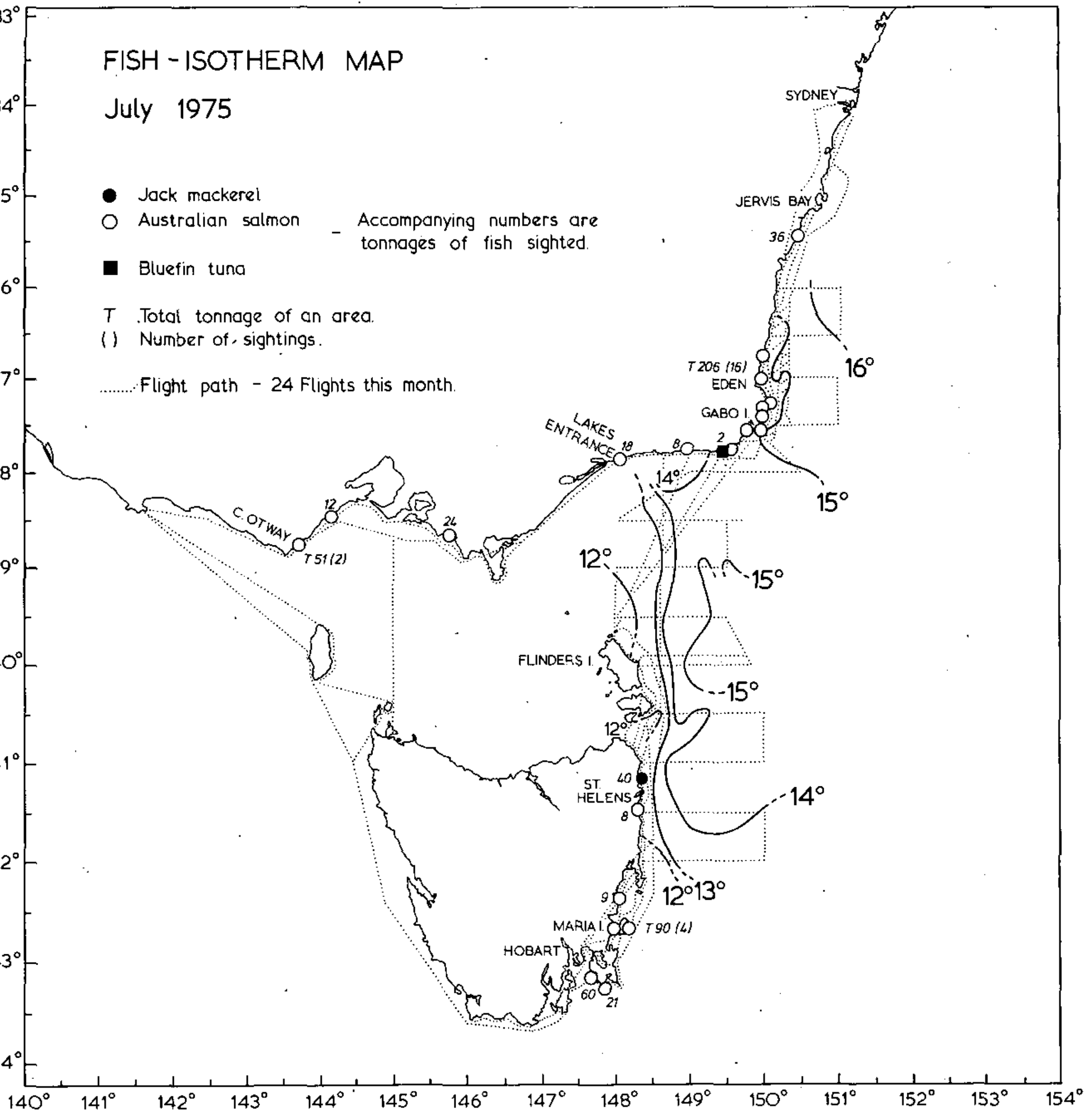

FISH - ISOTHERM MAP
July 1975
Jack mackerel
Australian salmon
Accompanying numbers are tonnages of fish sighted.
Bluefin tuna
T Total tonnage of an area.
( ) Number of sightings.
Flight path - 24 Flights this month.
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 206 (16)
T 51 (2)
T 90 (4)
16°
15°
14°
13°
12°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 25.

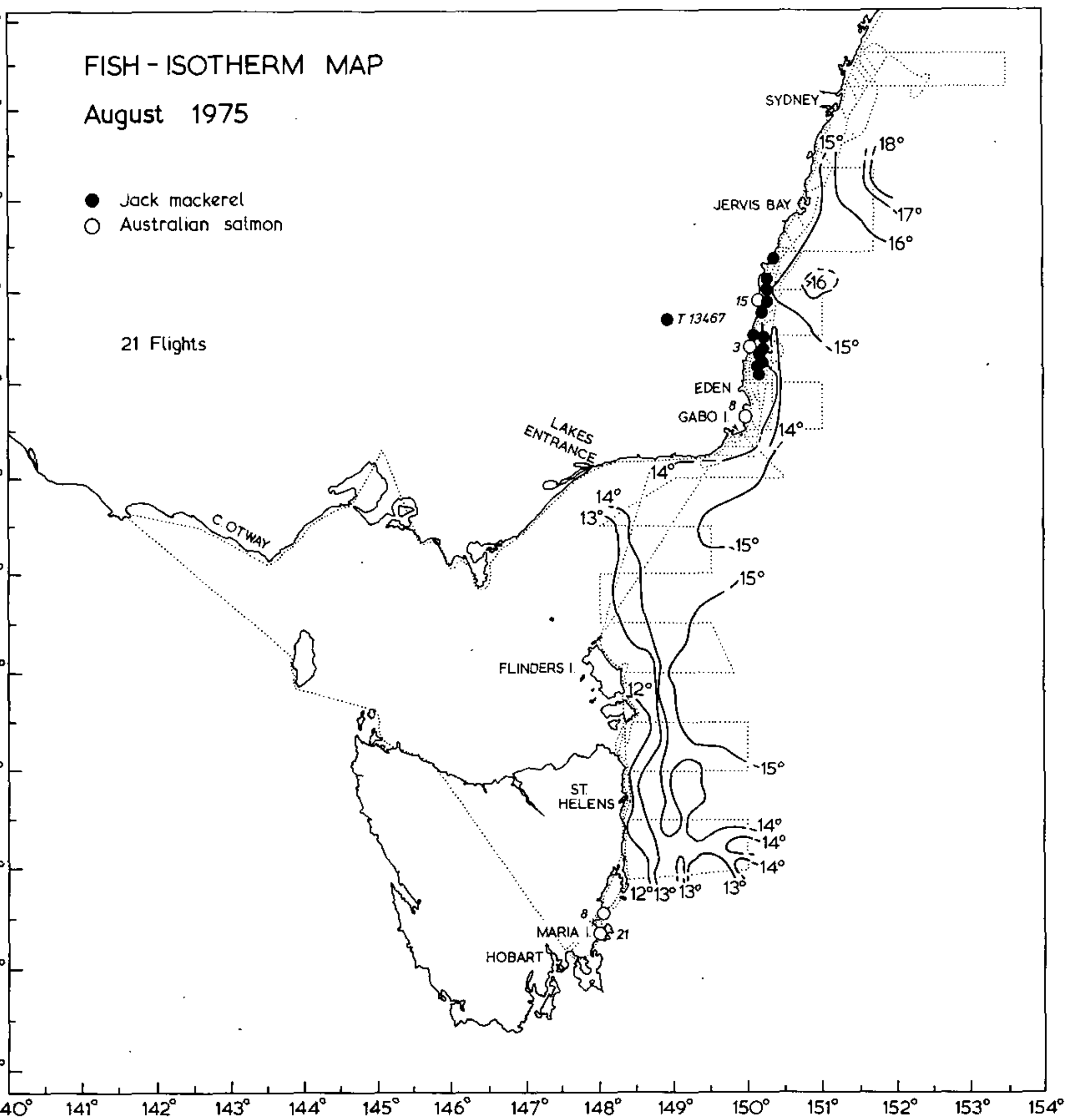

FISH - ISOTHERM MAP
August 1975
Jack mackerel
Australian salmon
21 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 13467
15°
16°
17°
18°
14°
13°
12°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 26.

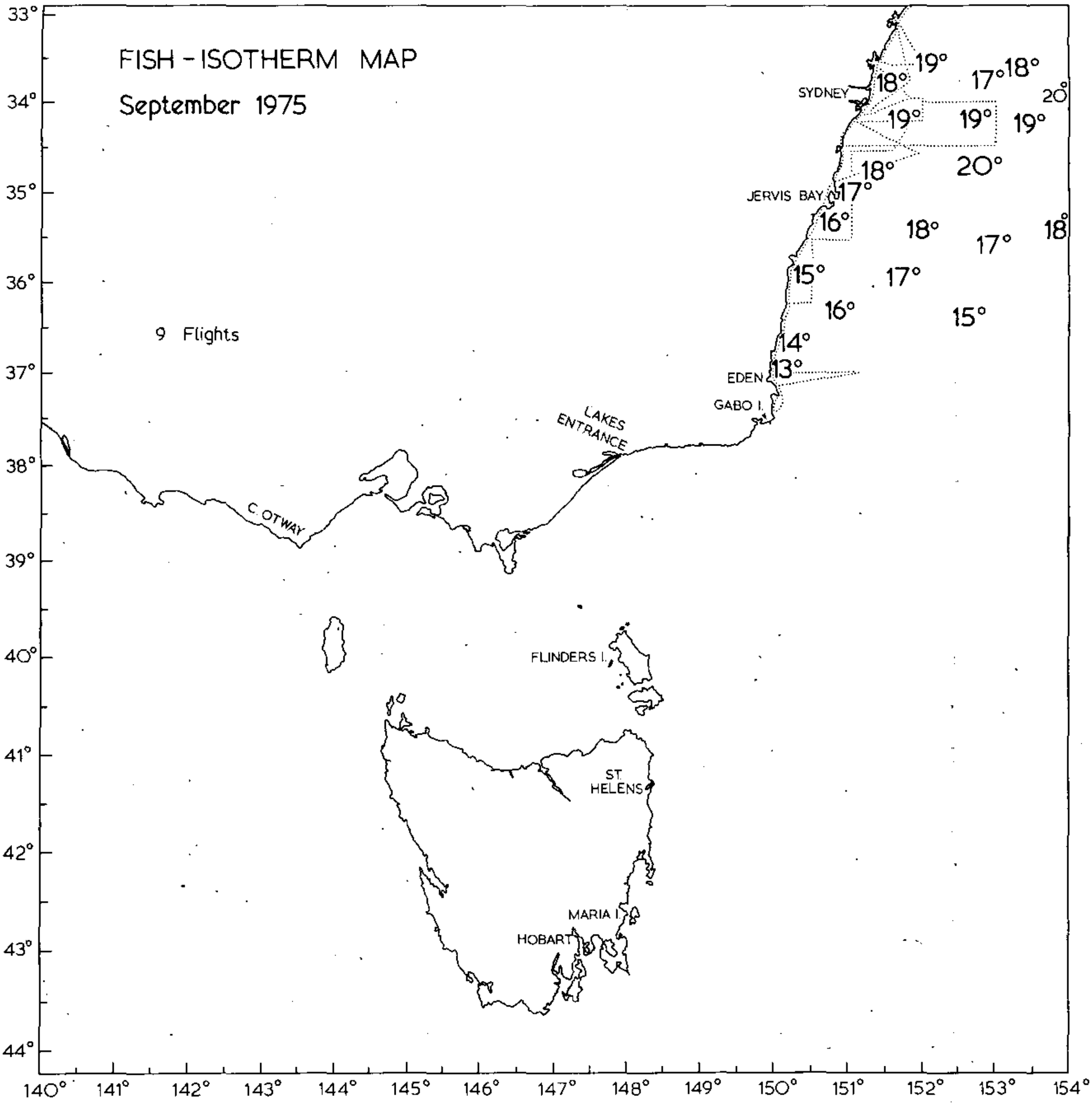

FISH - ISOTHERM MAP
September 1975
9 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
19°
17°
18°
20°
18°
19°
19°
19°
20°
18°
17°
16°
18°
17°
18°
15°
17°
16°
15°
14°
13°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 27.

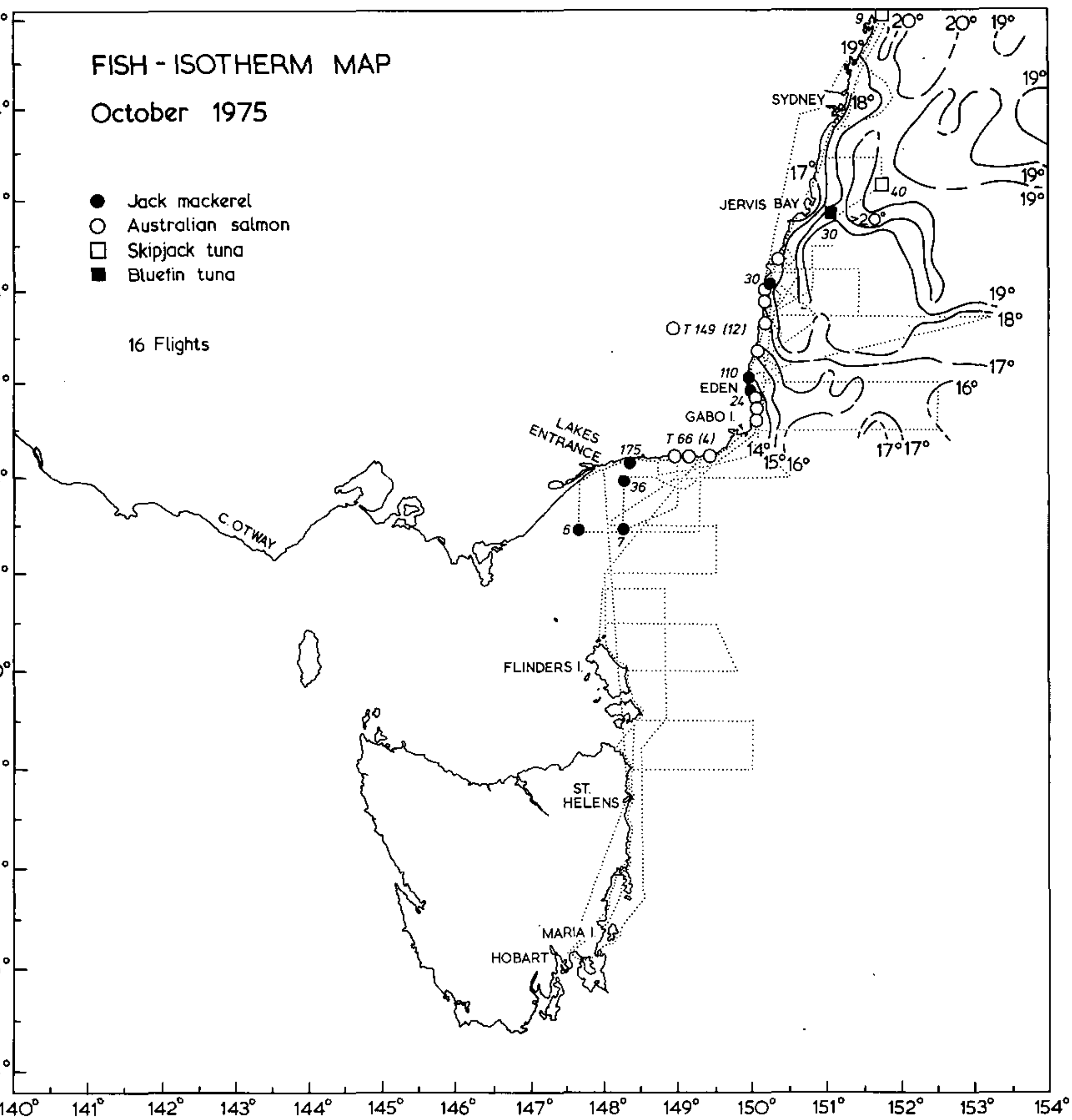

FISH - ISOTHERM MAP
October 1975
Jack mackerel
Australian salmon
Skipjack tuna
Bluefin tuna
16 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 149 (12)
T 66 (4)
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 28.

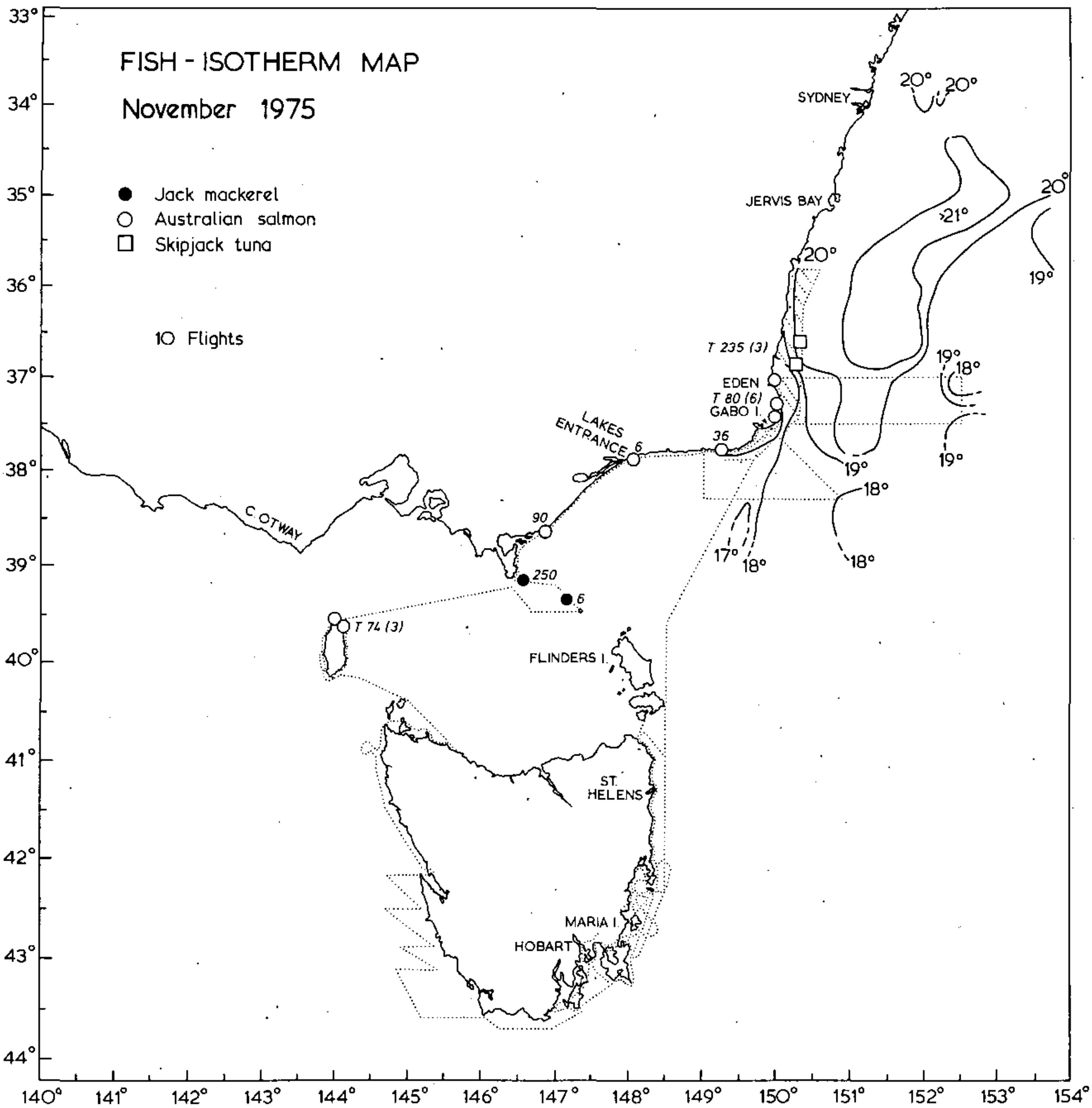
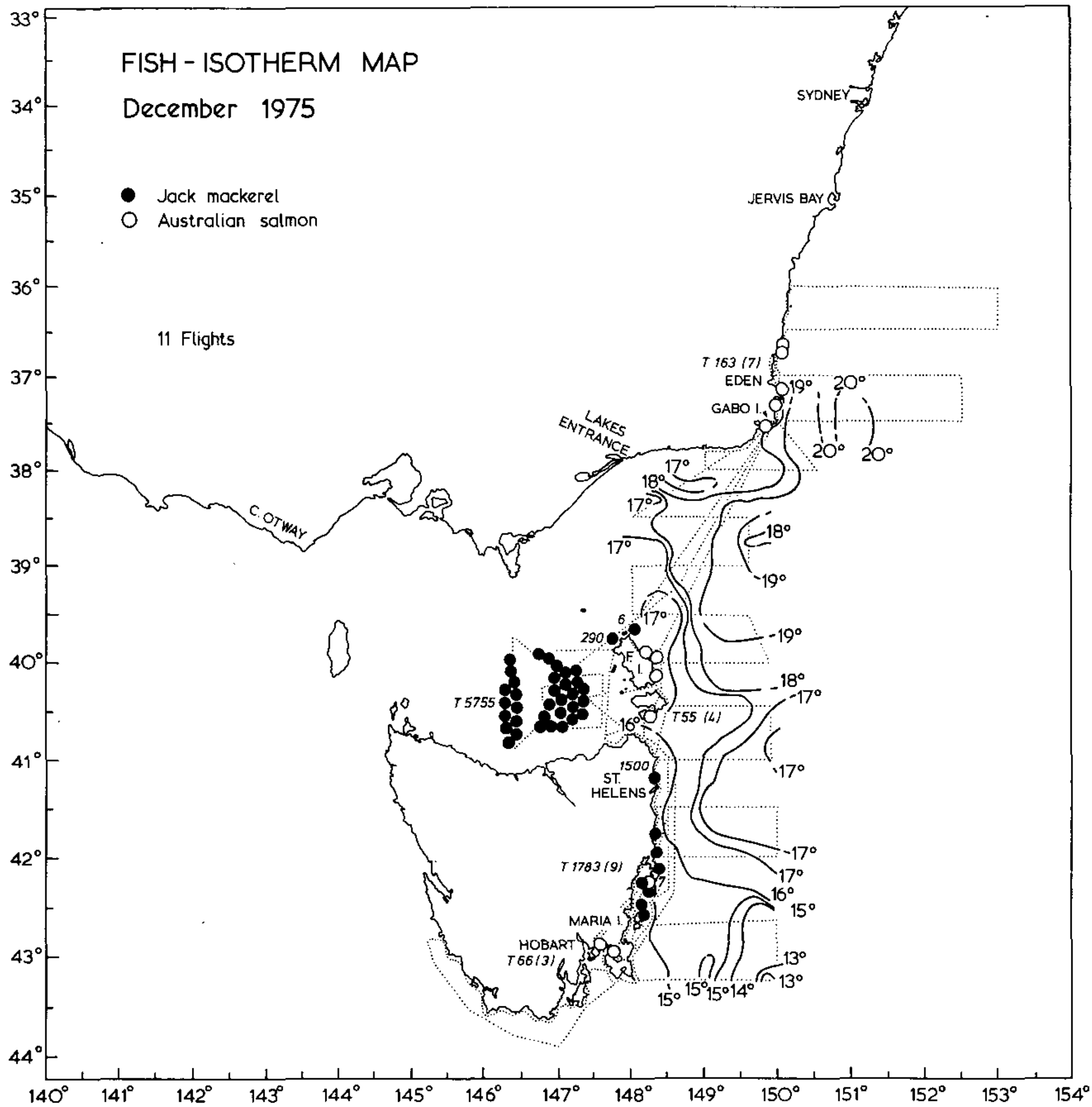
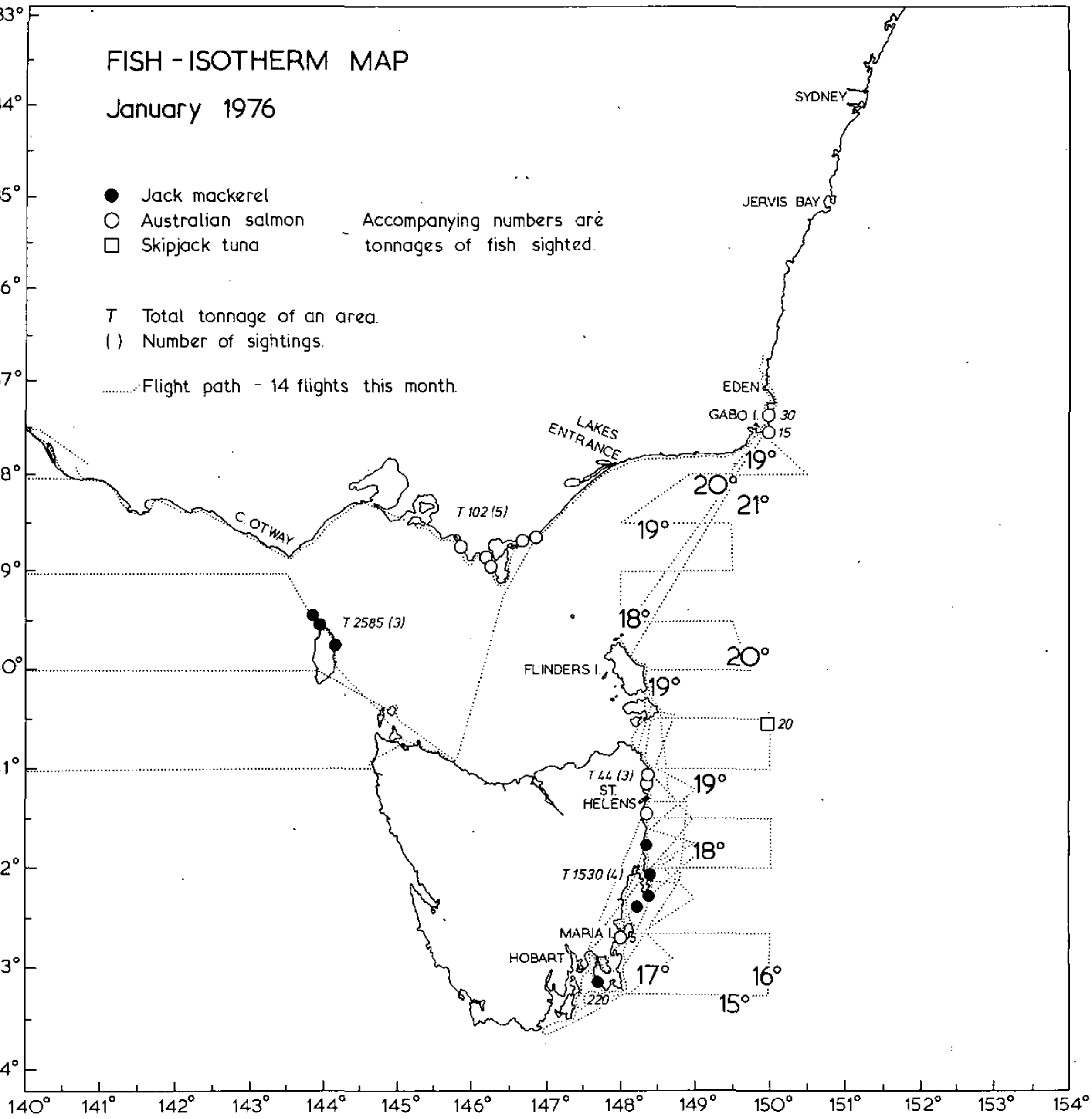

FISH - ISOTHERM MAP
November 1975
Jack mackerel
Australian salmon
Skipjack tuna
10 Flights
SYDNEY
JERVIS BAY
EDEN
T 235 (3)
T 80 (6)
GABO I.
LAKES ENTRANCE
C. OTWAY
T 74 (3)
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
250
90
36
6
20°
>21°
19°
18°
17°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 29.



FISH - ISOTHERM MAP
December 1975
Jack mackerel
Australian salmon
11 Flights
SYDNEY
JERVIS BAY
T 163 (7)
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
290
6
F. I.
T 5755
T55 (4)
1500
ST. HELENS
T 1783 (9)
MARIA I.
HOBART
T 66 (3)
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 30.



FISH - ISOTHERM MAP
January 1976
Jack mackerel
Australian salmon
Skipjack tuna
Accompanying numbers are tonnages of fish sighted.
T Total tonnage of an area.
( ) Number of sightings.
Flight path - 14 flights this month.
SYDNEY
JERVIS BAY
EDEN
GABO I.
30
15
LAKES ENTRANCE
C. OTWAY
T 102 (5)
T 2585 (3)
FLINDERS I.
20
T 44 (3)
ST. HELENS
T 1530 (4)
MARIA I.
HOBART
220
19°
20°
21°
19°
18°
20°
19°
19°
18°
17°
16°
15°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 31.

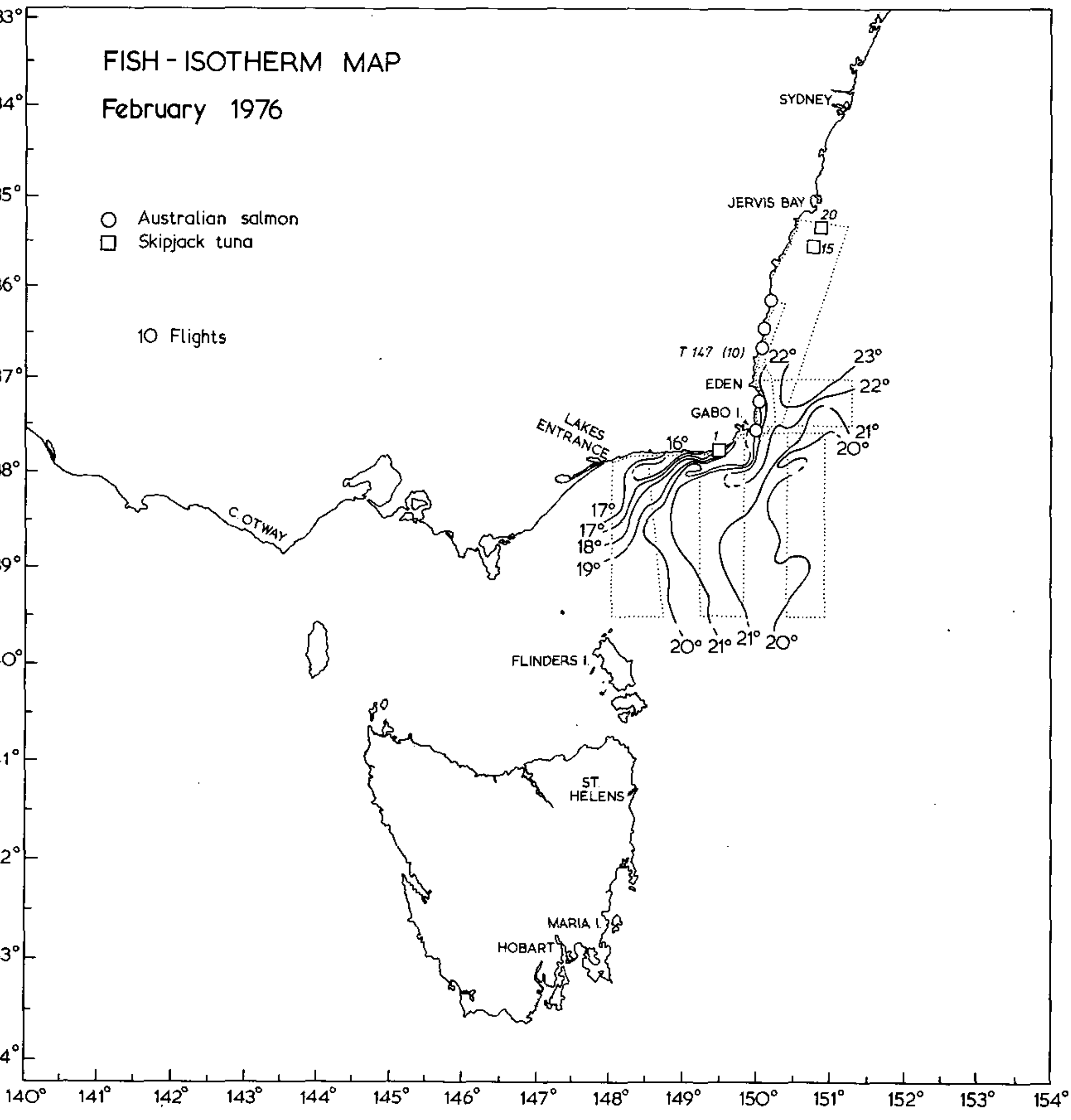
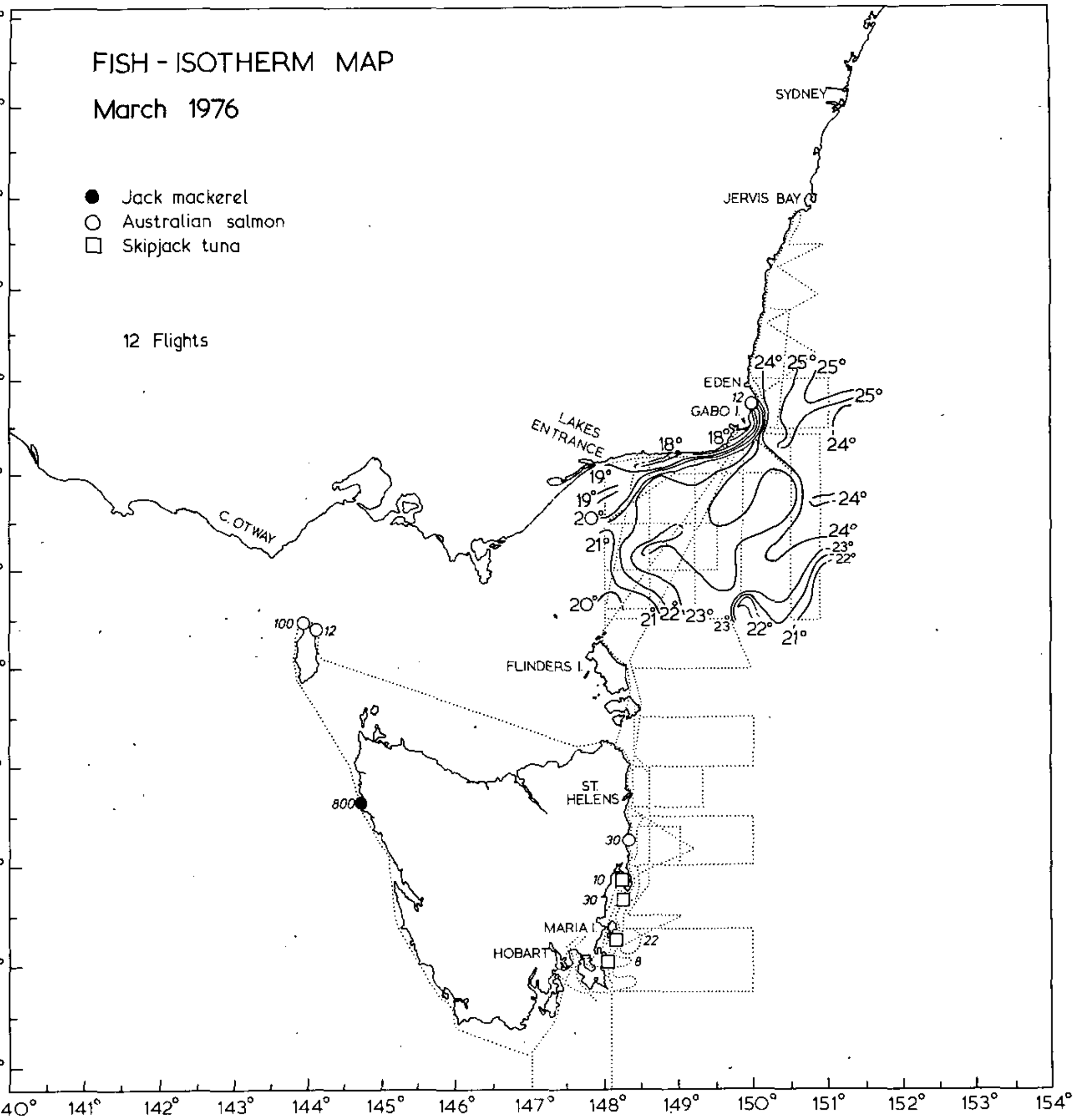

FISH - ISOTHERM MAP
February 1976
Australian salmon
Skipjack tuna
10 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 147 (10)
20
15
1
16°
17°
17°
18°
19°
20°
21°
21°
20°
22°
23°
22°
21°
20°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 32.



FISH - ISOTHERM MAP
March 1976
Jack mackerel
Australian salmon
Skipjack tuna
12 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART

Fig. 33.

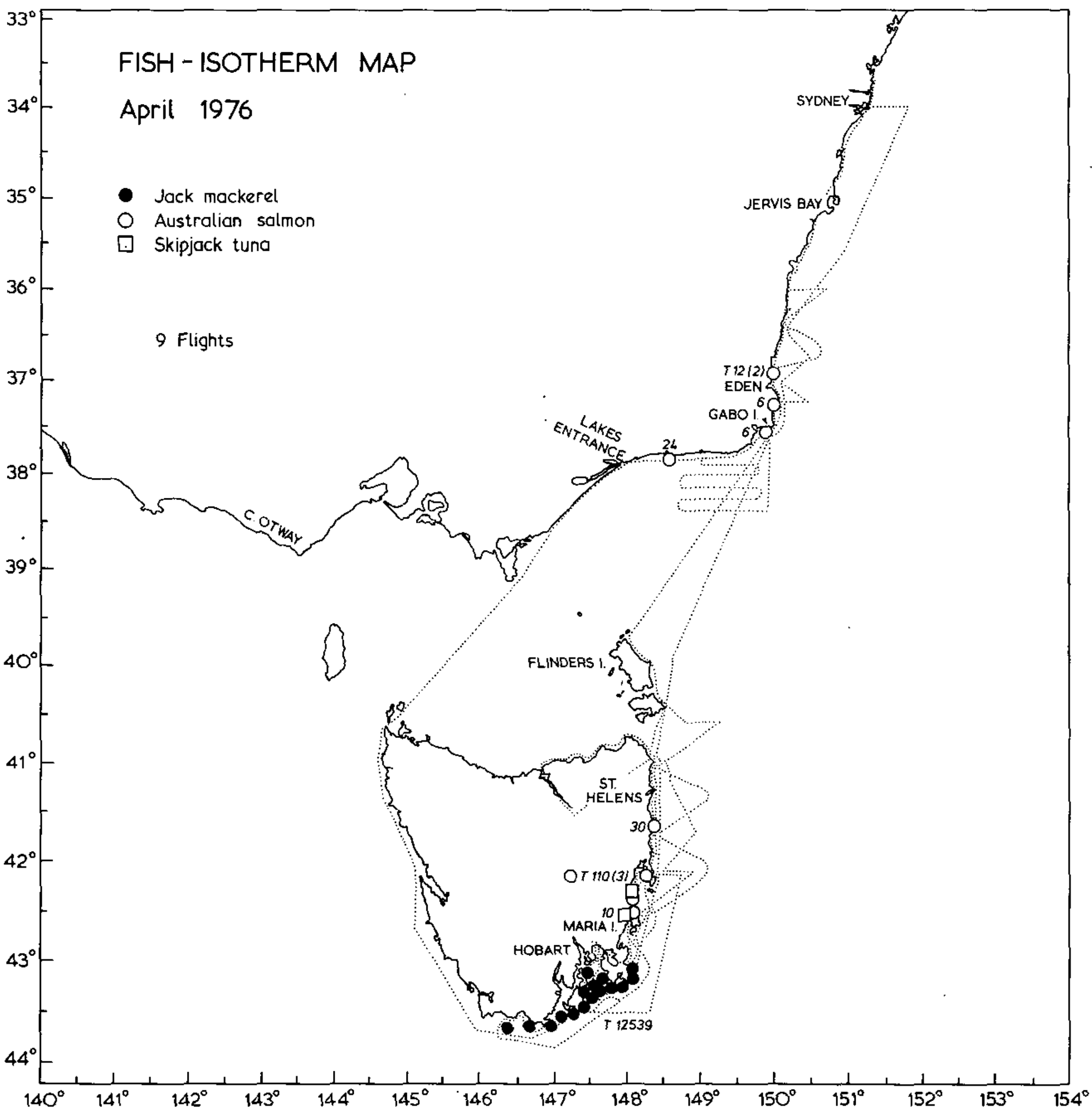

FISH - ISOTHERM MAP
April 1976
Jack mackerel
Australian salmon
Skipjack tuna
9 Flights
SYDNEY
JERVIS BAY
T 12 (2)
EDEN
6
GABO I.
6
24
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
30
T 110 (3)
10
MARIA I.
HOBART
T 12539
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 34.

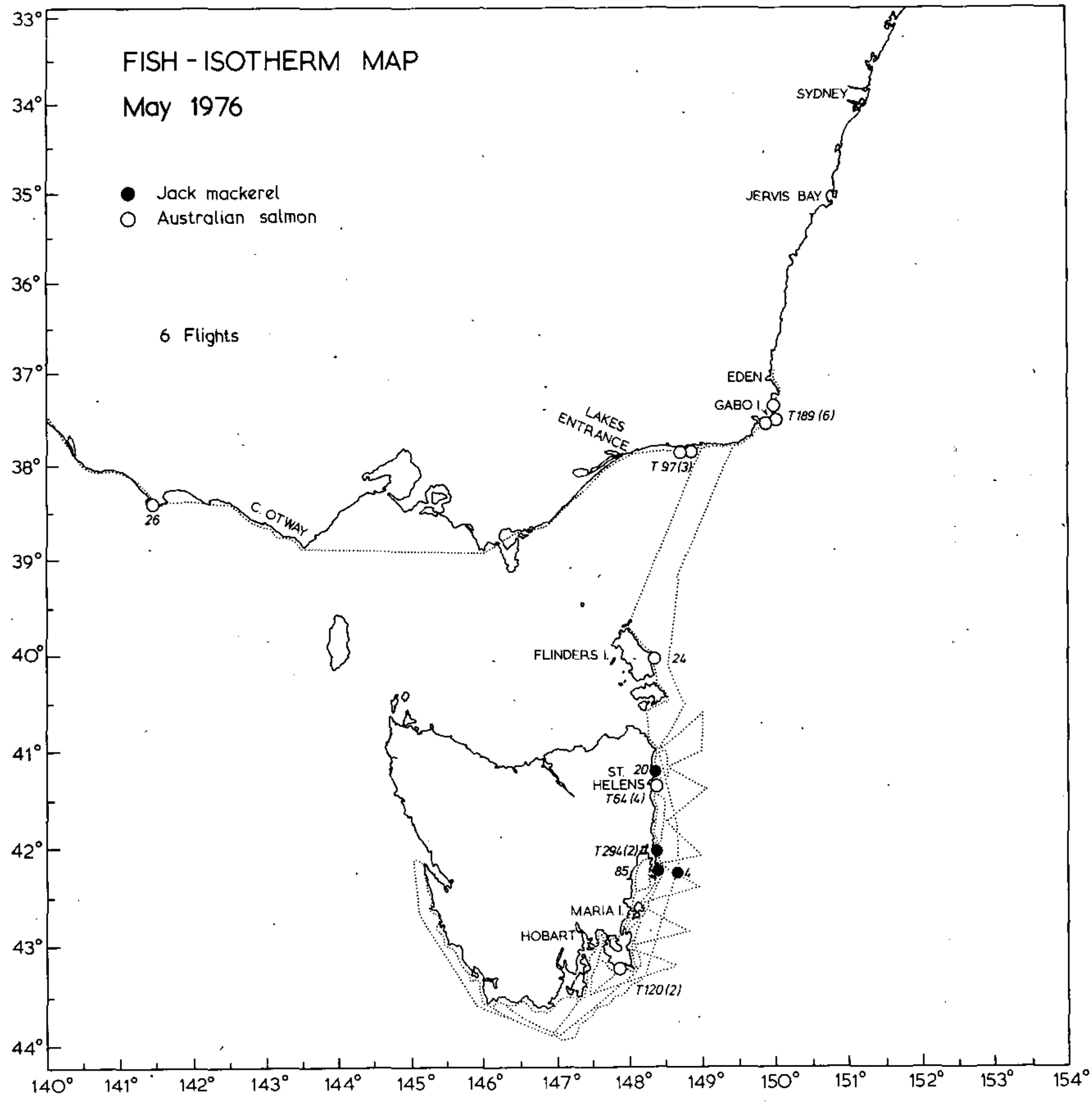

FISH - ISOTHERM MAP
May 1976
Jack mackerel
Australian salmon
6 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
T189 (6)
LAKES ENTRANCE
T 97 (3)
26
C. OTWAY
FLINDERS I.
24
ST. HELENS
20
T64 (4)
T294 (2)
85
4
MARIA I.
HOBART
T120 (2)
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 35.

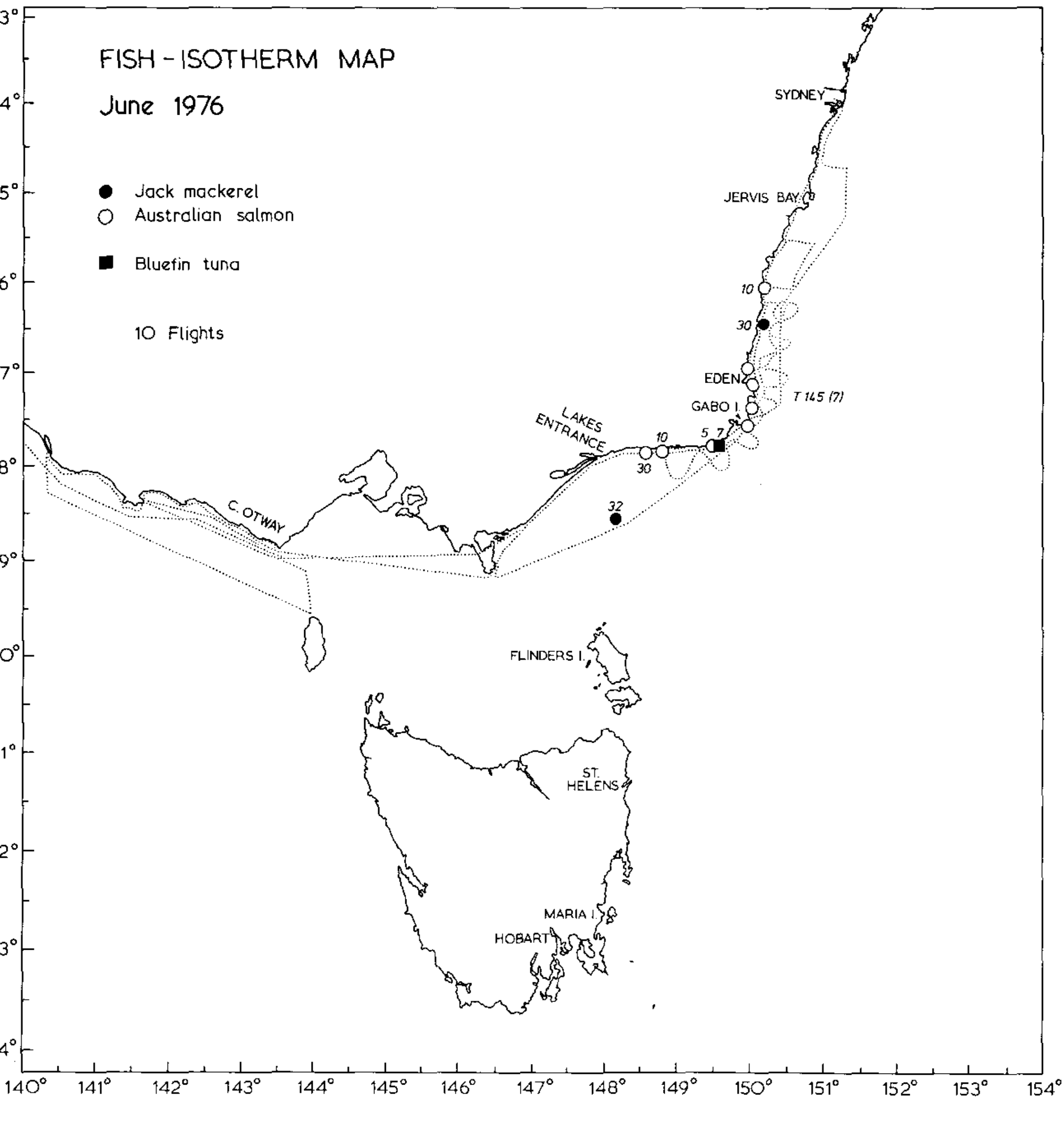

FISH - ISOTHERM MAP
June 1976
Jack mackerel
Australian salmon
Bluefin tuna
10 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
T 14.5 (7)
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
10
30
10
30
5
7
32
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 36.

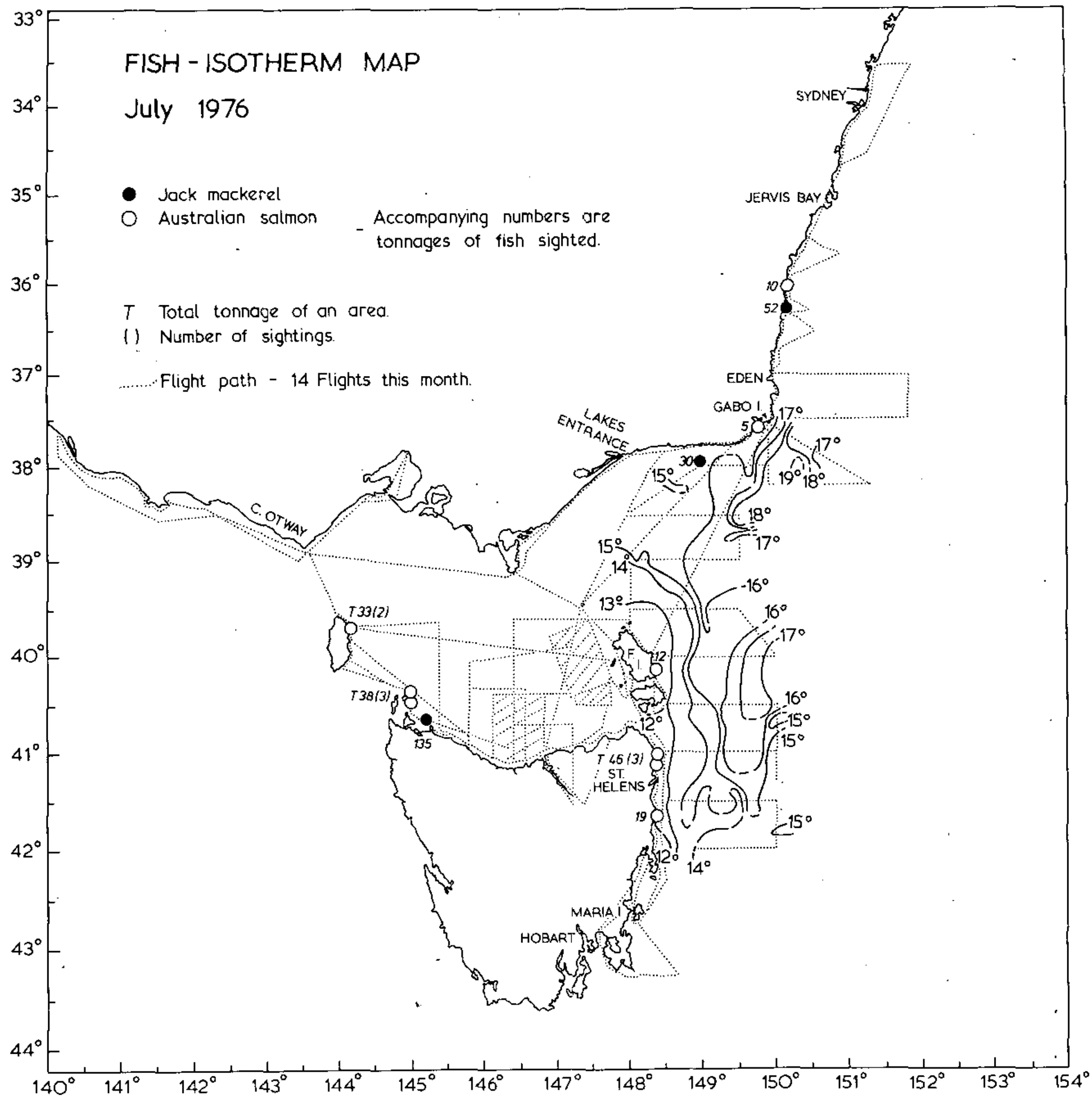

FISH - ISOTHERM MAP
July 1976
Jack mackerel
Australian salmon
Accompanying numbers are tonnages of fish sighted.
T Total tonnage of an area.
( ) Number of sightings.
Flight path - 14 Flights this month.
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
F. I.
ST. HELENS
MARIA I.
HOBART
T 33(2)
T 38(3)
T 46 (3)
135
10
52
5
30
12
19
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 37.

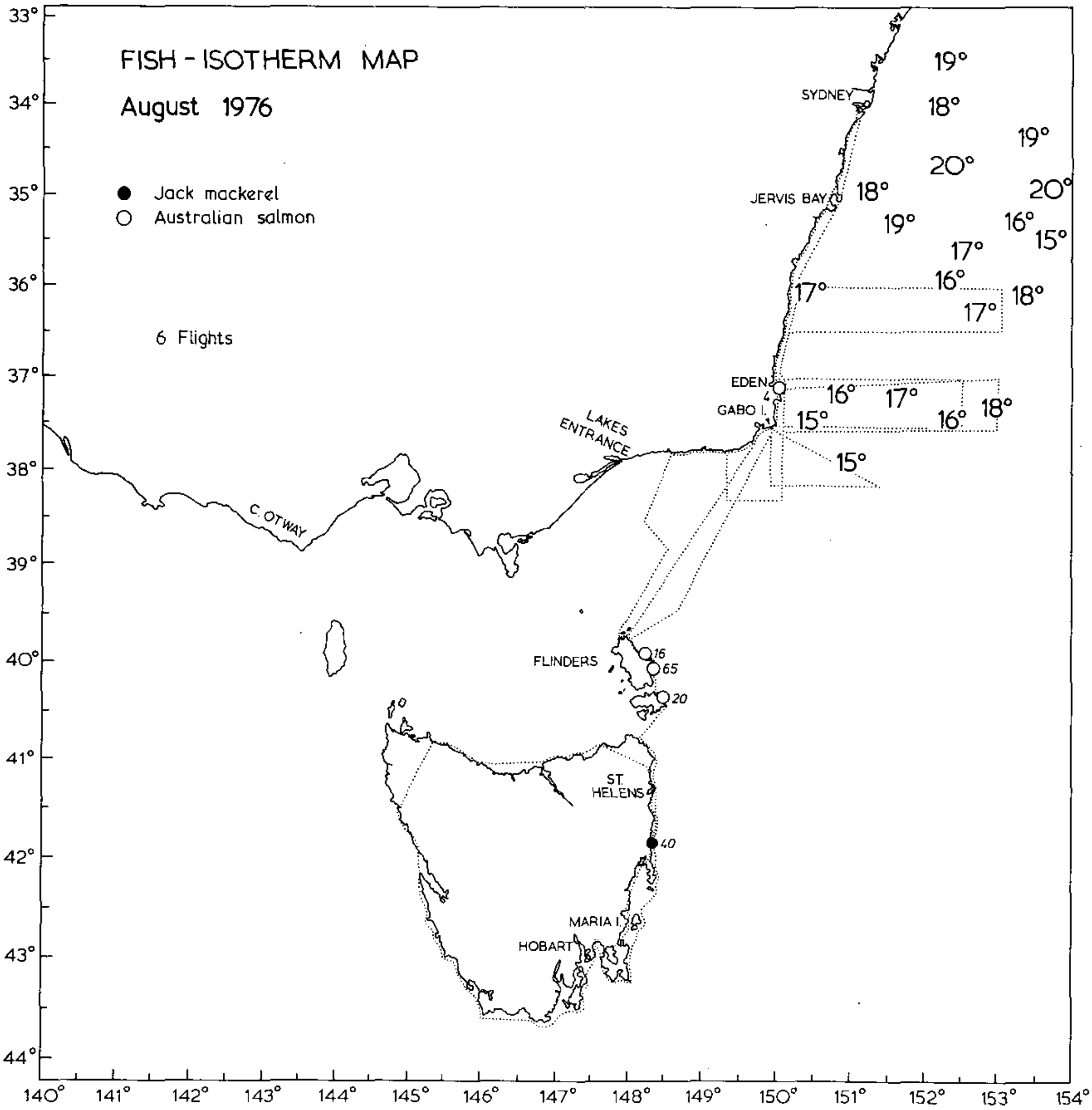

FISH - ISOTHERM MAP
August 1976
Jack mackerel
Australian salmon
6 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS
ST. HELENS
MARIA I.
HOBART
19°
18°
19°
20°
20°
18°
19°
16°
15°
17°
17°
16°
18°
17°
16°
17°
18°
15°
16°
15°
16
65
20
40
4
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 38.

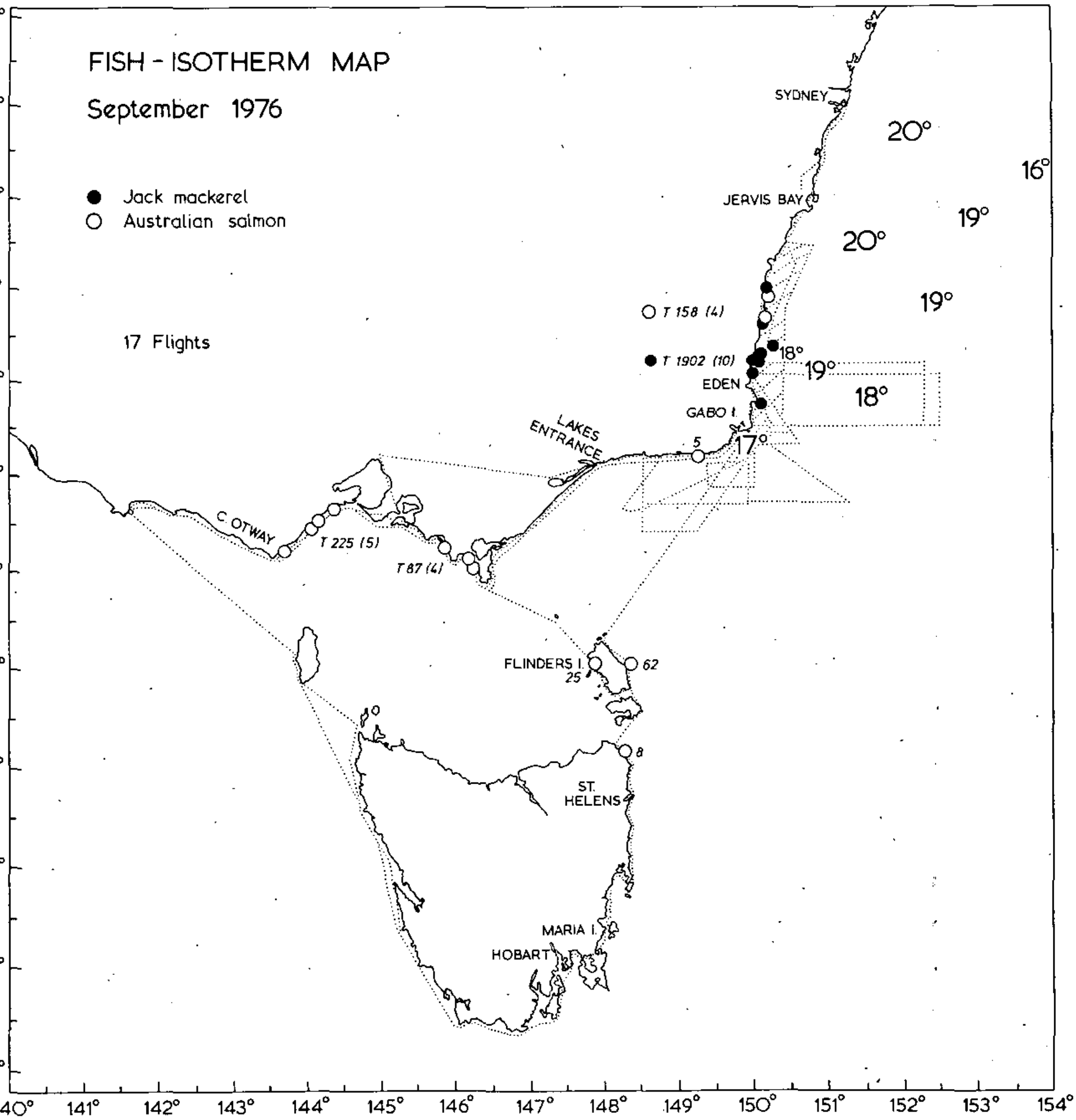
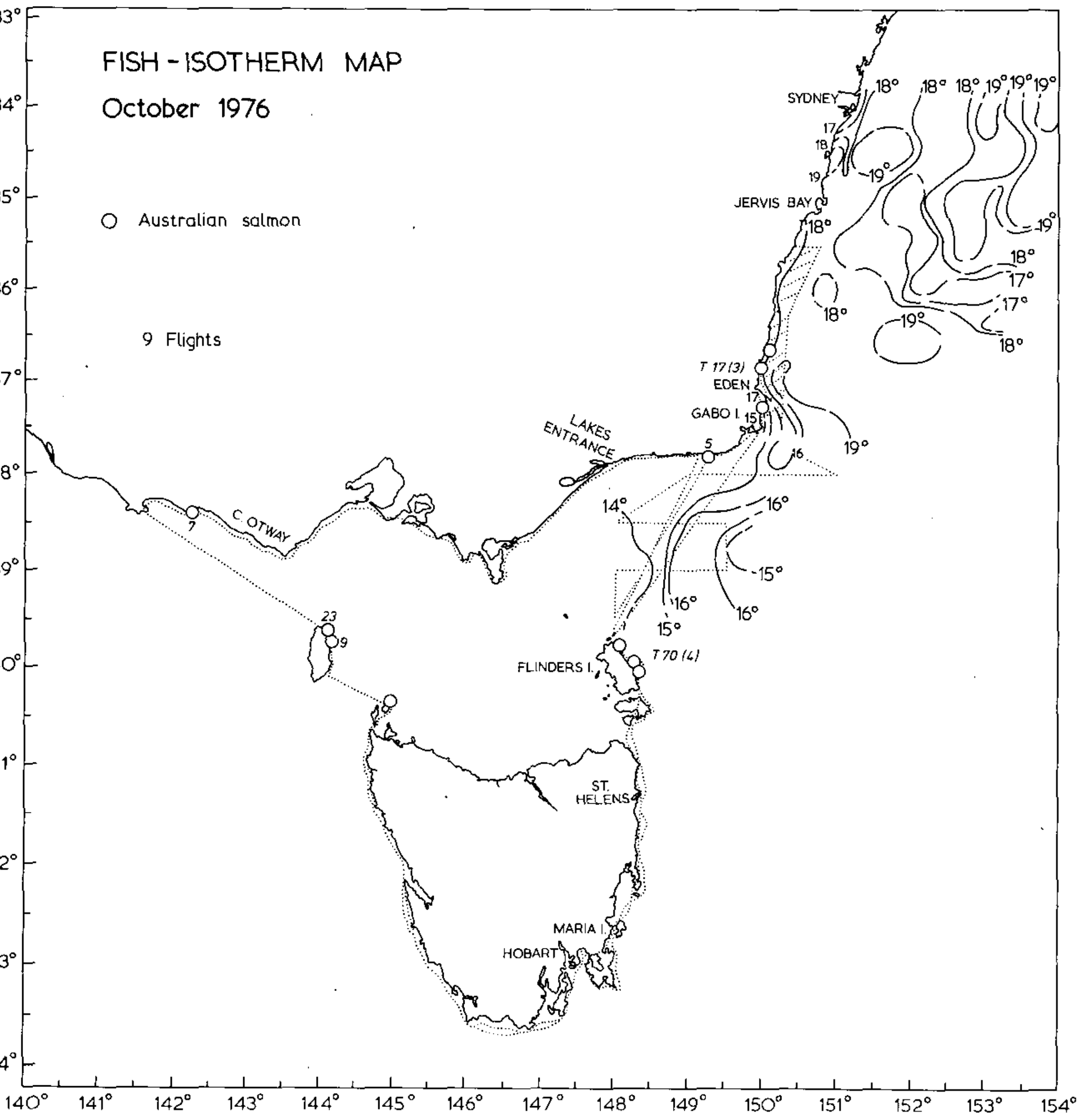

FISH - ISOTHERM MAP
September 1976
Jack mackerel
Australian salmon
17 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 158 (4)
T 1902 (10)
T 225 (5)
T 87 (4)
5
25
62
8
20°
16°
19°
20°
19°
18°
19°
18°
17°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 39.



FISH - ISOTHERM MAP
October 1976
Australian salmon
9 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 17 (3)
T 70 (4)
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 40.

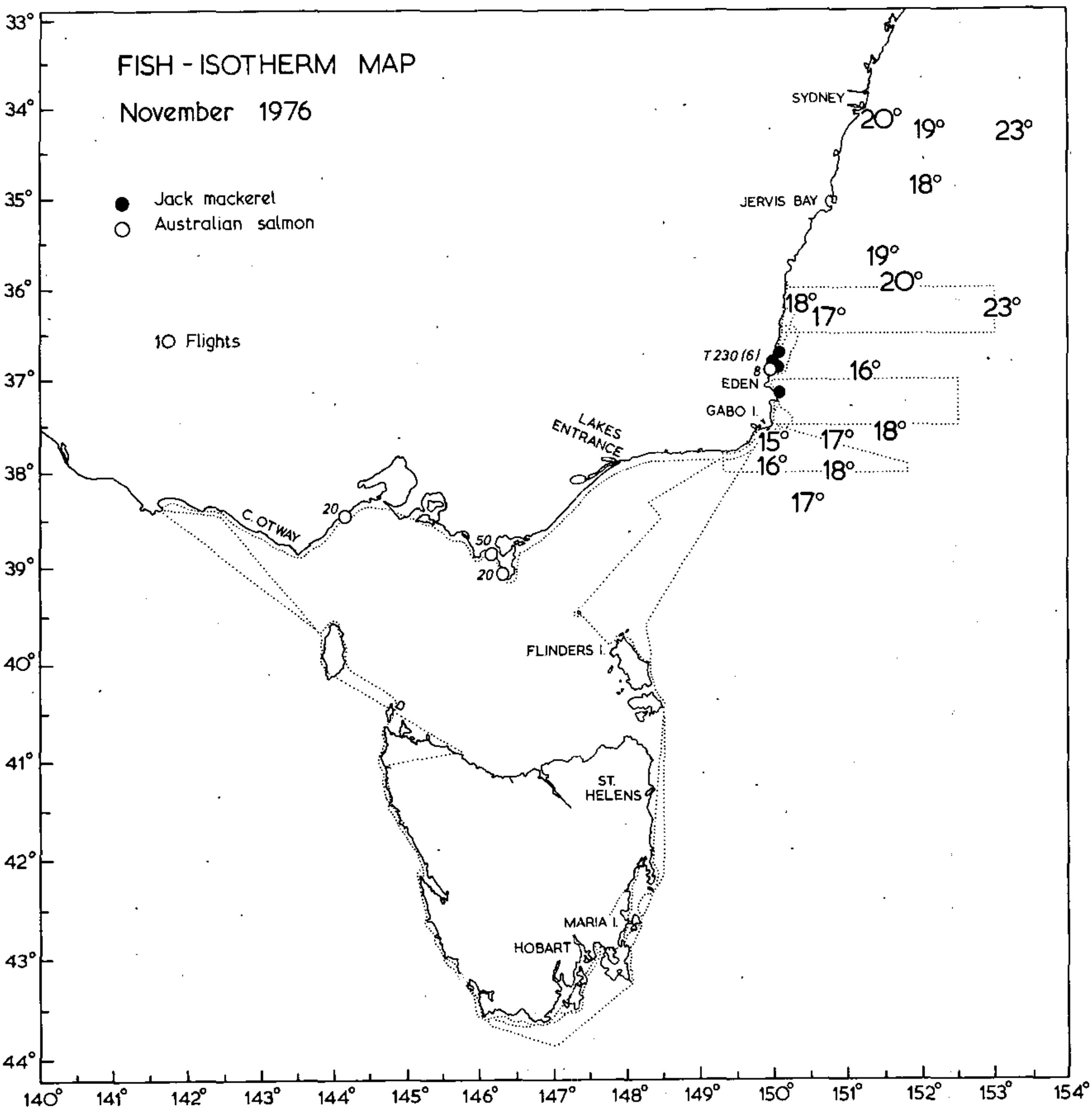

FISH - ISOTHERM MAP
November 1976
Jack mackerel
Australian salmon
10 Flights
SYDNEY
JERVIS BAY
T230 (6)
8
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
20
50
20
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
20°
19°
23°
18°
19°
20°
18°
17°
23°
16°
15°
17°
18°
16°
18°
17°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 41.

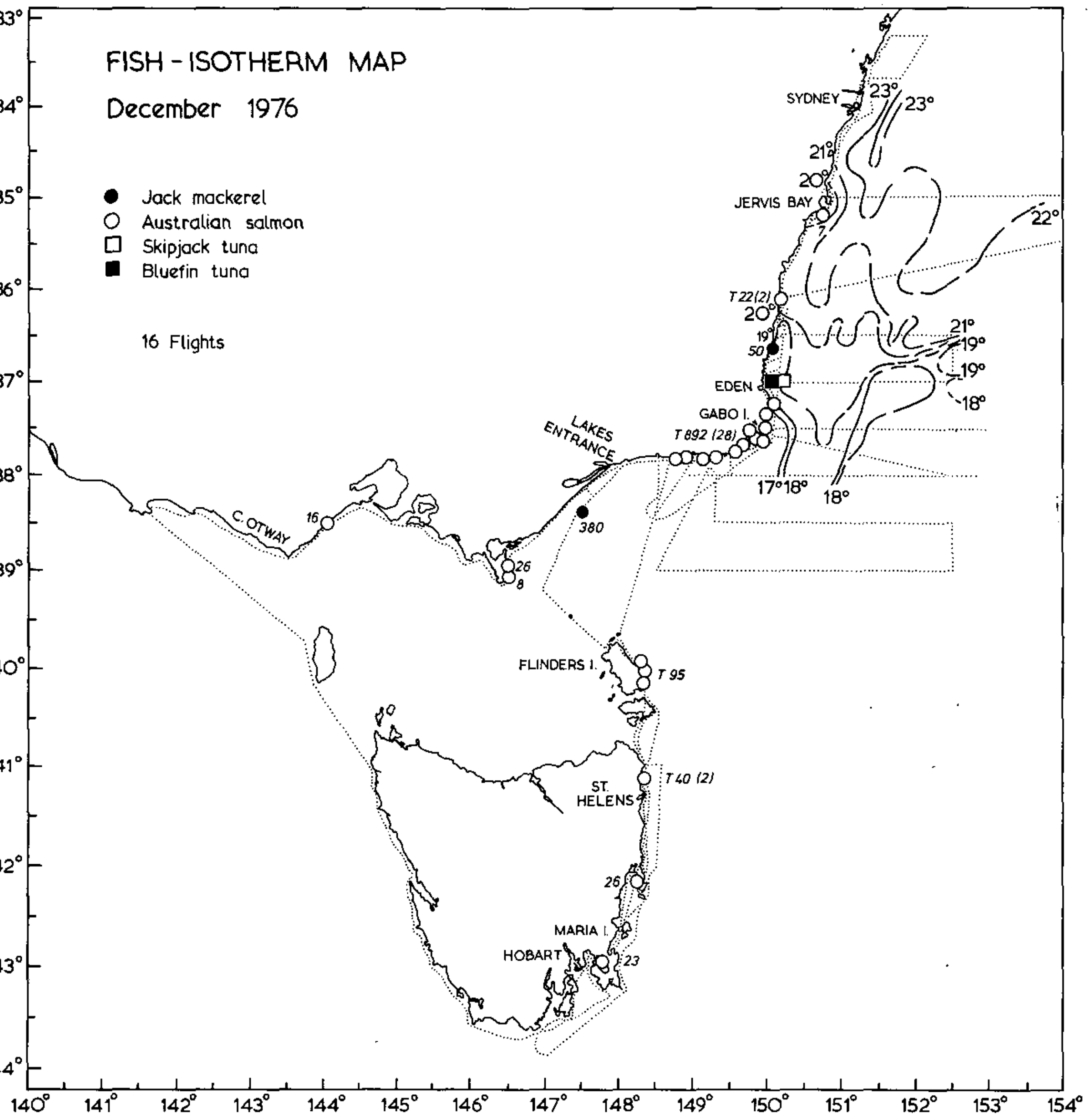

FISH - ISOTHERM MAP
December 1976
Jack mackerel
Australian salmon
Skipjack tuna
Bluefin tuna
16 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 22 (2)
T 892 (28)
T 95
T 40 (2)
380
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 42.

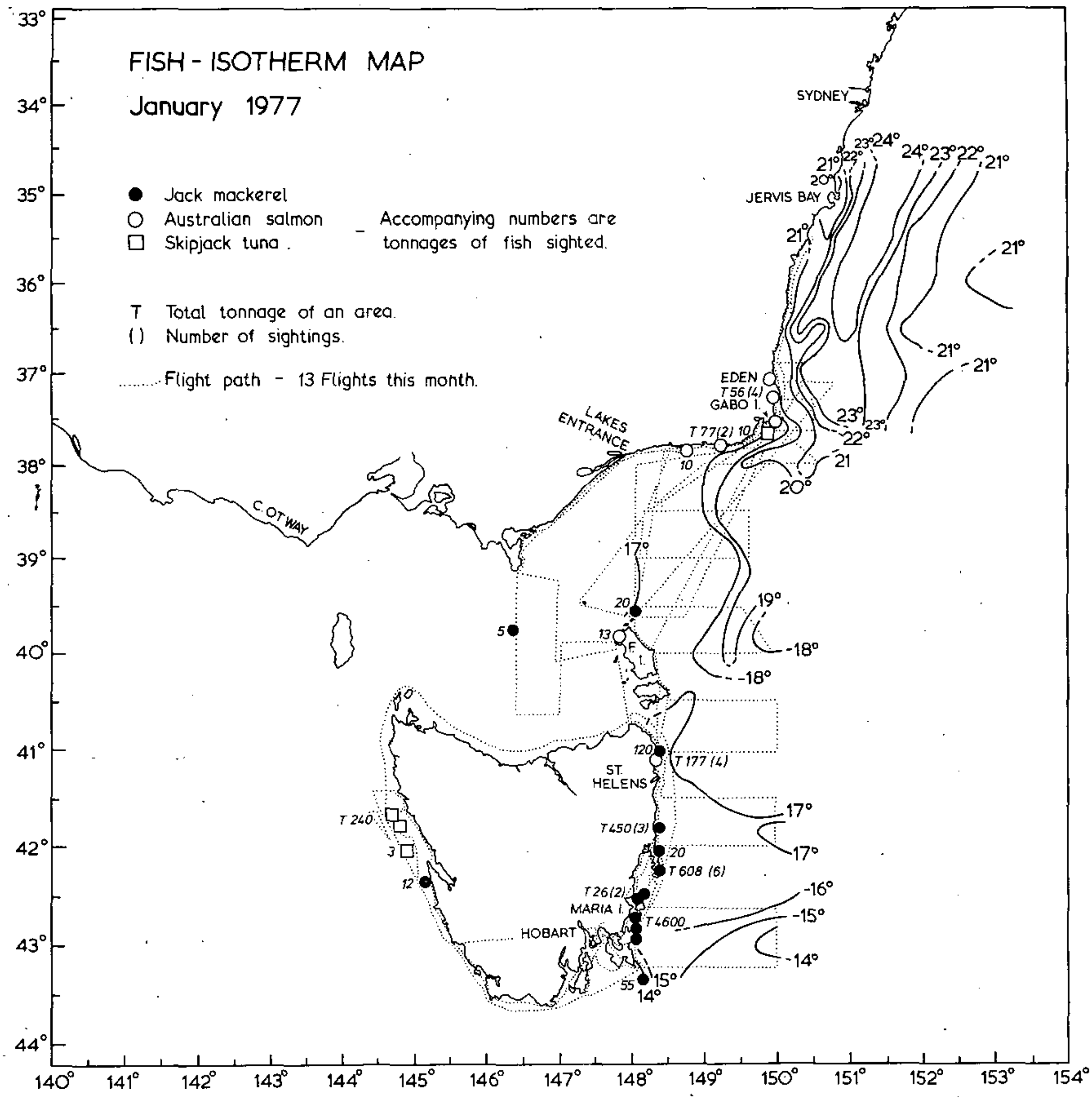

FISH - ISOTHERM MAP
January 1977
Jack mackerel
Australian salmon
Skipjack tuna.
Accompanying numbers are tonnages of fish sighted.
T Total tonnage of an area.
( ) Number of sightings.
Flight path - 13 Flights this month.
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
ST. HELENS
MARIA I.
HOBART
T 56 (4)
T 77 (2)
T 177 (4)
T 450 (3)
T 608 (6)
T 26 (2)
T 4600
T 240
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 43.

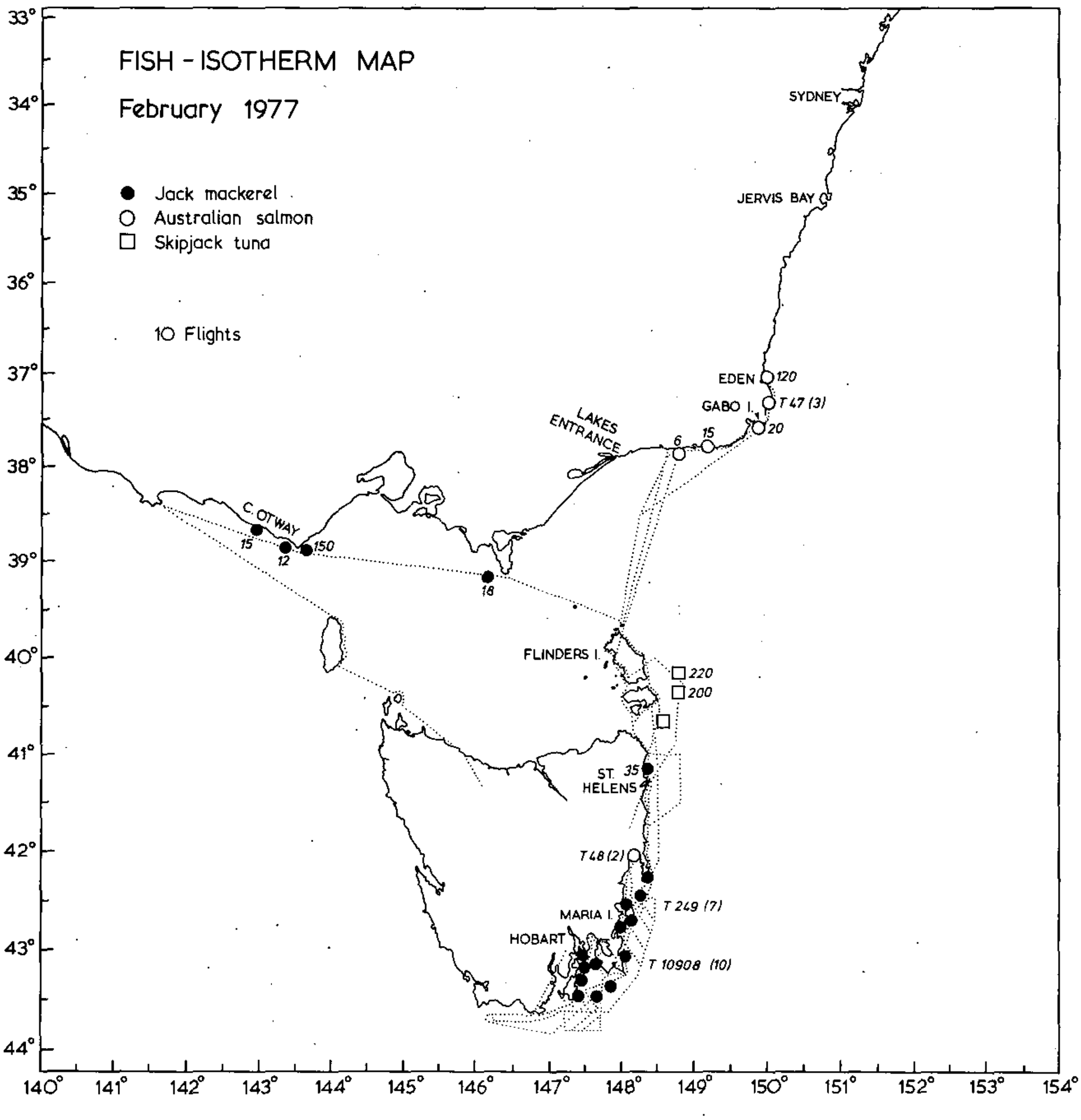
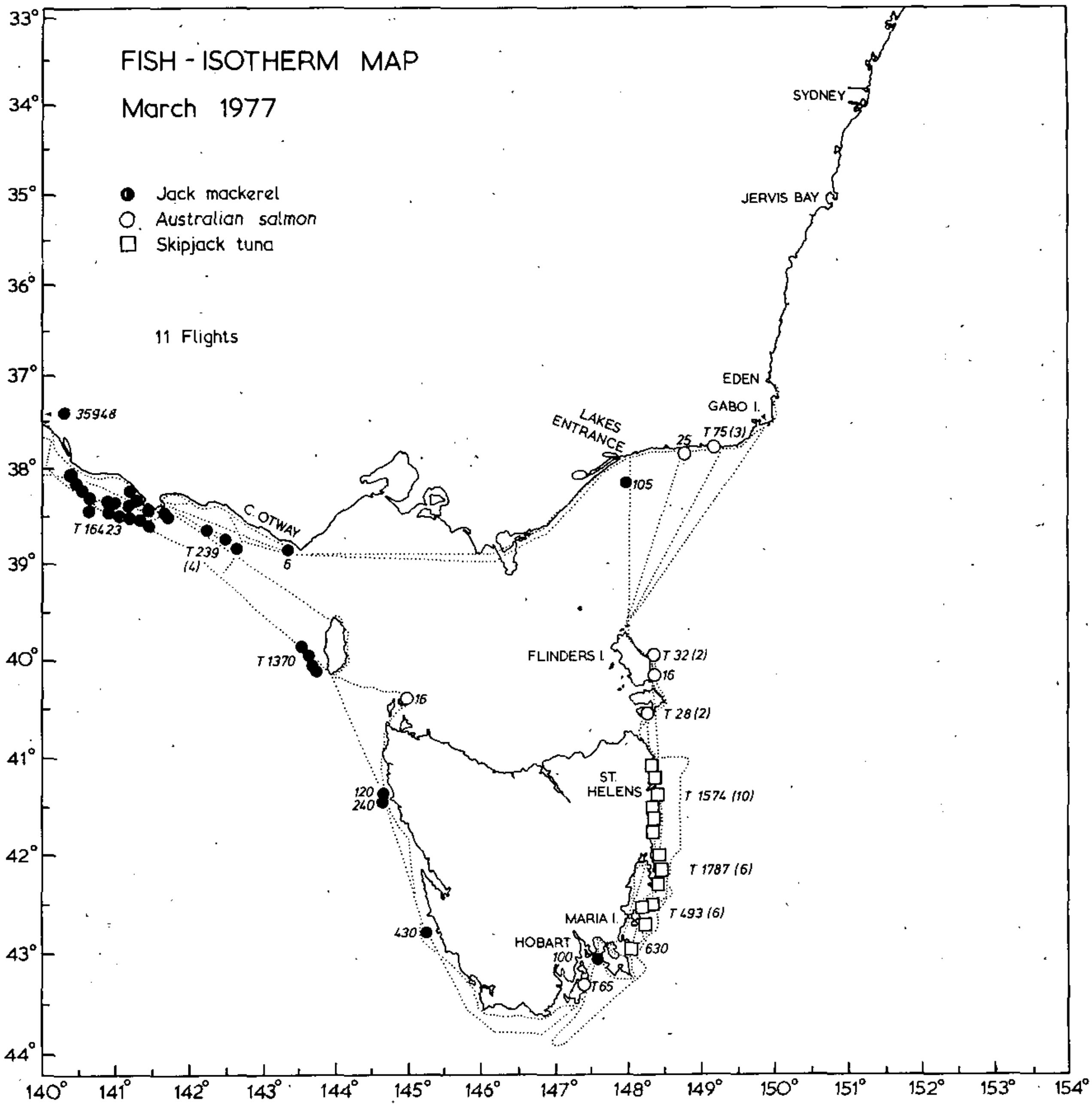

FISH - ISOTHERM MAP
February 1977
Jack mackerel
Australian salmon
Skipjack tuna
10 Flights
SYDNEY
JERVIS BAY
EDEN
120
GABO I.
T 47 (3)
20
LAKES ENTRANCE
15
6
C. OTWAY
15
12
150
18
FLINDERS I.
220
200
ST. HELENS
35
T 48 (2)
T 249 (7)
MARIA I.
HOBART
T 10908 (10)
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 44.



FISH - ISOTHERM MAP
March 1977
Jack mackerel
Australian salmon
Skipjack tuna
11 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
35948
T 16423
T 239 (4)
6
105
25
T 75 (3)
T 1370
16
T 32 (2)
16
T 28 (2)
T 1574 (10)
T 1787 (6)
T 493 (6)
630
120
240
430
100
T 65
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 45.

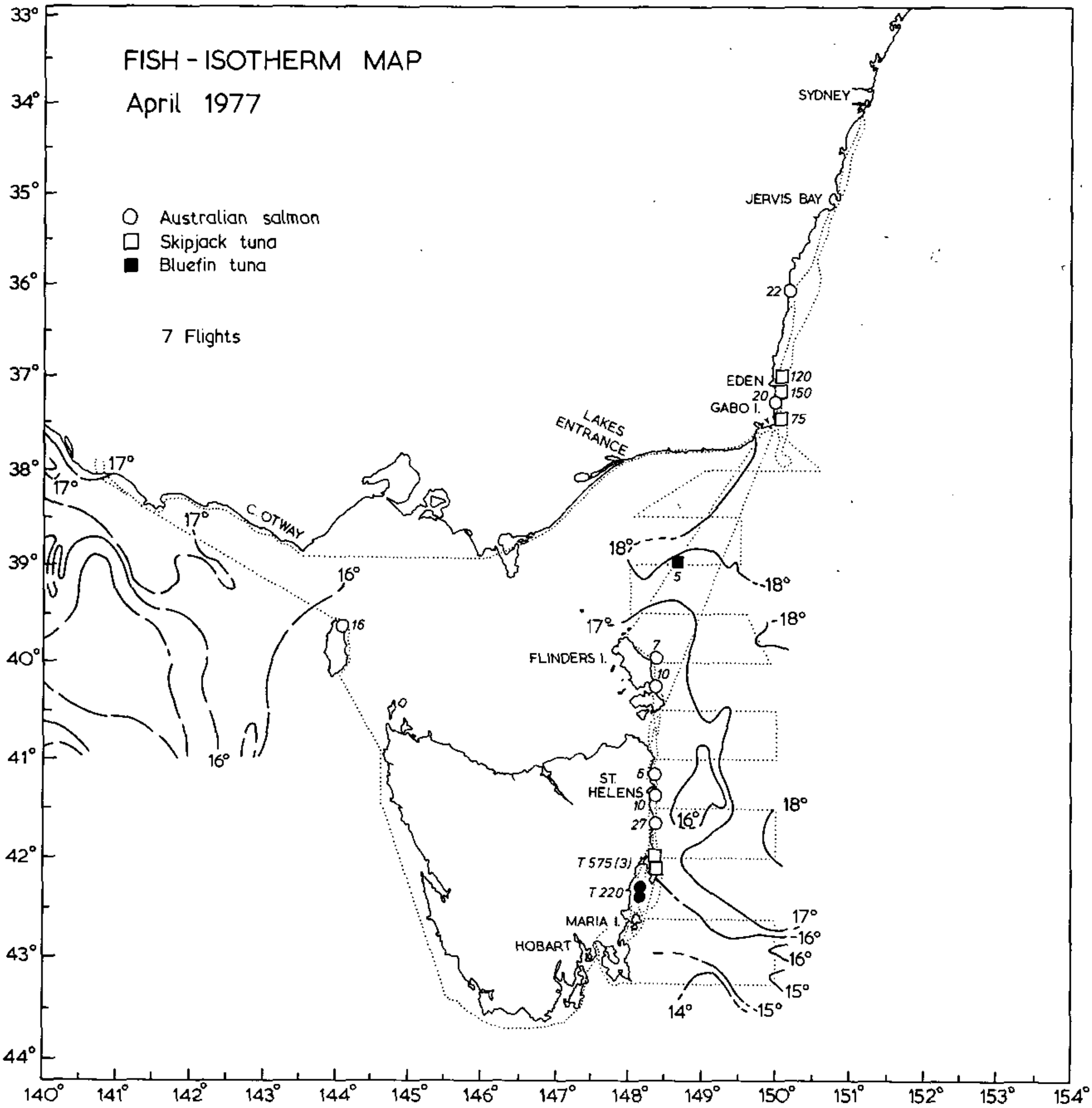

FISH - ISOTHERM MAP
April 1977
Australian salmon
Skipjack tuna
Bluefin tuna
7 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 575 (3)
T 220

Fig. 46.

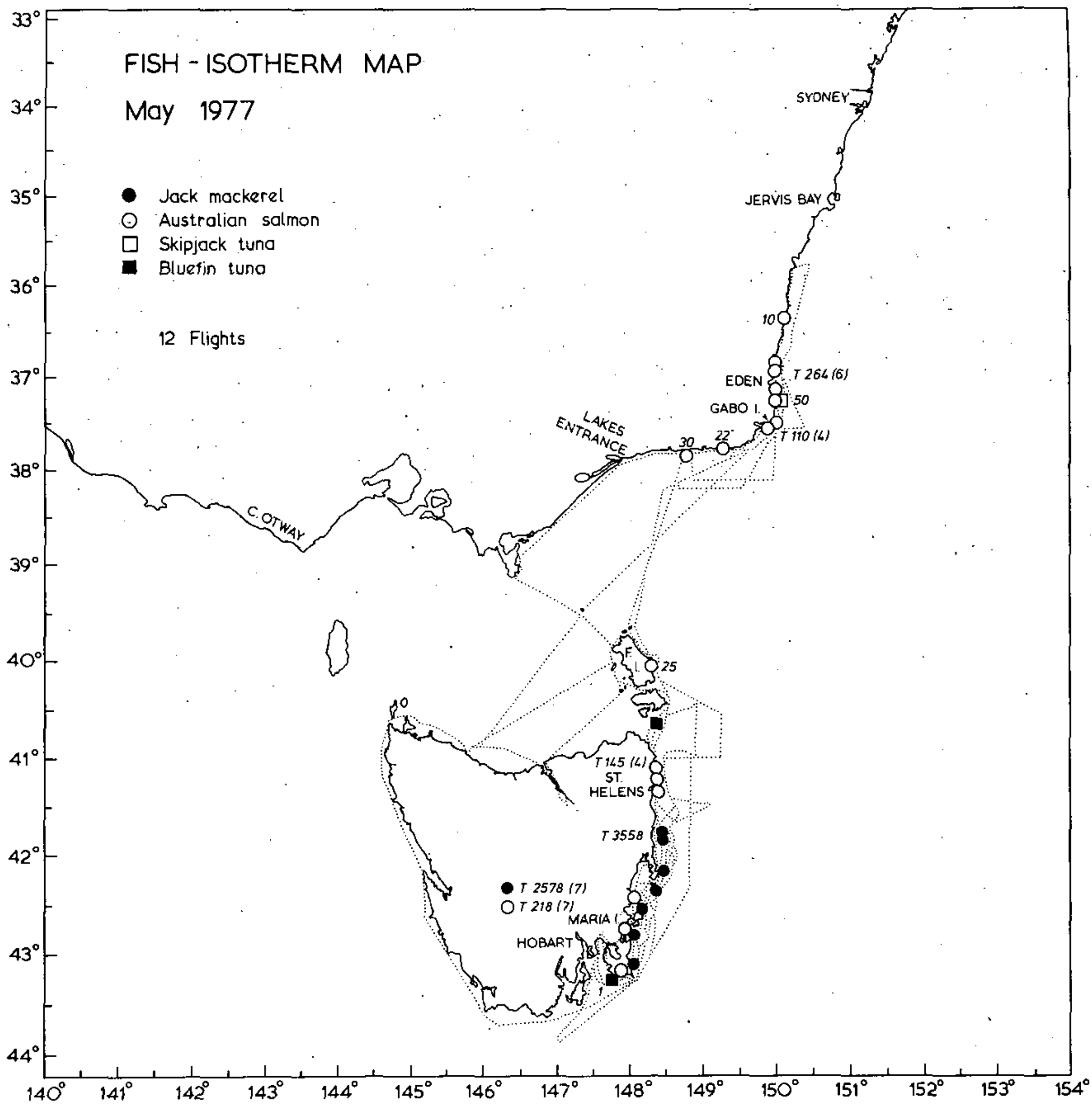
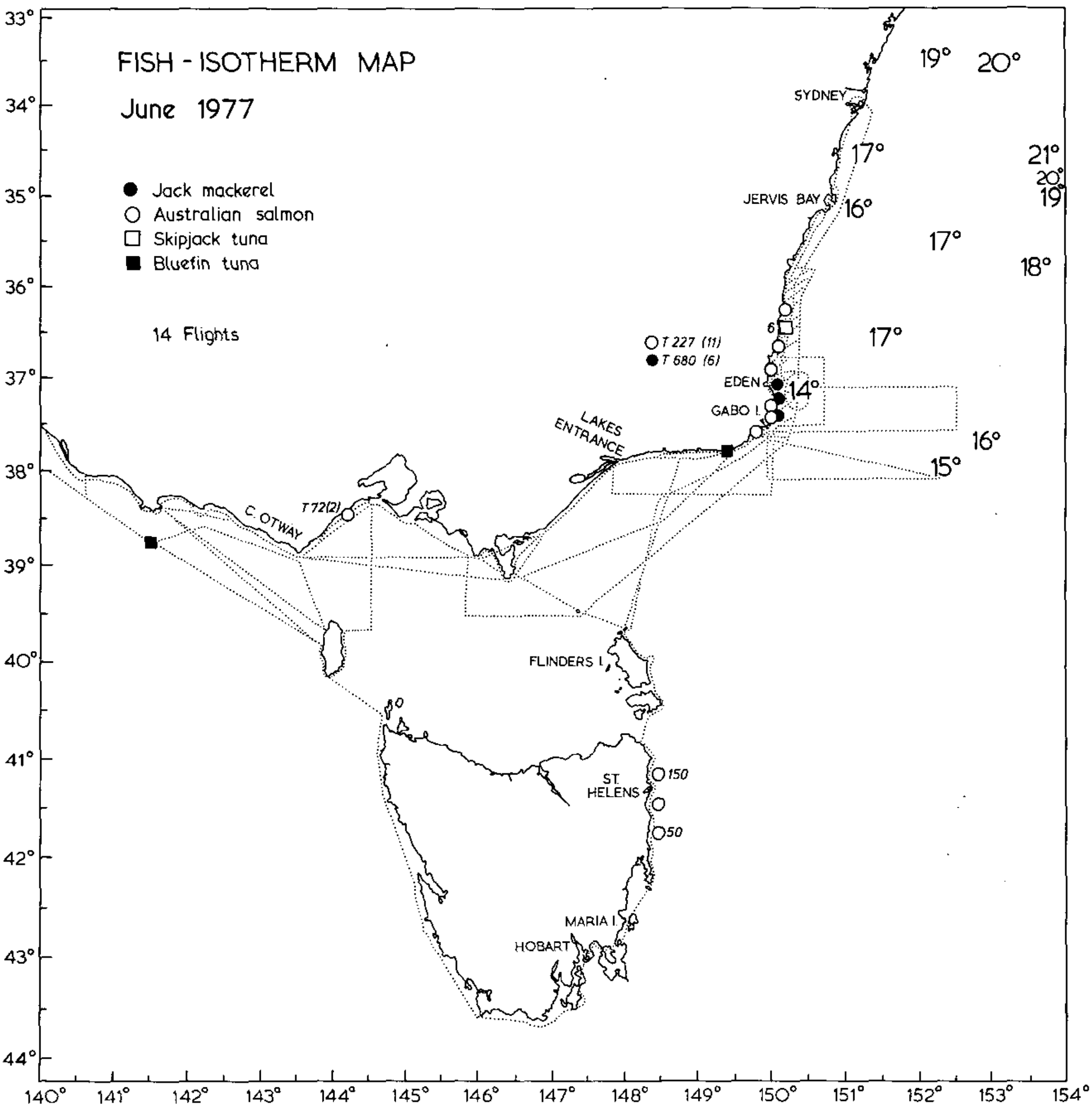

FISH - ISOTHERM MAP
May 1977
Jack mackerel
Australian salmon
Skipjack tuna
Bluefin tuna
12 Flights
SYDNEY
JERVIS BAY
10
EDEN
T 264 (6)
GABO I.
50
LAKES ENTRANCE
30
22
T 110 (4)
C. OTWAY
F. I.
25
T 145 (4)
ST. HELENS
T 3558
T 2578 (7)
T 218 (7)
MARIA I.
HOBART
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 47.



FISH - ISOTHERM MAP
June 1977
Jack mackerel
Australian salmon
Skipjack tuna
Bluefin tuna
14 Flights
SYDNEY
JERVIS BAY
EDEN
GABO I.
LAKES ENTRANCE
C. OTWAY
FLINDERS I.
ST. HELENS
MARIA I.
HOBART
T 227 (11)
T 680 (6)
T 72(2)
150
50
6
19°
20°
17°
21°
20°
19°
16°
17°
18°
17°
14°
16°
15°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
140°
141°
142°
143°
144°
145°
146°
147°
148°
149°
150°
151°
152°
153°
154°

Fig. 48.

Fig. 49. Jack mackerel sightings related to time of day (two low periods) for the whole survey period 1973-77.

CSIRO
Division of Fisheries and Oceanography

HEADQUARTERS
202 Nicholson Parade, Cronulla, NSW
P.O. Box 21, Cronulla, NSW 2230

NORTHEASTERN REGIONAL LABORATORY
233 Middle Street, Cleveland, Qld
P.O. Box 120, Cleveland, Qld 4163

WESTERN REGIONAL LABORATORY
Leach Street, Marmion, WA 6020
P.O. Box 20, North Beach, WA 6020