WP 17.

SPAR/WP/

Movements of albacore tuna (Thunnus alalunga) in the South Pacific: evidence from parasites.

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SUMMARY

Parasites were collected from 384 albacore caught by surface trolling and longlining in the south- west Pacific. Parasite data show a decrease in prevalence of didymozoid parasites with increasing fish length up to a fork length of 85- 90 cm. The subsequent increase in prevalence in large longline caught fish is consistent with fish returning from spawning in tropical waters. Albacore of 50- 70 cm fork length collected at widely separate locations in the south west Pacific have differences in parasite prevalence which, together with tagging and fishery data supports an hypothesis that juvenile albacore migrate to New Zealand from the tropics and then move east along the Subtropical Convergence Zone.

INTRODUCTION

Albacore (Thunnus alalunga) are the basis of several fisheries in the South Pacific including surface trolling,longline and pelagic gillnetting methods. The interaction between the different fisheries is unknown.

Albacore prefer waters between 15 and 21 °C and appear to congregate along convergence zones and temperature discontinuities (Roberts 1980). The lack of commercial catches in equatorial regions supports the hypothesis of separate stocks in each hemisphere (Wang 1988). Although albacore are caught from

40 -125 cm in length, juveniles and sub- adults (<85 cm) make up the majority of albacore caught at the surface (Laurs 1989) while adults swim in deeper waters. Albacore reach sexual maturity at about 85-90 cm and spawning occurs in the tropics. Larvae have been reported from Fiji, Solomons and the Coral Sea. Albacore of all sizes are thought to move into high latitudes in search of prey (Roberts 1971, Hallier, 1984).

In New Zealand waters, albacore of 40-80cm form the basis of a summer troll fishery and albacore are also taken as by-catch in the longline fishery for southern bluefin tuna (Thunnus maccoyii) off East Cape (Fig. 1) primarily in winter (June-July).

Roberts & James (1974) hypothesised that 1 yr old juvenile albacore (<44 cm) caught off the west coasts of New Zealand in February and March were migrating south down the west coast of both islands from the tropical Pacific. More recently Murray and Bailey (1986) suggested, from observed differences in the length frequency data, that two bodies of albacore might be moving onto the New Zealand coast - "large juveniles" (55-70 cm) albacore moving to the West coast of the South Island along the sub-tropical convergence from Australia, while "small juveniles" (45-55 cm) albacore arrive off the North Island in the SE flow over the Norfolk trough.

Tagging with plastic dart tags has been tried in an effort to identify movements of albacore. Just under 450 tags were released in 1972 but there were no returns (Roberts 1974). A current International tagging programme in the South Pacific has seen over 5000 tags released to date with 5 returns, all from longliners (Laurs 1989, FRC records).

Parasites have been used for separating "stocks" of fish (see reviews by McKenzie 1983,1986) including various species of Scombridae. Aloncle and Delaport (1970, 1974) successfully used the albacore stomach parasite Hirudinella as a biological

stock marker in the North Atlantic and also showed that the presence of the nematode Thynnascaris was correlated with the type and quantity of the food in the albacore stomachs. Lester et al. (1985) studied school to school variation in skipjack (Katsuwonus pelamis) parasites to evaluate how long schools were staying together. Their evidence suggested that New Zealand caught skipjack smaller that 57 cm fork length had recently arrived from the tropics based on abundance figures for the trematode parasite Tentacularia. Rohde (1987) showed that populations of Scomber from New Zealand and Australia were different based on the morphology of a trematode parasite common to both areas.

This project seeks to describe parasite distribution patterns to help clarify patterns of movement and feeding of albacore in the South Pacific. Such information is particularly relevant in the absence, to date, of extensive tag recoveries.

MATERIALS AND METHODS

Provision of samples was an international effort. Parasites were collected from 143 albacore caught by surface trolling in waters around New Zealand and 103 from albacore caught by Japanese longliners operating in New Zealand waters. A further 119 albacore (caught by surface trolling) were obtained from the 1986 and 1987 cruises of the "R.V. Townsend Cromwell", and the 1987 cruise of the "R.V. Coriolis" to the central South Pacific, 10 longline caught albacore were provided from the Coral Sea courtesy of ORSTOM and 15 albacore were provided by the 'Alofa,' a Tongan longliner, courtesy of the Tongan Ministry of Agriculture Fisheries and Food. An additional 26 albacore were obtained from New South Wales sports fishermen courtesy of N.S.W. Fisheries Research Institute. Sample origins and dates are given in table 1.

Most of the albacore were received as frozen heads cut from the albacore by a diagonal cut passing from the back of the skull to a point posterior to the anus, thus preserving the gut cavity intact. In order to save weight and space, many of the longline caught samples were limited to frozen heads (cut off behind the opercula) and viscera only, or gills and viscera. Each head was identified with a cruise number and the length to caudal fork (LCF) and, where practical, the weight and sex of the albacore.

Where possible the sex of immature fish was determined by histological methods.

Each sample was thawed and examined for parasites, which were counted. The parasites "Didymozoid D", "Didymozoid L" and "Didymozoid S" were simply coded as present or absent due to the difficulty of counting each cyst. The stomach and contents were weighed to the nearest 1.0 gm before the contents of the stomach, and of the intestine were examined with the aid of a 10X dissecting microscope. Contents were not sieved. Sections were taken of the liver and spleen, and smears were made of the gall bladder and swim bladder. Histological sections were stained with haematoxylin and eosin, smears were stained with giemsa.

Parasite counts are approximately distributed as a negative binomial and many species had a variance greater than the mean indicating an overdispersed distribution (That is, the parasites are aggregated). A log -transformation (log (1+parasite count)) was therefore used to remove the influence of infrequent large parasite counts, and normalise the data (Cassie 1962).

Following the guidelines in Margolis et al. (1982) the term "prevalence as used in this paper is defined as the percentage of individuals in a sample infected by a particular parasite species. The term "abundance" is defined as the mean number of a particular parasite species per host examined.

RESULTS

Samples were combined without regard to the sex of the host since no significant difference was found in fork length, parasite prevalence or abundance between male and female fish.

Catches were pooled by geographic areas (figure 1) to increase sample sizes. Sample numbers (after pooling) are shown by area and year in table 2.

In many cases the parasites recovered (table 3) have not yet been identified to species.

The parasites found (table 3) were widely distributed throughout the region sampled, except for 6 (Anisakis, Oncophora, Hirudinella, Hepatoxylon, and Didymozoids "B" and "Z") not found in the small sample of fish from the Coral Sea (area 50) ; 3 (cestode "A", Hepatoxylon, Didymozoids "B" and "Z") not found in the sample of 15 fish from south of Tonga (area 60); and 2 (Anisakis, cestode "A") not found in the central South Pacific (areas 12 and 15). A cestode (type "B") was found in only one fish from the Coral Sea, and one decomposing Tentacularia (a species common in skipjack tuna (Lester et al. 1985)) was found in an albacore caught in 1985 off the west coast of the North Island, New Zealand.

Eleven of the parasites found were chosen as markers. These were parasites which were easily identified, able to be accurately counted, and were present in relatively large numbers. Presumed longevity was not used as a factor in choosing the markers.

Of the eleven, four were digenean trematodes and all but one of those were didymozoids (Hirudinella, and Didymozoids B,G, and Z). Three nematodes were included (two larval forms (Anisakis, and Hysterothylacium) and one adult (Oncophora)), two adult copepods (Euryphorus and Pseudocycnus), one cestode larvae

(Hepatoxylon), and one adult acanthocephalan (Rhadinorhynchus) were selected.

Annual changes in parasite prevalence.

There were three areas where sample sizes allowed a comparison between years. A comparison of the prevalence of the eleven marker parasites from areas 1 and 12 for 1986 and 1987 and area 2 for 1987 and 1988, (table 4) shows no significant differences (Wilcoxon paired samples test, $p < 0.05$).

Parasite fauna and host length:

To detect a possible relationship between parasite prevalence and host length, parasite data for all the fish were pooled.

A table of parasite prevalence by host length class shows clear trends which vary according to parasite species (Figs.2 - 4). However, pooling the data introduced the possibility of a bias by area, since 50 % of the small albacore (40-49 cm) came from the central South Pacific.

The effect of area bias on size of the fish, and thus parasite prevalence (since prevalence changes with area), was checked by examining just the longline caught albacore from the East Cape (area 2). The trends shown in figures 3 - 5 were not altered.

It is apparent (Fig. 2) that the acanthocephalan Rhadinorhynchus accumulates with age, reaching 100 % in albacore over 100 cm LCF. The trematode Hirudinella, after a gradual rise to a maximum 28% at 60-69 cm, declines to low levels in albacore over 90 cm.

Nematodes (Fig. 3) also accumulate with age. Hysterothylacium appears to level off at 60-69 cm, while Anisakis and Oncophora increase at 80-89 cm and 70-79 cm respectively, peaking in fish of 90- 100 cm before declining in prevalence in

fish over 100 cm.

The trematode Didymozoid "B" (Fig. 4) declines dramatically from 70-79 cm (89%) to 26% in the 80-89 cm group. Didymozoid "C" appears to accumulate slowly with age, or alternatively remains relatively constant to 70-79 cm then begins to increase in abundance. Didymozoid "G" shows an increase at 90-99 cm but otherwise declines from an initial high (75%) level. Didymozoid "Z" declines to low levels from a high of 17% at 50-59 cm.

Parasite fauna and area:

Prevalences of the parasite markers (all years combined) were tabled against area (table 5). Hysterothylacium was absent from the west coast of the North Island, New Zealand, and has a low prevalence off the west coast, South Island, the New South Wales coast of Australia, and the Coral Sea.

Hepatoxylon has a higher prevalence around New Zealand than in the central South Pacific. Anisakis is absent from the central South Pacific, the Australian samples and the Coral Sea (Anisakis does occur in other New South Wales fish - Bruce, pers comm.). The decline in prevalence of Anisakis and Hepatoxylon to the east of New Zealand is not seen for didymozoids "B" or "G".

DISCUSSION

The parasite fauna of albacore appears to be generally widespread and common. Such faunas are strongly indicative of extensive host movements (Polyanski 1958).

The majority of the parasites found were didymozoid trematodes. The Pacific Ocean is apparently the centre of origin of the Didymozoidae and the majority of known species are found in tropical or sub- tropical waters (Nikolaeva 1985). Adult didymozoids have not so far been recorded from fish resident in New Zealand waters. Larval didymozoids are found in Crustacea, cephalopods or small fish (Køie and Lester 1985) all of which are

found in the diet of albacore. The decline in prevalence of Didymozoid "G", Didymozoid "Z", Didymozoid "B", and perhaps the non-didymozoid trematode Hirudinella, (see Figs. 2 - 4) indicates that the albacore are not being reinfected by these parasites in temperate waters.

The increase in parasite prevalence seen in the 90-100 cm length group would fit with an hypothesis that albacore, having returned to the tropics to spawn, have been re-infected with didymozoids before their return to temperate waters.

The prevalence of the larval nematode Hysterothylacium remains reasonably constant once the albacore reach 60 - 70 cm LCF suggesting that the intermediate host, an amphipod, is no longer eaten.

The parasite prevalence data for the nematodes Hysterothylacium, Anisakis, and Oncophora strongly indicates that a diet change occurs at around 70-80 cm. This is also about the upper limit for troll caught fish (i.e. those feeding at the surface). Feeding studies support this observation. Bailey & Habib (1982) and Bailey (1983) found a pronounced change in diet with increasing length of albacore around the New Zealand coast. Food for small and medium sized fish consisted of euphausiids, hyperiids and cephalopods changing to teleosts such as Scomber australasicus in large specimens. Euphausiids (which carry Anisakis) were the principal food in 35-55 cm fish but had practically disappeared in larger specimens, and by a length of 75 cm crustaceans (including the amphipod hosts of Hysterothylacium) no longer figured as prey. This study supports the results of Roberts (1972) who found that troll- caught albacore 55-73 cm in length were feeding mainly on fish (77% by weight) and squid (13%).

The central South Pacific (area 15) is an area of low prevalence for parasites other than didymozoids. In particular the prevalence of Anisakis and Hepatoxylon, both extremely common

parasites in a wide variety of New Zealand fishes, declines to the east. Anisakis is an extremely hardy parasite, living in the flesh for at least several years, though Hepatoxylon is more readily overcome and probably dies relatively quickly. Dead Hepatoxylon were recovered from the area 15 fish.

There are four possible explanations for the observed decline in prevalence:

a) For albacore moving towards New Zealand from the west there is an increase in the availability of infective stages of Anisakis, and Hepatoxylon and they accumulate in the fish, but Rhadinorhynchus, Oncophora and the didymozoids remain relatively constant. The presence of only dead Hepatoxylon in area 15 is not consistant with this explanation.

b) There is a movement away from New Zealand along the sub-tropical Convergence by the tuna, with a gradual loss of Hepatoxylon and no re-infection. Anisakis is no longer picked up and prevalence drops due to "dilution" by uninfected fish moving down from the tropics (where Rhadinorhynchus and Oncophora have a high prevalence).

c) A combination of both a and b.

d) Separate "stocks" of albacore in area 15 from those around New Zealand.

Four of the five tag returns have been from the central South Pacific in the vicinity of area 12. Two were from fish showing a northern movement to the tropics, and two were fish showing eastward movement. The tag returns together with the parasite data strongly suggests that there is a general eastward movement of the albacore along the Convergence Zone, with fish moving north into tropical waters to spawn, and returning to the south once spawning is complete.

ACKNOWLEDGEMENTS:

I wish to thank all those involved in this project, and especially the crews of the 'Alofa,' 'Coriolis', 'Kaharoa', and 'Townsend Cromwell', and the staff of ORSTOM, the Tongan Ministry of Agriculture Fisheries and Food, the N.S.W. Fisheries Research Institute, the NMFS/AFRF exploratory fishing surveys, and FRC who provided the samples, and the technical staff who helped in the tedious and time consuming task of dissecting out the parasites. I also wish to thank Dr T, Murray for his encouraging advice; and Dr N. Bruce (Queensland Museum) for help in identifying the nematodes.

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Table 1

List of stations sampled for the albacore used in this study:

CRUISE No.	MONTH	SAMPLE No.	LOCALITY
1985			
K05/85	2	18	WEST COAST SOUTH ISLAND
K07/85	4	26	EAST COAST NORTH ISLAND
K18/85	10	9	NORTH CAPE
1986			
TC8601	2/3	31	CENTRAL SOUTH PACIFIC
K03/86	2	35	CHATHAM RISE
K05/86	3	24	NORTH CAPE - NORFOLK ISLE
NEWCA86	8	10	CORAL SEA (Longliner)
K14/86	11/12	16	NW NORTH ISLAND - NORFOLK ISLE
1987			
K04/87	2	15	CHATHAM RISE
TC8701	1	37	CENTRAL SOUTH PACIFIC
COR87	3	51	EASTERN SOUTH PACIFIC
TAPR87	4	15	TONGA (Longliner)
JW87+ KM87	6	53	EAST CAPE (Longliners)
AUST/87	3/6	26	NEW SOUTH WALES (AUSTRALIA)
	6	18*	EAST CAPE (Longliners)
		384	

* = additional 32 not yet coded.

Table 2

Table of sample numbers by area and year.

Area	85	86	87	88	Total
1	24	46	15	0	85
2	0	0	53	18*	71
3	9	0	0	0	9
4	0	35	0	0	35
5	0	4	0	0	4
11	18	0	0	0	18
12	0	18	36	0	54
15	0	0	46	0	46
20	0	0	26	0	26
50	0	10	0	0	10
60	0	0	15	0	15
	51	113	191	18	373
not used in analysis	2	3	6	0	3 8 4

* = part of a sample of 50 awaiting coding.

Table 3: Parasites found in albacore during the survey. Those used as markers are indicated with an #.

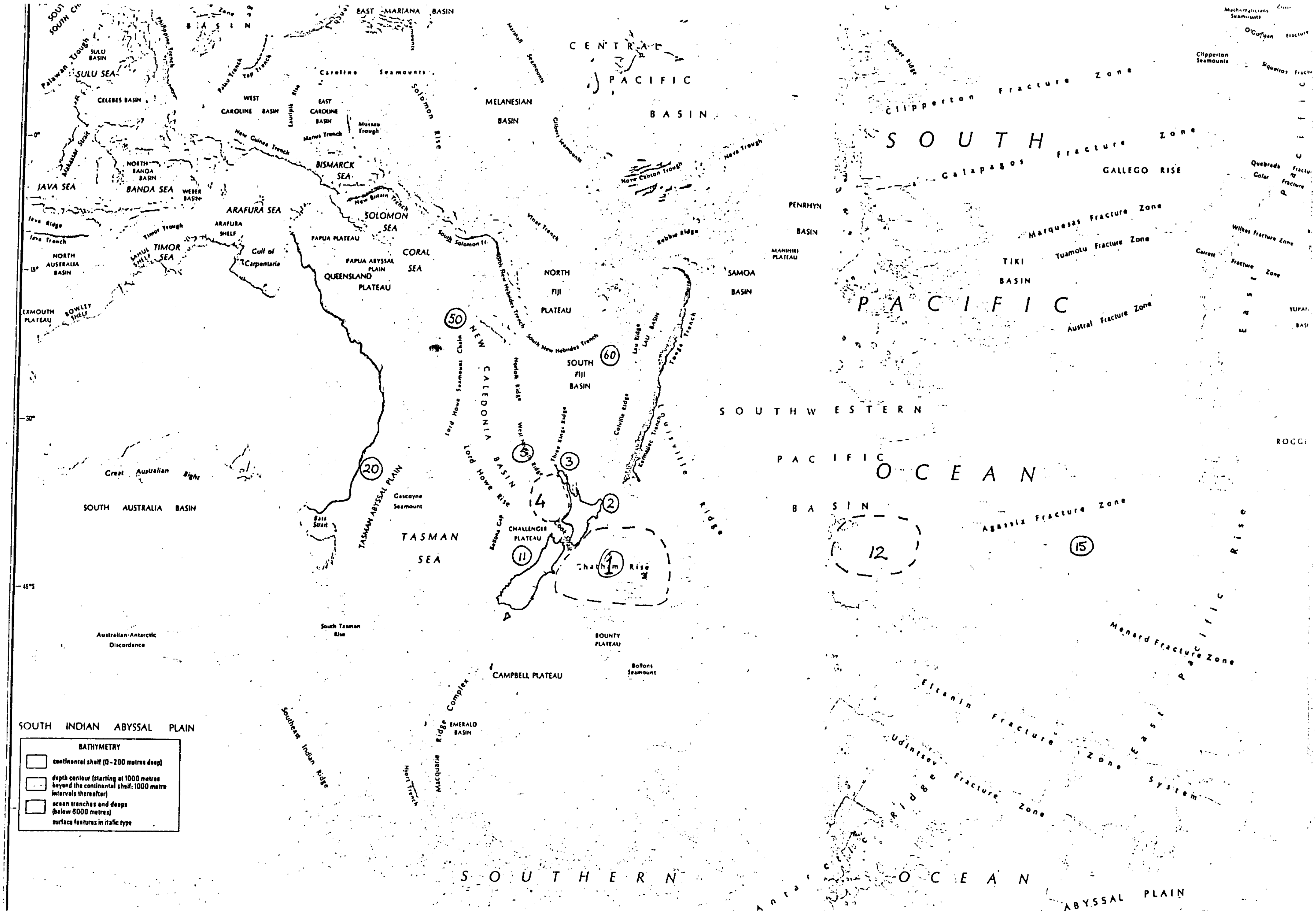
PHYLUM	Code	Identity
MICROSPOREA		
	MICR	Microsporida in intestine.
APICOMPLEXA		
	COCC	Goussia auxidis (Dogiel, 1948)
NEMATODA		
	#ANIS	Anisakis simplex
	CALC	Overcome nematodes
	#NEMR	Oncophora sp. (red colour)
	#CONT	Hysterothylacium cornutum
CESTODA		
	CEST	Cestode
	CESB	
	#HEPA	Hepatoxylon trichiuri
	HEPD	dead or decomposing Hepatoxylon
	TENT	Tentacularia (dead)
ACANTHOCEPHALA		
	#ORAC	Rhadinorhynchus sp.
DIGENEA		
DIDYMOZOIDAE		
	#DIDB	
	DIDC	
	DIDD	
	DIDE	
	#DIDG	
	DIDI	
	DIDL	
	DIDR	
	DIDS	
	DIDX	
	DIDY	Koellikeria sp.
	#DIDZ	
	PLAL	Platocystis alalongae
HIRUDINELLIDAE		
	#HIRU	Hirudinella sp.
COPEPODA		
	#ELBR	Euryphorus brachyptera
	#PSAP	Pseudocycnus appendiculus

Table 4: Comparison of parasite prevalence for the eleven 'markers'

	Area 1		Area 2		Area 12	
	1986	1987	1987	1988	1986	1987
number in sample	46	15	53	18	18	36
median of LCF	66	71	92	90	71	71
ORAC	59	80	100	83	83	75
HEPA	30	15	32	44	11	0
CONT	22	47	32	33	33	33
ANIS	17	33	50	39	0	0
NEMR	22	27	57	28	11	33
DIDB	89	93	n/a	67	89	n/a
DIDG	63	67	66	66	50	55
DIDZ	0	20	8	11	11	0
HIRU	26	13	6	28	17	33
PSAP	63	53	36	39	50	44
ELBR	33	60	25	44	22	8

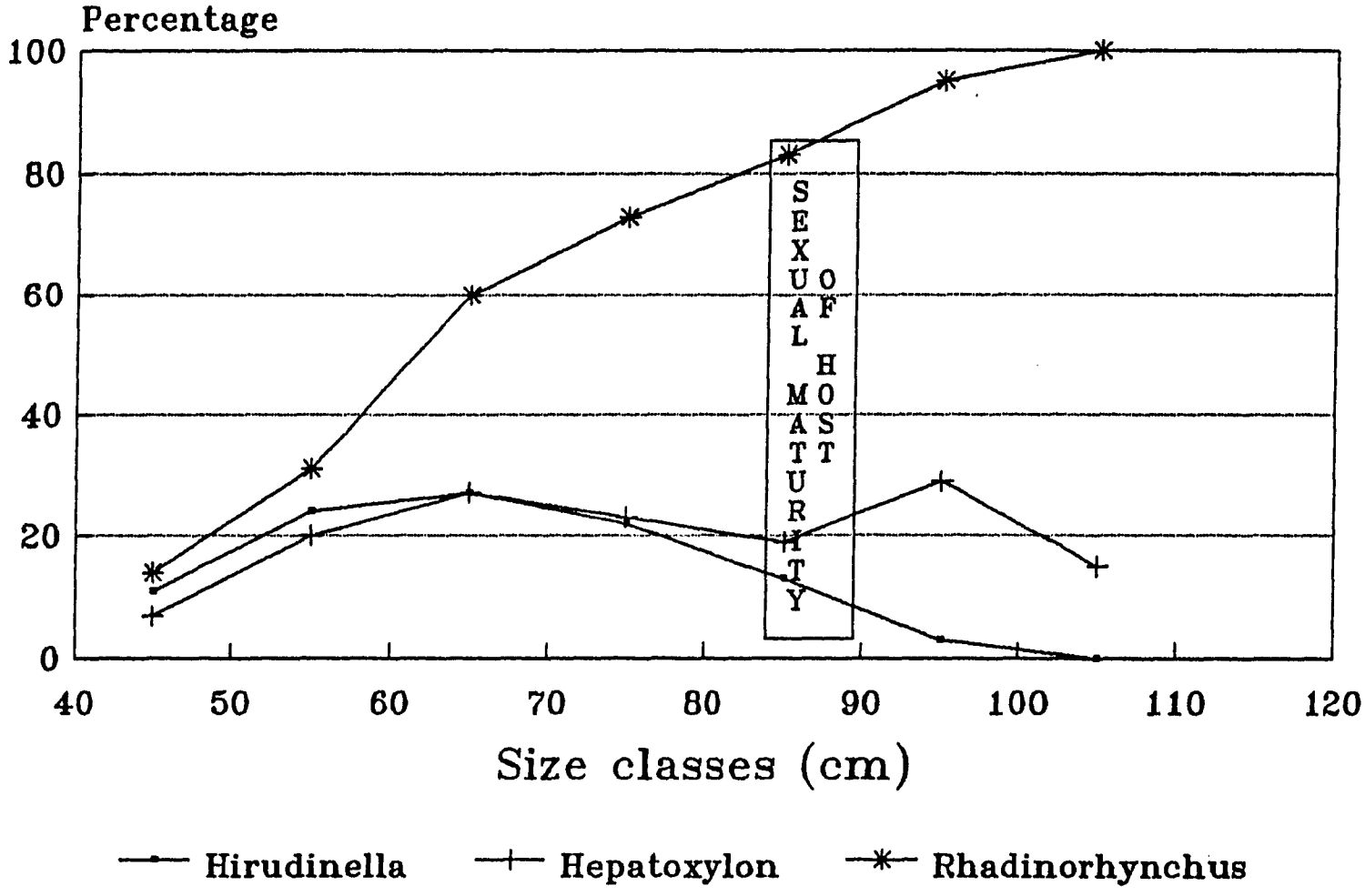
Table 6. Prevalence of selected parasites by area, all years combined.

area	1	2	3	4	5	11	12	15	20	50	60
Sample	85	71	9	35	4	18	54	46	26	10	15
LCF	65	92	67	54	76	58	71	65	71	98	98
ORAC	47	96	89	37	75	83	78	11	69	100	0
HEPA	46	35	11	14	0	11	4	0	35	20	0
CONT	20	32	78	0	0	11	33	22	4	10	27
ANIS	20	48	44	11	25	11	0	0	0	0	33
NEMR	21	49	11	37	25	6	26	0	50	0	73
DIDB	91	49	44	77	75	83	89	n/a	n/a	0	0
DIDG	69	66	33	80	25	94	54	67	38	50	47
DIDZ	14	8	0	23	0	0	4	0	0	0	0
PSAP	60	37	56	86	50	89	46	26	58	40	20
ELBR	31	30	89	51	100	94	13	13	27	20	53
HIRU	16	11	89	34	0	28	28	2	27	0	7



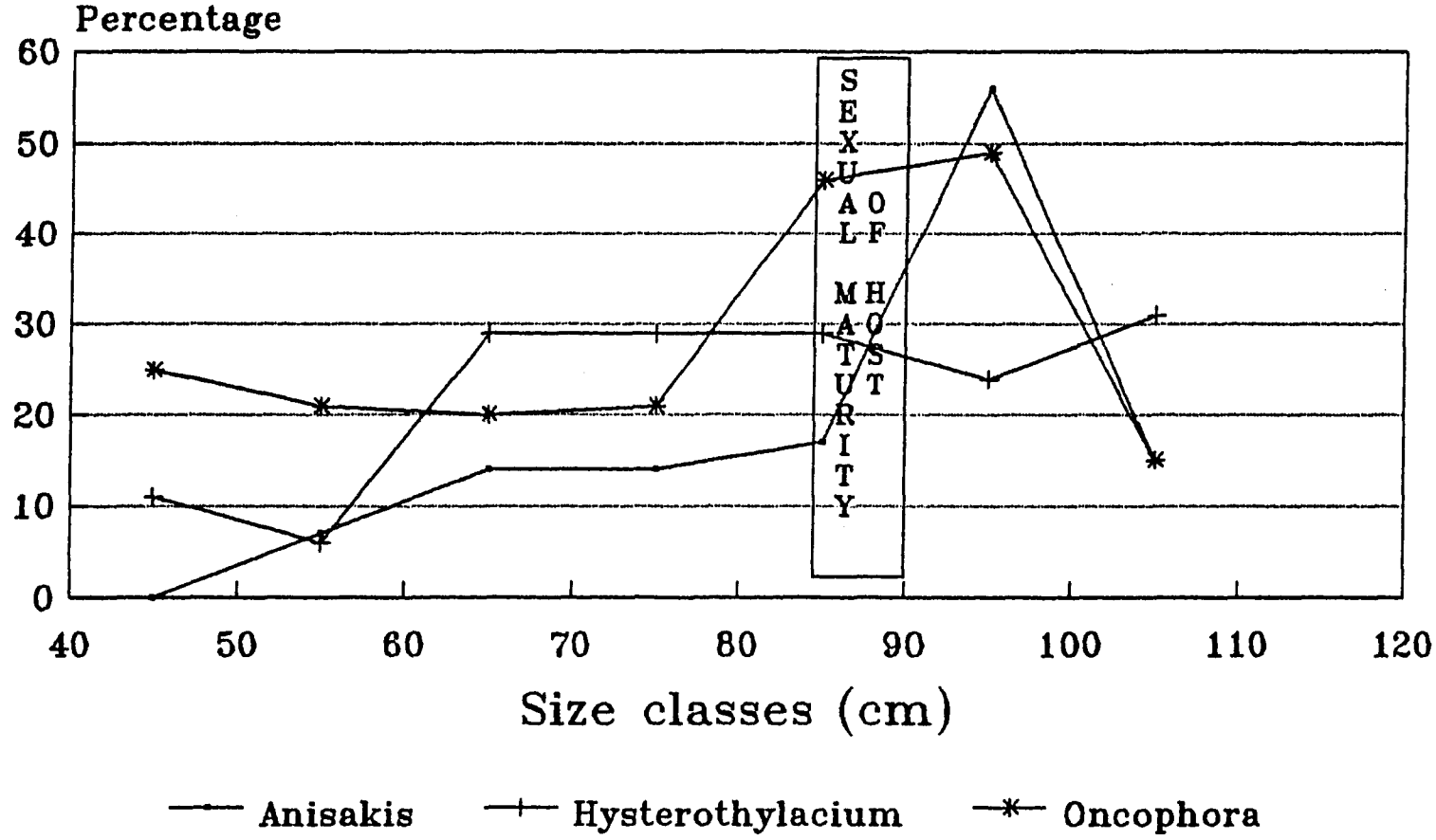
CENTRAL PACIFIC BASIN
MELANESIAN BASIN
SOUTH PACIFIC
SULU SEA
JAVA SEA
BANDA SEA
ARAFURA SEA
TIMOR SEA
BISMARCK SEA
SOLOMON SEA
CORAL SEA
QUEENSLAND PLATEAU
NORTH FIJI PLATEAU
SOUTH FIJI BASIN
NEW CALEDONIA BASIN
SAMOA BASIN
PENRHYN BASIN
TIKI BASIN
GALLEGO RISE
Clipperton Fracture Zone
Galapagos Fracture Zone
Marquesas Fracture Zone
Tuamotu Fracture Zone
Austral Fracture Zone
SOUTHWESTERN PACIFIC BASIN
OCEAN
Agassiz Fracture Zone
Menard Fracture Zone
Eltanin Fracture Zone
Udintsev Fracture Zone
East Pacific Rise System
TASMAN SEA
TASMAN ABYSSAL PLAIN
Lord Howe Rise
Lord Howe Seamount Chain
Norfolk Ridge
West Norfolk Ridge
Three Kings Ridge
Colville Ridge
Kermadec Trench
Tonga Trench
Louisville Ridge
CHALLENGER PLATEAU
Chatham Rise
Cook Strait
BOUNTY PLATEAU
Bollons Seamount
CAMPBELL PLATEAU
EMERALD BASIN
Macquarie Ridge Complex
Hjort Trench
Southeast Indian Ridge
South Tasman Rise
Australian-Antarctic Discordance
SOUTH AUSTRALIA BASIN
Great Australian Bight
Gascoyne Seamount
Bass Strait
SOUTH INDIAN ABYSSAL PLAIN
SOUTHERN OCEAN
ABYSSAL PLAIN
50
60
20
5
3
4
2
1
11
12
15
BATHYMETRY
continental shelf (0–200 metres deep)
depth contour (starting at 1000 metres beyond the continental shelf: 1000 metre intervals thereafter)
ocean trenches and deeps (below 6000 metres)
surface features in italic type

Parasite prevalence



Parasite prevalence

Nematodes



Parasite prevalence

Didymozoids