No 19 82/33

- ☐ NEW PROPOSAL
- ☐ CONTINUING PROJECT
- ☒ FINAL REPORT
- ☐ PROGRESS REPORT

FISHING INDUSTRY RESEARCH TRUST ACCOUNT

TITLE OF PROPOSAL/PROJECT: A SURVEY OF THE INCIDENCE OF CIGUATOXIN IN 'HIGH RISK' FISH FROM THE CAIRNS REGION.

ORGANISATION: QIT

PERSON(S) RESPONSIBLE: DR M.F. CAPRA

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F139—12/84

Ciguatera poisoning: Incidence and Implications

A Final Report

on

(FIRTA 82/33) "A survey of the incidence of ciguatoxin in "high risk" fish from the Cairns region"

by

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INTRODUCTION

Ciguatera poisoning is a form of seafood poisoning that occurs in humans after the ingestion of particular specimens of a variety of tropical fish species. The poisoning is caused by the presence of very small quantities of a powerful toxin, ciguatoxin, in the flesh of the offending fish. Ciguatoxin is a compound of, as yet, unknown structure that is believed to be produced by a microscopic single celled organism, the dinoflagellate Gambierdiscus toxicus. Gambierdiscus inhabits tropical waters where it can be found on dead coral or living as a epiphyte on several species of macroalgae. Surveys of the numbers of Gambierdiscus on reefs in various parts of the Pacific show a reasonable correlation between the numbers of the dinoflagellate and the endemicity of ciguatera poisoning. The physical and chemical factors responsible for upward movements in the population density of Gambierdiscus are not yet fully appreciated. The possibility exists that not all populations of Gambierdiscus produce ciguatoxin. Changes in the physico-chemical conditions or shifts in ecological pressures may induce non toxic population of Gambierdiscus to become toxic. The toxin elaborated by Gambierdiscus is believed to enter the food chain via herbivorous browsing species of fish such as the surgeon fish. The toxin then presumably moves through a hierarchy of carnivores and predators to perhaps become concentrated in the higher level carnivores such as barracuda, mackerel and coral trout. An intriguing and unresolved question that is currently under study at the Queensland Institute of Technology is how fish carry ciguatoxin without displaying overt symptoms.

Many species of fish have been implicated as potential carriers of ciguatoxin. Cases of ciguatera poisoning have been reported in Australia after the consumption of some of our most prized and commercially important species of tropical fish, including coral trout and Spanish mackerel. In August 1984 an outbreak of ciguatera poisoning occurred in South-east Queensland when several people ate commercially obtained barracuda. No comprehensive check list of potentially toxic species is available for Australia although both the Queensland Fisheries Service and the Northern Territory Health Department issue literature advising the avoidance of consumption of certain species. In Fiji some seventeen species have been confirmed as potentially toxic while thirty two species have been shown to carry ciguatoxin in Tahiti. Even when a species is a confirmed carrier, this does not mean that every individual fish will carry ciguatoxin. The incidence of toxicity may also vary seasonally. In Queensland three species of reef fish, the Red Bass, Chinaman-fish and Paddletail have for many years been considered as high risk species. Data presented below will confirm the potential toxicity of these species.

There have been many reports of the clinical manifestations and symptomology of ciguatera poisoning in man. After the ingestion of a toxic fish, the course of the affliction usually follows a reasonably predictable pattern. The initial symptoms are gastrointestinal and usually develop at an early stage some three

to twelve hours after the meal. These symptoms can include nausea, vomiting, diarrhoea and abdominal pain. The usual time for onset is around six hours after the meal; the severity of the symptoms is variable and may depend upon the toxicity and quantity of ingested fish. Following the gastrointestinal dysfunction, neurological symptoms usually begin to appear twelve to eighteen hours after the fish was eaten. The neurological symptoms can include, abnormal and unpleasant sensations around the mouth and in the limbs, muscle pain, joint pain, dental pain, itch and associated skin rash and reversed temperature perception (when this symptom is present patients report a cold sensation when touching a hot object and vice versa). Cardio-vascular effects are sometimes manifest as abnormal changes in heart rate and drops in arterial blood pressure.

The course of the neurological disturbance varies from mild discomfort for a few days to more severe symptoms that may last for weeks. In extreme cases symptoms may persist for many months or even years. Mortality appears to be low and in Queensland there has been only one well documented death that would appear to be due to the consumption of toxic fish. Studies in the Pacific Islands estimate a mortality rate of 0.1% among the victims of the toxin.

The symptomology of ciguatera poisoning sets it apart from some of the more common but less severe types of food poisoning and hence, outbreaks of ciguatera poisoning are likely to attract media attention. Certainly over the past four to five years public awareness of ciguatera poisoning has increased. The topic has been covered both on ABC Televison (Four Corners 1981) and commercial television (0-10 network "Australian Killers" 1982). Numerous reports of ciguatera poisoning have appeared in the daily press and specialized publications including fishing magazines. The reports in the popular press are usually based on outbreaks of poisoning that follow the sale of a toxic specimen from a retail outlet. Press reports in many instances tend to overstate the nature of the problem and sensationalization of a few cases of human intoxication can easily lead to a false impression of the incidence of ciguatera poisoning. Prior to this current study there were no data available on the actual incidence of ciguatera poisoning in Australia.

The study reported here was undertaken to gain information on the actual incidence of ciguatera poisoning and on the attitudes of Australians to this particular food-borne disease. A second objective of the study was to obtain quantitative information on the incidence of toxicity in some of the putative carrier species, Red Bass, Chinaman-fish and Paddletail.

EPIDEMIOLOGICAL AND SOCIAL SURVEYS OF THE INCIDENCE OF AND ATTITUDES TOWARDS CIGUATERA POISONING IN TWO QUEENSLAND COMMUNITIES.

Methods

Two Queensland communities in which cases of ciguatera poisoning were known to have occurred were chosen for study (Figure 1), Cairns in North Queensland and the Maryborough-Hervey Bay region below the southern limits of the Great Barrier Reef.

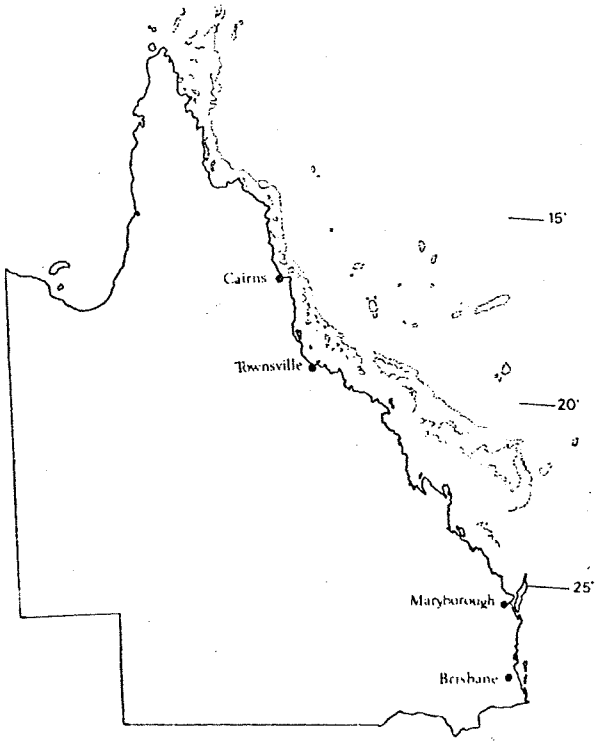


Figure 1 Map of Queensland showing the survey sites of Cairns and Maryborough-Hervey Bay

The surveys in Cairns and Maryborough-Hervey Bay were conducted on the basis of a telephone questionnaire. The questionnaire was formulated to gain information in four areas:-

(i) the knowledge of each of the communities of ciguatera poisoning and how such knowledge was obtained;

(ii) the incidence of poisoning;

(iii) the opinions of the communities on health and industry aspects of ciguatera poisoning;

(iv) general information on the social structure of each of the communities.

In order to obtain a reasonable estimate of the incidence of ciguatera poisoning relatively large samples were taken in each locality. Sampling was done on the basis of randomly contacting five percent of the private telephone listings in each area.

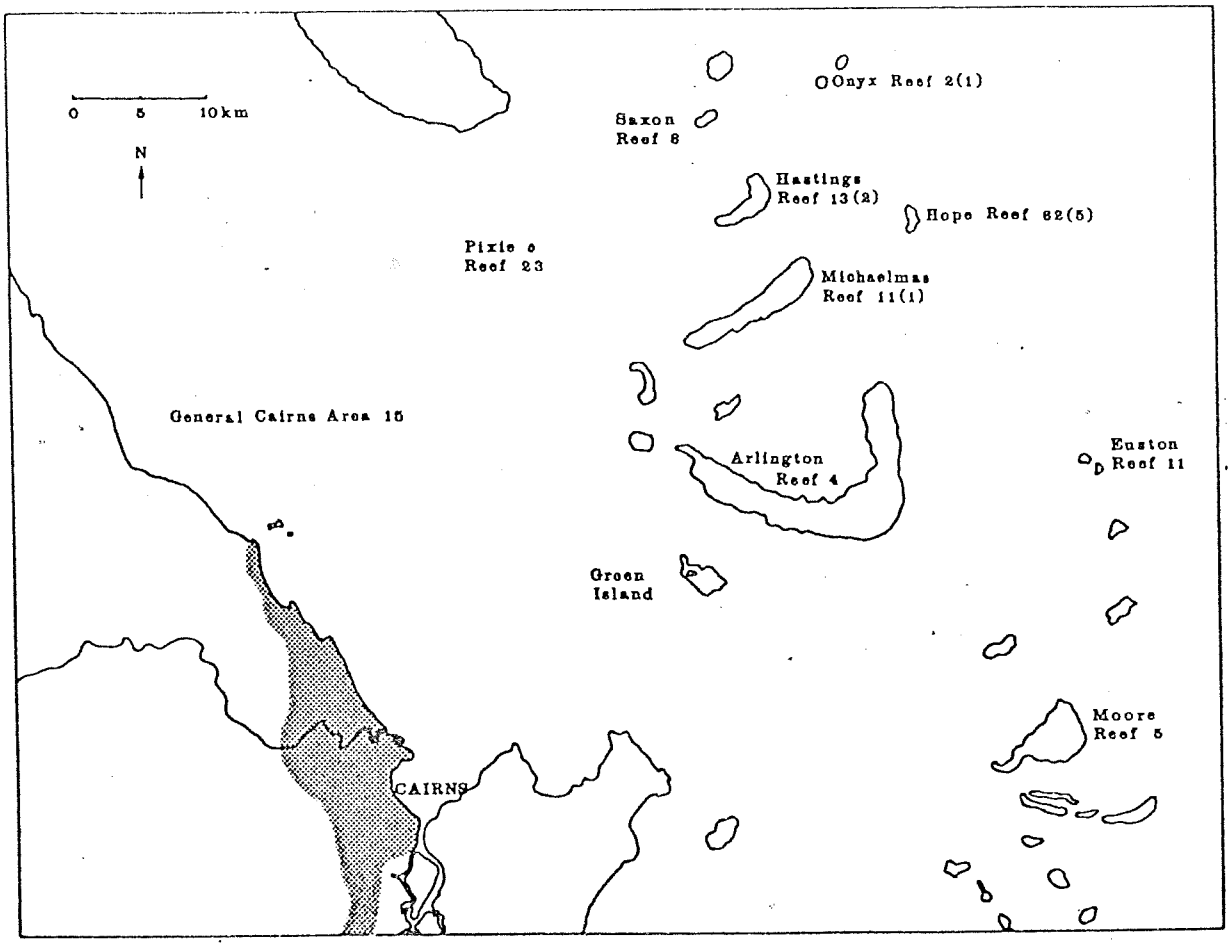


Figure 2 Map of the Cairns region showing the extent of the area contacted during the telephone survey (stippled area). The Cairns survey was conducted during June 1983. Also shown are regions from which Red Bass, Chinaman-fish and Paddletail were captured for the study of the incidence of ciguatoxin in these species. Numerals on the map indicate the number of fish captured in each locality and the numbers in brackets show the number and locality of toxic fish.

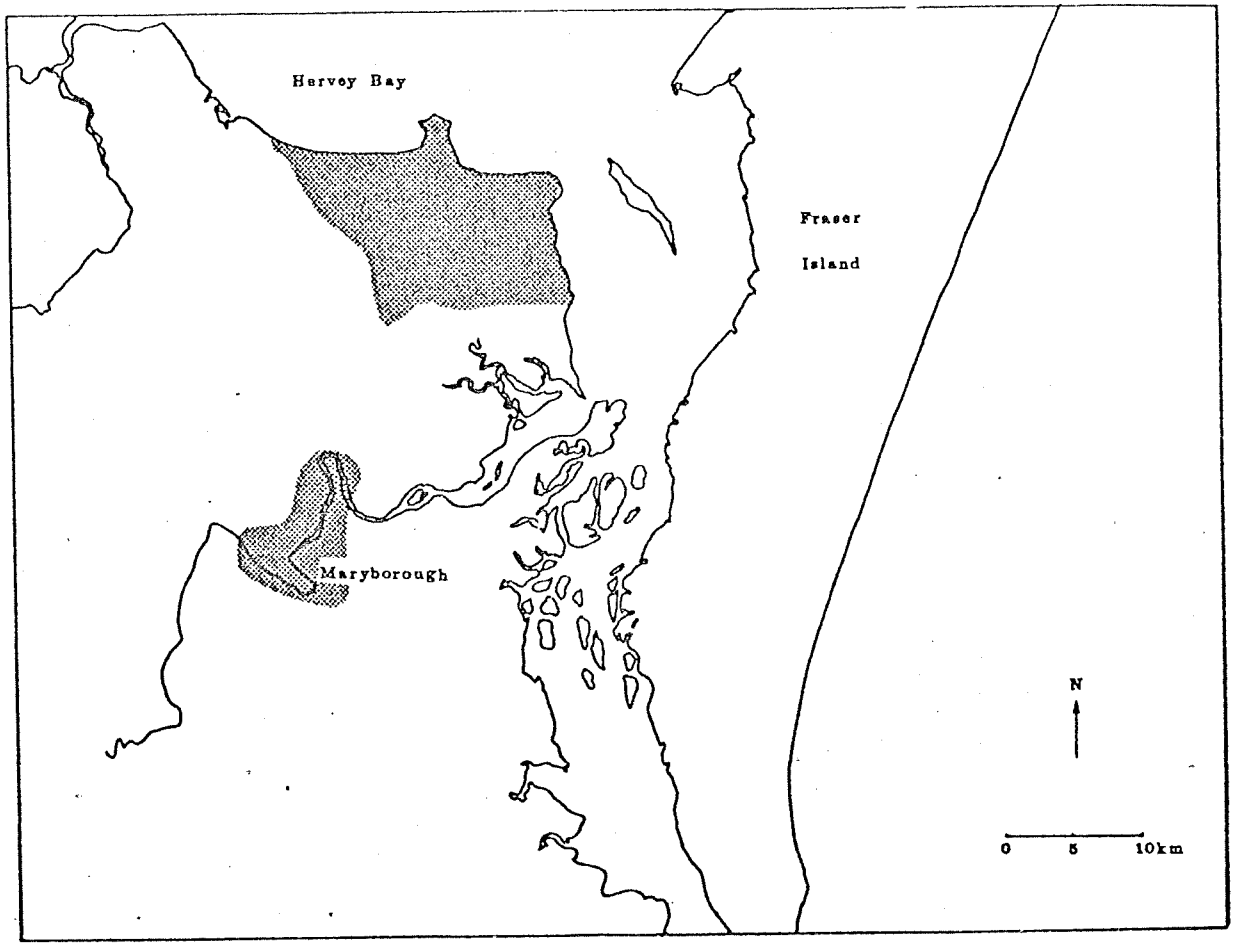


Figure 3 Map of the Maryborough-Hervey Bay region showing the extent of the areas contacted during the telephone survey (stippled areas). The Maryborough-Hervey Bay survey was conducted during October 1982. The two discrete areas represent population concentrations within a single telephone area. There are population concentrations within the township of Maryborough and along the coastal strip of Hervey Bay.

TABLE I

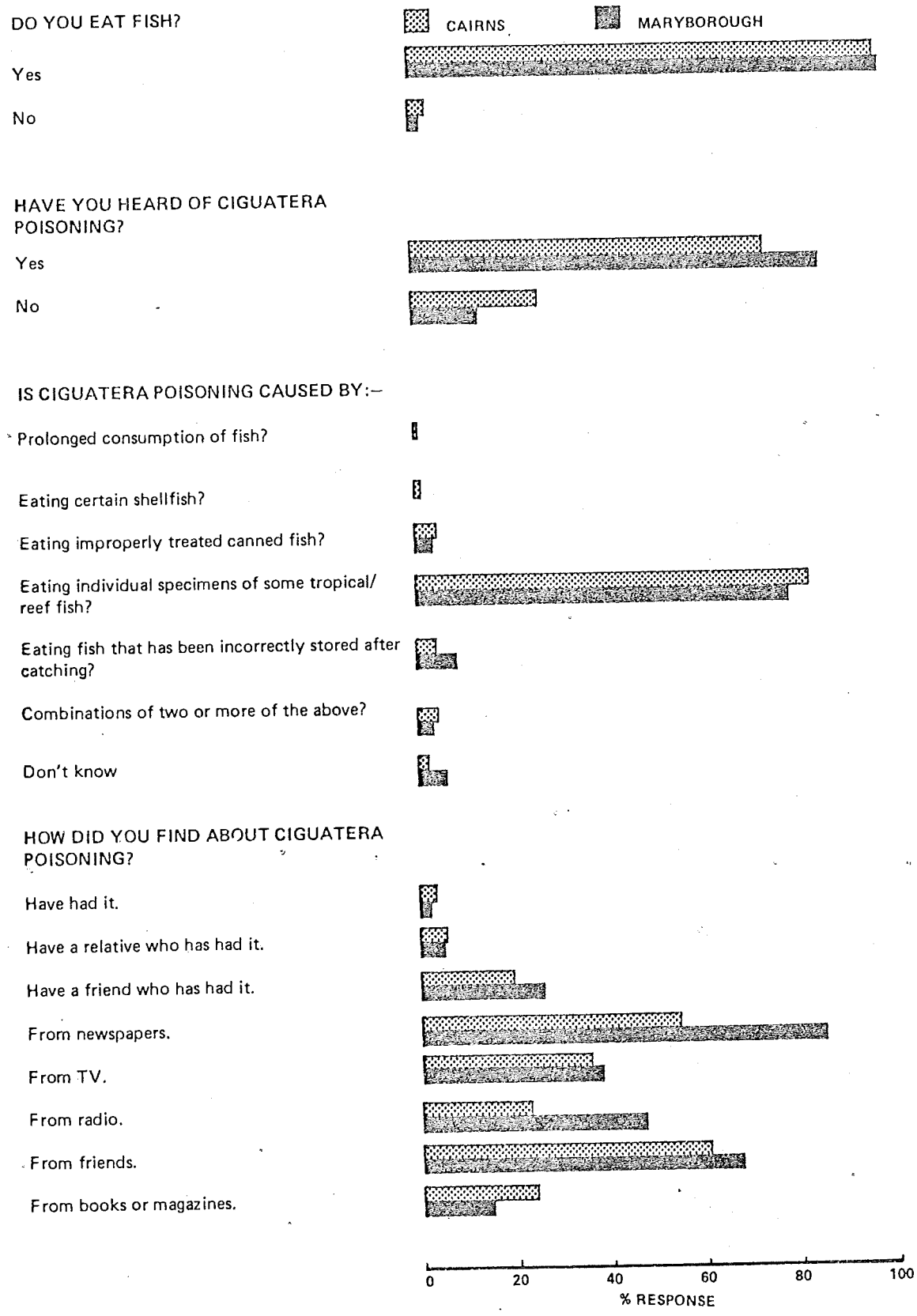
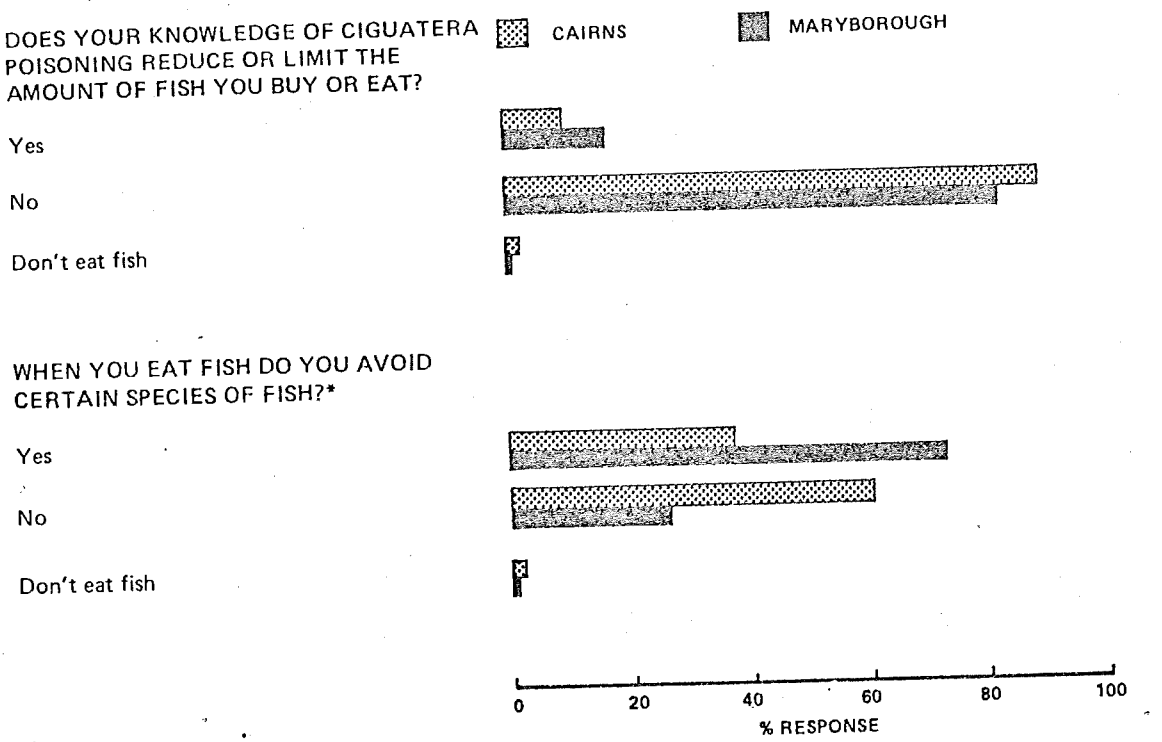

DO YOU EAT FISH?
CAIRNS
MARYBOROUGH
Yes
No
HAVE YOU HEARD OF CIGUATERA POISONING?
Yes
No
IS CIGUATERA POISONING CAUSED BY:–
Prolonged consumption of fish?
Eating certain shellfish?
Eating improperly treated canned fish?
Eating individual specimens of some tropical/ reef fish?
Eating fish that has been incorrectly stored after catching?
Combinations of two or more of the above?
Don't know
HOW DID YOU FIND ABOUT CIGUATERA POISONING?
Have had it.
Have a relative who has had it.
Have a friend who has had it.
From newspapers.
From TV.
From radio.
From friends.
From books or magazines.
0
20
40
60
80
100
% RESPONSE

TABLE I (cont)


DOES YOUR KNOWLEDGE OF CIGUATERA POISONING REDUCE OR LIMIT THE AMOUNT OF FISH YOU BUY OR EAT?
CAIRNS
MARYBOROUGH
Yes
No
Don't eat fish
WHEN YOU EAT FISH DO YOU AVOID CERTAIN SPECIES OF FISH?*
Yes
No
Don't eat fish
0
20
40
60
80
100
% RESPONSE

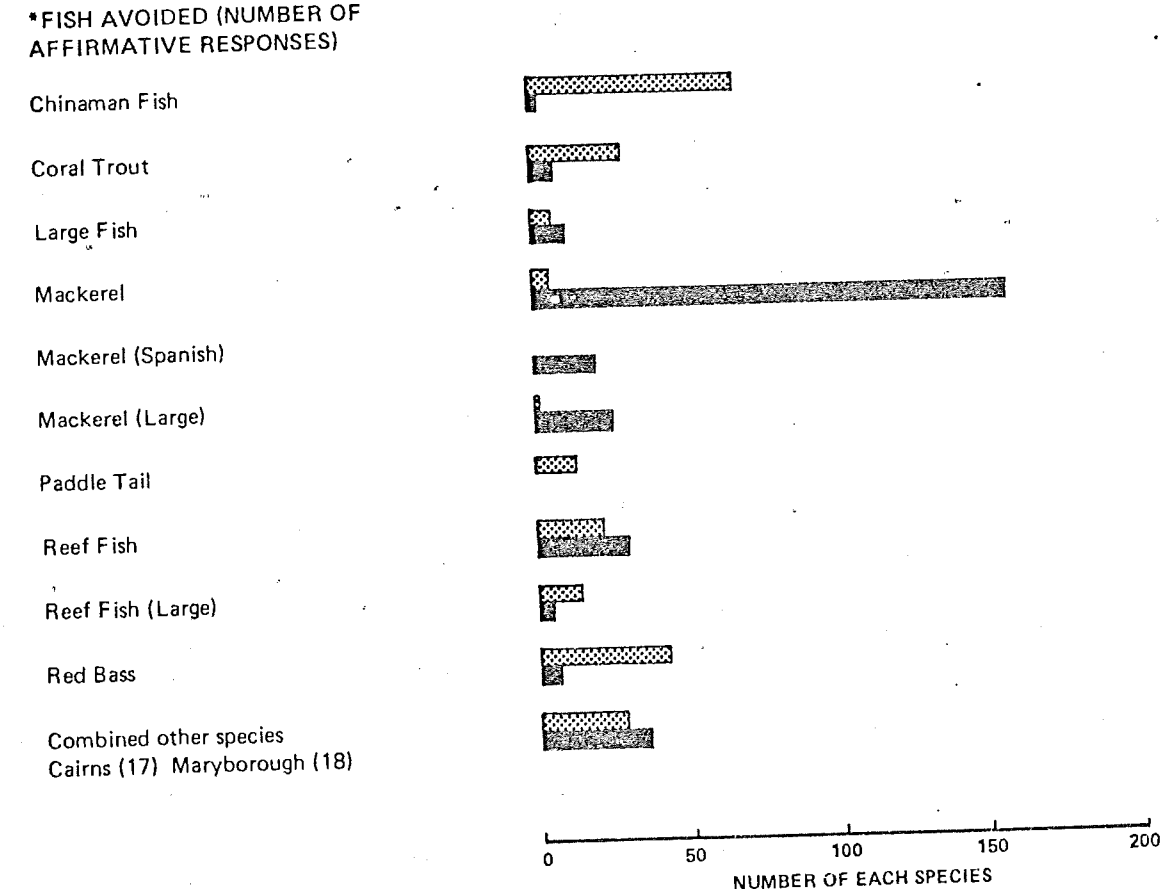

*FISH AVOIDED (NUMBER OF AFFIRMATIVE RESPONSES)
Chinaman Fish
Coral Trout
Large Fish
Mackerel
Mackerel (Spanish)
Mackerel (Large)
Paddle Tail
Reef Fish
Reef Fish (Large)
Red Bass
Combined other species
Cairns (17) Maryborough (18)
0
50
100
150
200
NUMBER OF EACH SPECIES

TABLE I (cont)

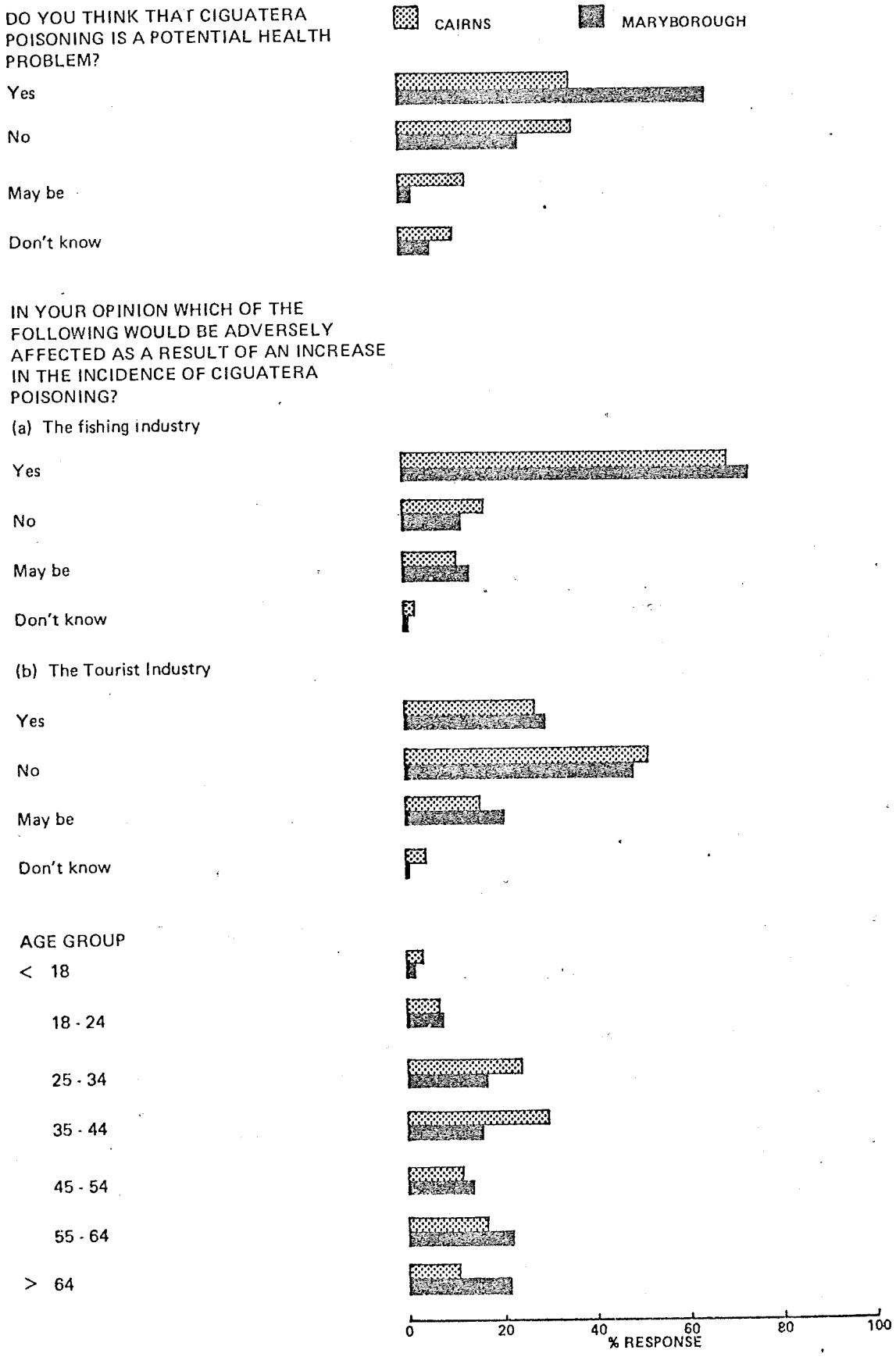
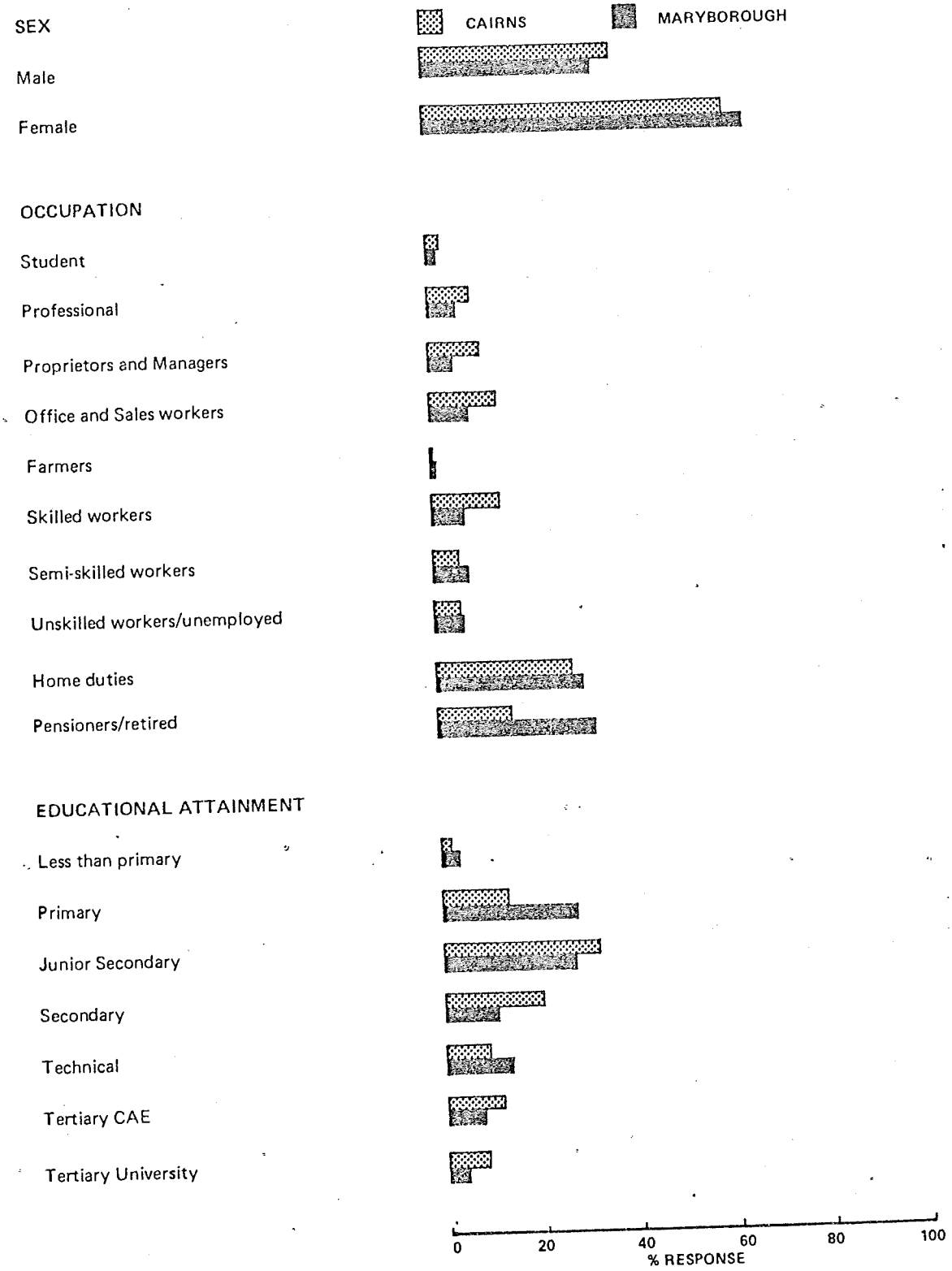

DO YOU THINK THAT CIGUATERA POISONING IS A POTENTIAL HEALTH PROBLEM?
CAIRNS
MARYBOROUGH
Yes
No
May be
Don't know
IN YOUR OPINION WHICH OF THE FOLLOWING WOULD BE ADVERSELY AFFECTED AS A RESULT OF AN INCREASE IN THE INCIDENCE OF CIGUATERA POISONING?
(a) The fishing industry
Yes
No
May be
Don't know
(b) The Tourist Industry
Yes
No
May be
Don't know
AGE GROUP
< 18
18 - 24
25 - 34
35 - 44
45 - 54
55 - 64
> 64
0
20
40
60
80
100
% RESPONSE

TABLE I (cont)


SEX
CAIRNS
MARYBOROUGH
Male
Female
OCCUPATION
Student
Professional
Proprietors and Managers
Office and Sales workers
Farmers
Skilled workers
Semi-skilled workers
Unskilled workers/unemployed
Home duties
Pensioners/retired
EDUCATIONAL ATTAINMENT
Less than primary
Primary
Junior Secondary
Secondary
Technical
Tertiary CAE
Tertiary University
0
20
40
60
80
100
% RESPONSE

Results and Discussion

In the surveys, a standard bank of questions was given to each interviewee; 564 people were interviewed in Cairns and 386 in Maryborough-Hervey Bay. The percentage response to the alternative answers for each question is shown in Table 1.

(i) Community knowledge of ciguatera poisoning and the estimated incidence of poisoning

The first group of questions was designed to obtain data on the awareness of each of the communities to ciguatera poisoning. From responses within this group it was possible to gain an estimate of the incidence of poisoning.

By way of an introduction to the survey people were asked if they ate fish. In both communities most of the population consumed fish (98%). People were next asked if they had heard of ciguatera poisoning. In each community there was a high degree of awareness of ciguatera poisoning (Cairns 73.8%; Maryborough-Hervey Bay 86.3%). Individuals who were aware of ciguatera poisoning were then given the rest of the questionnaire. Those who had not heard of the subject were given only questions relating to the social structure of the community.

Awareness of the term ciguatera poisoning does not imply a sound knowledge of the cause of the affliction. The "aware" group were given a number of possible causes of ciguatera poisoning and asked to identify the correct cause. A very large proportion of interviewees (Cairns 82.9%; Maryborough-Hervey Bay 79.3%) who had heard of ciguatera poisoning were able to correctly identify the cause, namely eating individual specimens of some tropical/reef fish.

From the responses to the next question, "How did you find out about ciguatera poisoning?", an estimation of the incidence of affliction in each of the communities could be made. In Cairns, 3.4% of the interviewees answering the above question had experienced an episode of ciguatera poisoning; in Maryborough-Hervey Bay the figure was 2.1%. When these figures were adjusted for the total sample it was estimated that within the Cairns population 25 people per thousand had at some stage in their life suffered an episode of ciguatera poisoning; the figure for Maryborough-Hervey Bay is 18 per thousand (see Table II below). Assuming an average life expectancy of seventy four years, the projected annual figures for each community are given in Table III.

TABLE II - Incidence of ciguatera poisoning in two Queensland communities

Community	Incidence cases/1000 population
Cairns	25
Maryborough-Hervey Bay	18

TABLE III - Estimated annual incidence of ciguatera poisoning in two Queensland communities based on an average life expectancy of 74.7 years (Australian Government Actuarial Tables 1980-1982)

Community	Annual incidence cases/10,000
Cairns	3.35
Maryborough-Hervey Bay	2.41

Interviewees who believed that they had suffered from ciguatera poisoning were asked to answer a detailed medical questionnaire on the course and symptoms of their poisoning. Acceptance of a positive reply was made only on the basis of the occurrence of both gastrointestinal and neurological symptoms after (3-24 hrs) a meal of fish.

The other responses to the question on how the knowledge of ciguatera was derived are shown in Table I. A significant proportion of those aware of ciguatera poisoning have a relative or friend who has been poisoned. It can be seen from Table I that the media, particularly newspapers, are responsible for the level of awareness. However, large proportions of people in each of the communities have discussed ciguatera poisoning with friends. This method of dissemination of information would seem to be quite significant.

(ii) Impact of ciguatera poisoning

Cairns and Maryborough-Hervey Bay are Queensland coastal communities in which fishing and tourism make significant contributions to the local economy. The impact of ciguatera poisoning on these industries as well as the health implications of the ciguatera poisoning were assessed in the next series of questions (Table I).

Small but significant numbers of people limit their consumption of fish because of the danger of ciguatera poisoning (Cairns 8.7%; Maryborough-Hervey Bay 16.2%). Many more modify their

consumption pattern and actively avoid certain species of fish (Cairns 37.7%; Maryborough-Hervey Bay 73.3%). The fish avoided are shown in Table I. The putative carriers Chinaman-fish, Paddletail and Red Bass are actively avoided in Cairns, as too are Coral Trout and general reef fish. The avoidance pattern is quite different in the Maryborough-Hervey Bay district where there is a very high avoidance of Mackerel. Over the past few years the local press have implicated Mackerel in a number of severe cases of ciguatera poisoning in the Maryborough-Hervey Bay district. Altered consumption patterns are generally more evident in Maryborough-Hervey Bay although the actual incidence of poisoning is lower than in Cairns. A number of factors may be responsible for this. The nature of past press reports must be a contributing factor. Also the age structure of the two populations is somewhat different, with Maryborough-Hervey Bay being an older population. It may be inferred that older people are more likely to be conscious of environmental factors that can produce episodes of severe and debilitating illness. In addition there is a large immigrant population of retired people from New South Wales and Victoria in the Hervey Bay district.

These people perhaps had never heard of ciguatera poisoning before moving north and are more likely to be unduely worried than people who have been aware of ciguatera poisoning for most of their lives. If this is indeed a contributing factor then reported outbreaks of ciguatera poisoning from fish shipped to the large southern markets where the populace is naive with respect to ciguatera poisoning, may have some very serious consequences for the general marketability of fish.

The differences between Cairns and Maryborough-Hervey Bay are again highlighted in the responses to the question on health. The Maryborough-Hervey Bay population is much more concerned about the potential health problem of ciguatera poisoning than is the Cairns population. The variation in attitude again probably reflects the degree of publicity ciguatera poisoning has attracted in Maryborough-Hervey Bay and the different age and immigrant structures of the two populations.

The opinions of both populations on the impact of ciguatera poisoning on both the fishing and tourist industries were sought. The question was framed in terms of a possible increase in the incidence of ciguatera poisoning. It is impossible, of course, to say that such an event will occur. It is, however, quite conceivable that there will be a perceived increase in the incidence of poisoning because of two major factors. Firstly the trend for increased media coverage is now well established and secondly the upsurge of interest in ciguatera poisoning in the medical fraternity will lead to more frequent and correct diagnoses. In both Cairns and Maryborough-Hervey Bay large proportions of the populations could envisage problems for the fishing industry (Cairns 69.7%; Maryborough-Hervey Bay 73.6%) and to a lesser extent the tourist industry (Cairns 27.9%; Maryborough-Hervey Bay 29.7%).

(iii) Social structure of the two communities

Questions relating to age, sex, occupation and educational attainment appear in Table I. Of general interest are differences in age structure and occupation. Maryborough-Hervey Bay is an older population with a greater proportion of retired people. The sex ratio of both populations is biased towards females and possibly reflects the hours during which the surveys were conducted (9.00am to 9.00pm). The greatest proportion of interviews were during working hours at which time it is more probable that women rather than men will be in the home.

THE INCIDENCE OF TOXICITY AMONG POSSIBLE CARRIERS OF CIGUATOXIN IN THE CAIRNS REGION

The initial proposal in this study was to examine the incidence of toxicity in two highly suspect species of fish, Red Bass and Chinaman-fish (Figure 4) from the Cairns region. Some specimens of another highly suspect fish the Paddletail and of Parrot-fish which has been implicated in the Pacific as a carrier of ciguatoxin became available and these too were examined.

Figure 4 Specimens of the Red Bass, Lutjanus bohar (upper fish) and the Chinaman-fish Symphorus nematophorus. Photograph, Julian O'Brien, Qld Fisheries Service, Cairns.

Methods

Fish were taken by line from reefs in the Cairns area by professional fishermen and the staff of the Queensland Fisheries Service. The specimens were frozen and shipped whole to Brisbane for subsequent assay. Bioassay techniques were used to screen fish for toxicity. Samples of abdominal wall musculature were taken from each fish and used in the bioassay procedure. An estimate of the degree of potential human toxicity was made for each specimen found to contain ciguatoxin. Bioassays have been performed, in this laboratory, on fish that have caused human intoxication. The bioassay results for the Cairns fish were cross correlated with the results from fish that had induced various degrees of severity of poisoning in humans.

Results and discussion

A total of 154 fish were screened for the presence of ciguatoxin in their flesh (Table IV). The locations from which these fish were captured are shown on Figure 2. Varying degrees of toxicity were established in 9 of the 154 fish tested (Table V). Red Bass, Chinaman-fish and Paddletail were all shown to carry ciguatoxin. The sample size is relatively small, however, a pattern in the distribution of toxic fish is suggested (Figure 2). The toxic specimens were all taken from the waters bounded by Onyx, Hastings, Hope and Michaelmas reefs. Much larger samples would be needed to draw firm conclusions on the distribution of toxic fish. It is possible that certain reefs may be more toxic than others. This data suggests the need for a survey of Gambierdiscus population densities in the reefs of the Cairns region.

The estimated human toxicity of the flesh in the 9 toxic fish was variable (Table V). Only one fish, a small Red Bass would be capable of causing severe human intoxication. It has often been supposed that only large reef fish are dangerous. The results obtained for the small Red Bass and the two Paddletails are not in agreement with this often quoted premise. Two larger Red Bass could cause moderate poisoning while the remaining fish would cause mild poisoning (mild in the sense of a gastrointestinal upset with perhaps mild neurological symptoms for 3-4 days).

Even though the sample size was relatively small, 9 toxic fish were found. On the basis of these results an estimated incidence of toxicity in Red Bass, Chinaman-fish and Paddletail for the Cairns area is given in Table VI. All three species have a high incidence of toxicity and should continue to be considered as toxic species. Unscrupulous marketing of these species in mixed reef fillets could lead to unnecessary human poisoning.

TABLE IV

Details of the total number of fish assayed

Species	Number	Mean Weight (kg)	SD of Weight (kg)	Weight Range (kg)	Locality* (Number)
Red Bass *Lutjanus bohar*	93	3.18	2.96	0.20-8.10	B(47);C(5); D(4);E(10); F(3);I(7); H(8);I(2); J(7)
Chinaman-Fish *Symphorus nematophorus*	44	4.07	2.06	0.35-8.05	A(4);B(8); D(13);F(8); G(3);J(8)
Paddletail *Lutjanus gibbus*	11	0.63	0.19	0.35-1.00	B(7);E(1); F(2);G(1)
Parrot-fish *Scarus ghobban*	6	0.74	0.17	0.45-0.90	D(6)

* Localities
A, Arlington Reef; B, Hope Reef; C, Moore Reef; D, Pixie Reef; E, Michaelmas Reef; F, Hastings Reef; G, Saxon Reef; H, Euston Reef; I, Onyx Reef; J, General Cairns Area.

TABLE V

Detail of toxic fish

Species	Weight kg	Locality	Index of Toxicity
Red Bass	0.5	Michaelmas Reef	severe
Red Bass	2.9	Onyx Reef	mild
Red Bass	3.1	Hope Reef	moderate
Red Bass	4.0	Hope Reef	moderate
Chinaman-fish	4.1	Hastings Reef	mild
Chinaman-fish	5.1	Hope Reef	mild
Chinaman-fish	5.5	Hope Reef	mild
Paddletail	0.4	Hasting Reef	mild
Paddletail	0.5	Hope Reef	mild

TABLE VI

Estimated incidence of toxicity in surveyed species

Species	Incidence Toxic Fish/1000
Red Bass	43
Chinaman-Fish	68
Paddletail	182

CONCLUSION

Ciguatera poisoning remains a potential threat to the marketability of fish, particularly in areas where adverse reports have appeared in the media. No detailed information on the incidence of ciguatera poisoning was available in Australia prior to this study. The results presented here indicated that the incidence of poisoning is significant, at least in areas in the proximity of the Great Barrier Reef. The incidence of poisoning can affect the desirability and hence marketability of particular species and this may be more marked for individuals who have little prior knowledge of ciguatera poisoning.

The suspect species in the transfer of ciguatera poisoning to humans, Red Bass, Chinaman-fish and Paddletail would appear to deserve their reputation.

Our knowledge of ciguatera poisoning is still fragmentary and there is a need to continue research in this area. The treatment of ciguatera poisoning is largely ineffective and at best, attempts can be made to treat only the symptoms and not the underlying cause of the symptoms. Research is continuing in this laboratory on the underlying mechanisms responsible for the actions of ciguatoxin on mammalian nerves. When an understanding of how this toxin can produce such severe neurological symptoms is available, more effective treatment regimes may be able to be introduced.

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