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The North Queensland Continental Shelf and Slope Surveys using TRIP

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Abstract

A Tethered Remote Instrument Package (TRIP) was employed in a survey of the demersal megafauna of the continental shelf and upper continental slope in that part of the Great Barrier Reef Province near Cairns, Queensland. The objective of the survey was to determine the extent of the demersal fish resource by surveying areas outside of the known fishing grounds.

Results of the survey indicate a marked faunal zonation roughly paralleling the coastline and seperable into near shore, near reef, and shelf edge habitats. Both near shore and near reef habitats are essentially muddy, however many small rocky outcrops occur in the latter. The shelf edge habitat is sandy with irregularly spaced low profile outcrops supporting dense growths of soft coral, large algae, and sponges. The presence of large demersal fishes in the shelf edge habitat suggests that the extent of the resource may have been previously underestimated.

Introduction

In Great Barrier Reef waters between Cape Melville and Hinchinbrook Is there are two commercial, demersal fisheries namely, that for prawns and that for coral-reef fin-fish. Because knowledge is limited and the data upon which to base sound fisheries management unavailable these fisheries continue to opperate on unknown and thus unpredictable resources. Recent research on the fin-fish fishery, for example, (Goeden, 1979) has shown that the added imposition of small, private fishing parties together with existing commercial pressures has produced a marked degradation of previously productive reef fishing grounds. Although research is underway which will provide management recommendations for the Mossman to Innisfail region, the long term value of these recommendations is intimately dependant on an understanding of the full extent of the resources in both the shallower, heavily exploited areas and the deeper, unexploited areas. In order to explore these resources the present program of trawls and remote visual observation was undertaken.

In past years research requirements on Queensland's continental shelf have been met using the more traditional techniques of trawling and sampling. Where a visual image of the study site was required limited-duration air-breathing equipment has been used. Since 1976 the Queensland Fisheries Service has been involved in the development of photographic equipment capable of extending the researcher's depth capabilities without increasing the hazards associated with deep diving. The prototype system developed to meet these requirements is a Tethered Remote Instrument Package (TRIP) which is a diverse collection of remotely controlled or automated instruments matched and integrated to perform generalized medium-depth benthic surveys. Several camera systems such as TRIP are now in use throughout the world. Some very simple systems employ television but lack elaborate control (Machan and Fedra, 1975) while very complex systems such as RUM may carry tools and manipulators (Thiel and Hessler, 1974).

This present study was designed to test and improve TRIP as a survey device and to use the full capacity of video and photo recording as a data gathering and storage medium where water clarity allowed and where sampling with nets could not be carried out.

Methods

The field operation consisted of a series of short traverses across the ocean floor utilizing TRIP and, where practicable, a one fathom try net. TRIP was used to obtain a photographic and continous video record in those areas where discernable images could be obtained. The try net provided samples from sites with 'trawlable' bottoms and proved to be the only means of gathering data over the muddy substrates near shore. The advantages of fauna sampling as a 'ground truth' suppliment to photographic surveys are discussed by Holme and Barrett (1977) and Uzmann et al (1977).

The survey system employed is similar to the "pogo stick" method (Siapno, 1975) and consists of a number of lowerings and retrivals of the gear rather than a continous strip transect.

TRIP was lowered for periods of approximately 30 minutes during which the ship towed the cameras over about 1000m of the bottom. The gear was then retrieved and the try net lowered. The trawler then steamed back over the area on a reversed course for 10 minutes at about 3 knots thus covering approximately 1000m and sampling the same habitat as surveyed on the first pass. This method was selected due to the unpredictable nature of the bottom and the need to reduce the risk of entanglements of the sampling gear among coral outcrops.

Eleven sites were surveyed between the 10 fathom and 50 fathom bathymetric contours in the Cairns region from Cape Grafton north to Port Douglas. The location of each survey site is illustrated in Figure 1. The region contains a large number of shallow coral reefs and deeper coral outcrops. There is a large input of freshwater and silt from the Barron River and Trinity Inlet during the summer monsoon. A brackish surface layer is regularly noticed as far offshore as Green Island during periods of peak runoff and light winds.

The survey site descriptions are listed together with the dates of survey in Table 1.

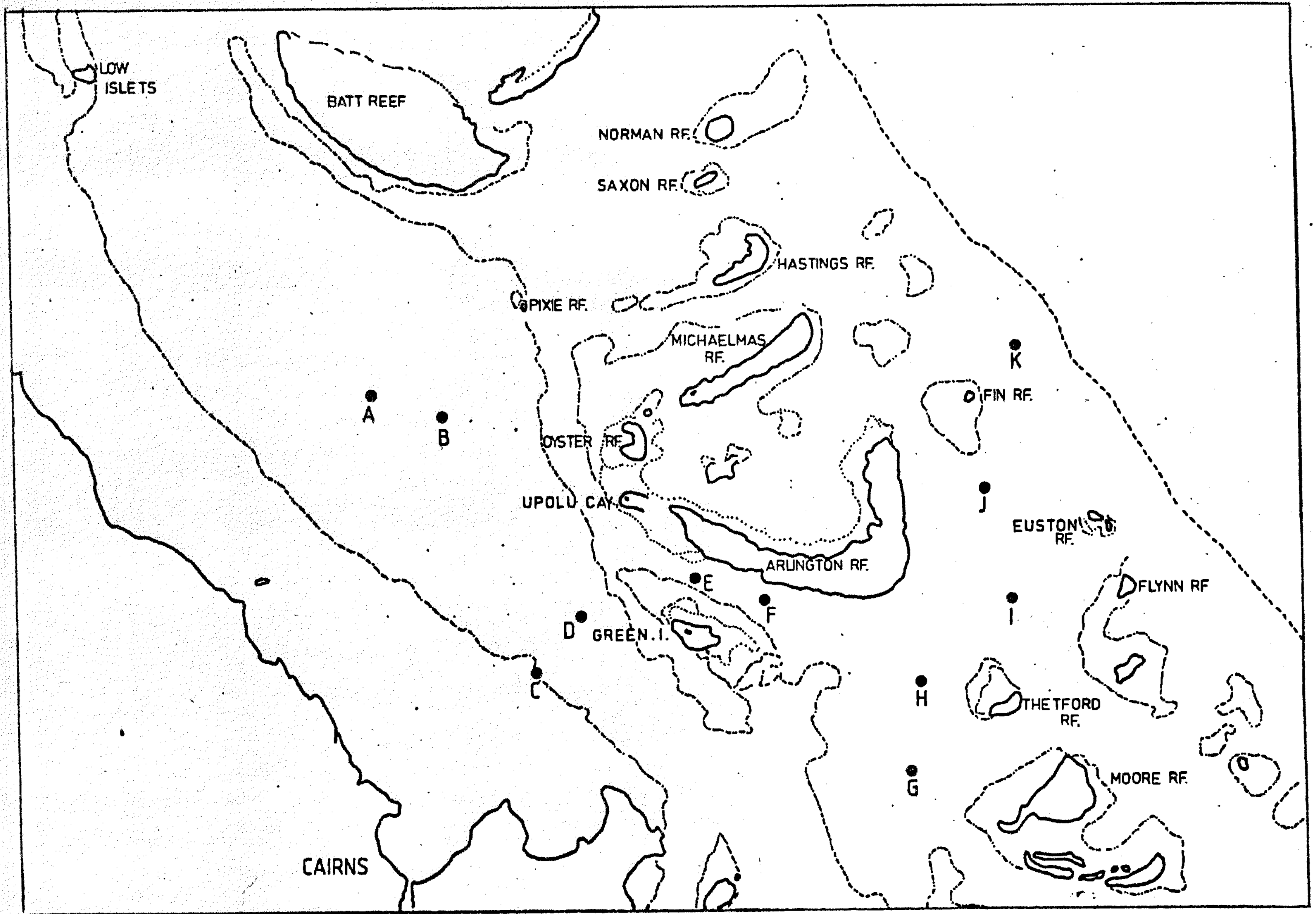
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Figure 1

Table 1. Descriptions of survey sites, 15 to 50 fathoms.

SITE	DATE	DEPTH (FMS)	BOTTOM TYPE
A	19/2/79	18	mud
B	19/2/79	15	mud
C	20/2/79	15	mud
D	20/2/79	20	mud
E	20/2/79	24	sand/mud
F	20/2/79, 12/12/79	30	sand/mud
G	21/2/79	24	mud
H	21/2/79	27	shell
I	21/2/79, 13/12/79	35	sand/mud
J	21/2/79	40	sand, sponge/coral
K	21/2/79 14/12/79	45	sand/shell and *Halimeda*

Laboratory operations consisted of the identification of trawled organisms and the numberical handling of their abundance. Video recordings and photographs are being classified in terms of habitat type, dominant sessile organisms and the number and size of any potential commercial species.

Comparisons of animal communities both between and within habitats were made using the Kolmogorov-Smirnov two sample test (Siegel, 1956) with the Goodman (1954) chi-square approximation.

Because many of the samples were small the tests tend to be conservative. The fishes were analysed at the family level and the invertebrate at the order level. The coarser grouping of invertebrates was necessary because of sample size.

The general feeding habits for the sampled fishes were established from Hiatt and Strasburg (1960) and Munro (1967) and sorted into categories of fish, large decapods, small invertebrates including cephalopods, and algae. Each fish family's diet was weighted in relation to the abundance of that family within the habitat.

Results

The results of this survey fall under two distinct headings and cover 1) the biological results of surveys carried out between 15 and 50 fathoms over the continental shelf and upper continental slope, and 2) operation and development of the survey equipment (to be published seperately). The limited depths of the survey resulted from the inability of TRIP to cope with the near vertical continental slope when it was deployed in its original sled configuration. During the period 2/79 - 10/79 TRIP was redesigned and a new unit constructed (Goeden, ms.). It is currently undergoing sea trials.

Biological Results, Continental Shelf and Upper Continental Slope

The Fish Community

Eight of the 11 sites yielded samples of fish in the try net. The three sites where fish were not taken, (ie. H, J, and K) had comparatively clear water and hard or shell bottoms. Several hundred fish were observed and video recorded at these sites and many of these could be tentatively identified (Table 2).

Table 2. Species list for fishes tentatively identified along the continental shelf and upper continental slope based on video recordings.

ORDER	FAMILY	SCIENTIFIC NAME
Myliobatiformes	Dasyatidae	Dasyatis sephen (Forskal)
Perciformes	Apogonidae	Lovamia fasciata (Shaw)
	Nemipteridae	Pentapodus nemurus (Bleeker)
	Lethrinidae	Lethrinus sp.
	Pomacentridae	Pomacentrus spp.
	Chromidae	Chromis dimidiatus (Klunzinger)
	Coridae	Thalassoma sp.
		Halichoeres sp.
	Zanclidae	Zanclus canescens (Linnaeus)
	Acanthuridae	Acanthurus xanthopterus (Valenciennes)

A total of 105 fish were collected on the continental shelf representing 14 families and 19 species (Table 3). Of these fish the Lethrinids and Platycephalids have the greatest market potential.

Between Habitat Analysis : Fish Communities

The eleven sites were divided into three fairly distinct habitats based on bottom type and proximity to the coast, coral reefs, or shelf edge. The habitat types are :

I near shore - characterised by a muddy bottom and depths of 20 fathoms or less paralleling the coast (sites A, B, and C).

Table 3. Species list for fishes collected between 15 and 50 fathoms.

ORDER	FAMILY	SCIENTIFIC NAME
Myctophiformes	Synodontidae	*Saurida tumbil* (Bloch)
		S. undosquamis (Richardson)
Pleuronectiformes	Psettodidae	*Psettodes erumei* (Bloch and Schneider)
	Bothidae	*Arnoglossus intermedius* (Bleeker)
		Bothus ovalis (Regan)
		Grammatobothus pennatus (Ogilby)
		Pseudorhombus elevatus (Ogilby)
Syngnathiformes	Fistularidae	*Fistularia petimba* (Lacepede)
Perciformes	Leiognathidae	*Leiognathus sp.*
	Apogonidae	*Lovamia fasciata* (Shaw)
	Priacanthidae	*Priacanthus tayenus* (Richardson)
	Nemipteridae	*Nemipterus peronii* (Valenciennes)
	Lethrinidae	*Lethrinella nematacantha* (Bleeker)
	Mullidae	*Upeneus vittatus* (Forskal)
	Platycephalidae	*Platycephalus indicus* (Linnaeus)
		Platycephalus sp.
Tetrodontiformes	Lagocephalidae	*Gastrophysus spadiceus* (Richardson)
	Aluteridae	*Scobinichthys granulatus* (Shaw)
Lophiiformes	Antennariidae	*Tathicarpus muscosus* (Ogilby)

II near reef - characterised by a sand/mud bottom between 20 and 35 fathoms and near the shallow coral reefs (sites D, E, F, G, & I).

III shelf edge - hard sand and rubble bottoms with shell and coral ranging from 27 to 45 fathoms along the continental shelf edge and intruding into Grafton Passage (sites H, J, and K).

The fish community structures of the near shore and near reef habitats were compared. The two habitats had significantly different fish faunas ($p < .001$). The near shore fish community was characterised by Leiognathids, Nemipterids, and Mullids while the near reef fish community was characterised by Bothids and Apogonids.

The shelf edge fish community could not be treated in the statistical analysis of try net data since no fish were taken, however less than 20% of the tentatively identified species occurred in either of the other two habitat types and the proportion relative to species composition is even lower due to the abundance of Pomacentrids among the observations. Because of this difference the shelf edge fish community is treated here as "significantly different" from the other communities. Figure 2 is a zonation map for the three fish communities. Zone boundaries follow bathymetric contours or are located approximately equidistant between sample sites.

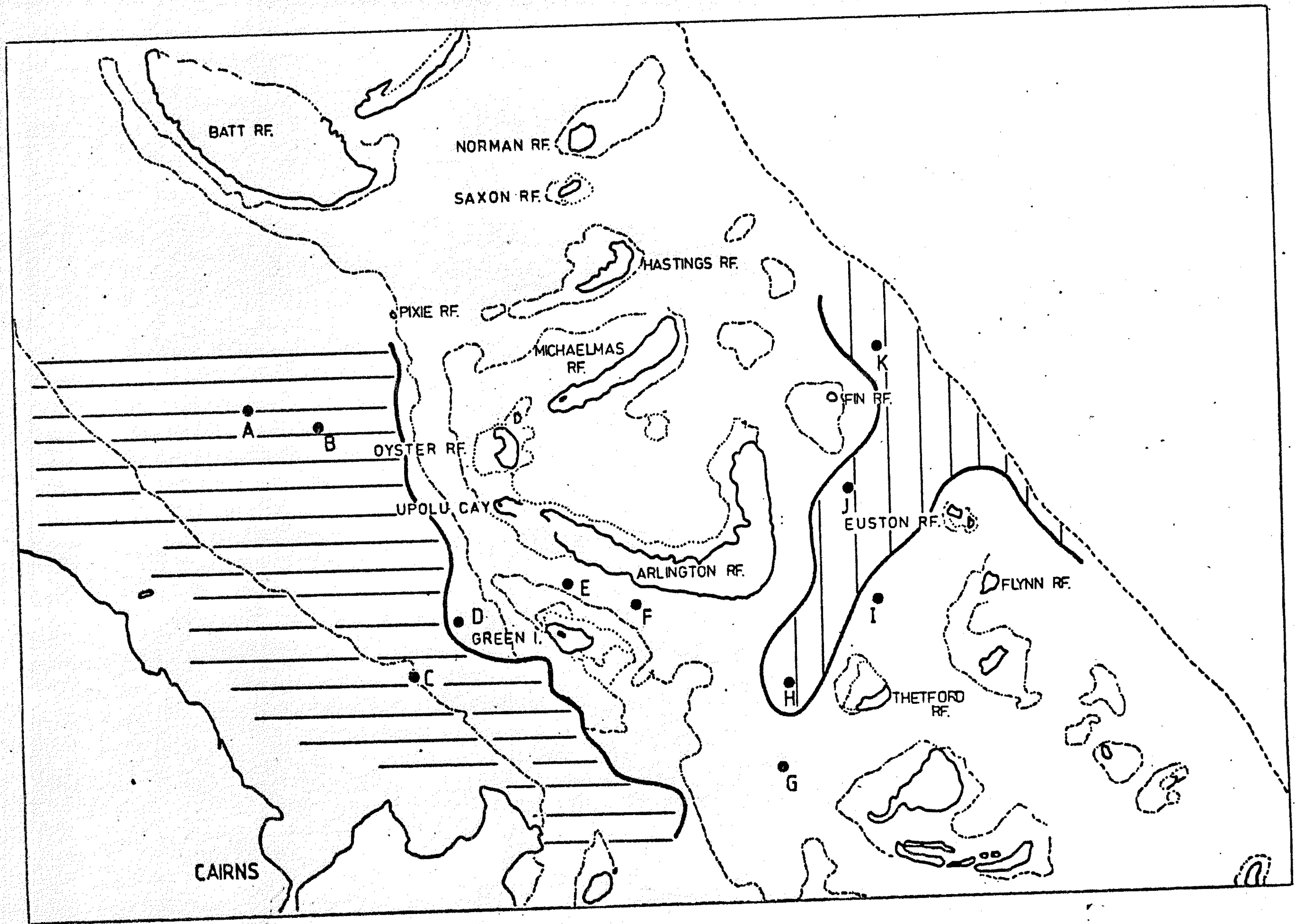
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Figure 2

Within Habitat Analysis, Fish Communities

Between site comparisons were made within each habitat. Each site within the near shore habitat was equal to each other site (ie. A=B, B=C, and A=C). Within habitat analysis of the near reef fish community demonstrated that each site was equal to each other site. Sites G and E may have been marginally different from each other ($p < .10$) but the samples from these sites were too small to demonstrate a more significant relationship.

The Invertebrate Community

Each of the eleven sites yielded samples of the invertebrate community in the try net. Table 4 lists the species obtained in the samples. Commercially valuable invertebrates included *Amusium balloti*, *Sepia sp.*, *Penaeus semisulcatus*, and *Thenus orientalis*.

Between Habitat Analysis, Invertebrates Communities

Each habitat's invertebrate community was significantly different from each other. The near shore invertebrate community differed from the near reef community ($p < .05$) due to the abundance of Gymnolaemata (Bryozoans) and Crinoids in the latter. The near shore invertebrate community is characterised by an abundance of Asteroids and bivalves.

The near reef invertebrate community was significantly different ($p < .001$) from the shelf edge community due to the abundance of Cnidarians, in the former.

Table 4 Species list for invertebrates collected between 15 and 50 fathoms.

PHYLUM ORDER	FAMILY	SCIENTIFIC NAME
PROTOZOA		
Sarcodina	Foraminifera	*Discobotellina biperforata*
PORIFERA		
Demospongiae	Choristidae	*Stellata* ?
		Jaspis ?
	Dictyoceratida	*Dysidea* ?
	Halichondrida	*Halichondria* ?
	Haplosclerida	*Haliclona* ?
CNIDARIA		
Hydroida	Aglaopheniidae	*Lytocarpus* sp.
	Syntheciidae	*Synthecium* sp.
Gorgonacea	Anthothelidae	*Iciligorgia* ?
	Briareidae	*Solenocaulon* sp.
	Ellisellidae	*Ellisella* ?
Alcyonacea	Nephthyidae	*Dendronephthya* sp.
	Siphonogorgiidae	*Siphonogorgia* ?
Antipatharia	Antipathidae	*Cirripathes* sp.? A
		Cirripathes sp.? B
Pennatulacea	Veretillidae	*Lituaria australasiae*
Telestacea	Telestidae	*Telesto rubra*
		Telesto sp.
Zoantharia	Zoanthidae	*Sphenopus marsupialis*
Scleractinia	Poritidae	*Alveopora mortenseni*
	Fungiidae	*Diaseris* sp.
	Faviidae	*Caulastrea furcata*
BRYOZOA		
Gymnolaemata	Cheilostomato	*Nellia oculata*
		Nellia sp.
		UNDETERMINED 3 spp.?

CRUSTACEA		
Stomatopoda	Squillidae	Squilla woodmasoni
Decapoda	Peneidae	Penaeus semisulcatus
	Palinura	Thenus orientalis
	Brachyura	Cryptopodia queenslandi
		Portunis argentatus
		P. pelagicus
		P. rubromarginatus
		P. tenuipes
MOLLUSCA		
Gastropoda	Xenophoridae	Xenophora sp.
	Bursidae	Bursa sp.
	Fasciolariidae	Fusinis sp.
	Strombidae	Strombus erythrinus
Bivalvia	Pectinidae	Amusium balloti
	Spondylidae	UNDETERMINED
Cephalopoda	Sepioidea	Sepia sp.
	Loliginidae	Loligo sp.
	Teuthoidea	Peronella lesueri
ECHINODERMATA		
Crinoidea	Colobometridae	Coenometra bella
	Comasteridae	Comantheria rotula
		Comaster sp.
		Comatula purpurea
		C. rotularia
	Zygometridae	Zygometra microdiscus
		Z. comata
	Himerometridae	Heterometra variipinna
Asteroidea	Astropectinidae	Astropecten zebra
	Goniasteridae	Anthenea mertoni
		Stellaster equestris
	Oreasteridae	Pentaceraster gracilis
	Metrodiridae	Metrodira subulata
Echinoidea	Diadematidae	Astropyga radiata
	Laganidae	Peronella lesueuri
	Toxopneustidae	Tripneustes gratilla

Ophiuroidea	Ophiotrichidae	Placophiothrix melanosticta
		Macrophiothrix sp.
		Ophiothrix mereidina
		O. martensi
		O. miles
Holothuroidea	Phyllophoridae	Phyllophorus holothuroides
UROCHORDATA		
Ascidiacea	Ascidiidae	Phallusia depressiuscula
	Styelidae	Polycarpa clavata
		P. pedunculata

The near shore invertebrate community was also significantly different ($p < .001$) from the shelf edge community. The invertebrate community along the shelf edge was dominated by Demospongids while the near shore community was dominated by Asteroids.

The zonation of these different invertebrate communities follow that of the fish communities (Figure 2).

Within Habitat Analysis, Invertebrate Communities

The invertebrate community structure within each habitat was investigated by between site comparisons. Each site within the near shore habitat had invertebrate community structures that were statistically inseparable (ie, A=B, B=C, and A=C). Site by site comparisons of the near reef community revealed that the invertebrate community at site I differed significantly from sites D ($p < .05$), E ($p < .05$), and F ($p < .02$). All other site combinations were equal. Within the shelf edge community site J was marginally different from site H ($p < .10$) and differed significantly from site K ($p < .02$). Site I (near reef) and the shelf edge sites had similar communities.

Although between habitat analysis demonstrated significant difference between the zones of Figure 2, within habitat analysis indicates that site I is more closely associated with the shelf edge than with the near reef invertebrate community. This association would alter the invertebrate community zonation to Figure 3. The difference between sites J and H-K suggests that there may be a small scale variation in habitat in this region.

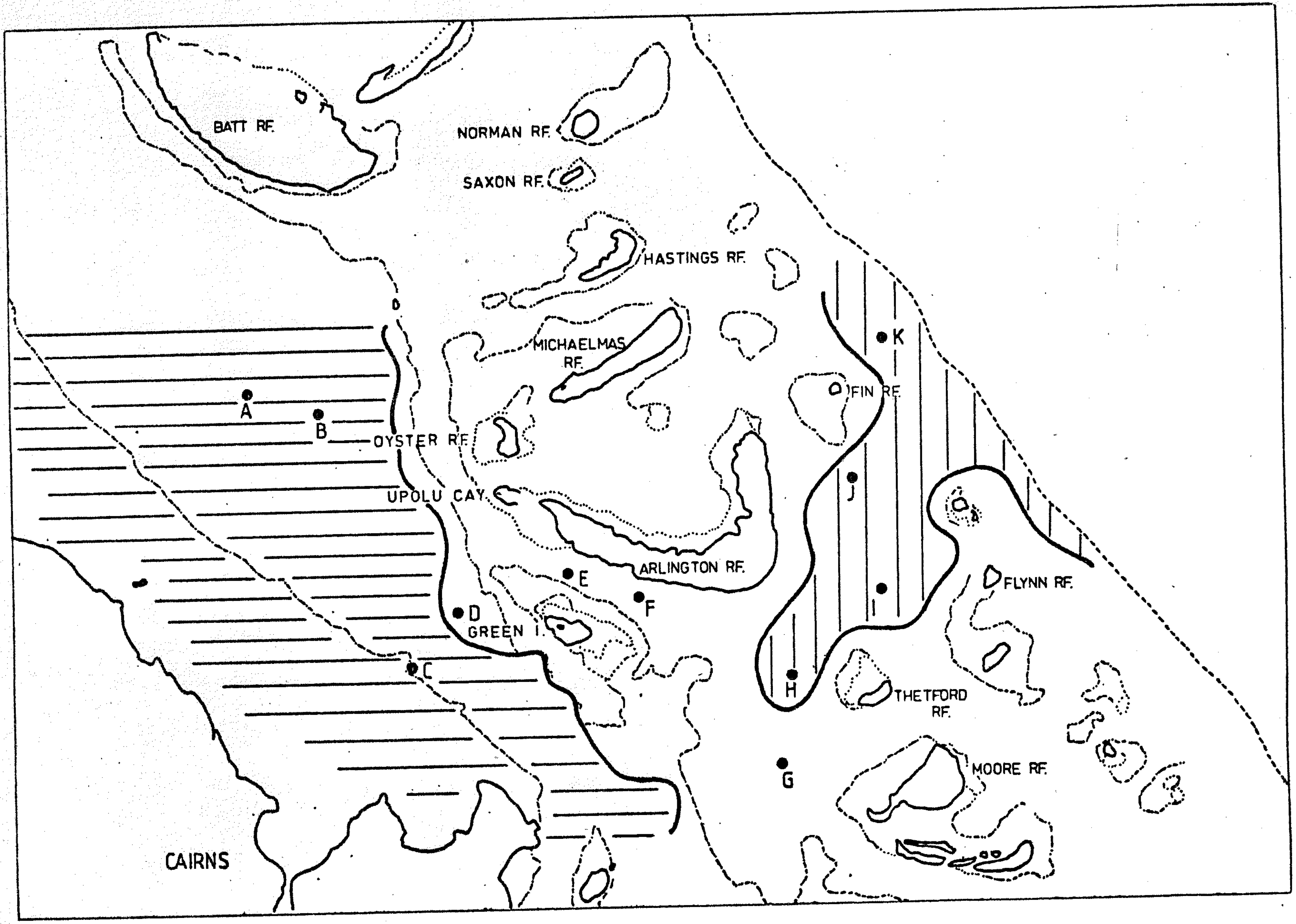
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Figure 3

The Total Community

The fish and invertebrate collections were pooled for each site and and analysed using the same procedure as applied to fish and invertebrates separately.

Each habitat had a significantly different fauna ($p < .001$) when compared with each other habitat. The near reef fauna was relatively rich in Bryzoans and Echinoderms relative to the near shore fauna but poorer in Porifera and Cnidaria relative to the fauna of the shelf edge. This same abundance of Porifera and Cnidaria within the shelf edge community seperates it from the near shore collections. An artists impression of the video tape recordings from each habitat is used to demonstrate both structural and community differences on a scale larger than could be photographed at any one time (Figure 4).

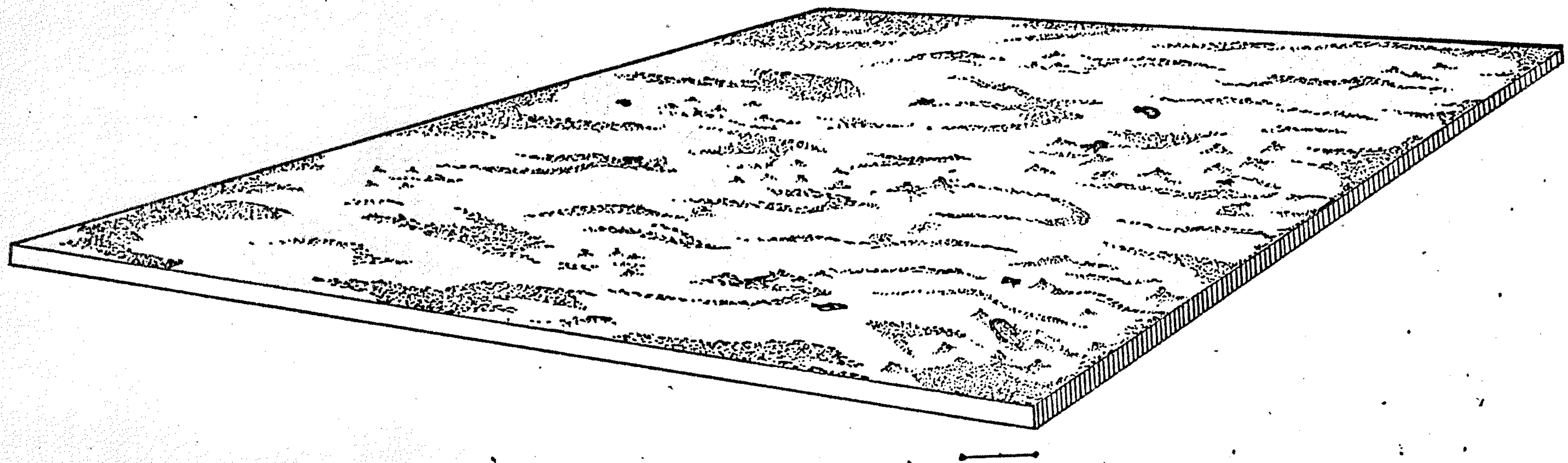
Discussion

The Cairns offshore region, corresponding to the continental shelf and upper continental slope, can be broadly separated into three quite distinct habitats based upon depth and sediment types which correspond to near shore, near reef, and shelf edge locations. Within these habitats the distribution of the megafauna is fairly uniform. These findings are echoed in the work of Grassle et. al. (1975) for bathyal megafauna where distribution only varied markedly between each of the depth regimes sampled. Other workers have found depth correlated distributions for bathyal macrofauna (Hartman, 1965, Sanders and Hessler, 1969, Jones and Sanders, 1972).

Figure 4a

Artist's impression of the near shore habitat.

Scale line is approximately 1m.



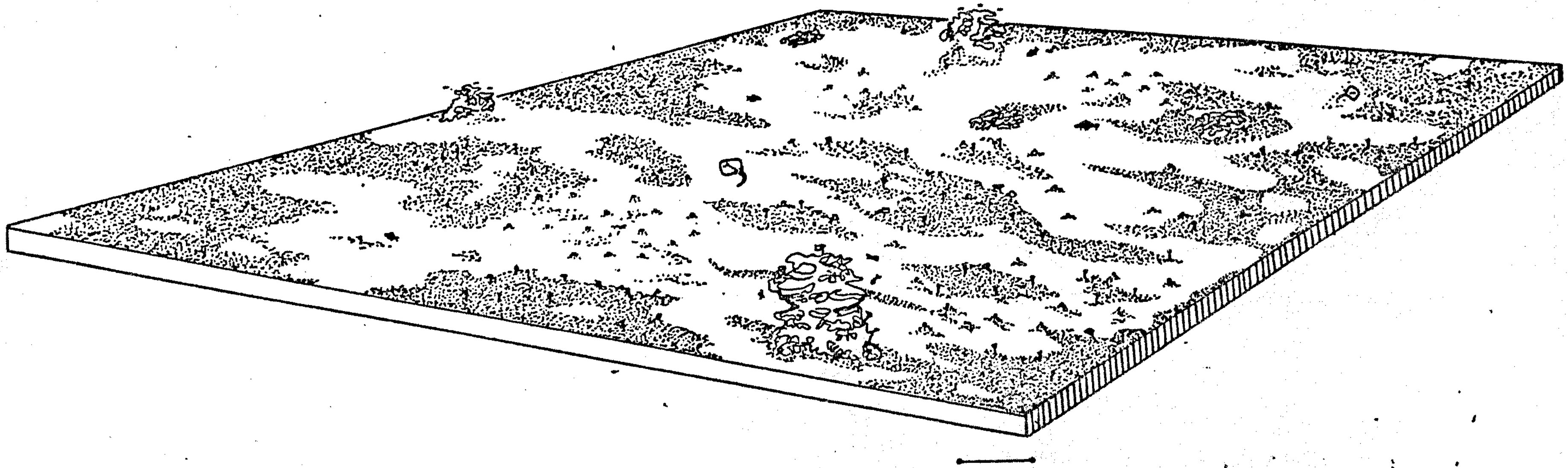


Figure 4b

Artist's impression of the near reef habitat.

Scale line is approximately 1m.

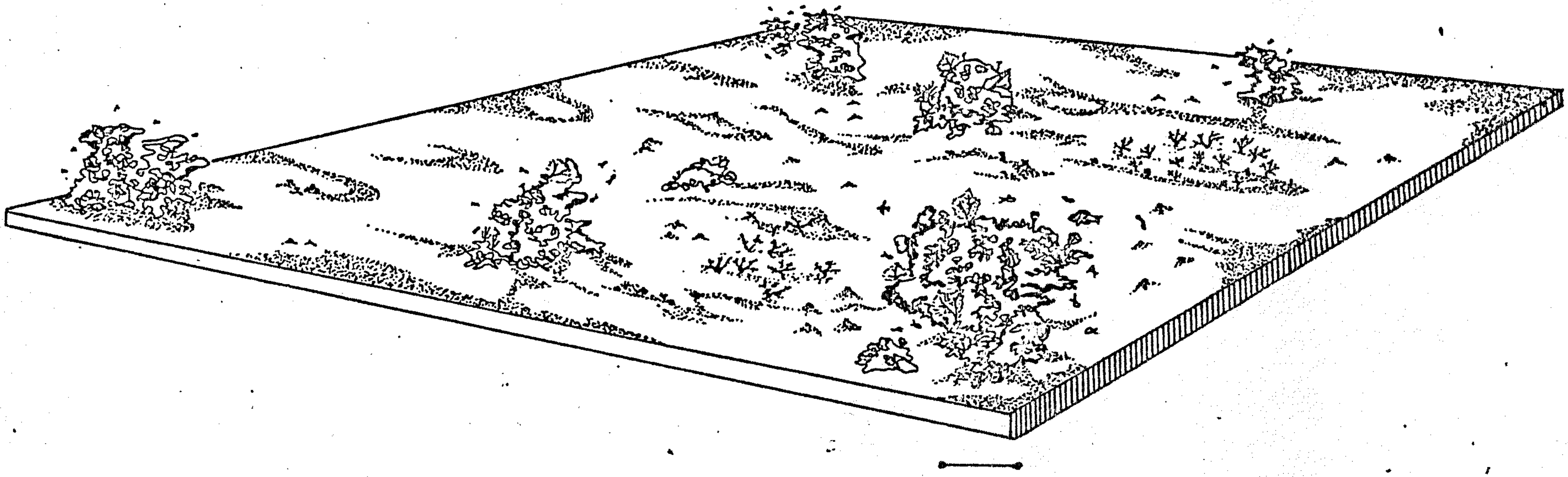


Figure 4c

Artist's impression of the shelf edge habitat.

Scale is approximately 1m.

Analysis of the data demonstrated that there is an intrusion of shelf edge fauna into the near reef area in Grafton Passage. In addition to depth constraints within Grafton Passage, tidal flushing of the water mass and scour of the substrate may reduce the chances of survival for organisms adapted to the muddy and turbid conditions found in the near reef and near shore habitats.

Although there is largely congruence between fish and invertebrate community distributions, it is apparent that a slightly greater diversity can be found among the invertebrate sample sites than the fish sample sites. It is our contention that these differences are the result of the way the organisms utilise their habitat.

All of the demersal fishes collected were relatively large and mobile organisms. It is likely that they moved over fairly large areas of the substrate in search of invertebrate and some small-fish prey items.

Considerable movement of the megafauna certainly characterises bathyal regions. Dayton and Hessler (1972) and Hessler and Mills (1972) have demonstrated an unexpected abundance of large mobile predators (mostly fish) in the deep sea. Wolff (1977) states that baits dropped into these areas are stripped within a few hours by amphipods and fish which enter the area.

If mobility also characterizes the demersal fish community in the 15 to 50 fathom range, then a high degree of intra-community mixing may be possible. The significant differences between invertebrate communities from one habitat to the next probably represent differences in the fishes' food resources between these habitats. Such differences would tend to restrict mixing of demersal fishes between habitats. Thus the fish communities appear to partition the continental shelf on a coarse scale, similar in magnitude to the area of the habitat types.

The invertebrates were, by contrast, largely sessile organisms and many of these were attached. The abundance of many of these would be dependant on a host of factors including the availability of suitalbe surfaces (eg. rocky outcrops), siltation rate, and water movements. Invertebrate mixing between sites may be less a matter of elected movements and more a measure of successful recruitment to specific microhabitats. The invertebrates apparently partition the continental shelf on both fine and coarse scales. The distribution of a particular taxa is probably related closely to the distribution of certain microhabitat types. These fine scale variations may account for the lower within habitat similarities shown by the invertebrates (eg. the shelf edge community) and bring about more loosely defined communities. On the coarser scale these communities, which may be quite diverse, are statistically seperable at the taxonomic level of orders. The distribution of these coarser community divisions seems to follow boundaries recognised by the demersal fish communities and may be a consequence of broader environmental conditions.

Both near shore and near reef habitats were muddy and maintained a thick nepheloid layer extending several metres above the substrate. Although this habitat supported a variety of small prey items, the dinsity of nepheloid material was so great that these items may have been very difficult to locate and rare from the predatory fish's point of view. Comparisons of the weighted generalised feeding habits of fishes in the near shore habitat with those in the near reef habitat suggest that, although the kinds of fish may differ, their feeding strategies are the same. Fish made up approximately 40% of the combined prey while large decapods and small invertebrates each made up about 30%. Only two of the sampled fishes were at all herbivorous. Sedberry and Musick (1978) found that most demersal fishes from the upper continental slope either fed on smaller pelagic fishes or benthic invertebrates. His examination of their gut contents indicated almost complete reliance on the organic matter of the nepheloid layer as the foundation for the mesopelagic food wed. A similar system seems likely for the near shore and near reef habitats of the Cairns region.

In contrast with Sedberry and Musick's (1978) work, our results show that the shelf edge habitat along the upper continental slope had little nepheloid material. Its trophic base was apparently founded on coral and algae beds which Emery (1978) states, "contribute significantly to an increase in diversity within (its) fish communities".

The existence of such a complex community along the shelf edge or upper slope is somewhat surprising in view of the less "diverse" nature of the near shore and much of the near reef areas. Although very limited working time was available to TRIP several commercial demersal fish (Lethrinids) were observed along the upper slope. It appears likely that other valuable species will be found in this area and possibly in large numbers.

That high relief bottoms with extensive algal cover, such as those located within the shelf edge habitat, may support large standing crops of resident fishes is indicated by the work of Russell (1977). He found that high relief areas supported up to 100 times the biomass of resident species found in low relief areas and in general varied little between temperate and tropical situations. It is our contention that there is now some evidence to suggest that the demersal reef fish resource in the Cairns region may be considerably larger than previously assumed and that those areas along the upper continental slope may provide some recruitment to the shallower, heavily fished coral reef stocks. Attempts to harvest selected species from this area may result in a rapid decline in the megafaunal diversity (Emery, 1978) and may, under conditions of heavy fishing, result in unpredictable and relatively permanent changes to the shelf edge community (Goeden, ms.).

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