A. F. Amos

BATHYMETRIC AND HYDROGRAPHIC SURVEY OF THE COASTAL WATERS OF THE DOMINICAN REPUBLIC

Final Report

to

Instituto Dominicano de Tecnologia Industrial (INDOTEC)

prepared by

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THE PROXIMITY OF DEEP WATER TO TROPICAL COASTLINES

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1978

CHAPTER V

SITE CHARACTERISTICS

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INTRODUCTION

The approach to the site characteristics problem has been to examine the coastal bathymetry and hydrography for the entire tropical oceans (between 20^{o}N and 20^{o}S latitude). Due to the limited time available, the goals were confined to: (1) obtaining the data base, (2) a preliminary survey of suitable bathymetric locations, (3) a preliminary examination of suitable temperature difference (ΔT) locations, (4) a more detailed hydrographic study of one 10^{o} latitude x 10^{o} longitude region in the Caribbean, (5) the development of a computer system for storage, retrieval and display of OTEC hydrographic data, and (6) forming some tentative conclusions on site selection criteria and suitable coastal regions where actual sites may be selected for more detailed investigation. The guidelines have been strictly limited to suitable ΔTs and the proximity of deep, cold water to a shoreline. No demographic, political or geological (other than submarine) parameters have been studied except on a very broad scale. These crucial points must be taken into consideration for any final site selection.

THE DATA BASE

Bathymetric Data

For the initial data base, all the coastal charts for the entire OTEC-feasible region were obtained using the Catalog of Nautical Charts (U.S. Defense Mapping Agency, 1977). More detailed charts of selected regions were also obtained, in particular the Pacific Ocean islands. Much of the unequal geographical distribution of data mentioned in the next section also applies to bathymetry. The nautical charts show soundings made along ships' tracks (frequently commercial ships) in fathoms, and are usually crudely contoured at the 100 fm and 1000 fm depth offshore. Concentrations of data are found adjacent to populous countries, large harbors and economically strategic straits, isthmuses and offshore islands. The more data available, the more reliable it will be. Much specialized offshore bathymetric data exists, none of it synthesized in a comprehensive data bank:

—Large-scale bathymetric charts have been produced, notably those of Heezen and Tharp (1961, 1964, 1968, 1971). These are useful for broadly defining coastlines that are potential OTEC regions.

—Many detailed surveys have been done by oceanographic research institutions for selected regions and a literature search would have to be done to locate these.

—Regional bathymetric maps, most of which are unpublished, have been produced by such institutions.

—Seismic surveys carried out by universities, government, and particularly commercial oil exploration companies, exist for a variety of offshore regions. Generally, OTEC and offshore oil environmental requirements are diametrically opposed: OTEC requires deep water as close as possible to shore, offshore oil exploration is limited to comparatively shallow water and may be many tens of kilometers from shore. However, offshore oil exploration is continually extending into deeper waters and these seismic surveys may be the most valuable source of detailed nearshore topography for OTEC site selection.

—Some detailed bathymetric charts are available for regions in the Gulf of Mexico and U.S. east coast (NOAA, 1977).

—Bottom contour charts (BC charts) are available for the Pacific to 7° latitude, each chart, and have been produced from 1952. They are frequently contoured on insufficient data and have limited application for OTEC technology.

— Other bathymetric charts are available from foreign agencies such as the British Admiralty.

All of these sources will have to be studied for any detailed OTEC site selection survey.

Hydrographic Data

The major archive for hydrographic data is the National Oceanographic Data Center (NODC) in Washington, D.C., part of the National Oceanic and Atmospheric Administration (NOAA). NODC has on file some 600,000 hydrographic stations and over 1,000,000 bathythermograph (mechanical and expendable) observations. In this preliminary effort, no bathythermographic (BT) data were obtained. The format of these BT data is different from standard NODC station data and there was not enough time to obtain and process the huge volume of information as well as the station data. BTs will be an important data base for future OTEC ΔT studies and site selection. The station data are important because they include information on salinity, oxygen and micronutrients as well as temperature—all parameters of interest to any mariculture aspect of OTEC technology.

To avoid getting unneeded data, computer generated maps showing hydrographic station distribution by 2° squares (2° of latitude x 2° of longitude) were first obtained. Figure V-1 shows the data density in regions adjacent to the continents or in open ocean areas where islands are located. In many coastal regions there is a surprising paucity of data. In many regions there are statistically insufficient data to examine monthly variations in water-column structure (for example, the northeastern coast of Brazil and the Pacific coast of Mexico and Central America). Both of these regions are potential OTEC sites.

Our initial data collection was limited to 1° squares, adjacent to coastlines and only where a preliminary examination of world-wide offshore bathymetry indicated that suitable water was close to shore. To refine the data base further, a ΔT of $20^{\circ}C$ was adopted as a selection criterion (Office of Technology Assessment, 1978). Using the U.S. Department of Energy (1978) ΔT maps, those areas where the yearly average $\Delta T < 20^{\circ}C$ at 1000-m depth were eliminated from the search. A standard NODC printout was ordered: temperature vertical array summaries by month for each of the selected 1° squares. This was the maximum amount of processing NODC could do in the allotted time frame imposed by this proposal. Magnetic tapes of all station data (from 1900 to the present) in these squares were ordered from the archives of NODC. These tapes have not yet arrived at this writing. Consequently, nothing could be deduced about coastal distribution of nutrients for inclusion in this report.

The preliminary analysis of these data showed that the initial criteria had been too selective. OTEC technology requirements arbitrarily divide the physical world of hydrography and bathymetry into isolated regions that are really connected in nature. In order to understand the system that produces the temperature gradients and the sub-sea topography, one must go outside the bounds of OTEC restrictions. Consequently, the rest of the existing data in 1^o squares bordering coastlines was ordered and the region was extended into such areas as the Middle East (northwestern Indian Ocean, Persian Gulf, etc.) and the northern Gulf of Mexico, Florida and the Caribbean. These data have not yet arrived and this report will be confined to the 20^oS to 20^oN zone.

One thing that readily emerges from examining the distribution of station data on archive (Figure V-1), is its extreme spatial heterogeneity. Several reasons can be cited for this, many of them not directly related to oceanography. The overwhelming majority of stations have been collected by the major industrial nations (56% by Japan, U.S.A. and U.S.S.R.)*, consequently, station distribution is intensified around those nations' coastal regions or in areas that are of strategic or economic importance to those nations.

— Only 56* of the more than 120 nations that have coastlines bordering oceans report data to the World Data Center A.

— Waters adjacent to politically sensitive coastlines are undersampled.

— Coastlines remote from major ports are undersampled.

— Regions of unique oceanographic interest have been intensely surveyed (e.g. major current systems, upwelling regions, river outflows).

— Where major international cooperative investigations have taken place (CUEA, GATE, BOMEX, etc.) there are concentrations of data.

*NODC, 1977.

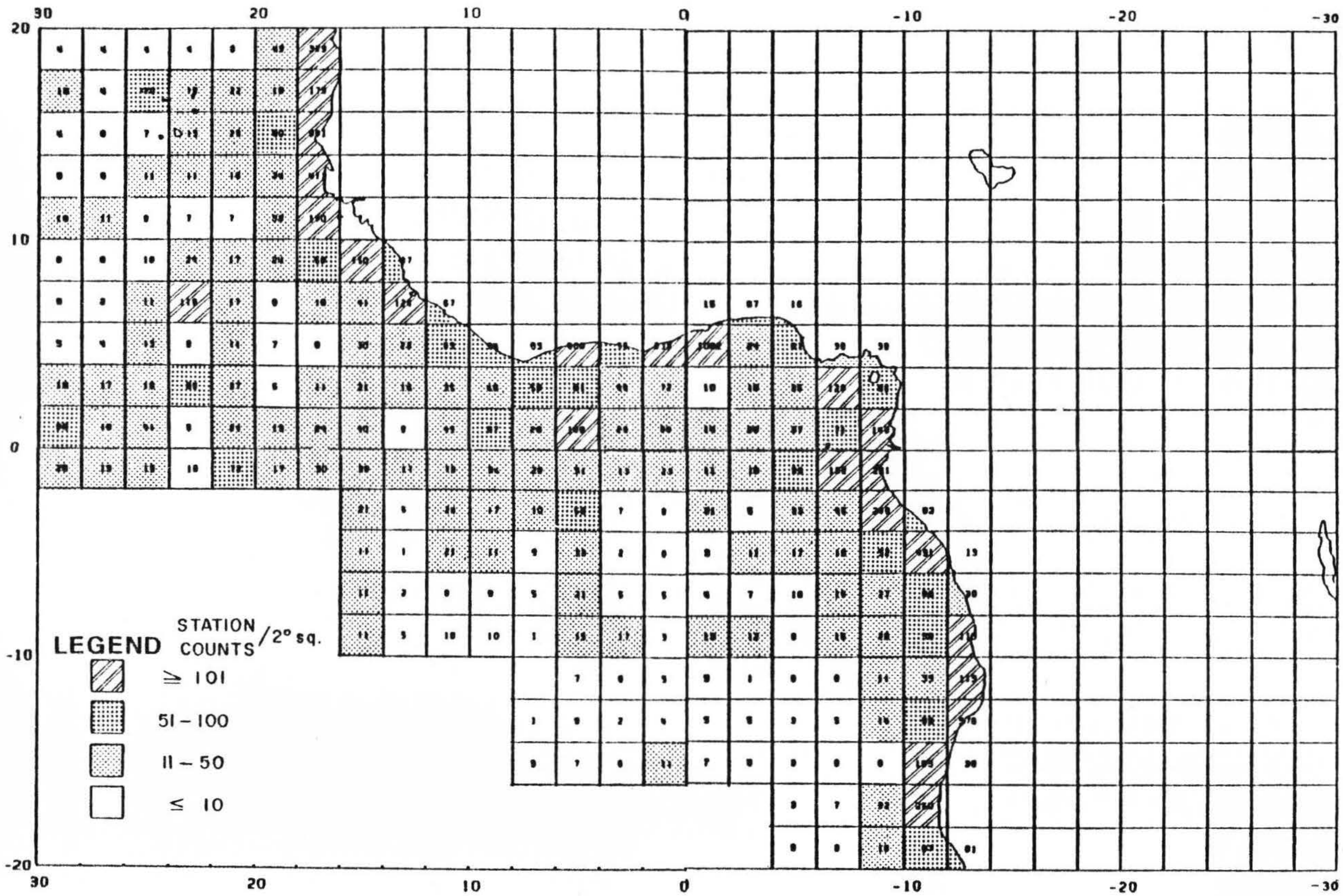


Figure V-1: Distribution of archived station data near coastal regions in the tropics. (A) West coast of Africa

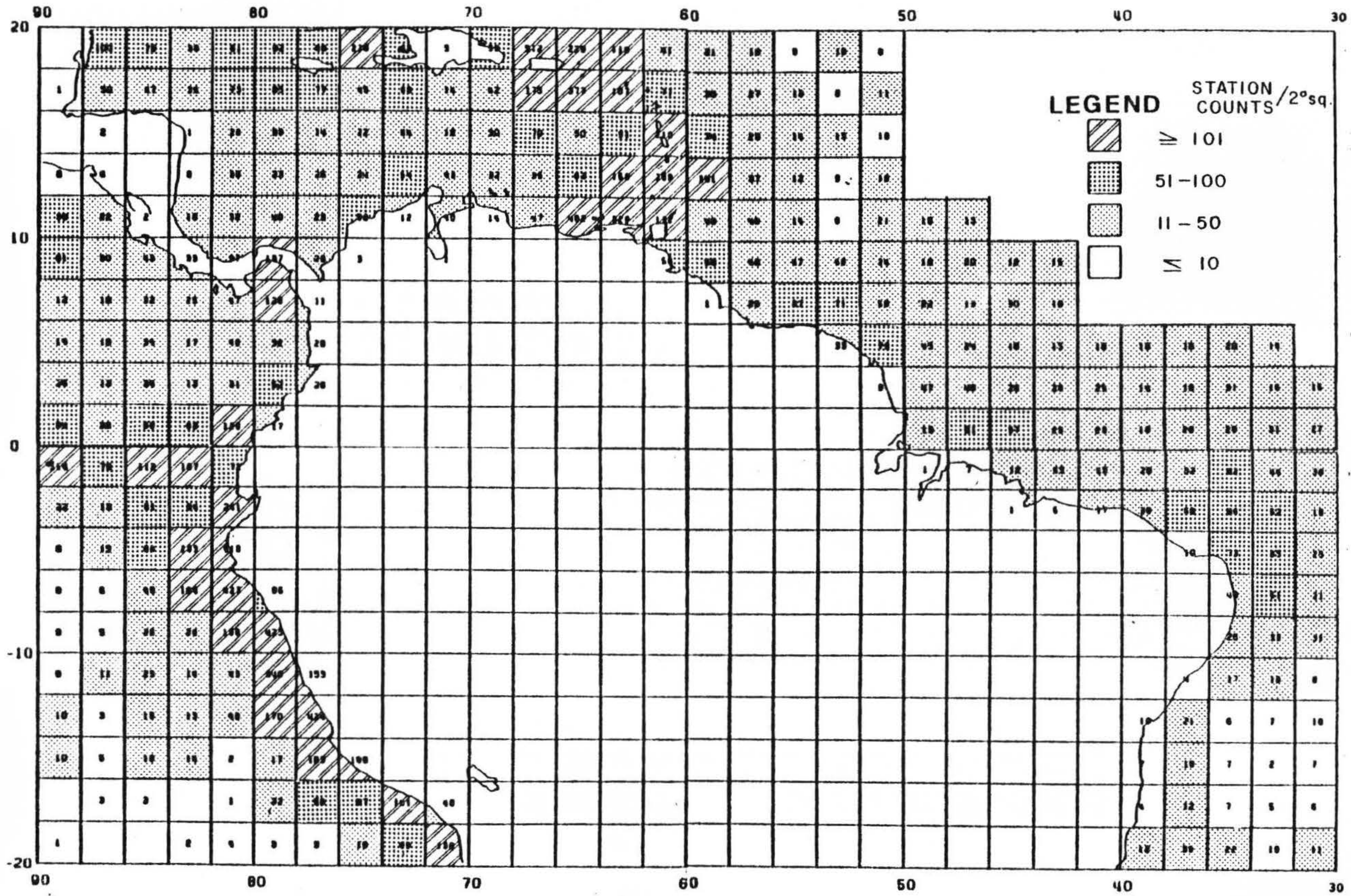


Figure V-1: Distribution of archived station data near coastal regions in the tropics. (B) Central America, the eastern Caribbean and South America

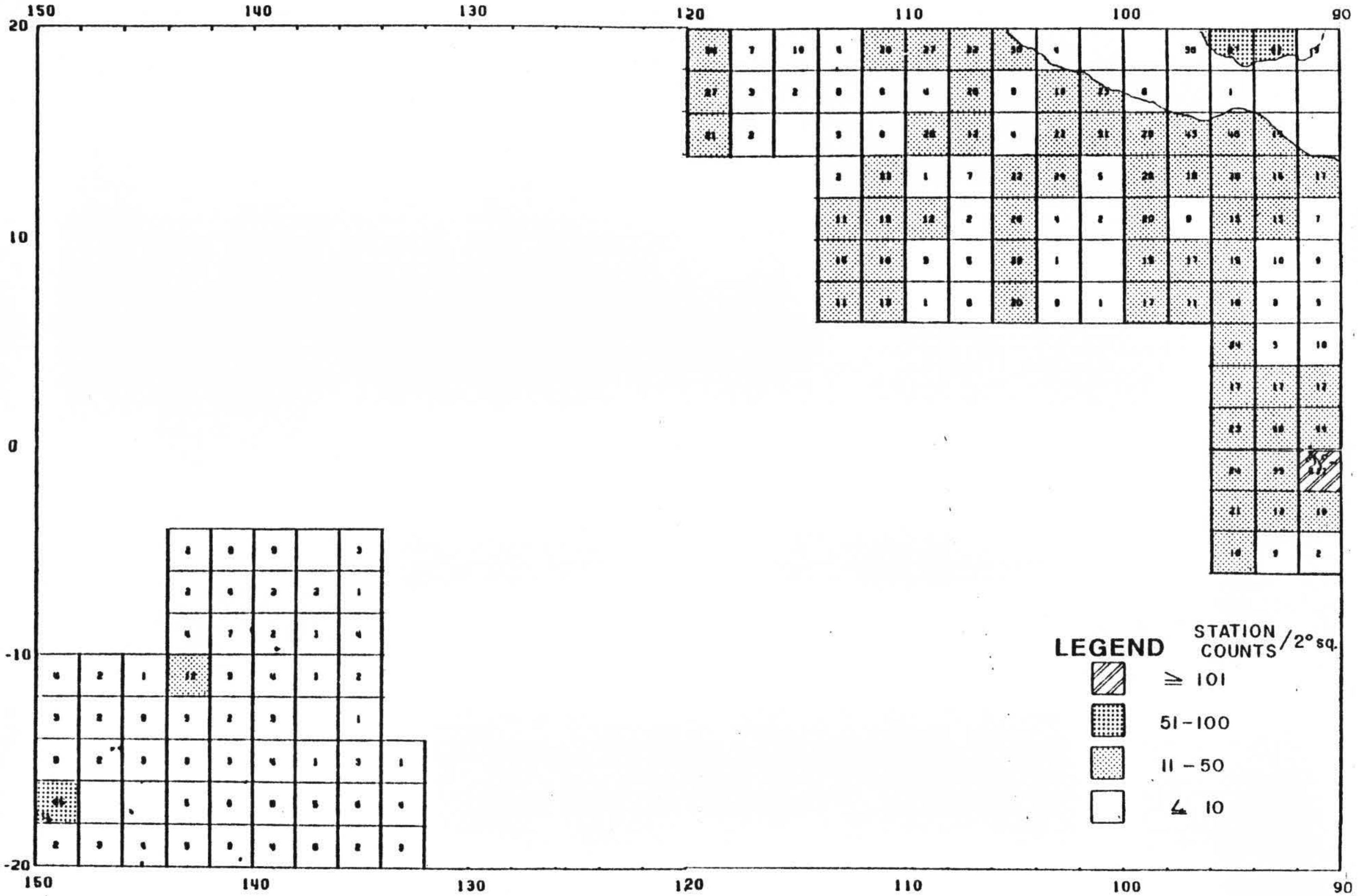


Figure V-1: Distribution of archived station data near coastal regions in the tropics. (C) Pacific coast of Central America, Pacific Ocean (Oceania) from Galapagos to Tahiti

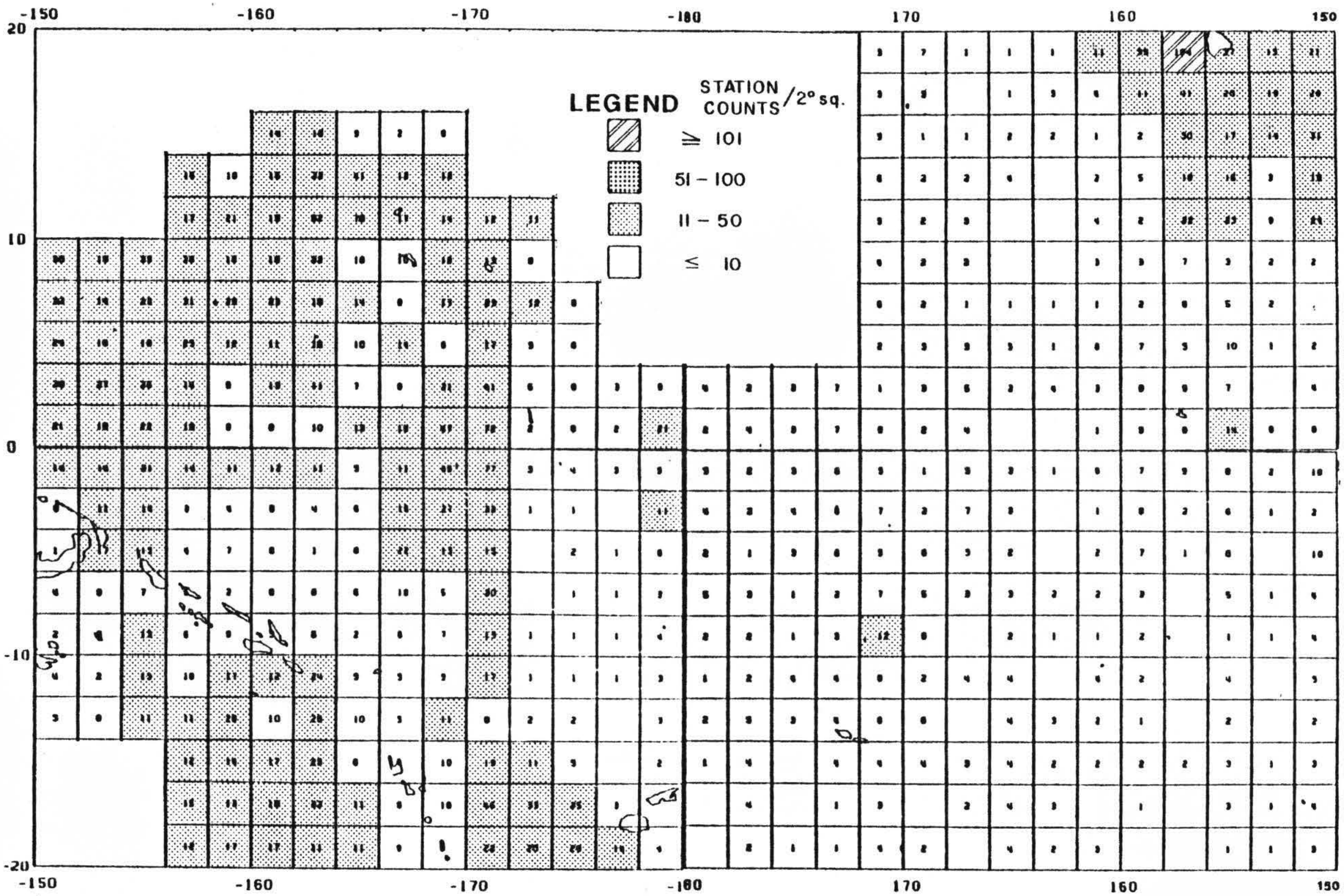


Figure V-1: Distribution of archived station data near coastal regions in the tropics. (D) Pacific Ocean (Oceania) from Hawaii to the Bismarck Archipelago including parts of Papua-New Guinea, Fiji, Marshall Islands, Samoa and Tonga

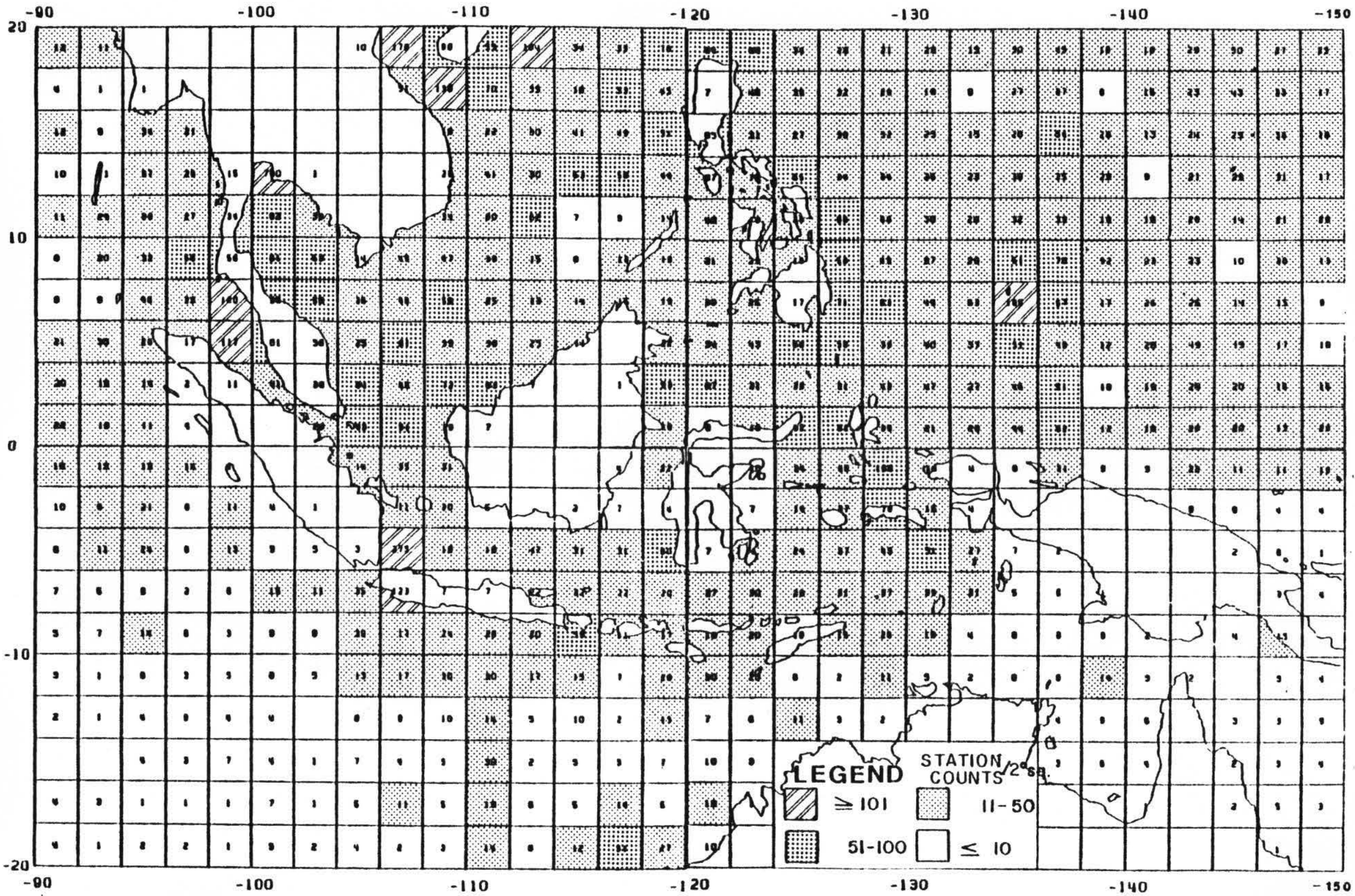


Figure V-1: Distribution of archived station data near coastal regions in the tropics. (E) Southeast Asia including Indonesia and the Philippines and part of Oceania, including Papua-New Guinea, Northern Australia, the Carolines and Marianas

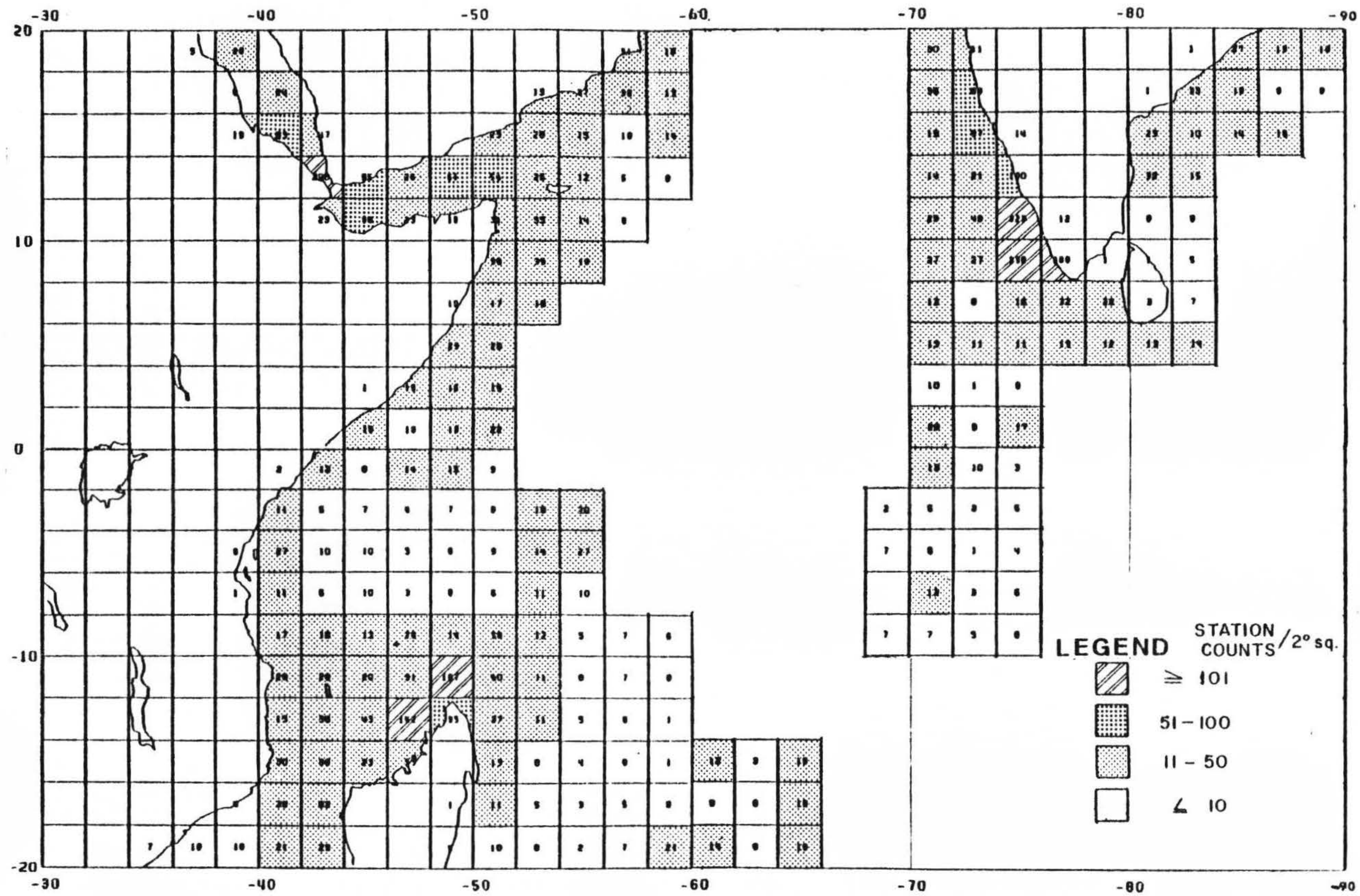


Figure V-1: Distribution of archived station data near coastal regions in the tropics. (F) The Indian Ocean, India, Sri-Lanka, Malagasay Republic, the east coast of Africa, Gulf of Aden and Red Sea

—Research cruises in coastal regions are often biased seasonally because small research vessels are unable to work during winter months. In the tropics, however, more stations may be found in the winter months as it becomes more attractive to work in warm waters at that time of year.

As an example of how this affects site selection, both coasts of equatorial Africa have zones that are potential OTEC sites (from an oceanographic point of view). Due to some of the reasons cited above, the west coast has been intensely sampled while the east coast has been sparsely sampled (see Table V-1).

TABLE V-1 STATION DISTRIBUTION OFF COASTS OF EQUATORIAL AFRICA

Latitude	Number of Stations Within 2° Squares Adjacent To and Including a Coastline	
	West Coast	East Coast
10°N - 20°N	1990	548
Equator - 10°N	3730	92
Equator - 10°N	1152	51
10°S - 20°S	1288	115
Total:	6160	806

Furthermore, and not readily apparent in Table V-1, there is a hemispherical bias and an oceanic bias in the data distribution (see Table V-2). This considerable imbalance in data distribution requires little further elaboration** except that it primarily reflects the demographic and economic importance of Northern Hemisphere, Atlantic Ocean countries.

**The data distribution may, however, bias the interpretation of archived data—see section "DETAILED STUDY OF A CARIBBEAN REGION".

TABLE V-2 GEOGRAPHIC DISTRIBUTION OF STATION DATA (NODC, 1977)

Region	Percentage of Total Data	Region	Percentage of Total Data	Percentage of World's Ocean Area
N. Atlantic	41	Atlantic	45	24*
S. Atlantic	4	Pacific	34	46*
N. Pacific	31	Indian	3	20*
S. Pacific	3	N. Hemisphere	89	43†
Indian	3	S. Hemisphere	11	57†
Arctic	17			
Antarctic	1			

*Menard and Smith, 1966

†Kossinna, 1921

An even greater imbalance is found in the distribution of information on micronutrients, specifically nitrate, nitrite, ammonia, phosphase and silicate. Dissolved oxygen measurements are also sparse compared to the total number of hydrographic stations in the archives, although there are many more of these than nutrient data on file. There will be virtually no systematic information on nutrients in the NODC archives for any coastal regions except where special studies have been done (e.g., MESA, BLM-OCS, CUEA). Information on seasonal fluctuations in nutrient levels is just about nonexistent. A literature search and a search for special publications on these surveys will have to be done to gain knowledge on what nutrient distribution information exists.

PRELIMINARY SURVEY OF SUITABLE BATHYMETRIC LOCATIONS

Using the coastal charts, we examined all coastlines and measured the approximate distances of the 1000-m contour. Actually, the 500 fm (914 m) was chosen to facilitate this job as all charts are marked in fathoms. Maps were prepared (Fig. V-2) with shading showing offshore waters where 1000-m depth is found closer than 5 km, between 5 km and 10 km, between 10 km and 50 km, and greater than 50 km from shore. Where the temperature structure was not suitable, e.g., off the coast of Peru, no data are shown, even though the coastal topography is suitable for OTEC. For completeness, this and other coastlines will be examined later.

Table V-3 lists the information contained in Figure V-2, in detail, showing country, geographic names of points, capes, bays and harbors and the bathymetric category outlined above. The approximate ΔT for 1000-m deep water is included (taken from U.S. Department of Energy maps (1978)). This information, except in the broadest sense, has not been combined with the ΔT data. Future versions of Table V-3 would necessarily need accurate ΔT information. What does emerge from this preliminary examination of the world's tropical coastlines is that potential OTEC sites are only to be found along very small stretches of the coasts of major continents. Several islands, particularly in the Caribbean, the Philippines, and the Pacific Ocean, however, do appear to be potential sites, with both favorable deep-water proximity and ΔT characteristics.

To see how a more detailed examination of a coastline might be carried out, quasi-hypsometric curves for the 100-fm and 500-fm contours

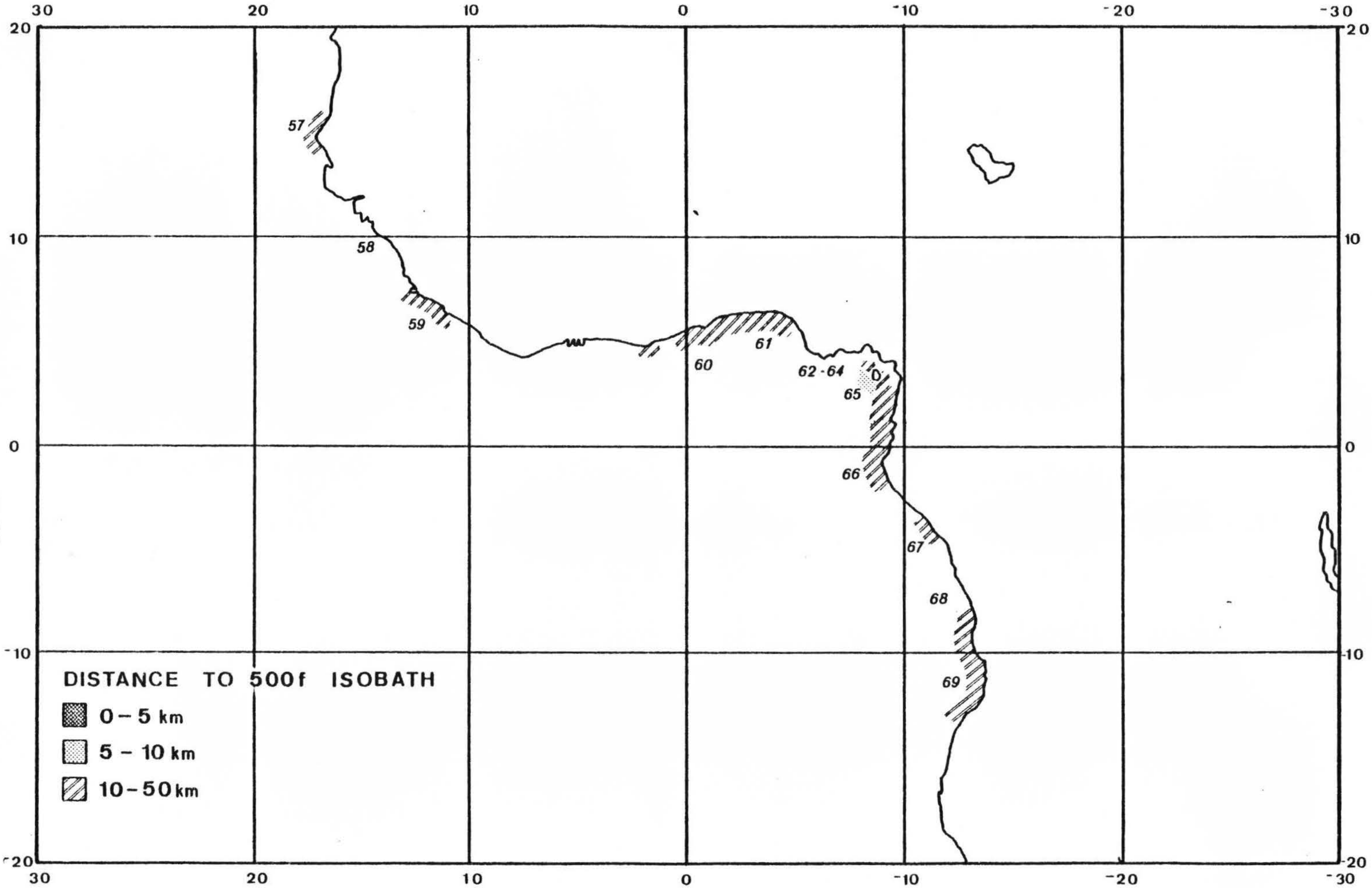


Figure V-2: Characteristics of coastal bathymetry in the tropics showing the distance in km from the coastline to the 500 fm isobath. No shading indicates a distance of > 50 km. (A) West coast of Africa

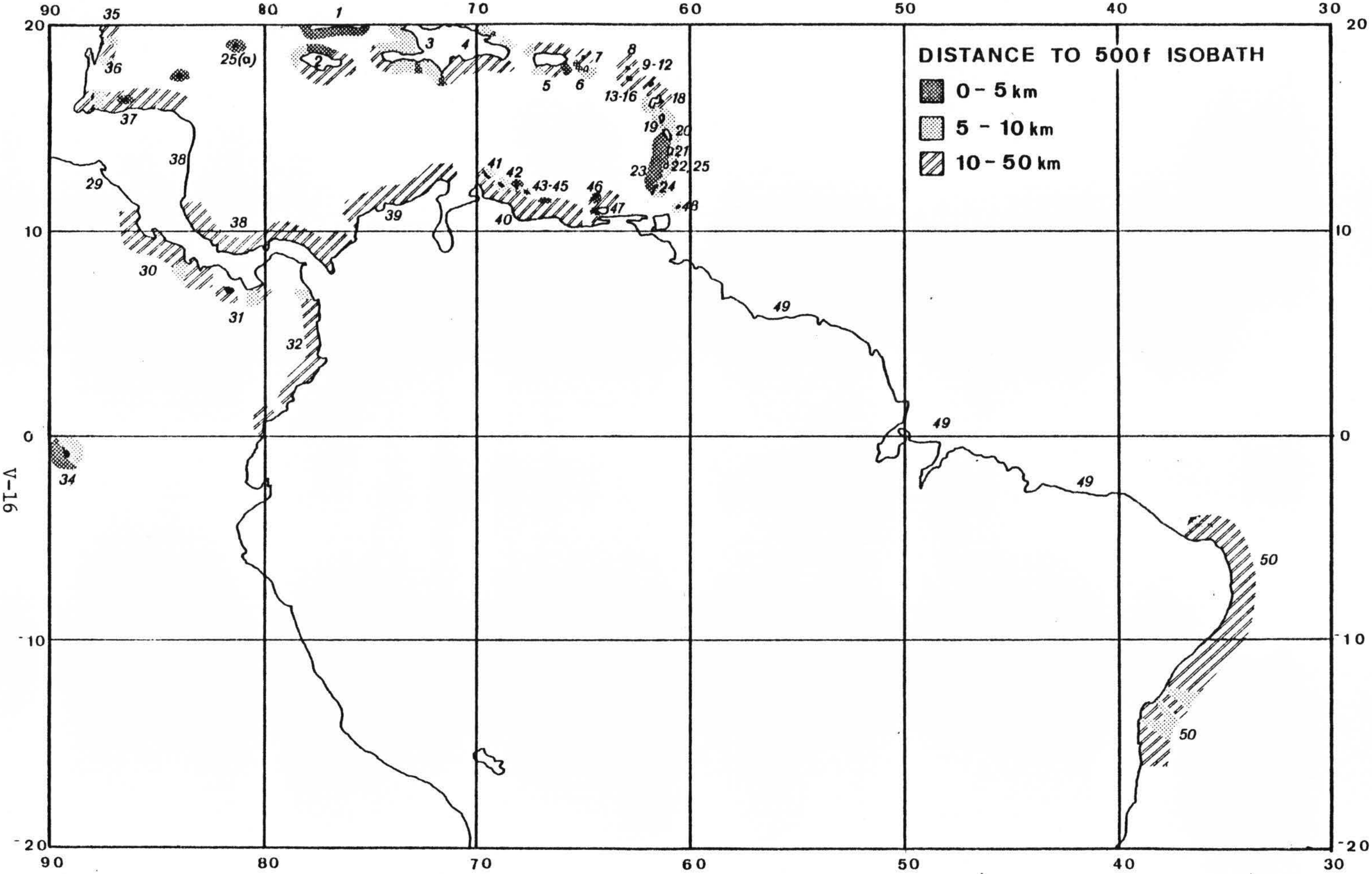


Figure V-2: Characteristics of coastal bathymetry in the tropics showing the distance in km from the coastline to the 500 fm isobath. No shading indicates a distance of > 50 km. (B) Central America, the eastern Caribbean and South America

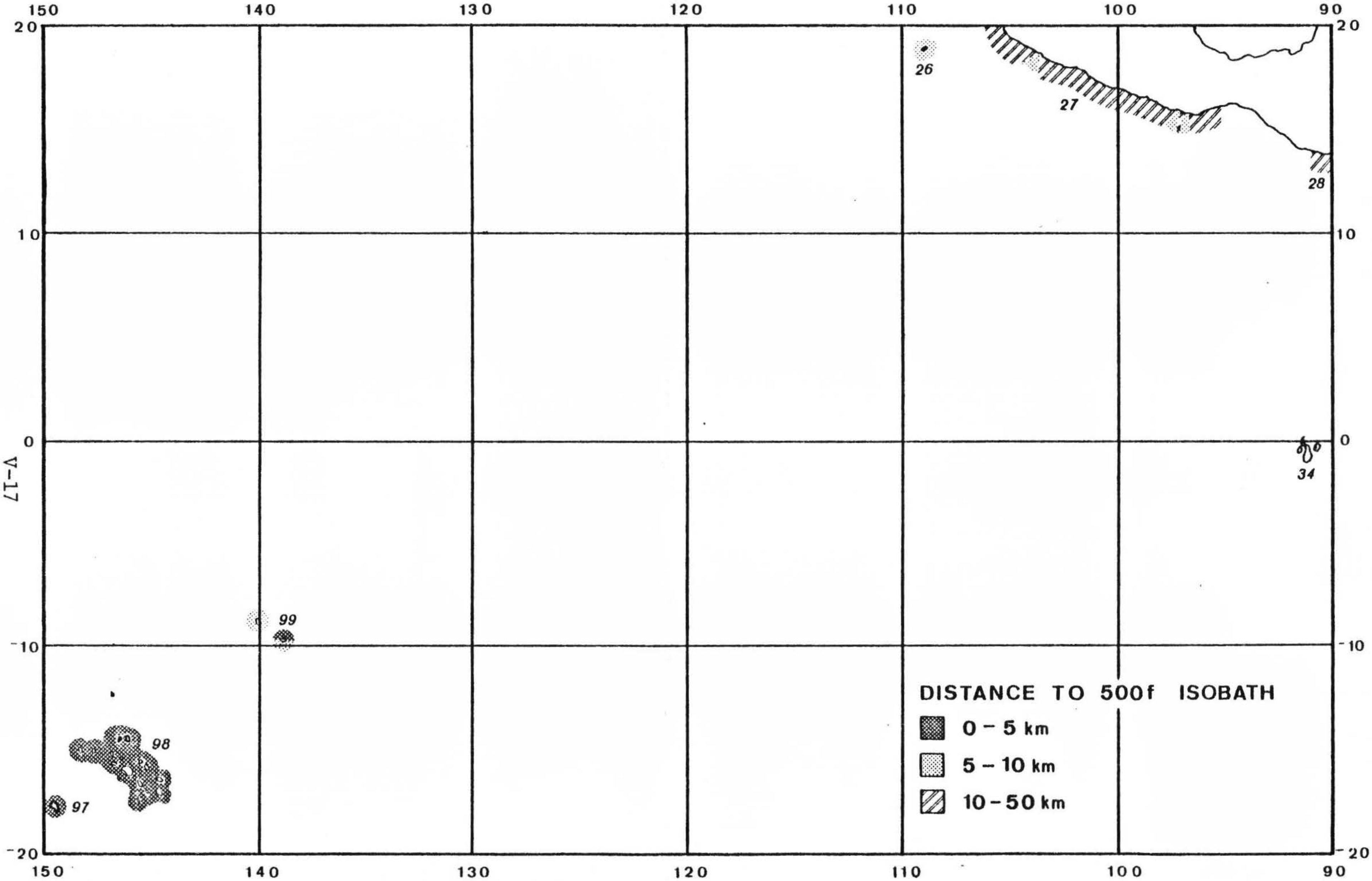
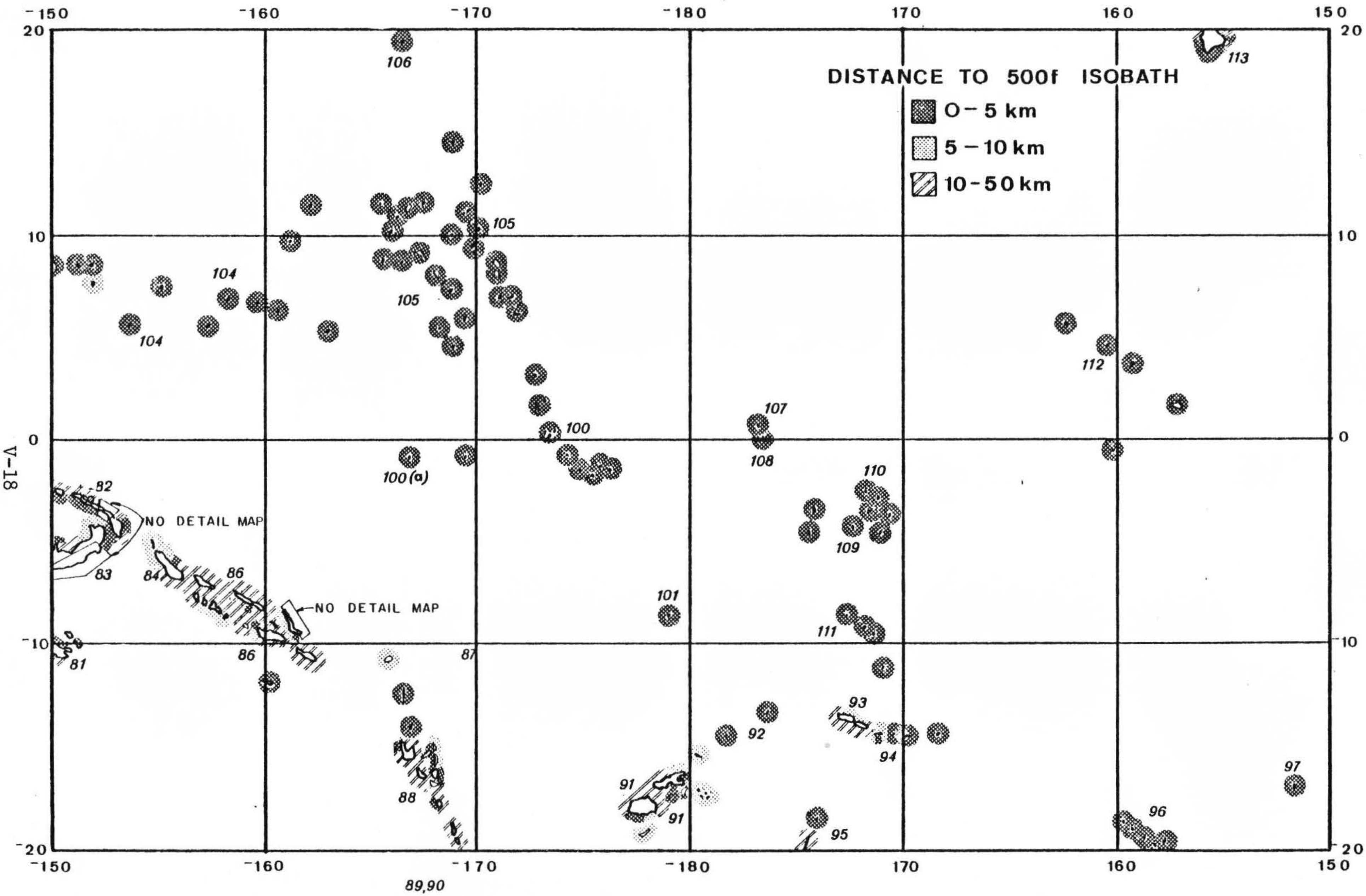


Figure V-2: Characteristics of coastal bathymetry in the tropics showing the distance in km from the coastline to the 500 fm isobath. No shading indicates a distance of > 50 km. (C) Pacific coast of Central America, Pacific Ocean (Oceania) from Galapagos to Tahiti



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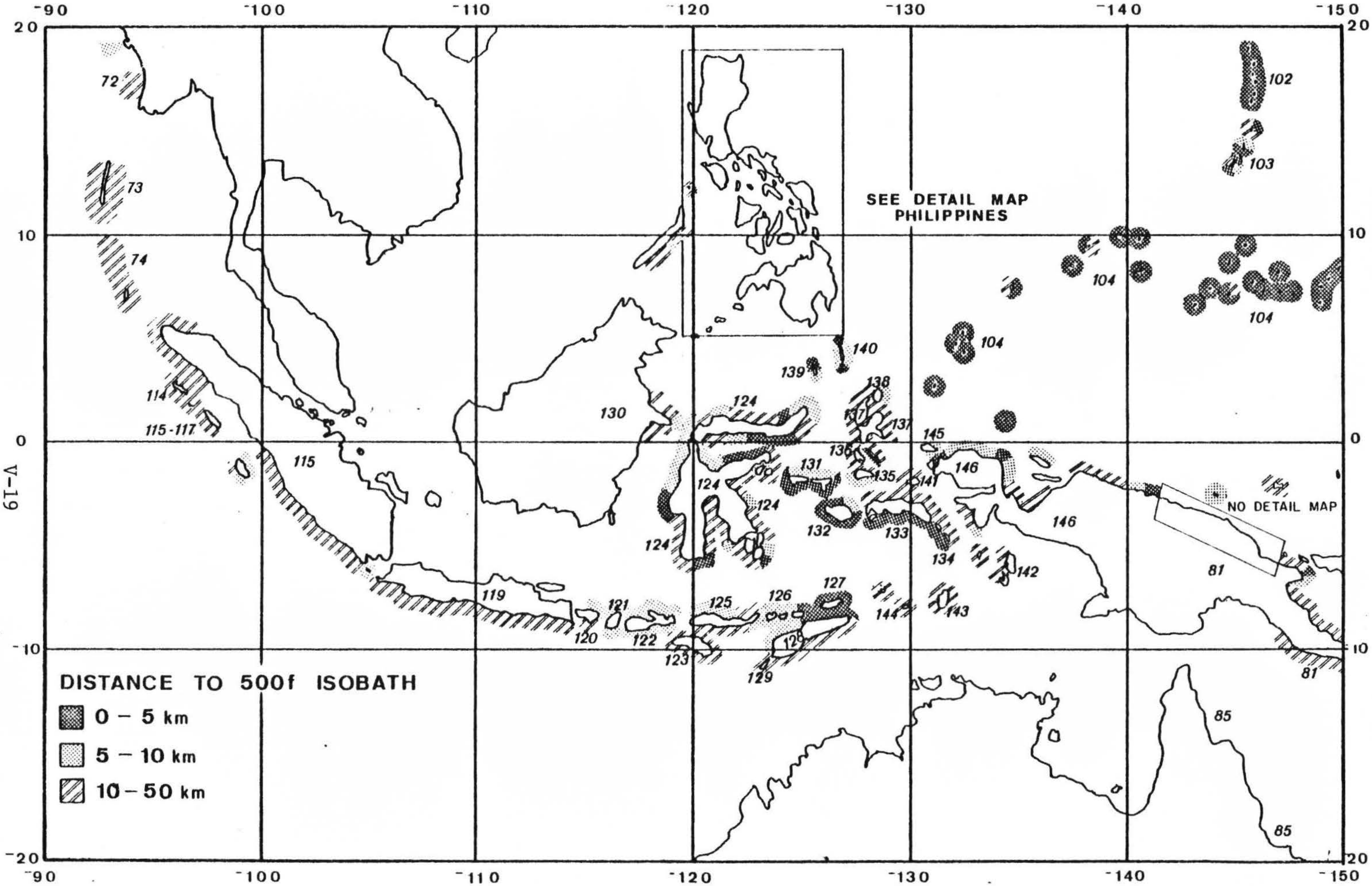

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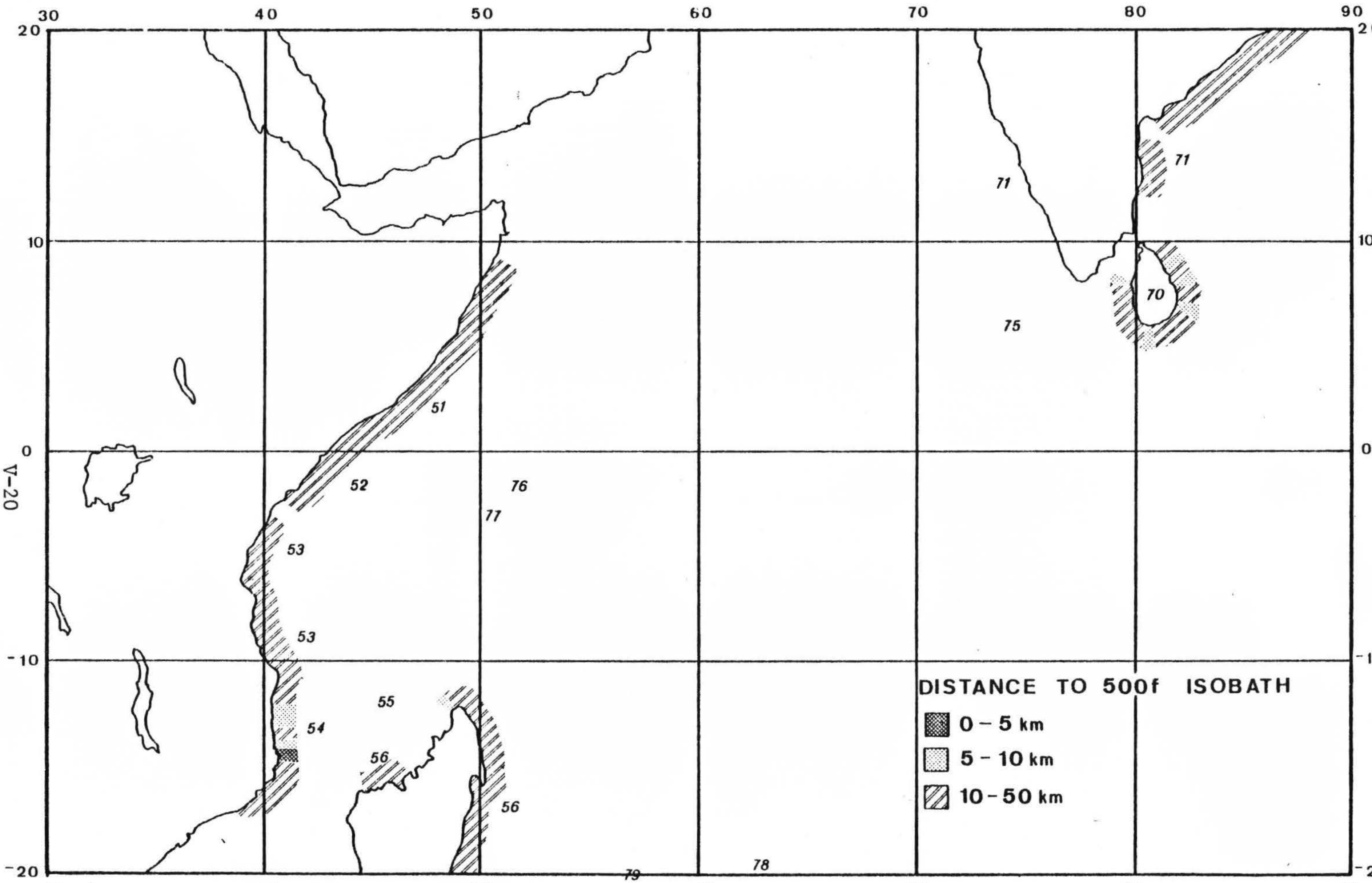

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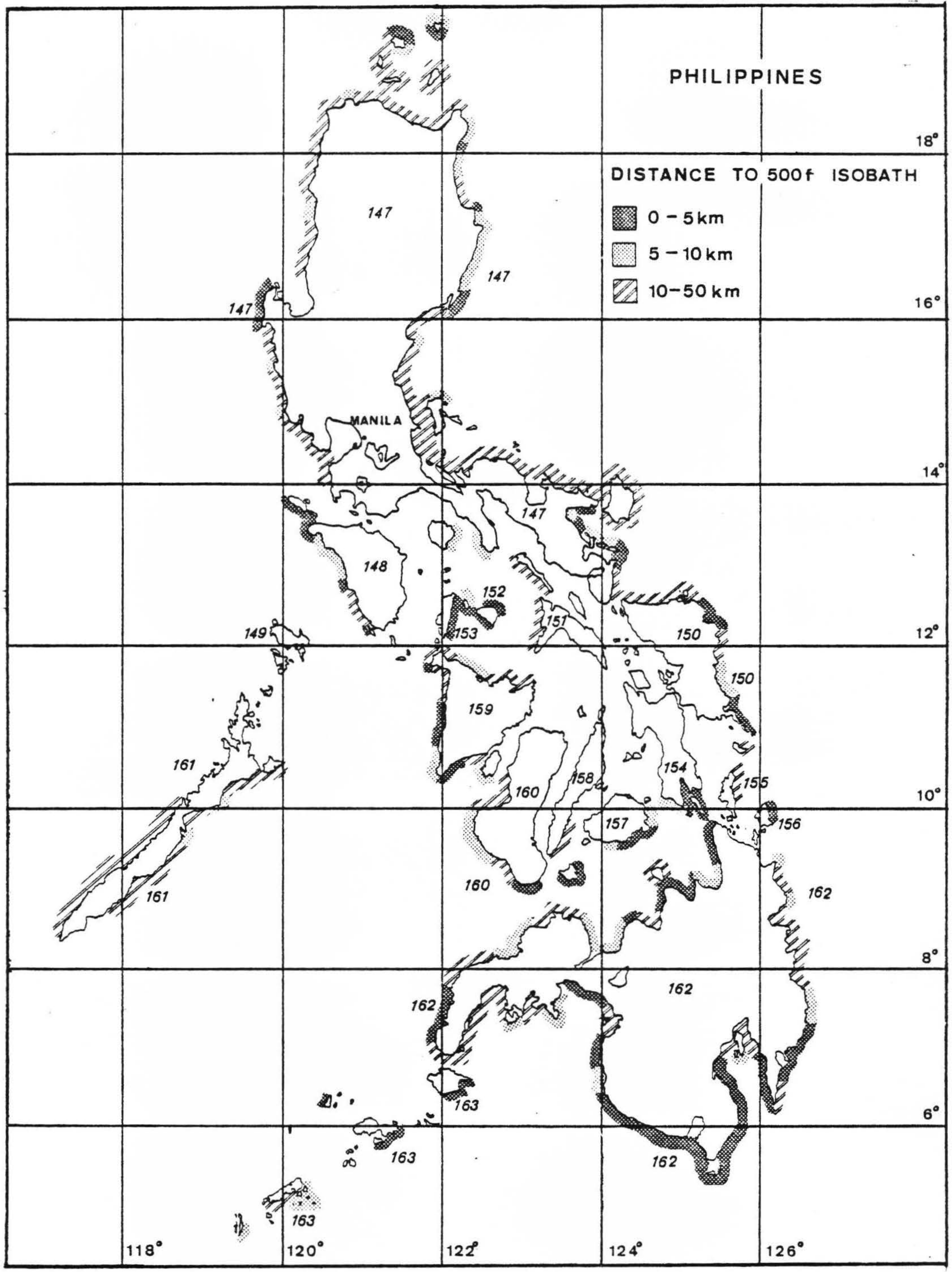

Figure V-2: Characteristics of coastal bathymetry in the tropics showing the distance in km from the coastline to the 500 fm isobath. No shading indicates a distance of > 50 km. (G) The Philippines

TABLE V-3 DISTANCE OF 1000-m ISOBATH FROM SHORELINES OF TROPICAL COUNTRIES

EXPLANATION

Table 3 lists the major results of the bathymetric survey undertaken under this proposal. It is entirely the result of examining the Defense Mapping Agency's nautical charts that are numbered in Column 1 of the table.

The table is indexed to provide some demographic input into this survey. Countries are named according to current usage (Information Please Almanac, 1978). Their more familiar names are cross-referenced in the index and given in square brackets in Column 2 of the main table.

Other sources consulted for names and loations were National Geographic (1963) and the Times Atlas of the World (1967).

The main table is arranged in broad oceanic regions, following the arrangement of the nautical charts. These are: Caribbean, Central and South America East Coasts (including part of the Caribbean), Central and South America West Coasts, West Africa, East Africa, Oceania, and two expanded regions of potential OTEC interest: Indonesia and the Philippines. The coastlines have been followed in sequence, going from one country to the next, consequently, in Central America, where countries have both east and west coastlines, multiple entries will be found.

Political affiliation is shown in parentheses after the country name in the index and main table. These are also grouped together in the index if one country has possessions or other territories outside their national boundaries (e.g., France, United Kingdom, United States).

Names given under Location are usually those names given on the nautical charts and of importance to navigation rather than being population centers or well-known places. ΔT is only approximate and is taken from the Department of Energy (1978) maps. Under the Distance columns, in some cases, one of the divisions are applicable, i.e., the water is shallower than 1000 m extending to the next landmass. This will be noted as "water too shallow."

Italicized numbers in Columns 1 and 2 are location identifiers: refer to Figure V-2 maps to locate country by number. Asterisks mean that the country or island is outside the bounds of the maps in Figure V-2.

TABLE V-3 DISTANCE OF 1000-m ISOBATH FROM SHORELINES OF TROPICAL COUNTRIES

INDEX

C A R I B B E A N

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
27000 *1*	Cuba	S shore	22-24	X			
27000 26010 *2*	Jamaica	NW corner;	22-24		X		
		N & NE shores;		X			
		W tip & S shore				X	
26020 *3*	Haiti [Hispaniola]	NW, Cap du Mole - E end Ile de Tortue	22-24	X			
		E of Ile de Tortue - 72°W;	22-24		X		
4	Dominican Republic [Hispaniola]	72°W-71°W, Cabo Isabela	22-24			X	
		Cabo Isabela - Cabo Macoris	22-24	X			
		Cabo Macoris - Cabo Cabron	22-24		X		
		Cabo Cabron	22-24	X			
		Punta Nisibon - N of Cabo Engano	22-24		X		
		E shore	22-24				X
		SE shore & S shore - Cabo Beata	22-24			X	
		Cabo Beata	22-24	X			
		Cabo Beata - Cabo Falso	22-24			X	
		Cabo Falso - 72°14'W	22-24		X		
3	Haiti [Hispaniola]	72 15'W	22-24	X			
		72 16'W - Cap Dame Marie	22-24		X		
		Cap Dame Marie;	22-24			X	
		NW shore			X		

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
25008 5	Puerto Rico (U.S.)	Far W & E shore;	22-24				X
		most of N shore;				X	
		Punta Boringuen;			X		
		Most of S shore;				X	
		Cabo Rojo;			X		
		Punta Tuna		X			
		Isla de Vieques, S shore;	22-24	X			
		W, N, E shores				X	
25641 6	Virgin Isl. (U.S.)	St. Thomas	22-24			X	
		St. John	22-24			X	
7	Virgin Isl. (U.K.)	Tortola	22-24			X	
		Virgin Gorda, at Pajaros Point;	22-24		X		
		remaining				X	
6	Virgin Isl. (U.S.)	St. Croix, NW shore;	22-24	X			
		NE, E & S shores				X	
25600 7	Virgin Isl. (U.K.)	Anegada, N shore;	22-24		X		
		S shore				X	
8	Anguilla(U.K.)	all	22-24			X	
9	St. Martin (Fr.)	all	22-24			X	
10	St. Barthelemy (Fr.)	all	22-24			X	
11	Saba (Neth.)	N shore;	22-24		X		
		remaining				X	
12	St. Eustatius (Neth.)	all	22-24			X	
13	St. Kitts (W.I.)	all	22-24			X	
14	Nevis (W.I.)	all	22-24			X	

CARIBBEAN (Page 3)

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
25600 *15*	Barbuda (U.K.)	NE shore;	22-24			X	
		remaining					X
16	Antigua (W.I.)	NE shore;	22-24			X	
		remaining					X
17	Montserrat (U.K.)	S & SW shores;	22-24			X	
		remaining					X
25563 *18*	Guadeloupe (Fr.)	Basse-Terre, NW curve at 16°19'N;	22-24	X			
		W shore, Pte. du Corps-de-Garde;		X			
		remaining W shore;			X		
		N shore;					X
		S & E shores				X	
		Grande-Terre, NE shore	22-24		X		
		remaining				X	
		Marie-Galante	22-24			X	
		La Desirade, N shore;	22-24	X			
		remaining				X	
25561 *19*	Dominica (W.I.)	S & W shores;	22-24	X			
		E shore			X		
25524 *20*	Martinique (Fr.)	S & W shores;	22-24	X			
		NE shore;				X	
		SE shore			X		
25521 *21*	St. Lucia (W.I.)	Far W shore;	22-24	X			
		remaining			X		
25484 *22*	St. Vincent (W.I.)	W shore;	22-24	X			
		remaining			X		
24032 *23*	Grenadine Islands (U.K.)	E shore of group;	22-24			X	
		Most of W shore/group;			X		
		W tip Carriacon		X			
24481 *24*	Grenada	NE shore;	22-24	X			
		N & W shores;			X		
		remaining				X	

CARIBBEAN (Page 4)

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
25485 *25*	Barbados	N tip; remaining	22-24		X	 X	
27241 *25a*	Cayman Is. (U.K.)	maps not obtained; good OTEC possibilities	22-24				

CENTRAL/SOUTH AMERICA (WEST COAST)

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
21017 *	Mexico	Pozo de Cota - Cabo San Lucus, Southern Baja	20-21		X		
		Cabo San Lucus, up NW coast of Baja - 20°10'N	20-21			X	
		Mazatlan 22°N	20-21			X	
		22°N - Punta de Mita	20-21				X
26	Islas Revillagigedo	Isl. Roca Partida & Isl. Socorro	20-21	X			
*	Las Tres Marias	All west shores	20-21	X			
21020 27	Mexico	Cabo Corrientes - Punta San Telmo	21-22			X	
		Punto San Telmo	21-22		X		
21020 21023		Punta San Telmo - Punta Galera	21-24			X	
		Punta Galera	22-24		X		
		Punta Galera - Boca Tomameca	22-24			X	
		Boca Tomameca	22-24		X		
		Boca Tomameca - Salina Cruz	22-24			X	
21026 28	Mexico - Guatemala	Salina Cruz - Champerico	22-24				X
29	Guatemala	Champerico - San Jose	22-24			X	
	Guatemala - Costa Rica	San Jose - Cabo de Santa Elena	22-24				X

CENTRAL/SOUTH AMERICA (WEST COAST)(Page 2)

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
21026 *30*	Costa Rica	Cabo de Santa Elena - Cabo Velas	22-24				X
		Cabo Velas - Punta Salsipuedes	22-24			X	
		Punta Salsipuedes	22-24		X		
	Costa Rica - Panama	Punta Salsipuedes - Isla Brava	22-24			X	
31	Panama	Isla Brava - Punta Mariato	21-22				X
		Isla Coiba, S shore	21-22			X	
		Isla Jicaron, S shore	21-22		X		
		Punta Mariato - Morro Puercos	21-22		X		
21026 21033		Morro Puercos - Punta Mala	21-22			X	
		Punta Mala - Punta Cocalito	21-22				X
	Panama - Colombia	Punta Cocalito - Punta Marzo	21-22		X		
32	Colombia	Punta Marzo - Cabo Corrientes	21-22			X	
		Cabo Corrientes	21		X		
		Cabo Corrientes - Cabo Manglares	19-21			X	
	Colombia - Ecuador	Cabo Manglares - Punta Coquito	19-20				X
33	Ecuador	Punta Galera - 0°30'N	<20			X	
22000 *34*	Galapagos Islands (Ecuador)	N, W & SW shores of complex; S, SE & E shores	19-20	X	X		

CENTRAL/SOUTH AMERICA (EAST COAST)

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
28015	Mexico	Cozumel, E shore	22-24	X			
35		Puerto Morelos - Punta Piedra	22-24			X	
		Punta Piedra	22-24		X		
		Punta Piedra - Punta Herrero	22-24			X	
		Punta Herrero - El Placer	22-24		X		
		El Placer - Gavilan	22-24			X	
28015 28000	Mexico - Belize	Gavilan - Tip of Cangerjo Cay	22-24		X		
36	Belize	Cangerjo Cay - Colson Point	22-24			X	
		Turneffe Isl., W shore	22-24	X			
		Colson Point - Jonathan Point	22-24				X
	Belize - Honduras	Jonathan Point - Punta Caballos	22-24			X	
37	Honduras	Punta Caballos - Punta Sal	22-24		X		
		Punta Sal - Punta Patuca	22-24			X	
		Isla de Roatan	22-24	X			
		Isla de Cisne	22-24	X			
28000 26000	Honduras - Nicaragua	Punta Patuca - Punta Mico	22-24				X
38	Nicaragua - Columbia	Punta Mico - Punta Venados	22-24			X	

CENTRAL/SOUTH AMERICA (EAST COAST)(Page 2)

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
26000 39	Columbia	Punta Venados - Punta Baru	22-24				X
26000 24036		Punta Baru - Cabo Chichibocoa	22-24			X	
41	Aruba (Neth.)	NE shore	22-24		X		
24032 40	Venezuela	Cabo San Roman - Punta Carabelleda	22-24			X	
		Punta Carabelleda - Cabo Codera	22-24				X
		Cabo Codera - Punta de Arenas	22-24			X	
42	Curacao (Neth)	all	22-24	X			
42	Bonaire (Neth.)	N & NW coasts; E & S coasts	22-24	X	X		
43	Islas las Aves (Venez.)	all	22-24		X		
44	Islas los Roques (Venez.)	Cayo Grande: S shore; E & W shores; N shore	22-24	X	X	X	
		Cayo Nordeste: NE shore; remaining parts	22-24	X	X		
45	Isla la Tortuga (Venez.)	S shore; W, N & E shores	22-24	X		X	
46	Isla la Blanquilla (Venez.)	NW - S shores; N & E shores	22-24	X		X	
47	Isla de Margarita (Venez.)	N shore	22-24			X	
48	Tobago (Trin. & Tob.)	NE corner; N shore	22-24		X	X	

CENTRAL/SOUTH AMERICA (EAST COAST)(Page 3)

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
24032 24028 24024 24020 24016 *49*	Venezuela - Brazil	Punta de Arenas - Punta Redonda	22-24				X
24016 24012 *50*	Brazil	Punta Redonda - Punta Acu da Torre	22-24			X	
		Punta Acu da Torre	22-24		X		
		Punta Acu da Torre - Salvador	22-24			X	
		Salvador	22-24		X		
		Salvador - Punta Muta	22-24			X	
		Punta Muta	22-24		X		
		Punta Muta - Belmonte	22-24			X	
		Belmonte - Cabo Frio	20-21				X

E A S T   A F R I C A

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
61021 61018 61015	Somalia - Kenya *51*	Ras Mabber - Tenewiati Point	19-20			X	
52	Kenya	Tenewiati Point - Kilifi	20				X
61012 *53*	Kenya - Mozambique	Kilifi - Matemo Isl. incl. E shore of Pemba Isl. and Zanzibar Isl.	20-21			X	
54	Mozambique	Matemo Isl. Ibo Isl. Fumo Isl. Kiziva Isl. Lurio Pt.	20-21	 X 	X X X X		
		S of Lurio Pt. - N of Uifundo Pt.	20-21			X	
		Uifundo Pt.	20-21		X		
		S of Uifundo Pt. - Memba Bay	20-21			X	
		Pinda, S of Memba Bay; NE & SE sides of Fernao Veloso Bay	20-21	X			
61009		S of Fernao Veloso Bay - Raraga	19-20			X	
61012 *55*	Archipel des Comores	Grande Comore at Salimani & Samba; remaining parts	20		X	 X	
		Mobeli, N tip Oani Pt remaining parts	20	X		 X	
		Anjouan, N tips at La Selle & Oam; remaining parts	20	X		 X	
		Mayotte	20			X	

EAST AFRICA (Page 2)

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
61024		no information					
61027 *56*	Malagaysay Republic [Madagascar]	NW portion, Cap St. Andre - Pte. Komany	20-21			X	
		N of Pte. Komany - Cap d'Ambre	20-21				X
		Cap d'Ambre	20-21		X		
61030		SE of Cap d'Ambre - Antanambao	19-21			X	

W E S T A F R I C A

N to S

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
51027 *57*	Senegal	Cap Vert	18			X	
51037 *58*	Senegal-Sierra Leone	S of Cap Vert - N of Sherbro Isl.	18-20				X
59	Sierra Leone - Liberia	Sherbro Isl. - Monrovia	20-21			X	
57000		not available					
57006 *60*	Ghana	Cape Three Points	22-24			X	
		E of Cape Three Points - Winneba	22-24				X
61	Ghana - Nigeria	Winneba - Ogogoro	22-24			X	
62	Nigeria - Equatorial Guinea	Ogogoro - Punta Oscura	22-24				X
63	Equatorial Guinea	Punta Oscura - Punta Santiago	22-24		X		
64	Equatorial Guinea - Cameroon	Punta Santiago - Kribi	22-24				X
57014 *65*	Cameroon - Gabon	Kribi - Pointe Ste. Catherine	21-22			X	
66	Gabon - Congo Rep.	Pointe Ste. Catherine - N of Pt. Indienne	20-21				X
67	Congo Rep.	Pointe Indienne	20			X	
68	Congo Rep. - Angola	S of Pointe Indienne - N of Capulo	19-20				X
69	Angola	Capulo	19			X	
		S of Capulo - N of Ponta das Palmeirinhas	19				X

WEST AFRICA (Page 2)

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
57014 69	Angola	Ponta das Palmeirinhas - Ponta da Balela	18-19			X	

I N D I A N   O C E A N

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
62028 *	Iran - Pakistan	Ra's e Rasshial - Ra's Kachari	18-19			X	
63000 63005 63010 *	Pakistan	E of Ra's Kachari, W - India, S India - Sri Lanka	18-21				X
70	Sri Lanka [Ceylon]	Kalpitra Pen	21-22		X		
		S of Kalpitra Pen - Dondra Hd	21-22			X	
		Dondra Hd	21-22		X		
		Dondra Hd - E coast at 7°17'N	21-22			X	
		7°17'N	21-22		X		
		7°17'N - Elizabeth Pt	21-22			X	
		Elizabeth Pt	21-22		X		
		Elizabeth Pt - Pt Pedro on N shore	21-22			X	
63015 71	India	E coast at Koliar, N to Ramayapatam	20			X	
		Ramayapatam - False Divi Pt	20				X
63020		False Divi Pt - False Bay	20-21			X	
*	India - Burma	False Bay - Cheduba Is	21-22				X
72	Burma	Cheduba Isl	21-22			X	
		Cheduba Isl - Cocoanut Pt	21-22				X
63025		Cocoanut Pt - Migyaunggaung	21-22			X	

INDIAN OCEAN (Page 2)

MAP #	COUNTRY	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
63025 *73*	Andaman Isl. (Ind.)	all	20-22			X	
74	Nicobar Islands (Ind.)	Most of E coast; W coast	22-24		X	 X	
63010 *75*	Maldives	Most of E coast; NW coasts of northern groups; SW coasts of southern groups	21-24		X X	 X	
61036 *76*	Seychelles	Most of coastline	21			X	
77	Amirante (U.K.)	North Island; remaining	21	X	 X		
61601 *78*	Rodrigues (U.K)	all	21			X	
61591 *79*	Mauritius	N coast	21				X
		NW coast - Pte Quatre Cocos	21		X		
		Pte Quatre Cocos - Mahebourg	21			X	
		Mahebourg - point opposite Union Vale	21		X		
		S coast - Pte Sud Ouest	21			X	
		W coast at 20°15'S	21	X			
		20°15'S - Cannoniers Pte	21		X		
61581 *80*	Réunion (Fr.)	N coast, Pnte des Galets - St. Denis	21	X			
		rest of coastline	21		X		
71033	Christmas I. (Aust.)	all	22-24	X			
71191	Cocos Keeling I. (Aust.)	all	22-24	X			

O C E A N I A

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
None *81*	Papua - New Guinea	No detailed maps available between 141°E and 146°45'E. It is probable that suitable sites exist in this area	22-24				
73650		145°45'E to Cape Bredow	22-24			X	
		Cape Bredow	22-24	X			
		Cape Bredow to Markham Bay	22-24		X		
73601		Markham Bay to Cape Frere	22-24			X	
		Cape Frere to Excellent Point	22-24	X			
		Normanby I, N.E. tip; remaining;	22-24	 X 		 X	
73590		Isulailai Pt to 142°E	22-24			X	
		No detailed maps for Papua - New Guinea available west of 142°E					
82060		Admiralty Is., Manus & adjacent Is.	22-24			X	

OCEANIA (page 2)

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
82093 82	Papua - New Guinea	New Ireland, S. Shore on N.W. tip; N. Shore on N.W. tip;	22-24	 X 		 X	
82163 82		New Ireland, N. shore between Cape Sena and Cape Mimias; all remaining N.Shore; most of W. Shore	22-24	 X	X 	 X 	
82211 83		New Britain, N.E. shore; N & N.W. shore to Hummock Head; Hummock Head to N. Willaumep Pen.; N. tip of Willaumep Peninsula;	22-24	 X X	 X 	 X 	
82244 84		Bougainville I., N.E. shore between Tiaraka Pt. and Inus Pt; remaining NE & NW shores; remaining SE, S & SW shores;	22-24	 X 	 X 	 X	
82046		Ninigo group - all	22-24		X		
74021 * 74015	Australia	NW Shore Pt. Cloates Anchorage to Northwest Cape all remaining N shore	22-24			X 	 X
? 85		Cape York Peninsula South - possible locations down to Brisbane - no maps obtained yet	23-18				

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
82015 86	Solomon Islands	Choiseul I, all;	23-24			X	
	(U.K., independence, 1978?)	New Georgia group					
		S. shore of Gizo I,					
		Vonavona I., Vangunu	23-24				
		I, Nggatokae I &					
		New Georgia;			X		
		all remaining;				X	
82349		Santa Isabel, central					
		W. shore 8°45'S;			X		
		remaining NW part of					
		I.				X	
82356		N. shore at C.	23-24				
		Megapode			X		
		S. shore below 8°S to					
		8°15'S		X			
		all remaining SE					
		part of Island				X	
		Malaita I, NW					
		shore of N tip;			X		
		N. shore uncharted;	23-24	-	-	-	-
82374		S. shore of S. tip;		X			
		remaining S shore;			X		
		Nggela group, all;	23-24			X	
		Guadalcanal I,		X			
		N. tip;					
		remaining N. shore;				X	
		W. tip;			X		
		all remaining;				X	
82412		San Cristobal - All;	23-24			X	
82384		Russell I - all;	23-24			X	
		Rennell I - all	23-24	X			

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
82020 *87*	Santa Cruz I (U.K.)	No detailed coverage at least 6 km	23-24		X		
82527 *88*	New Hebrides Is. (condominium U.K.&France)	Torres I - all	22-23	X			
		Banks I - all	22-23	X			
82543		Espíritu Santo I., NW coast between C. Cumberland and Remarkable Pt;	22-23	X			
		SE shore at Palikulo Pt;			X		
		all remaining				X	
82564		Malékoula - all	22-23			X	
		Ambrym, N&E shores		X			
		south shore;	22-23			X	
		Pentecôte, E. shore;			X		
		W. shore;		X			
		Paama I., NE tip;	22-23	X			
		remaining;				X	
		Lopevi I., NE shore;		X			
		remaining;	22-23			X	
		Île Epi, E. tip at Sugarloaf Pt;	22-23	X			
		remaining;				X	

OCEANIA (page 5)

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
82654 *88*	New Hebrides Is. (condominium U.K.&France)	Îles Shepard, E. shore;	22-23		X		
		remaining				X	
		Tongariki I., E. shore;	22-23		X		
		remaining				X	
		Emae I.	22-23			X	
		Efaté I., NW shore,			X		
		remaining;	22-23			X	
82025		Erromango	22-23			X	
		Tanna	22-23			X	
		Île Ameytioum	22-23			X	
89	Nouvelle Caledonie (France)	Maps have very poor resolution; 1000m isobath at least 6 km from shore	22-23		X		
90	Îles Loyauté (France)		22-23		X		
83594 *91*	Fiji	Vanua Levu, all N. shore to Ngarotoka Pass at NE portion;				X	
		Ngarotoka Pass to Napotu;	22-23		X		
		N. shore of Natewa Bay to Lakemba;		X			
		S. shore of Natewa Bay to Nanggaravutu		S			
		S. shore west of Lesiatheva Pt.				X	

OCEANIA (page 6)

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
83594 *91*	Fiji	Vanua Levu (cont.), S. shore between Lesiatheva Pt & Urambuta Pa;	22-23	X			
		remaining S. shore E. of Urambuta Pt.			X		
		Rambi, N. shore;	22-23	X			
		S. shore;			X		
		Thikombia I - all	22-23		X		
		Taveuni I., SW & SE shore;	22-23	X			
		remaining;				X	
		Nggamea, S. shore;			X		
		remaining;	22-23			X	
		Koro - all	22-23	X			
83594 83582		most islands of Lau group; maps have poor resolution	22-23		X		
83611 83033 83608		Vitu Levu, W, N & E shores;				X	
		S shore west of Mbenga Passage;		X			
		S. shore east of Mbenga I;			X		
		Kandavu I - all	22-23		X		
		Ovalau, E. shore;			X		
		remaining;	22-23			X	

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
83608 *91*	Fiji	Ngau I. - all	22-23	X			
		Moala I. - all	22-23		X		
		Totoya I. - all	22-23	X			
		Matuku I. all	22-23	X			
83010 *92*	Îles de Horne (France	Horne I. - all	22-23	X			
		Ile Futuna - all	22-23	X			
		Ile Alofi - all	22-23	X			
92	Îles Wallis (France)	NE shores;	23-24	X			
		remaining;			X		
83473 *93*	Western Samoa	Savai'i, NE shore;			X		
		all remaining;	22-23			X	
		Upolū, N. shores at Cape Faleula;	22-23		X		
		remaining;				X	
83484 *94*	American Samoa (U.S.)	Tutuila I., S. shore between Steps Pt. & Matautuotafuna Pt;	22-23	X			
		remaining;			X		
		Ofu I. - all	22-23	X			

OCEANIA (page 8)

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
83484 *94*	American Samoa (U.S.)	Olosega I., all but SE portion; SE portion;	22-23	X		 X	
		Tau I., all but NW portion; NW portion;	22-23	X		 X	
		Swains I. - all	22-23	X			
		Rose I. - all	22-23	X			
83555 *95*	Tonga	Vava'u group, NE portion of group on open ocean side	22-23	X			
83030		Ha'apai group, E. shore; W. shore;	22-23	X		 X	
		Tofua I. - all	22-23	X			
		Kao I. - all	22-23	X			
		Nomuka group - all	22-23			X	
		Otu Tolu group - all	22-23			X	
		Tongatapu group, far W & E shores; remaining;	22-23		X	 X	

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
83425 *96*	Cook Is. (N.Z.)	Aitutaki - all	22-23	X			
		Manuae Atoll - all	22-23	X			
		Takutea - all	22-23	X			
		Aitu - all	22-23	X			
		Mauke - all	22-23	X			
		Rarotonga - all	22-23	X			
		Mangaia - all	22-23	X			
83392 *97*	Îles de la Société (France)	Île Maupiti	22-23	maps show no soundings			
		Île Motu-iti	22-23				
		Île Bora Bora	22-23	X			
		Île Raiatea	22-23	maps show no soundings			
		Île Hvahîné	22-23				
		Tahiti, NW tip; remaining;	22-23	X map shows no soundings			
		Moores - all	22-23	map shows no soundings			

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
83023	Îles	Mataiva Atoll - all	22-23	X			
	Tuamotu	Tikehau		X			
98	(France)	Makatea I. - all	22-23	X			
		Rangiroa Atoll - all	22-23	X			
		Arutua Atoll - all	22-23	X			
		Kaukura Atoll - all	22-23	X			
		Apataki Atoll - all	22-23	X			
		Toau Atoll - all	22-23	X			
		Niau Atoll - all	22-23	X			
		Ahe Atoll - all	22-23	X			
		Manihi Atoll - all	22-23	X			
		Takaroa Atoll - all	22-23	X			
		Tak'a poto Atoll -all	22-23	X			
		Aratika Atoll - all	22-23	X			
		Kauehi Atoll - all	22-23	X			
		Fakarava Atoll - all	22-23	X			
		Raraka Atoll - all	22-23	X			

OCEANIA (page 11)

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
83073 98	Îles Tuamotu (France)	Faaite Atoll - all	22-23	X			
		Katiu Atoll - all	22-23	X			
		Tahanea Atoll - all	22-23	X			
		Anaa Atoll - all	22-23	X			
		Tuauake Atoll - all	22-23	X			
		Hiti Atoll - all	22-23	X			
		Motutunga Atoll-all	22-23	X			
83207	Îles Marquises (France)	Nuku Hiva - all	22-23		X		
83217 99		Hiva Oa, N,E,&W; South shore;	22-23	X	X		
		Tahu Ata	22-23	map shows no soundings			
		Motaue	22-23				
83052 100	Gilbert Is. (U.K.)	Butaritari Atoll-all	>24	X			
		Marakei Atoll - all	>24	X			
83005		Abaiang Atoll - all	>24	X			
		Tarawa Atoll - all	>24	X			

OCEANIA (page 12)

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
83053 *100*	Gilbert Is. (U.K.)	Maiana Atoll - all	>24	X			
		Abemama Atoll - all	>24	X			
		Aranuka Atoll - all	>24	X			
		Kuria Atoll - all	>24	X			
83044		Nonouti Atoll - all	>24	X			
		Ocean I. - all	>24	X			
100a	Nauru I. (Aust.)	all	>24	X			
83005 *100*	Gilbert Is. (U.K.)	Tabiteues - all	>24	X			
		Beru - all	>24	X			
		Onotoa - all	>24	X			
		Nukunau - all	>24	X			
		Arorae - all	>24	X			
83094 *101*	Tuvalu Is. [Ellice Is.] (U.K.)	Funafuti - all	23-24	X			
97000 *	Kazdu Rettō (Volcano Is.) (Japan)	Kita-Iō Jima, SE; South, East, NE; remaining;		X	X	X	

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
97000 *	Kazdu Retto (Volcano Is.) (Japan)	Iō Jima (Iwo Jima)	23-24			X	
81005 *102*	Mariana Is. (U.S. Trust Territory)	Farallon de Pajaros	23-24	X			
		Maug Is. - all	23-24	X			
		Asuncion I. - all	23-24	X			
		Agihan I. - all	23-24	X			
		Pagan I.	23-24	X			
		Alamagan I.	23-24	X			
		Guguan I.	23-24	X			
		Sarigan I.	23-24	X			
		Anataban I.	23-24	X			
		Farallon de Medinilla	23-24		X		
		Saipan I., E. shore; N&W shore;	23-24	X		 X	
		Tinian I., E. shore; S&W shore;	23-24		X	 X	
		Aguijan I. - all	23-24			X	

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
81063 *102*	Mariana Is. (U.S. Trust Territory)	Rota I., N. shore;			X		
		S. shore;	23-24	X			
81048 *103*	Guam (U.S.)	NW & N shores;				X	
		NE shore,	23-24	X			
		E shore,			X		
		S,SE,SW & W shores		X			
81002	Carolina Is. (U.S. Trust Territory) *104*	Ulithi - all	>24	X			
81141		Palau Is., E. shores;		X			
		W shores;	>24			X	
81166		Ngulu Is. - all	>24	X			
81187		Yap Is., NW shore	>24	X			
		NE & SE shore			X		
81237		Woleai Atoll - all	>24	X			
81133		Fais I. - all	>24	X			
		Sorol Is. - all	>24	X			
		Eauripik Atoll - all	>24	X			
		Īfalik Atoll, NE	>24			X	
		remaining		X			
81249		Faraulep Atoll - all	>24	X			
		Gaferut Atoll - all	>24	X			

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
81133	Caroline Is. (U.S. Trust Territory) 104	Olimarao Atoll- all	>24	X			
81249		Lamotrek and Elato Atoll - all	>24	X			
81133		West Fayu Atoll - all	>24	X			
		Satawal Atoll - all	>24	X			
		Puluwat Atoll, NE; remaining	>24	X (remaining)		X (NE)	
		Pulap Atoll - all	>24	X			
81288		Namonuito Atoll - all open shores	>24	X			
81133		East Fayu I. - all	>24	X			
81303		Hall Is. - all open shores	>24	X			
81338		Truk Is. - most open ocean shores	>24		X		
81133		Namoluk Atoll - all	>24	X			
81345		Namoi (Mortlock) Is. - all	>24	X			
81249		Nukuoro Is. - all	>24	X			
		Kapingamarangi Is.- all	>24	X			

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
81411	Caroline Is. (U.S. Trust Territory) 104	Oroluk Lagoon	>24	X			
81019		Ngatik Atoll - all	>24	X			
81016		Pakin Is. - all	>24	X			
81133		Sonsoral Is. - all	>24	X			
		Palo Anna - all	>24	X			
		Merir - all	>24	X			
		Tobi - all	23-24	X			
		Kepulauan Mapia - all	23-24	X			
81016		Andema Is. - all	>24	X			
		Senyavin Is. - all	>24	X			
81133		Mokil Is. - all	>24	X			
		Pingelap Is. - all	>24	X			
81488		Kusaie - all	>24	X			
81016	Marshall Is. (U.S. Trust Territory) 105	Eniwetok Atoll - all	23-24	X			
81511		Ujelang Atoll - all	23-24	X			

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
81544	Marshall Is. (U.S. Trust Territory) 105	Bikini Atoll - all	23-24	X			
81557		Ailinginae Atoll -all	23-24	X			
81563		Rongelap Atoll - all	23-24	X			
81557		Rongerik Atoll- all	23-24	X			
81030		Wotho Atoll - all	23-24	X			
		Vjae Atoll - all	23-24	X			
81557		Lae Atoll - all	23-24	X			
81715		Kwajalein Atoll - all	23-24	X			
81626		Taongi Atoll - all	23-24	X			
81587		Likiep Atoll - all	23-24	X			
81612		Ailuk Atoll - all	23-24	X			
81601		Wotje Atoll - all	23-24	X			
81007		Erikub Atoll - all	23-24	X			
81616		Utirik Atoll - all	23-24	X			
		Taka Atoll - all	23-24	X			
81626		Bikar Atoll - all	23-24	X			

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
81723	Marshall Is. (U.S. Trust Territory) *105*	Namu Atoll - all	23-24	X			
81737		Ailinglapalap Atoll-all	23-24	X			
81817		Jaluit Atoll - all	23-24	X			
81030		Namorik Atoll - all	23-24	X			
		Ebon Atoll - all	23-24	X			
81771		Aur Atoll - all	23-24	X			
		Maloelap Atoll - all	23-24	X			
81782		Majuro Atoll - all	23-24	X			
81791		Arno Atoll - all	23-24	X			
81726		Mili Atoll - all	23-24	X			
81664 *106*	Wake I. (U.S.)	all	23-24	X			
83010 *107*	Howland I. (U.S.)	all	23-24	X			
108	Baker I. (U.S.)	all	23-24	X			
83037 *109*	Phoenix Is. (U.K.,claimed by U.S.	Gardner Atoll - all	23-24	X			

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
83037 *109*	Phoenix I. (U.K., claimed by U.S.)	McKean Atoll - all	23-24	X			
		Hull Atoll - all	23-24	X			
		Birnie I. - all	23-24	X			
		Phoenix I. - all	23-24	X			
		Sydney I. - all	23-24	X			
110	Canton I. (U.S.&U.K.)	all	23-24	X			
	Enderbury I, (U.S.&U.K.)	all	23-24	X			
83010 *111*	Tokelau Is. (N.Z., claimed by U.S.)	Atafu	23-24	X			
		Nukunono	23-24	X			
		Fakaofo	23-24	X			
83157	Line Is. (U.S.)	Palmyra Atoll - all	22-23	X			
83116 *112*		Jarvis I. - all	22-23	X			
83153	Line Is. (U.K.)	Washington I. - all	22-23	X			
83158 *112*		Fanning Atoll - all	22-23	X			
83015		Christmas I. - all	22-23	X			

OCEANIA (page 20)

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
19320 *113*	U.S.A. (Hawaii)	Hawaii, W. shore at Keahole Pt around N. shore to Paauhau;				X	
		Paauhau to Maula Bay;			X		
		Maulua Bay to Leleiwi Pt;	20-22			X	
		Leleiwi Pt. to Nanawale Bay		X			
		Nanawale Bay to Kapoho Pt.				X	
		Kapoho Pt. around S. shore to Keahole Pt.		X			
19340 *		Maui, S. shore at Kamanamana Pt. to Lapehu Pt;			X		
		Lapehu Pt. to Alau I;		X			
		Alau I. to Umalei Pt;	20-22		X		
		Umalei Pt. to Kalahu Pt;		X			
		Kahalu Pt. around N & W shores to S. shore at Kamanamana Pt;				X	
*		Kahoolawe, S. shore;	20-22	X			
		remaining				X	
*		Lanai - all	20-22			X	
*		Molokai, N. shore;	20-22		X		
		remaining				X	
*		Oahu, N, E & S shores	20-21			X	
		(except Mokapu Pt);			X		
		W. shore			X		

OCEANIA (page 21)

MAP #	COUNTRY OR ISLAND GROUP	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
19380 *	U.S.A. (Hawaii)	Kauai, map on order - W. coast and S. coast and S. coast look very promising	20-21				
*		Niihau - as above - less promising	20-21				

I N D O N E S I A

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
71000 *114*	Pulau Simeulue	N & S shores;	22-24			X	
115	Sumatera* [Sumatra]	NW shore from Agam Agam (97°C) to S. shore at Banjak Is.	22-24			X	
71009 to 71015		Vdjung Masang to Cukuh Balim bing	22-24			X	
71009 *116*	Pulau Tanahbala	West shore	22-24			X	
71180 *117*	Pulau Panaitan	SW shore	22-24		X		
71012 *118*	Siberut	E & W shores	22-24		X		
71033 72021 *119*	Djawa* [Java]	S coast from Tunjung Guakolak to Tadjung Bantenan	22-24			X	
120	Bali	N. shore Tandjung Bungkulan to Gili Selang	22-24		X		
		S shore at Tg. Balungdaja	22-24			X	
121	Lombok	N & S shores	22-24		X		
122	Sumbawa	N & S shores	22-24		X		

*The major portion of the main Islands of Sumatera, Djawa and Borneo border on the Java Sea and the Straits of Moluccs which are everywhere shallow and unsuitable for OTEC.

INDONESIA (page 2)

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
73002 *123*	Sumba	all	22-24			X	
72021 *124*	Sulawesi [Celebes]	W shore from 120°E to Tandjung Rangasa	22-24			X	
		Tandjung (Tg.) Rangasa to Tg. Rangas	22-24	X			
		Tg. Rangas to Pulau Simatang	22-24		X		
		Pulau Simatang to Vjung Malangka	22-24			X	
		(North Shore) Vjung Malangka to Tg. Kandi	22-24		X		
		Tg. Kandi to 124°E	22-24			X	
		124°E to Tetapaän	22-24			X	
		Tetapaän	22-24	X			
		Tetapaän to Batu Kapal	22-24		X		
		Batu Kapal to Tg. Flesko	22-24			X	
		Tg. Flesko to 122°22'E	22-24	X			

INDONESIA (page 3)

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
72021 *124*	Sulawesi [Celebes]	122°22'E to Tg. Pandjang	22-24		X		
		Tg. Pandjang to Laimanta	22-24			X	
		Laimanta to Tongku	22-24		X		
		Tongku to Teluk Poh	22-24	X			
		Teluk Poh to Maleh	22-24			X	
		Maleh to Tg. Botok	22-24		X		
		Tg. Botok to Bonebabakal	22-24			X	
		Bonebabakal to Tg. Maoloh	22-24		X		
73008		Tg. Maoloh to Tg. Losoni	22-24			X	
		Tg. Losoni to Lolompa	22-24		X		
		Lolompa to E. coast of Poelau Wowoni	22-24			X	
		E. Poelau Wowoni to Tg. Kasolanatombi on E coast of Poelau Boetoeng			X		

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
73008 *124*	Sulawesi [Celebes]	Tg. Kasolanatomb to Tg. Batoe Toero	22-24	X			
		Tg. Batoe Toero to Tg. Ponopono	22-24			X	
		Tg. Ponopono	22-24		X		
		Tg. Ponopono to Tg. Lassa	22-24			X	
		Tg. Lassa	22-24	X			
73002 *125*	Flores	N shore from Longgo to Tg. Batumanuk	22-24		X		
		S shore from Toro Kerita to Tg. Boba	22-24			X	
73000		S shore from Tg. Boba to Tg. Sibelsh on Alor of the Alor Is.	22-24		X		
126	Alor	E of Tg. Sibelah, W shore & N shore	22-24	X			
125	Flores	N shore from Tg. Batumanuk to Tg. Gedong	22-24			X	
		N shore from Tg. Gedong to Tg. Matari on N shore of Alor	22-24		X		

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
73000 127	Wetar	all	22-24	X			
128	Timor	all S shore	22-24			X	
		N shore from W tip to 125°E	22-24		X		
		N shore from 125°E to E tip	22-24	X			
129	Roti	all	22-24			X	
72014 130	Borneo *	E coast from equator N to Tg. Mangkalihat	22-24			X	
		Tg. Mangkalihat	22-24		X		
		Tg. Mangkalihat to Tg. Semuntai	22-24			X	
		Tg. Semuntai to Tg. Batu	22-24				X
		Tg. Batu to Tg. Sepikat	22-24			X	
71027 92005		all remaining shores*	22-24				X
73010 131	Soela Is. [Kepulauan Sula]	S shore	22-24	X			
		N shore	22-24		X		

*The major portion of the main Islands of Sumatera, Djawa and Borneo border on the Java Sea and the Straits of Moluccs which are everywhere shallow and unsuitable for OTEC.

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
73018 *132*	Buru	N shore between Tg. Wapoti & Tg. Pela	22-24		X		
		all remaining	22-24	X			
73018 73022 *133*	Seram [Ceram]	N shore	22-24			X	
		S shore	22-24	X			
73022 *134*	Gorong Is.	all E shores	22-24			X	
		all N shores	22-24	X			
	Watoebela Is.	all E shores	22-24			X	
		all W shores	22-24	X			
	Kai Is.	all	22-24			X	
73016 *135*	Obi Major	S shore	22-24		X		
		N shore	22-24			X	
136	Batjan	S coast between Tg. Maregarango and Tg. Lemo	22-24	X			
		E coast bordering Patientie Strait	22-24		X		

INDONESIA (page 7)

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
73016	Mandioli	W coast	22-24			X	
	Kasiruta	W coast	22-24			X	
137	Halmahera	W coast bordering Patientie Strait	22-24	X			
		W shoreline of Weda Bay	22-24			X	
		N shoreline of Weda Bay	22-24	X			
		all shorlines bordering Buli Bay	22-24			X	
		all NE portion around Kau Bay	22-24			X	
		all western shore	22-24			X	
138	Morotai	NW N & E shores	22-24		X		
		S & W shores	22-24			X	
		NW corner	22-24	X			
		remaining	22-24		X		
73341 139	Sangihe	NW corner	22-24	X			
		remaining	22-24		X		

INDONESIA (page 8)

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
73014 *140*	Kepulauan Talaud	SW & NW corners	22-24		X		
73022 *140*	Misool	NW & SW shore	22-24			X	
73130 *142*	Kepulauan Aru	W shore	22-24			X	
		E shore	22-24				X
73020 *143*	Kepulauan Tanimbar	all	22-24			X	
144	Kepulauan Sermata	all	22-24			X	
73034 *145*	Waigeo	NE, E & SE shore	22-24		X		
73020 *146*	Irian Jaya [New Guinea]	NW tip at Kaap van den Bosch	22-24		X		
		Kaap van den Bosch to Telok Sipatnanam	22-24			X	
		N coast from Tg. Sorong to Tg. Dore	22-24	X			
73034		Tg. Sorong to Tg. Memori	22-24		X		
		Tg. Memori	22-24	X			
73020		Tg. Memori to Tg. Oransbari	22-24		X		

INDONESIA (page 9)

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
73020 *146*	Irian Jaya [New Guinea]	Tg. Oransbari to 136°E	22-24			X	
		N shore of Kepulauan Schouten	22-24		X		
73030		137°E to Tg. Kamdara	22-24			X	
		Tg. Kmdara to Tg. Tanahmerah	22-24		X		
		Tg. Tanahmerah to 141°E	22-24	X			

PHILIPPINES

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
91010 *147*	Luzon	W shore at Cape Bolinao, N to Candon	22-24			X	
		Candon to San Esteban	22-24		X		
		San Esteban to Mayraira Pt.	22-24			X	
		Mayraira Pt.	22-24		X		
		Mayraira Pt. to Iligan Pt.	22-24			X	
		Iligan Pt. to J.B. Miller Bay	22-24		X		
		J.B. Miller Bay	22-24	X			
		J.B. Miller Bay to Baguio Pt.	22-24		X		
		Baguio Pt. to Aubarede Pt.	22-24			X	
		Aubarede Pt.	22-24	X			
91005		Aubarede Pt. to Dijohan Pt.	22-24		X		
		Dijohan Pt. to Cape San Ildefonso	22-24	X			

PHILIPPINES (Page 2)

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
91005 *147*	Luzon	Cape San Ildefonso to Cape Encanto	22-24			X	
		Cape Encanto	22-24		X		
		Cape Encanto to south edge of Cantanduanes I.	22-24			X	
		N shore of Polillo I	22-24		X		
		from S edge of Cantanduanes I, N & S shore of Lagoney Gulf	22-24	X			
		from S shore of Lagoney Gulf to S tip of Bondoc Peninsula	22-24	water too shallow			
		SW edge of Bondoc Pen.	22-24	X			
		SE edge of Marinduque I.	22-24	X			
		Lubang I. at W coast of Luzon, SW edge	22-24	X			
		from upper W coast of Bandoc Pen. across S coast to Nasugbu on W coast of Luzon	22-24	water too shallow			

PHILIPPINES (Page 3)

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
91005 147	Luzon	Nasugbu to 14°01'N	22-24			X	
		14°51'N to Palauig Pt.	22-24			X	
		Palauig Pt.	22-24		X		
		Palauig Pt. to 16°N	22-24			X	
		16°N to Cape Bolinao	22-24	X			
148	Mindoro	all N, E & S coast	22-24	water too shallow			
		W coast from S tip to Dongon Bay	22-24			X	
		Dongon Bay to a point opp. Pandan Is	22-24	X			
		Pandan Is. to Cape Calavite	22-24		X		
		Cape Calavite	22-24	X			
149	Busuanga I.	NW tip	22-24			X	
		remaining	22-24	water too shallow			
150	Samar	NW tip, W & S shores	22-24	water too shallow			
		NE tip to Cape Espiritu Santo	22-24			X	

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH 0-5	5-10	10-50	>50
91005	Masbate *151*	all	22-24		water too	shallow	
152	Sibuyan	NE shore, SW shore	22-24	X			
		remaining	22-24		water too	shallow	
153	Tablas	E shore	22-24	X			
		remaining	22-24		water too	shallow	
154	Leyte	N, E & W shores	22-24		water too	shallow	
		S shore at Cabalion Bay, Sogud Bay and Panaon Isl.	22-24	X			
155	Dinagut I.	all E shore	22-24			X	
		remaining	22-24		water too	shallow	
156	Siaragao I.	all E shore	22-24	X			
		remaining	22-24		water too	shallow	
157	Bohol	most of SE shore	22-24	X			
		remaining	22-24		water too	shallow	
158	Cebu	all	22-24		water too	shallow	
159	Panay	NE, E & SE shores	22-24		water too	shallow	
		NW shore - Potol Pt	22-24		X		
		Potol Pt - Pucio Pt	22-24			X	
		Pucio Pt	22-24	X			
		Pucio Pt - Tibiao Pt	22-24			X	
		Tibiao Pt - Dalipe Pt	22-24	X			
		Dalipe Pt - Naso Pt	22-24		X		
		Naso Pt - Miagao	22-24	X			

PHILIPPINES (Page 5)

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
91005 *160*	Negros	W coast above Sojoton Pt, around N shore & E shore	22-24		water too	shallow	
		W coast below Sojoton Pt - Cansilan Pt	22-24		X		
		Cansilan Pt - Siaton Pt	22-24			X	
92005		Siaton Pt	22-24	X			
91005 *161*	Palawan	E coast; Brake Pt - 10°N	22-24			X	
		10°N	22-24		X		
		10°N - Puerto Princessa	22-24			X	
92005		Puerto Princessa	22-24		X		
		Puerto Princessa - 8°45'N	22-24			X	
		remaining	22-24		water too	shallow	
162	Mindanao	Cauit Pt	22-24		X		
		Cauit Pt - Arangasa Isl	22-24			X	
		Arangasa Isl	22-24		X		
		Arangasa Isl - Bangai Pt	22-24			X	
		Bangai Pt - Pusan Pt	22-24		X		
		Pusan Pt - Nagas Pt	22-24	X			
		Nagas Pt - Cape San Augustin	22-24			X	
		Cape San Augustin - Upper Davao Bay	22-24			X	

PHILIPPINES (Page 6)

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
92005 162	Mindanao	Upper Davao Bay	22-24			X	
		Upper Davao Bay - Sangay Pt	22-24	X			
		Sangay Pt - Quidapil Pt	22-24		X		
		Quidapil Pt - Tapian Pt	22-24	X			
		Tapian Pt - Malabang	22-24			X	
		Malabang - Upper Illana Bay	22-24	X			
		Upper Illana Bay - Lower Maligay Bay	22-24		X		
		Lower Maligay Bay - Batorampon Pt	22-24			X	
		SE shore of Basilan Isl	22-24	X			
		Batorampon Pt - Coronado Pt	22-24	X			
		Coronado Pt - Sindangan Pt	22-24			X	
		Sindangan Pt - 123°13'E	22-24	X			
		123°13'E - Polo Pt	22-24		X		
		Polo Pt - Initao Pt	22-24		X		
		Initao Pt	22-24	X			
		Initao Pt - Sulauan Pt	22-24		X		
		Sulauan Pt - E shore Upper Macajabar Bay	22-24			X	

PHILIPPINES (Page 7)

MAP #	ISLAND	LOCATION	ΔT (°C)	DISTANCE (km) OF 1000 m ISOBATH			
				0-5	5-10	10-50	>50
92005 162	Mindanao	E shore Upper Macajabar Bay - Bagacay Pt	22-24	X			
		Bagacay Pt, around N end of Camiguin Isl - Sipaca Pt	22-24			X	
		Sipaca Pt - W shore Upper Butuan Bay	22-24	X			
		Upper Butuan Bay, W - E shores	22-24		X		
		E shore Upper Butuan Bay - Bilaa Pt	22-24	X			
		Bilaa Pt - Cauit Pt	22-24	water too shallow			
163	Sulu Archipelago	NW & SW shores (the open ocean shores) of most of the islands	22-24	X			

were plotted for the southwestern coast of Mexico and Central America (Fig. V-3a). This coastline is quite promising, both from the ΔT and bathymetric viewpoints. In Figure V-3b, distance to shore of these two contours has been plotted against linear distance along the coastline.

What this shows is that in various embayments and re-entrant coastal features, the distance to an offshore contour may be the same from many points along the bay, for example. Thus, several sites may be suitable for locating pipelines or transmission lines, a minimum distance from the offshore facility.

When plotted against latitude (this particular coastline trends WNW-ESE), these become single points along the curve (or form loops where lines of latitude are crossed more than once)(Fig. V-3c).

Work is continuing on combining the ΔT information (next section) with this type of plot to make "hypsothermal" curves that will act as indices of OTEC feasibility along coastlines.

TEMPERATURE DIFFERENCES BETWEEN SURFACE AND DEEP WATERS (ΔT)

In this preliminary report, only the broadest of outlines will be given on the variation of ΔT in tropical oceans and its underlying causes.

Basically, the hydrosphere is divided into two broad vertical zones; the thin, warm surface layer and the deep cold-water region. Simplistically, in the tropics, the surface layer is warmed by contact with the atmosphere, has some vertical dimensions due to mixing and stirring by wind and wave action and is transported westwards by the tradewind-driven equatorial current systems in the major oceans. These currents are deflected north or south by the oceanic boundaries and

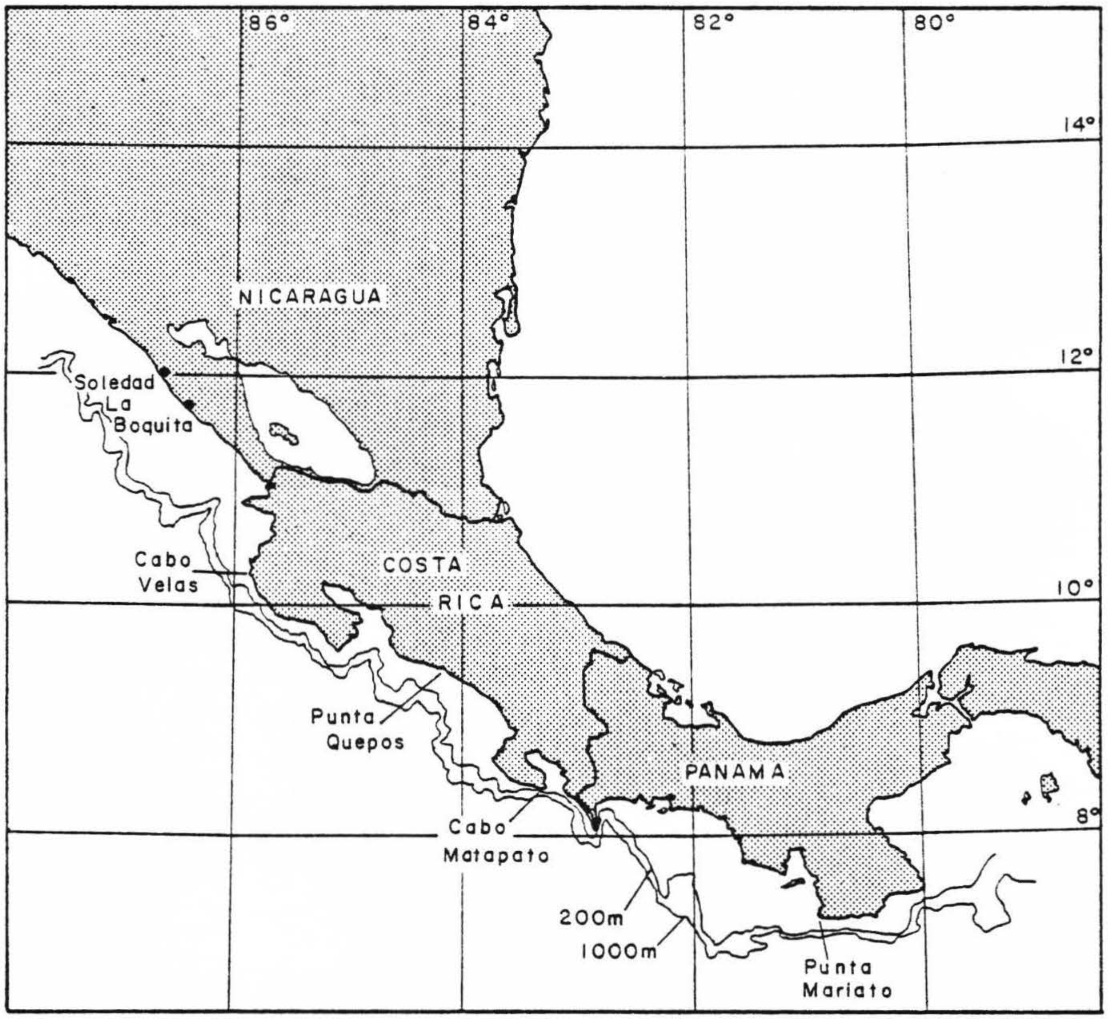

Figure V-3: The southern coast of Central America:
(A) Coastline and coastal bathymetry

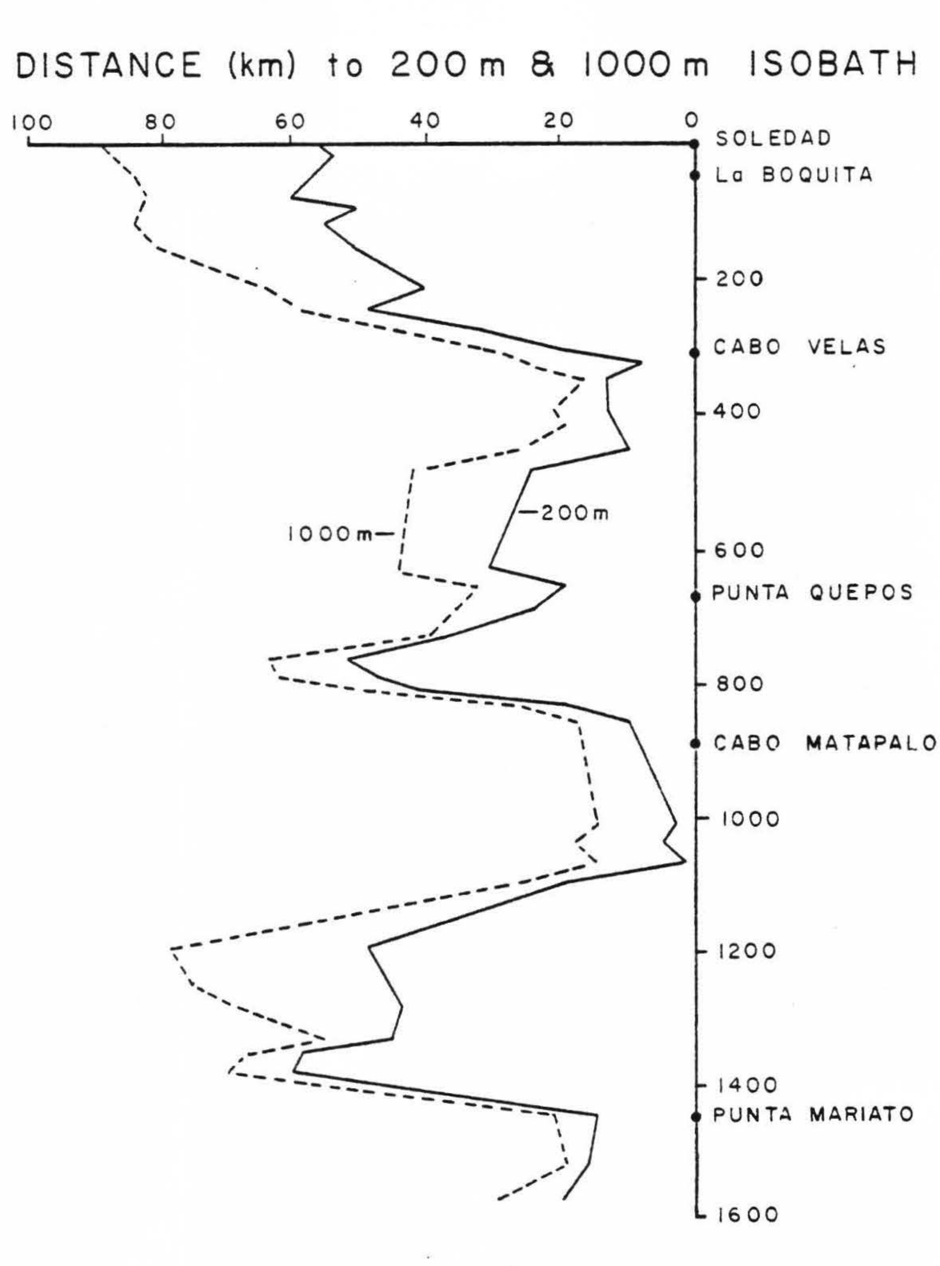

Figure V-3: The southern coast of Central America: (B) Distance to 100 fm and 500 fm isobaths plotted against linear distance along the coastline starting at Soledad

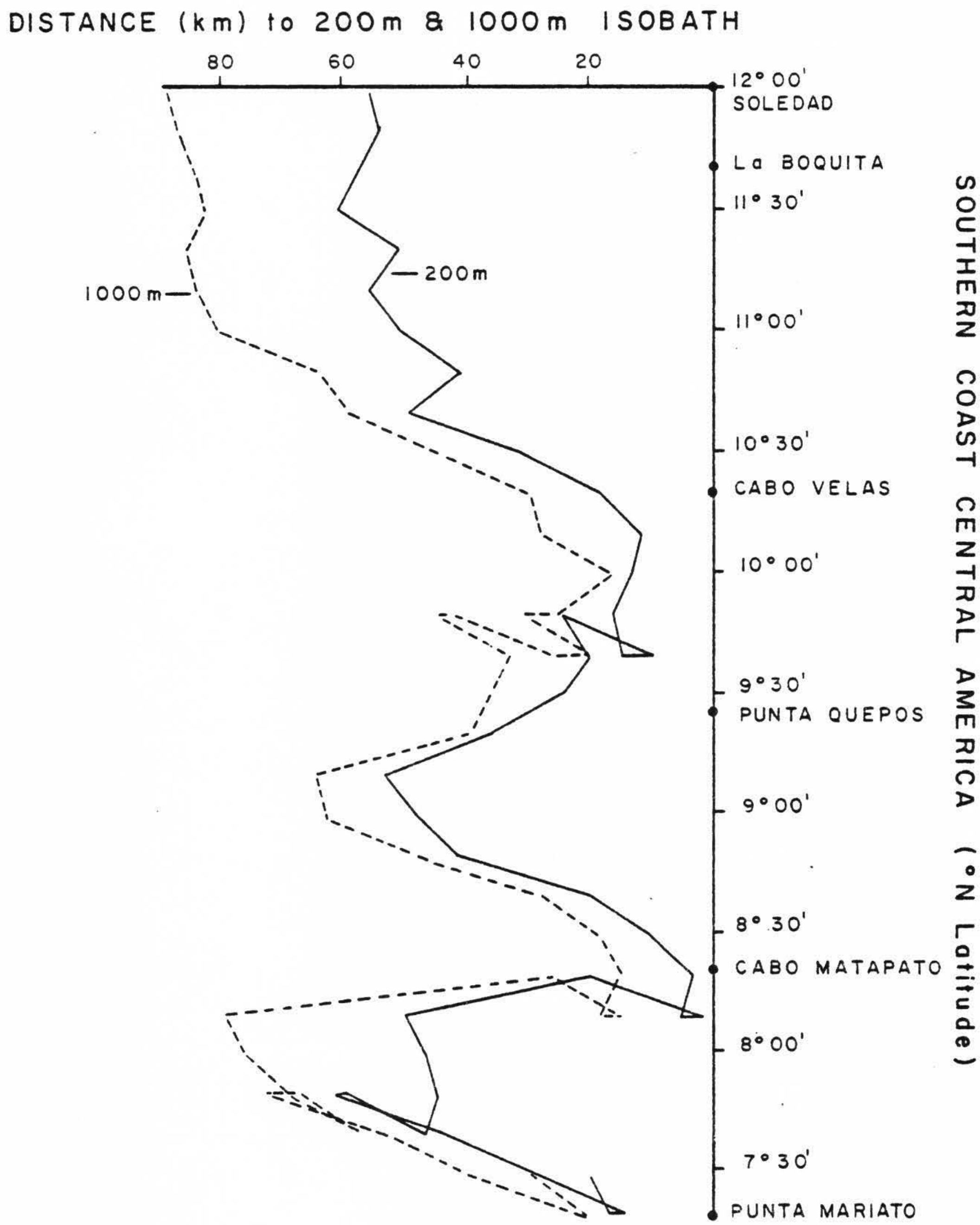

Figure V-3: The southern coast of Central America: (C) Distance to 100 fm and 500 fm isobaths plotted against latitude form the large subtropical current systems or gyres. Narrow equatorial gyres are formed in the doldrums due to the return of some of the water pushed westwards by the tradewinds. In polar regions, which receive less energy from solar radiation, cold sub-polar gyres* occur between the easterly and westerly wind systems. During polar winters, sea ice forms at the surface and in doing so rejects brine, increasing the density of water under the ice, which consequently sinks. In the Antarctic, few topographic barriers exist to impede the spreading of this Antarctic Bottom Water (AABW) and it fills the deep basins of the three major oceans, gradually mixing with northern water masses and, in the Atlantic, does not lose its identity until about 40°N. In the Arctic Ocean, a topographically enclosed basin, no such spreading of bottom water takes place. However, important intermediate water masses are formed as a result of outflow from the Arctic, in particular, upper North Atlantic Deep Water in the western Atlantic.** Of singular importance to OTEC is Antarctic Intermediate Water (AIW) formed at the surface at the Antarctic Polar Front and spreading northwards in all oceans as a cold, low-salinity water mass between 800-1000 m deep. The intermediate and bottom water masses comprise the cold water sphere and are separated from the warm surface layer by the thermocline, across which little natural communication takes place due to the dynamic barrier created by the strong density gradient (pycnocline). OTEC systems will penetrate the thermocline and artificially exchange water between the two spheres.

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*In the Antarctic, unimpeded by continental boundaries, the gyre is circumpolar in nature.

**North Atlantic Deep Water (NADW) is formed from several sources (Emery & Uchupi, 1972) and has been divided into upper, middle and lower NADW by Wüst (1936).

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**North Atlantic Deep Water (NADW) is formed from several sources (Emery & Uchupi, 1972) and has been divided into upper, middle and lower NADW by Wüst (1936).

An ideal OTEC site (excluding topographic considerations) would have a thin surface mixed layer underlain by an intense thermocline. Seasonal variations should be minimal. In tradewind regions the mixed layer is often 100 m thick or more, while in some regions of intense winter gales the water may be mixed to several hundred meters by winter's end. Fortunately, while upper mixed layers are among the ocean's thickest in tropical regions, the annual variation in incoming radiation is the least (Sverdrup et al., 1942), hence the seasonal temperature variation is small (2^{o}-4^{o}C, compared to 10^{o}-14^{o}C in the Gulf of Mexico and >14^{o}C on the northeast coast of the U.S. (see Schott, 1942). ΔT variations at 500 m and 1000 m (see U.S. Department of Energy, 1978, maps) are mainly a function of surface temperature in the tropics. More subtle variations are due to differences in the intermediate water masses. In the Pacific and Atlantic Oceans an asymetrical distribution of surface temperature occurs due to the combined effects of insolation and mixing of waters across the major gyres. Highest temperatures are found at the equator on the eastern margin of these oceans as water in the equatorial gyres flowing towards the east is warmed by insolation. Parts of these water masses, deflected either north or south, mix with cooler waters of the subtropical gyres. In flowing westwards again, they are warmed by insolation and form a broad warm region in the western tropics as they are deflected north or south. As they move polewards they are cooled by receiving less incoming radiation and by mixing with waters from the subpolar gyres before being deflected back again equatorward.

Thus, large ΔTs are found off the equatorial Pacific coasts of central and extreme northern South America, and the equatorial Atlantic coast of Africa. Broader regions are found in the western portion of both oceans. The highest ΔTs (>24°C) at 1000 m are found in the western Pacific. Here, the controlling factor may be that AAIW penetrates north of the equator in the west but only to 10°-15°S in the east (Reid, 1965). North Pacific Intermediate Water, having about the same characteristics as AAIW, penetrates almost to the equator and over-rides the AAIW. A similar westward intensification of AAIW is found in the Atlantic Ocean (Wüst, 1936). Other factors affecting the distribution of ΔT are upwelling along the equator (Cromwell, 1958) and the significant equatorward penetration of the cold Peru and California Currents in the Pacific Ocean, the thick band of "18° water" characteristic of the Sargasso Sea in the Atlantic (Worthington, 1958, 1976), and the monsoonal circulation in the Indian Ocean.

Another important factor in site selection will be the consideration of the density difference between the deep and the surface water. We have done several studies on this problem in connection with the environmental impact of deep ocean mining (Amos et al., 1972, 1973, 1977). Here, not only was ΔT considered, but also salinity and nutrient differences to see how artificially upwelled water behaved at the surface and whether any enrichment took place. The Pacific and Atlantic Oceans differ considerably in their surface salinity in equatorial regions. The Atlantic Ocean has much higher surface salinities due to differences in circulation patterns, evaporation/precipitation cycles, and land-sea distribution. Consequently, surface densities at the same temperatures will be higher in the Atlantic and will generally be higher than the density of intermediate waters if, having been brought to the surface, they are in temperature equilibrium with the surface water. However, near-coastal waters frequently have lower salinities than the open ocean due to freshwater run-off.

Regions of suitable ΔT for OTEC sites are to be found in the equatorial Pacific (Oceania), the eastern coast of India and Sri Lanka, off the Pacific coast of Central America, the Caribbean, the west coast of Africa, the northeast coast of South America, Brazil and the Philippines. The Gulf of Mexico and the Atlantic coast of Florida have suitable ΔTs at some times of the year but show marked seasonal fluctuations.

DETAILED STUDY OF A CARIBBEAN REGION

For the purpose of archiving oceanographic data, the world has been divided into numbered 10^o latitude x 10^o longitude squares. NODC now uses the "Modified Canadian Square" (MCS) system rather than the older, more familiar, Marsden Square. Each 10^o square is divided into one hundred 1^o squares numbered by taking the last digit of the latitude and longitude, e.g., 1^o square #12 would be 11^oN x 62^oW. MCS #1008 (which encompasses the eastern Caribbean, the coast of Venezuela, part of Hispaniola, Puerto Rico, the outer Antilles and part of the Atlantic Ocean) was chosen for a more detailed ΔT study. MCS #1008 is bordered by 10^oN-20^oN and 60^oW -70^oW. This region has some of the most promising OTEC sites in the world.

Using temperature vertical array summary printouts obtained from NODC, the average temperatures at the surface, 250 m, 500 m and 1000 m for each month in each 1^o square bordering a coastline were entered into the computer (see next section for details). All data in each I^o square were averaged to give a yearly mean temperature and ΔT at these four levels (Fig. V-4).

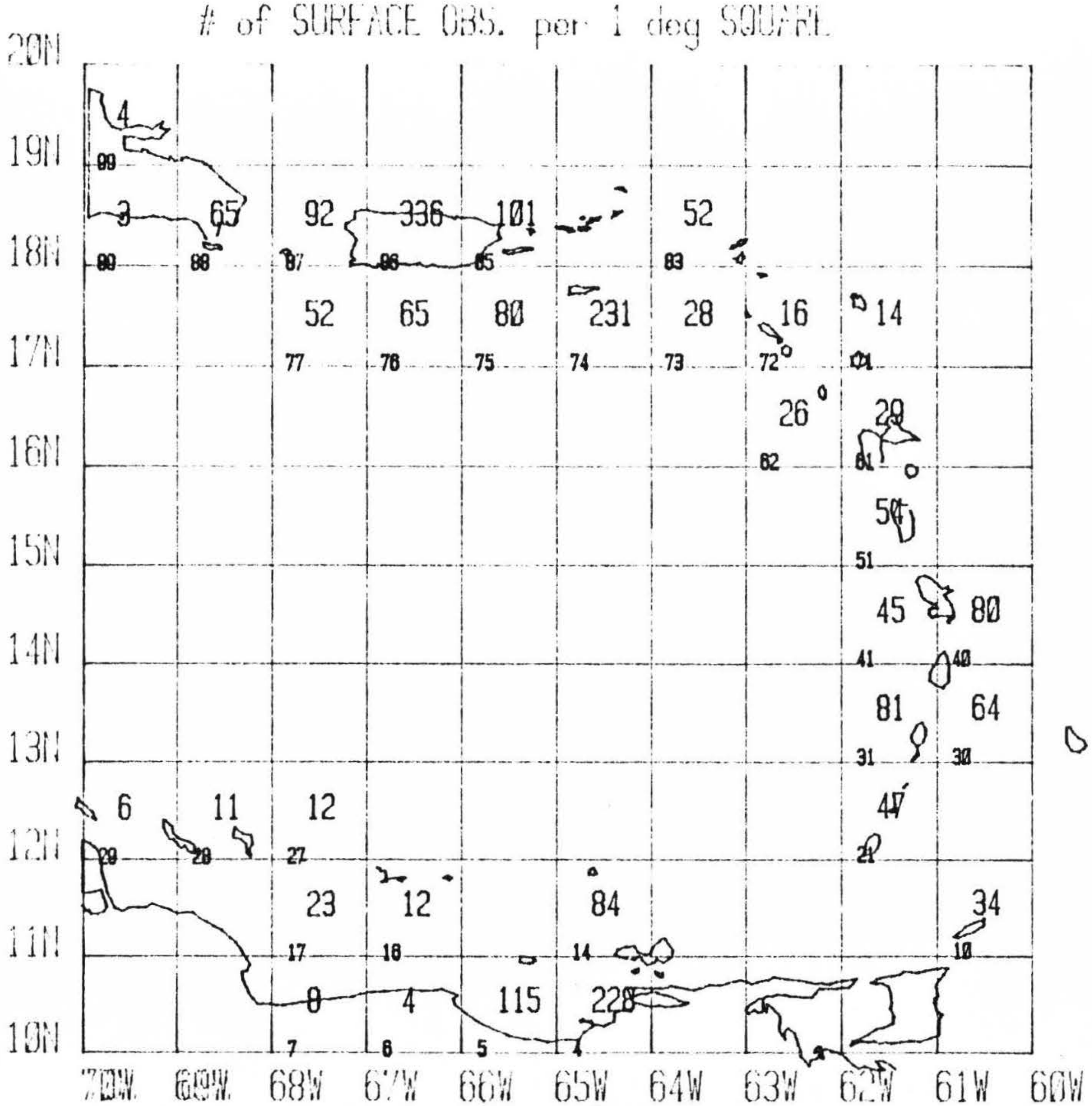

Figure V-4: Number of hydrographic station in each 1° square of Modified Canadian Square (MCS) #1008 (E. Caribbean) that include coastlines: (A) total number of stations on archive at NODC (i.e. surface observations). Smaller numbers in lower right-hand corner of each square is the 1° square number

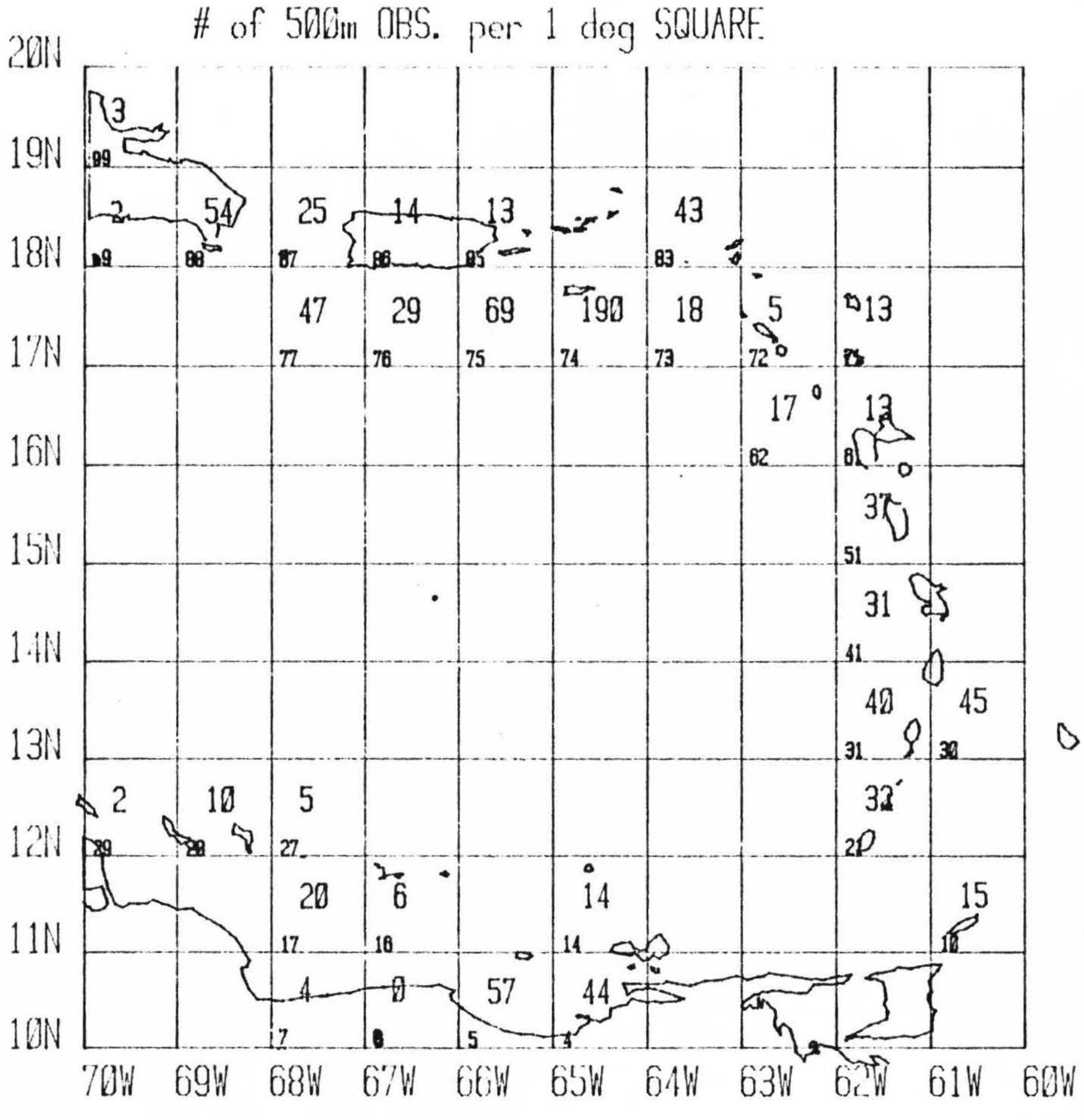

Figure V-4: Number of hydrographic station in each 1° square of Modified Canadian Square (MCS) #1008 (E. Caribbean) that include coastlines: (B) total number of stations on archive at NODC having observations to 500 m. Smaller number in lower right-hand corner of each square is the 1° square number

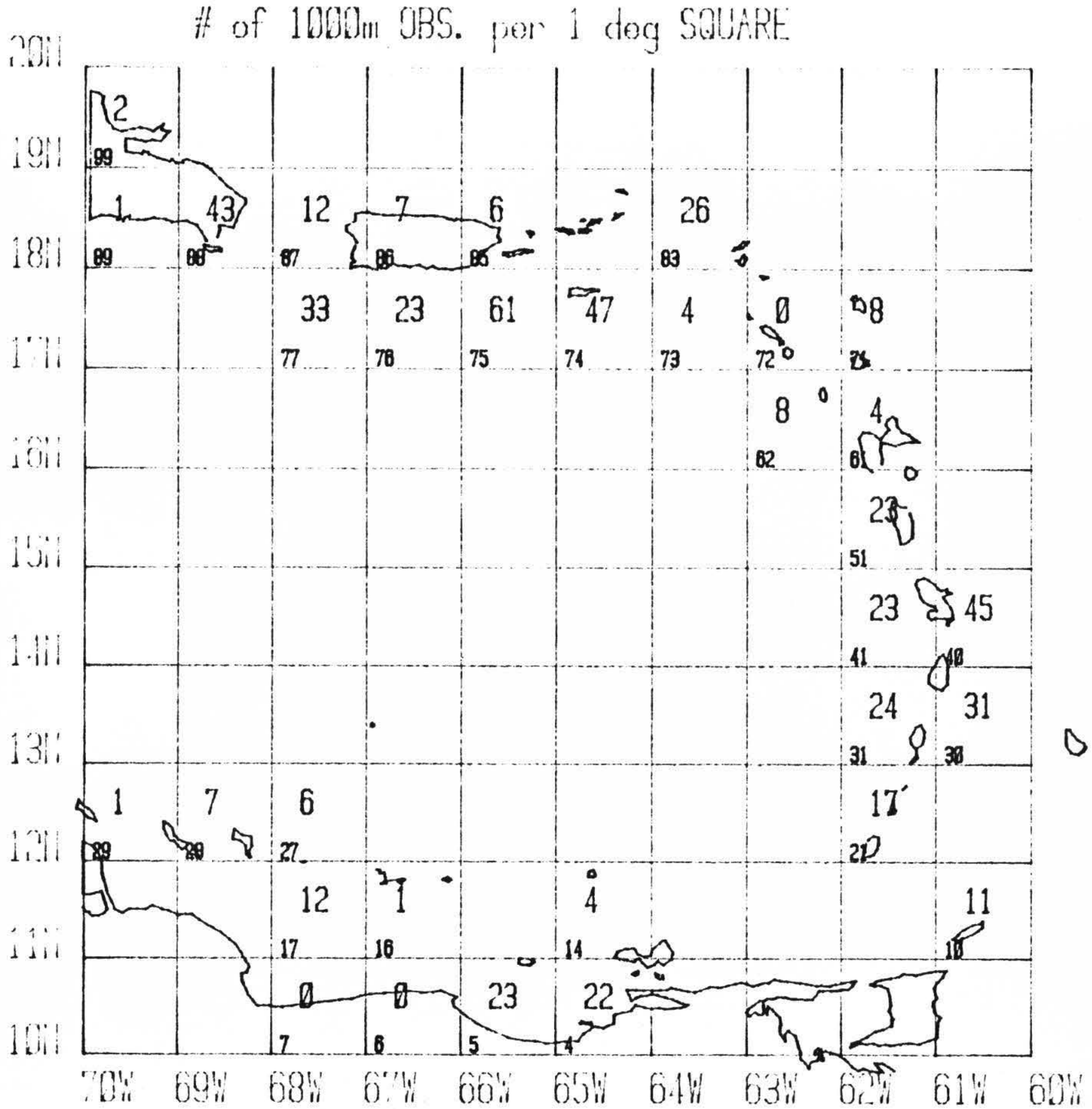

Figure V-4: Number of hydrographic stations in each 1^{o} square of Modified Canadian Square (MCS) #1008 (E. Caribbean) that include coastlines: (C) total number of stations on archive at NODC having observations to 1000 m. Smaller number in lower right-hand corner of each square is the 1^{o} square number

Data Distribution

The data on archive in MCS #1008 readily illustrate the non-systematic nature of oceanographic station distribution: it is biased geographically, seasonally and, not mentioned previously, bathymetrically.

Geographical Bias

Thirty-three of the 100 1° squares include coastlines that have deep water near to shore (square #84 was inadvertently left out of this survey). Figure V-4 shows the number of stations in each of these squares. The disparity can readily be seen. Squares 04, 05, 74 and 86 account for 43% of the total of 2102 stations, while squares 06 and 99 have only 4 stations each and square 98 has none. A 1° square is ~110x110 km ≃ 121,000 km^2. Squares 04 and 05 are above the Cariaco Trench, an enclosed anoxic basin of great interest oceanographically and therefore intensely studied. Square 74 contains the U.S. Virgin Islands and square 86 the north coast of Puerto Rico—both areas of economic, political and strategic importance and therefore well surveyed. Square 99 on the north coast of Haiti and the Dominican Republic are of lesser economic importance, may be politically sensitive, and are undersurveyed or the data are not in the World Data Center A bank.

Seasonal Bias

This is more difficult to document because of masking by the geographical heterogeneity. Table V-4 shows the seasonal variation as a percentage of the 1° squares surveyed that contain data tabulated monthly. Winter and early spring seem to be the preferred time to go to the Caribbean and do oceanography. Fall is a low, perhaps due to hurricane season. This trend is not so obvious when the average number of stations per square is tabulated (Table V-4). However, very large standard

TABLE V-4 MONTHLY SUMMARY OF STATION DATA ON ARCHIVE IN MCS #1008 BY 1° SQUARES THAT INCLUDE COASTLINES (TOTAL NUMBER 1° SQUARES = 33).

MONTH:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Percentage of 1° squares with data	76	85	88	70	61	58	61	73	64	36	85	58
Average number of stations per 1° square	7.4	8.1	6.7	13.7	9.1	10.8	5.6	3.3	4.6	15.7	6.2	2.2
Standard deviation	12.3	8.5	5.5	12.3	15.9	17.1	7.2	20.2	7.0	26.7	9.5	1.3

deviations (see May, June, August and October) show where geographical bias interferes, especially where it is caused by specific oceanographic expeditions that take many stations in one local area during a short period of time. For example, in square 74, 92 stations were taken in October alone and 47 in November, obviously from the same expedition. This is 48% of the October total in only one square. In August, 100 stations, or 45% of the monthly total, were taken in square 86.

The general dichotomy between an even seasonal distribution of stations and intense, short-time studies, can be seen in Table V-5 which also shows the preference for wintertime work in the Caribbean.

"Bathymetric" Bias

Oceanographers frequently measure the near-surface waters and ignore deeper waters. This is often because the underlying reason for the measurement is a study of the photic zone, or a study of coastal waters only, in small ships with limited cable capabilites. It is also easier to measure surface waters than deep waters. Out of a total of 2102 stations in the 33 squares, only 998 (48%) went as deep as 500 m and 539 (26%) as deep as 1000 m*. (See Figures V-4 and V-5 for distribution by square.) This trend is not only to be found in near-coastal studies where the stations may be limited to shallow waters but can be seen in open-ocean surveys as well. One reason for this is that deeper waters show little seasonal fluctuations and may reside in ocean basins for hundreds of years: therefore, deeper waters were assumed to be in steady state. The discovery that even bottom waters, for example, have small-scale but intense gradients (Amos, et al., 1971) that fluctuate temporarily (Biscaye & Eittreim,1976) could have important consequences in OTEC technology.

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*In many 1^{o} squares adjacent to coastlines there may be only a small portion of the square (or none at all) that contains water deeper than 1000 m.

TABLE V-5: 1^{o} SQUARES THAT INCLUDE COASTLINES IN MCS #1008 (EASTERN) CARIBBEAN). THE FREQUENCY OF OCCURRENCE OF A GIVEN NUMBER OF ARCHIVED STATIONS IN A 1^{o} SQUARE, TABULATED BY MONTH. (Expressed as the total number of stations represented by that occurrence, i.e., if six of the 1^{o} squares have six stations archived, then the Xs will represent 36 stations. In the case of no stations archived, the Xs represent the total number of 1^{o} squares that do not have any stations archived.) The table is designed to show the imbalance of archived data distribution, both seasonally and numerically. Code: blank=no stations, X=1-5; XX=6-10; etc.

# STNS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	XX	X	X	XX	XXX	XXX	XXX	XX	XXX	XXX	X	XXX
1	X	X	X		XX	XX	XX	X	XX	X	XXX	X
2	XX	X	XXX		XX	XX	XX	XXX	XX		XX	XXXX
3	XXX	XX	XX	X	XX	X	X	XXX	XXX	X	XX	XX
4	XX	XXX	X	XX			X	XX			X	
5	XX	XX	X	XX	X	X	XX		X	X	X	X
6	XXXXX XXX		XXXX	XX		XX	XX	XX	XX			XX
7		XX		XXXXX			XX	XX			XXXXX X	
8	XX	XX		XXXX		XX		XX	XX	XX		
9	XX	XXXX	XX	XXXX			XX				XXXX	
10	XX		XXXX			XX						
11		XXXXX XXXXX XX					XXX				XXX	
12			XXXXX XXX	XXX				XXXXX		XXX		
13		XXXXX X	XXXXX X	XXXXX X	XXX							
14			XXX		XXX							
15		XXX									XXX	
16-20	XXX	XXX	XXXXX XXX	XXXX		XXXX	XXXX	XXXX	XXXX			
21-30				XXXXX XXXXX	XXXXX X		XXXXX X	XXXXX X	XXXXX X	XXXXX	XXXXX	
31-40					XXXXX XXX	XXXXX XXX				XXXXX XXX		
41-50		XXXXX XXXX		XXXXX XXXX		XXXXX XXXXX					XXXXX XXXXX	
51-100	XXXXX XXXXX XXX			XXXXX XXXXX X	XXXXX XXXXX XXX	XXXXX XXXXX XX		XXXXX XXXXX XXXXX XXXXX		XXXXX XXXXX XXXXX XXX		

Figure V-5 shows total number of stations by month at surface, 500 m and 1000 m. The seasonal preference mentioned earlier can be more readily seen in the stations going to 500 m and 1000 m. Two peculiarities of data distribution in this region can also be seen: In May, of 180 stations, only 26 went to 500 m and 13 to 1000 m. Although 19 of the 33 squares had stations, almost all of them went to only 150 m depth, almost as if there were an archiving error. Only in the intensely surveyed squares 85 and 86 (55% of all data in May) did any stations go to 500 m or 100 m. Also, the great majority of stations taken in the intense October and November survey were only to 500 m in square 74, and, of the 100 stations taken in August in square 86, only 2 were as deep as 500 m and none went to 1000 m.

The major point to be made with all this is that a systematic survey of the hydrography of a region cannot generally be made by examining data in the archives.

Oceanography of the Eastern Caribbean Related to OTEC

Notwithstanding the above, several features of the oceanographic regime in this part of the Caribbean are readily apparent by examining Figure V-6. Average annual surface temperature (Fig. V-6a) varies from 25.1°C to 28.2°C, with a tendency for the lower temperatures to fall along the northern coast of Venezuela and the highest to be in the Windward Islands. The overall average annual surface temperature = 26.34°C (S.D. = 0.74°C). Eliminating the northern coast of S. America for reasons given later, average surface temperature = 27.23°C (S.D. = 0.41°C) and can be considered constant over the Caribbean island region. At 250 m, however (Fig. V-6b), a considerable range in temperatures occurs—from 12.9°C around Tobago to 19.1°C on the southern coast of Hispaniola —a range of 6.2°C. Note the remarkably constant values from 16°N

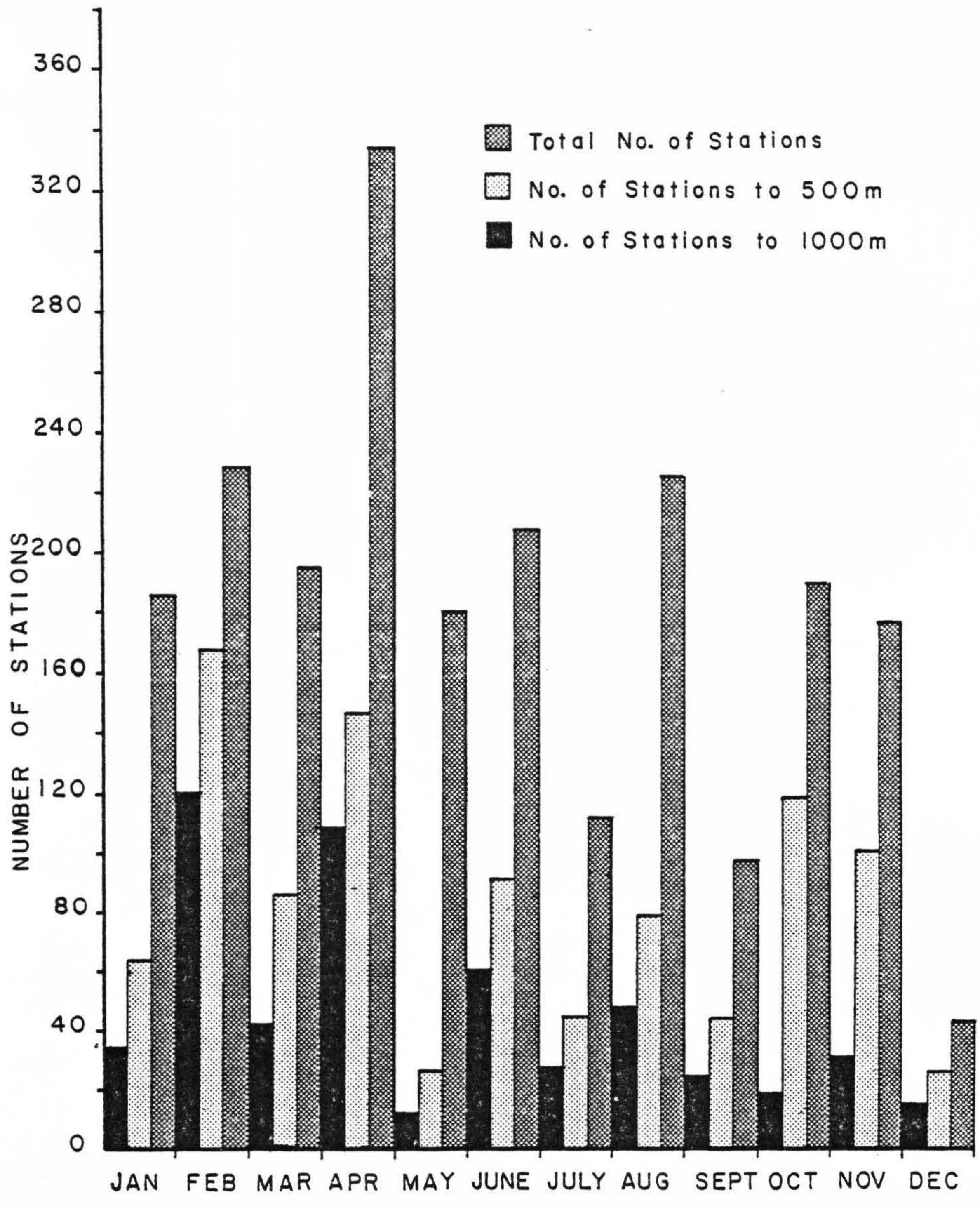
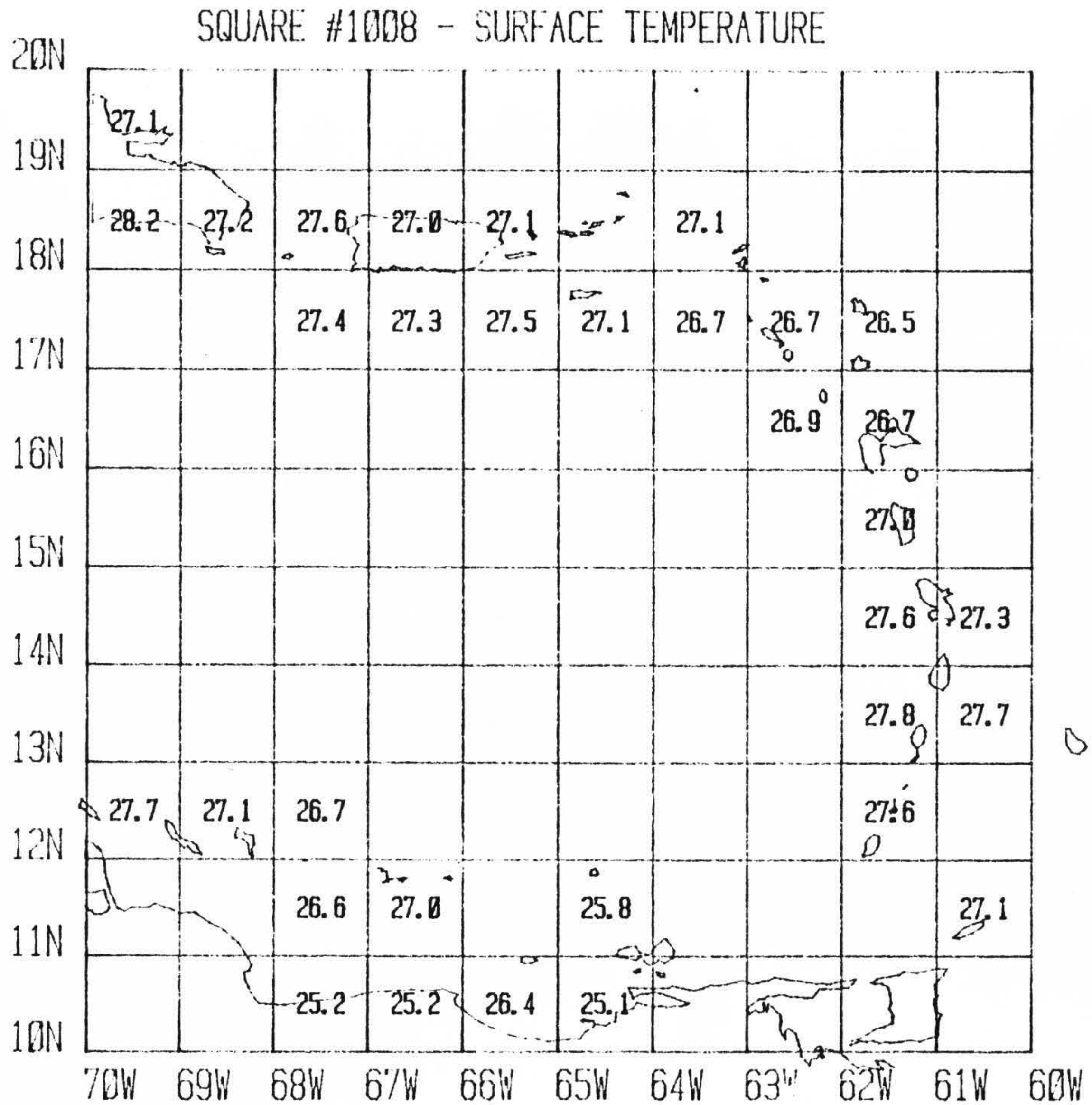


Figure V-5: Total number of stations in each 1° square of MCS #1008 (E. Caribbean) that include coastlines plotted by month for surface (total # of stations), 500 m and 1000 m observations.



~~Figure V-6:~~ Average annual temperature in each 1° square of ~~MCS #1008~~ (E. Caribbean) that include coastlines: ~~(A)~~ surface

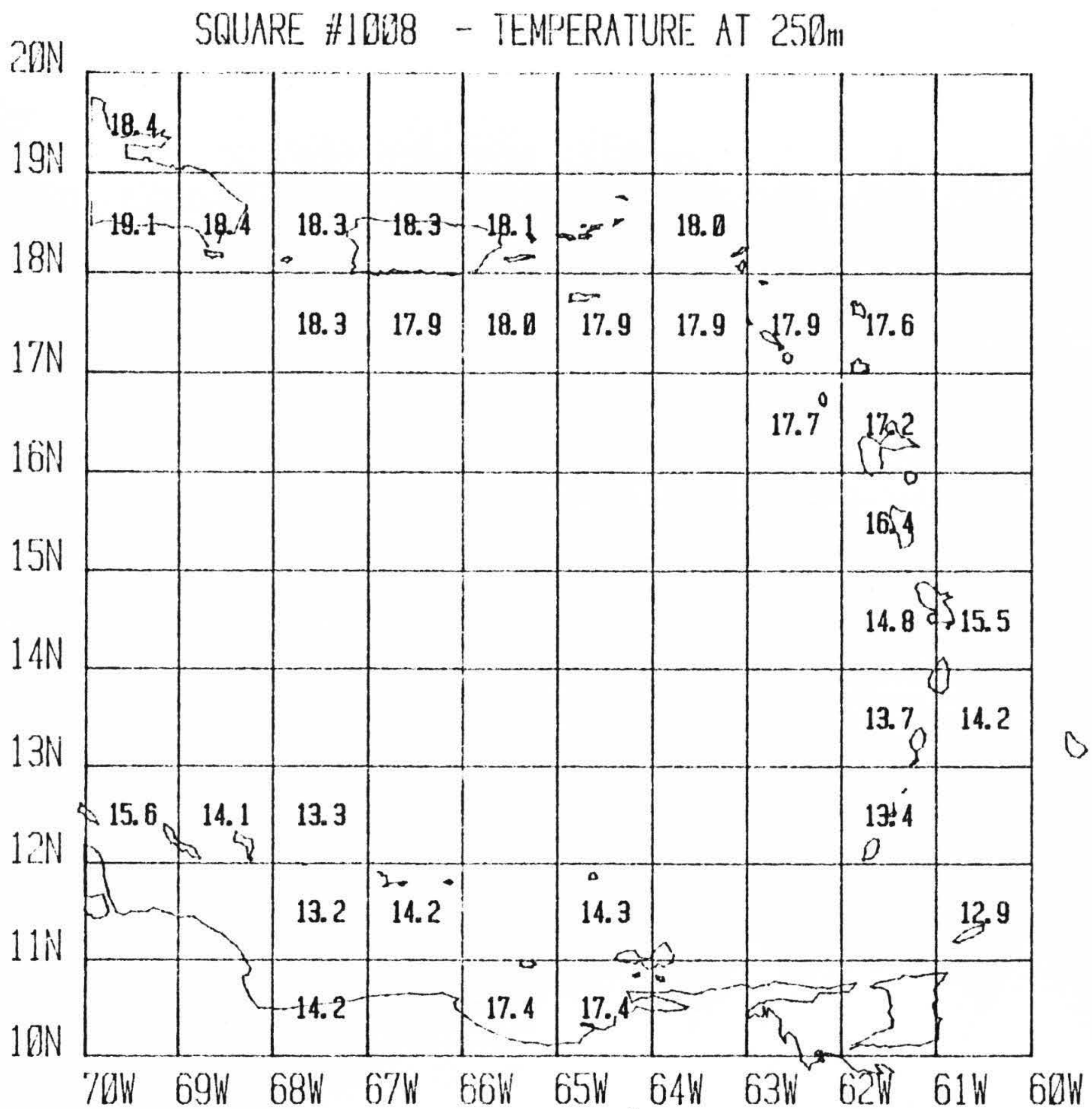


Figure V-6: Average annual temperature in each 1° square of MCS #1008 (E. Caribbean) that include coastlines: (B) 250 m

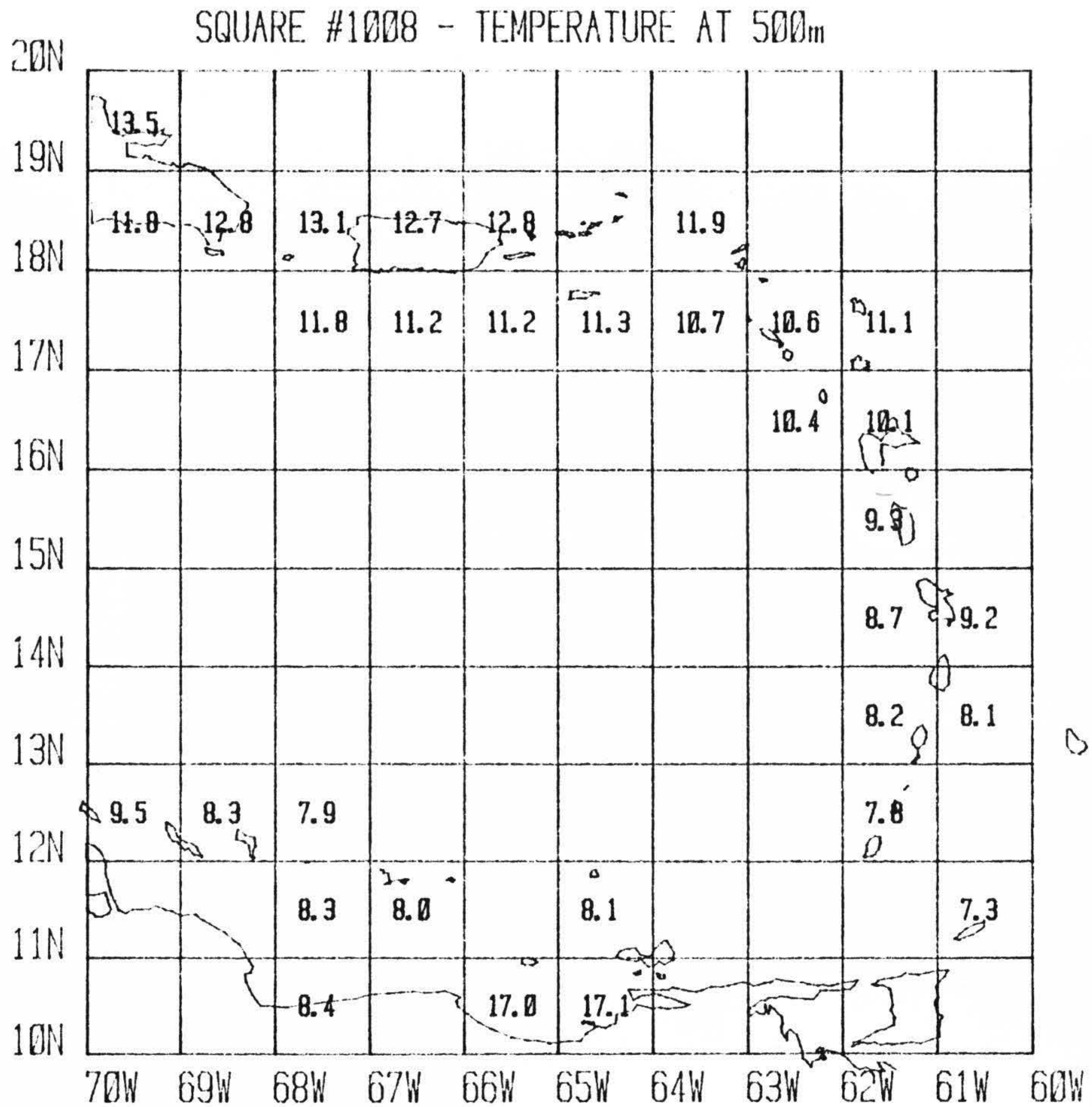


Figure V-6: Average annual temperature in each 1° square of MCS #1008 (E. Caribbean) that include coastlines: (C) 500 m

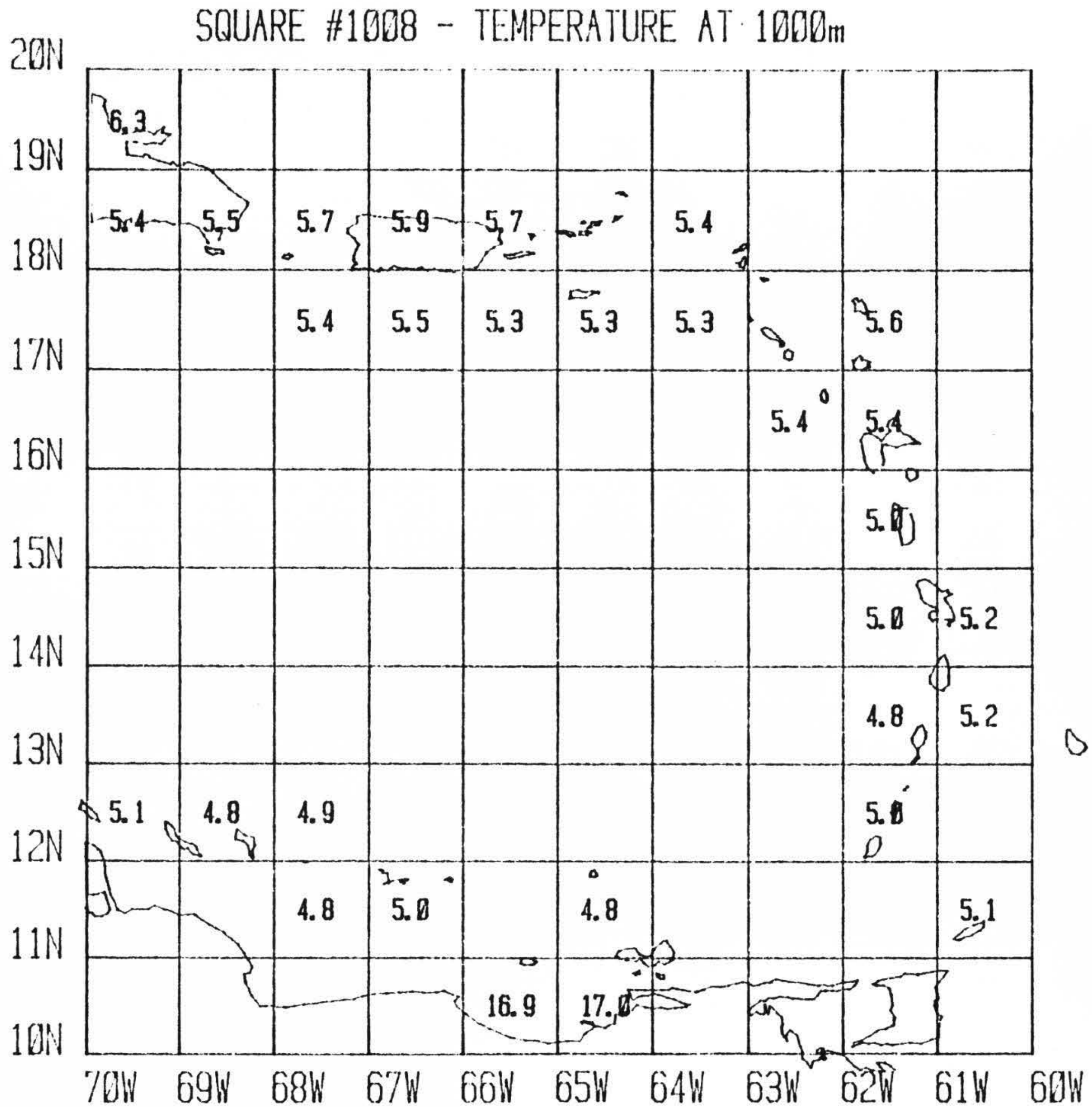


Figure V-6: Average annual temperature in each 1° square of MCS #1008 (E. Caribbean) that include coastlines: (D) 1000 m northwards of around 18°C. This is due to the penetration into the Caribbean of the "18° water" which is formed in the northern Sargasso Sea in winter when isothermal 18° water can be up to 500 m thick (Worthington, 1959, 1976). This far south, the "core" of the 18° water is about 250 m.

The seemingly paradoxical situation, where colder water is found closer to the equator, is due to the considerable influence of Antarctic Intermediate Water (AAIW) flowing north into the Caribbean (Wüst, 1964). At 500 m (Fig. V-6c), the south-to-north temperature difference is still 6.2°C, ranging from 7.3°C to 13.5°C as the effects of the 18° water in the north are still felt at this depth. At 1000 m (Fig. V-6d), however, AAIW dominates the entire region and the temperature varies from 4.8°C to 6.3°C, only 1.5°C difference.

In adjacent squares 04 and 05, the temperature varies little from 17.0°C at 250 m, 500 m or 1000 m. This is due to the underlying Cariaco Trench, a unique (for the Caribbean) anoxic basin first studied by Richards and Vacarro (1956) and accounting for most of the 343 stations in these squares.

ΔT (Figs. V-7a - c), because of the mainly constant surface temperature, varies as the temperature of the intermediate waters varies. At 250 m, ΔT is as high as 14.2°C around Tobago and, ignoring the anomalous Cariaco Trench, as low as 8.7°C off northern Hispaniola and Puerto Rico (Fig. V-7a). At 500 m (Fig. V-7b), the desired ΔT of 20°C is just about reached (19.9°C) around Tobago, while, for example, off St. Croix ΔT is 15.9°C, and 13.6°C off northern Hispaniola.

At 1000 m (Fig. V-7c), the much more uniform temperature of AAIW (1000 m is near the core of this water) results in a uniform ΔT, everywhere greater than the desired 20°C (except over the Cariaco Trench).

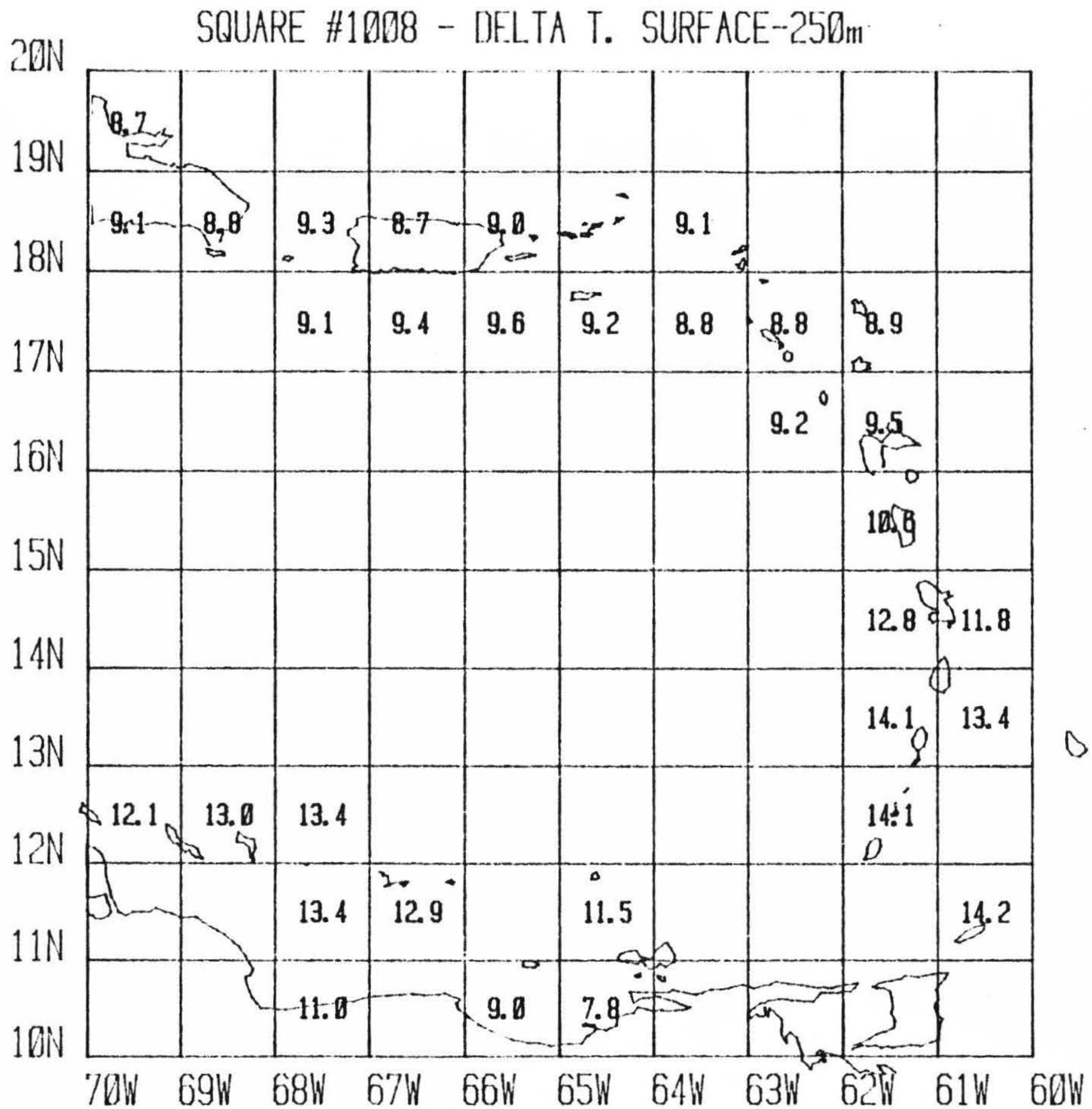


Figure V-7: Average annual temperature difference (ΔT) between surface and deep waters: (A) 250 m

ΔT varies from 20.9 to 22.9°C, with the lower ΔT being in the mostly Atlantic Ocean region off Barbuda and Antigua and the highest ΔT to the Caribbean side of St. Vincent and St. Lucia.

While these differences are quite small, they may be significant for OTEC; the closer to the surface that a suitable ΔT can be found year-round then the shorter the cold-water pipe will be. In this region, the most promising OTEC sites would seem to be off Tobago (which may not have deep water close enough to shore), the Grenadines, St. Vincent, St. Lucia and Barbados.

There are refinements that can be made to identify smaller areas, where ΔT is larger than it is in the general region, where it is closer to the surface and nearer to shore and maintains itself year-round. This would require first a general survey of all possible regions in the manner that we have done here for MCS #1008, being guided by considerations of global water-mass distribution. Next, in selected areas, literature searches should be made, more regional data sources checked and additional surveys made. To look at the ΔTs from a more pragmatic viewpoint, indices of OTEC feasibility might be developed for different regions.

One such index, which we have called the "psuedogradient", has been explored for this region to illustrate the north-south variability. Taking the average annual temperature data in squares 99 (Hispaniola) and 10 (Tobago) as a contrast, ΔT between the surface and each standard hydrographic depth was divided by that depth to give the pseudogradient $\frac{d(\Delta T)}{d_Z}$ in °C per meter. The pseudogradient for square 10 (Fig.V-8a) increases rapidly to .072°C/m at 200 m, then decreases at a slower rate to 1400 m — the deepest observation in square 10. For square 99, the pseudogradient also reaches a maximum at 200 m, but only at 0.039°C/m. Both curves

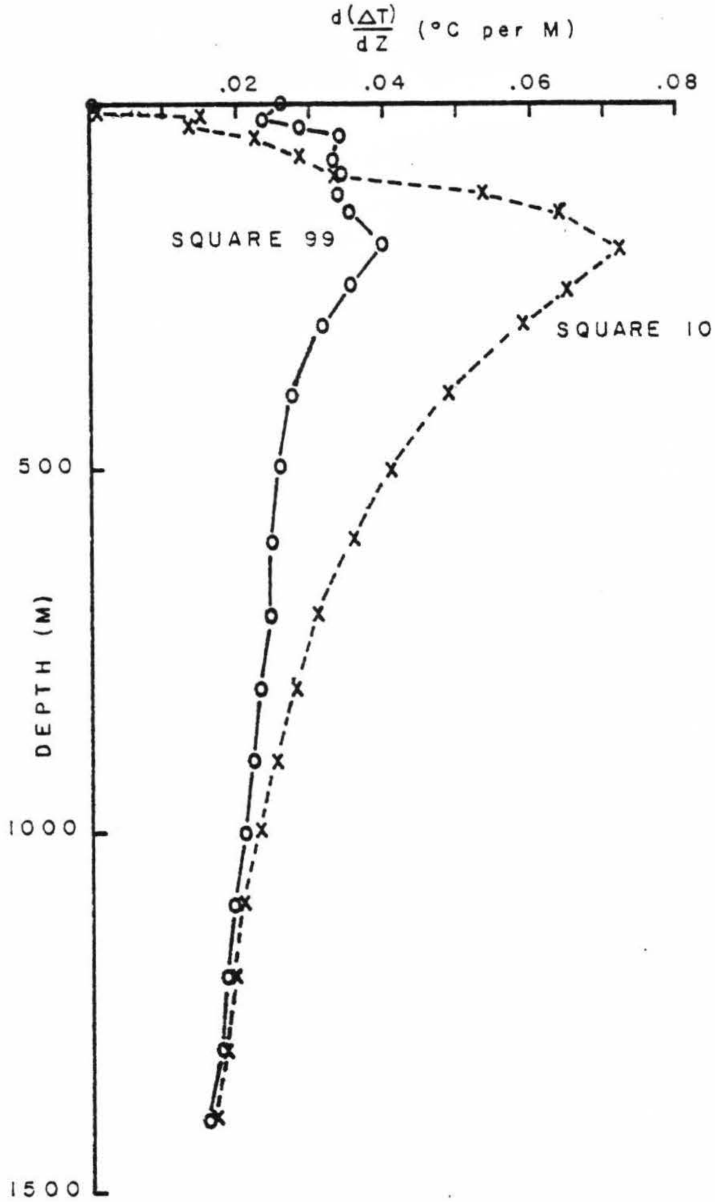


Figure V-8: Vertical temperature structure in two contrasting regions of the Caribbean; the waters surrounding the Island of Tobago (square 10) and off the north coast of Hispaniola (square 99): (A) "Pseudogradient" $\frac{d(\Delta T)}{d_Z}$ (see text)

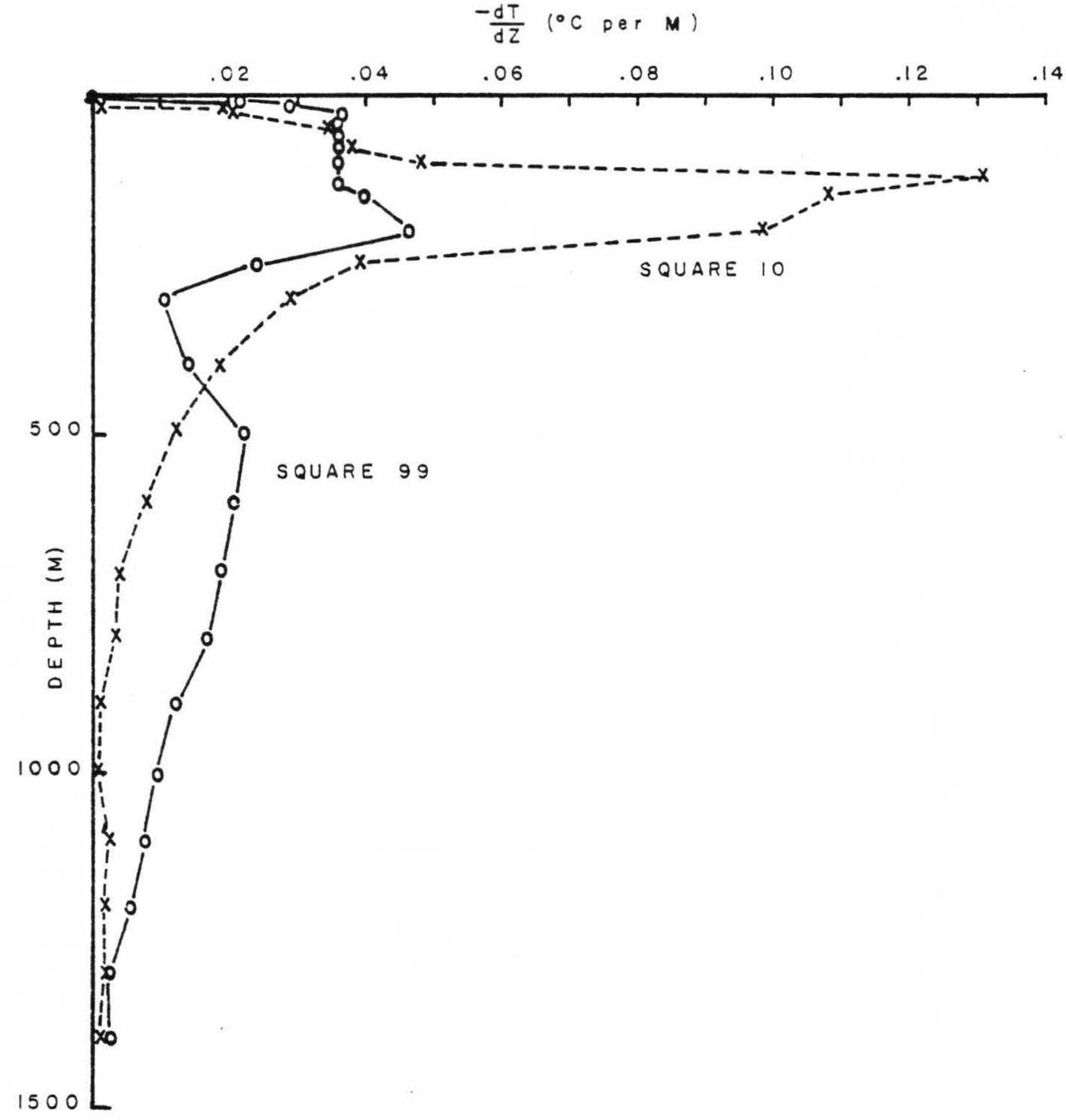


Figure V-8: Vertical temperature structure in two contrasting regions of the Caribbean; the waters surrounding the Island of Tobago (square 10) and off the north coast of Hispaniola (square 99): (B) In-situ temperature gradient $\frac{-dT}{d_Z}$

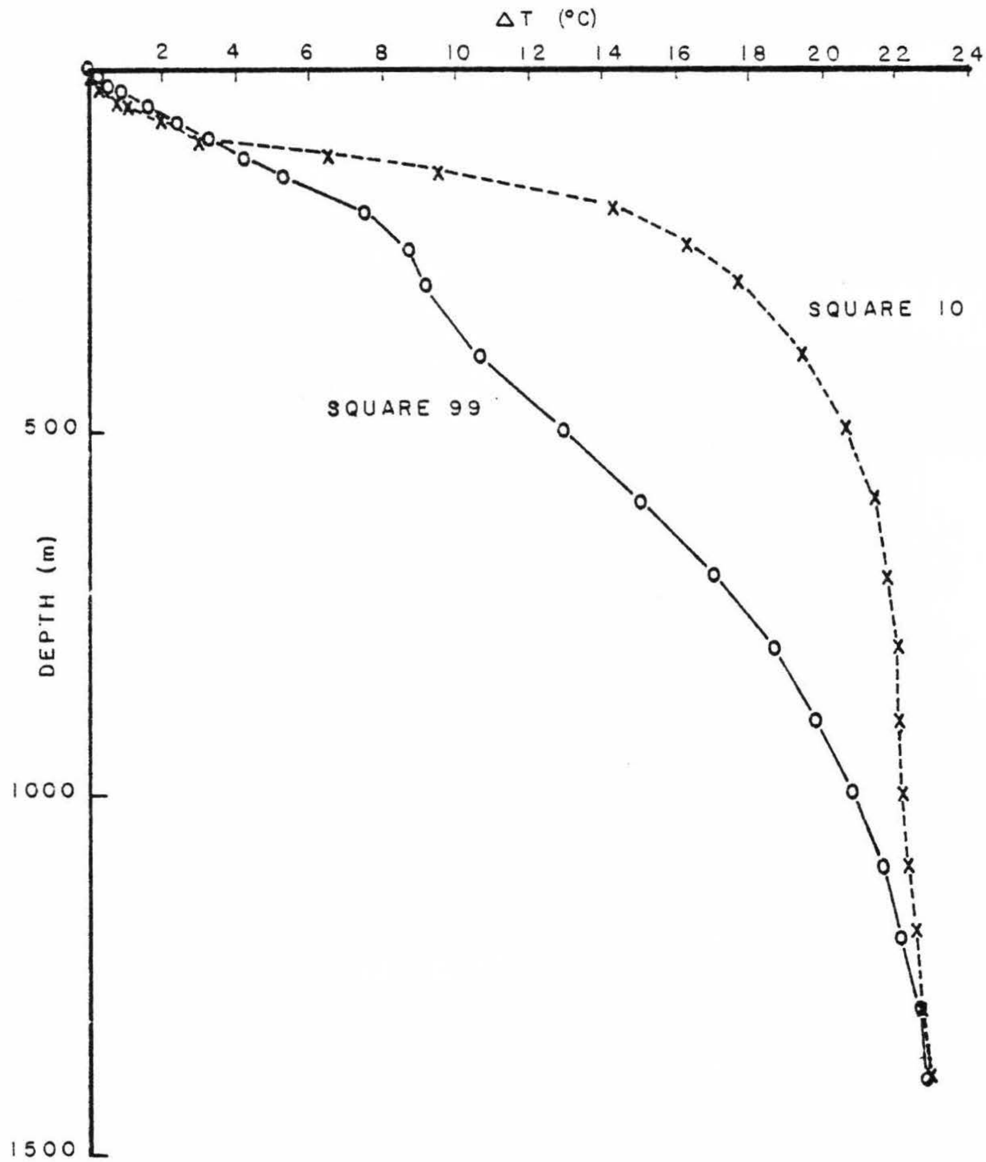


Figure V-8: Vertical temperature structure in two contrasting regions of the Caribbean; the waters surrounding the Island of Tobago (square 10) and off the north coast of Hispaniola (square 99): (C) ΔT plotted as a function of depth.

approach each other asymptotically at about 1100 m. Pseudogradient is the rate-of-change of the temperature difference with depth between surface water and water pumped into a pipe being lowered through the water column. In this sense, it is a pseudogradient and not directly related to the *in situ* temperature gradient ($\frac{-dT}{dZ}$). The *in situ* gradient in the water column (Fig. V-8b) is more sensitive to changes in the temperature field as a function of depth, but it is the way in which ΔT changes the deeper a pipe penetrates the water column that is of interest to OTEC technological requirements.

The magnitude of $\frac{d(\Delta T)}{dZ}$ and the depth of its inflection point may be useful indices to judge OTEC site suitability. Of course, plotting ΔT as a function of depth readily shows the difference between the two 1^o squares in this region (Fig. V-8c) and directly shows the depths of the water producing desirable ΔTs. Thus, pseudogradient may be trivial, but we feel that indices like these, perhaps a second derivative, $\frac{d(\Delta T)^2}{d^2Z}$, or other indices that introduce stability, density, or nutrient concentration, should be explored in a Phase II program as a measure of OTEC/mariculture potentiality.

Slant Distances of Pipelines from Shore to 500 m

Taking the most promising region of the Caribbean from a ΔT viewpoint (the Lesser Antilles), some preliminary observations on possible sites were made.

It must be stressed that these are highly tentative and are not the results of an exhaustive search.

St. Vincent

Off the town of Waterfalls, 0.45 miles east of De Volet Point on the north coast. Distance to 500 m ≃ 0.55 miles = 885 m.

Slant distance = 1016 m.

On the entire west and north coast, slant distances would be <1700 m. Generally, it is 0.25 miles to the 100 fm line.

St. Lucia

West coast: 100 fm line is ~0.2 miles offshore, along most of this coast. At Petit Piton, the 100 fm line is only 0.15 miles offshore. Charts do not show depths beyond 100 fm line, but this looks very promising. Off Beaumont Point, 500 m water is found 0.7 miles offshore, = 1127 m.

Slant distance = 1470 m.

All of Soufrière Bay looks promising.

Grenada

On northwest coast, distance to 548 m = 0.95 miles = 1529 m.

Slant distance = 1610 m.

Generally, it is 0.75 miles to 100 fm depth off west coast—in some places, the distance is 0.3 miles.

Note in Table V-6 the relationship between slant distance of a pipeline to shore and horizontal distance of the 500 m and 1000 m isobaths for different gradients of the continental slope. Also, from Table V-7, when the 500-m isobath is farther than about 1000 m from shore the horizontal and slant distances are within about 100 m of each other and slowly converge as one gets more distant from shore. The first differences shown in Column 3 are the differences in meters between a vertical pipe reading to 500 m long and the slant distance from the 500 m isobath to shore.

TABLE V-6

SLANT DISTANCES FROM A SHORELINE FOR DIFFERENT ANGLES (GRADIENTS OF OFFSHORE TOPOGRAPHY) FOR TWO VERTICAL DEPTHS; 500 M AND 1000 M

Angle (deg)	Horizontal Distance (m) D = 500 m	Horizontal Distance (m) D = 1000 m	Slant Distance (m) D = 500 m	Slant Distance (m) D = 1000 m
0	∞	∞	∞	∞
10	2835	5671	2879	5759
20	1373	2748	1461	2924
30	866	1732	1000	2000
40	596	1192	778	1556
50	420	839	652	1305
60	288	577	577	1155
70	182	364	532	1064
80	88	176	508	1015
90	0	0	500	1000

TABLE V-7

SLANT DISTANCES FOR PIPELINES NECESSARY TO REACH A DEPTH OF 500 M FOR DIFFERENT HORIZONTAL DISTANCES FROM A SHORELINE

Horiz. Dist.	Slant Dist. (m)	First Diff. (m)	Angle (deg)	Horiz. Dist.	Slant Dist. (m)	First Diff. (m)	Angle (deg)
0	500		90	1100	1208		24
100	510	10	79	1200	1300	800	23
200	539	39	68	1300	1393	893	21
300	583	83	59	1400	1487	987	20
400	640	140	51	1500	1581	1081	18
500	707	207	45	1600	1676	1176	17.4
600	781	281	40	1700	1772	1272	16.4
700	860	360	36	1800	1868	1368	15.5
800	943	443	32	1900	1965	1465	14.7
900	1030	530	29	2000	2062	1562	14.0
1000	1118	618	27				
		708					

COMPUTER PROGRAM SYSTEM

For this preliminary report, only printouts of average temperatures by selected 1^o squares could be obtained from NODC in the time allotted. An order has been placed for magnetic tapes of all station data so that chemistry, density and oxygen content in OTEC regions may be analyzed at a later date.

A Hewlett-Packard 9825-A desk-top computer was used to produce the maps in this report. It was equipped with a 9872A plotter, a 9866A printer, a 9885A flexible disk drive, 98034A interface-bus and 98036A serial interface for communication with UT's CDC-6600 at the Austin campus.

The I/O sequence for data used in this report is shown in Figure V-9. Listings of all programs are given in the Appendix.

A coastal chart of a suitable scale and encompassing one 10^o Modified Canadian Square (MCS) was digitized using the 9872A plotter (which can also be used as a digitizer) using program "Digitz". Listing and editing functions were performed using programs "Showme" and "Edplot". Data was stored on flexible disk. NODC data of monthly average temperatures in each 1^o square was entered into the HP 9825A in card image format using program "OTECA". This program stored surface temperature, and temperature at 250 m, 500 m and 1000 m. for each month on disk. "OTECA" has the capability of both listing and editing the disk-stored data. Using program OTECB", annual averages for each 1^o square were computed and the results stored on disk.

Finally, using program "Mrcatr" the digitized country outlines were plotted on an annotated Mercator scale, divided into 1^o squares and the temperatures and ΔTs calculated and plotted in their respective locations (see Figure V-9 for flow diagram).

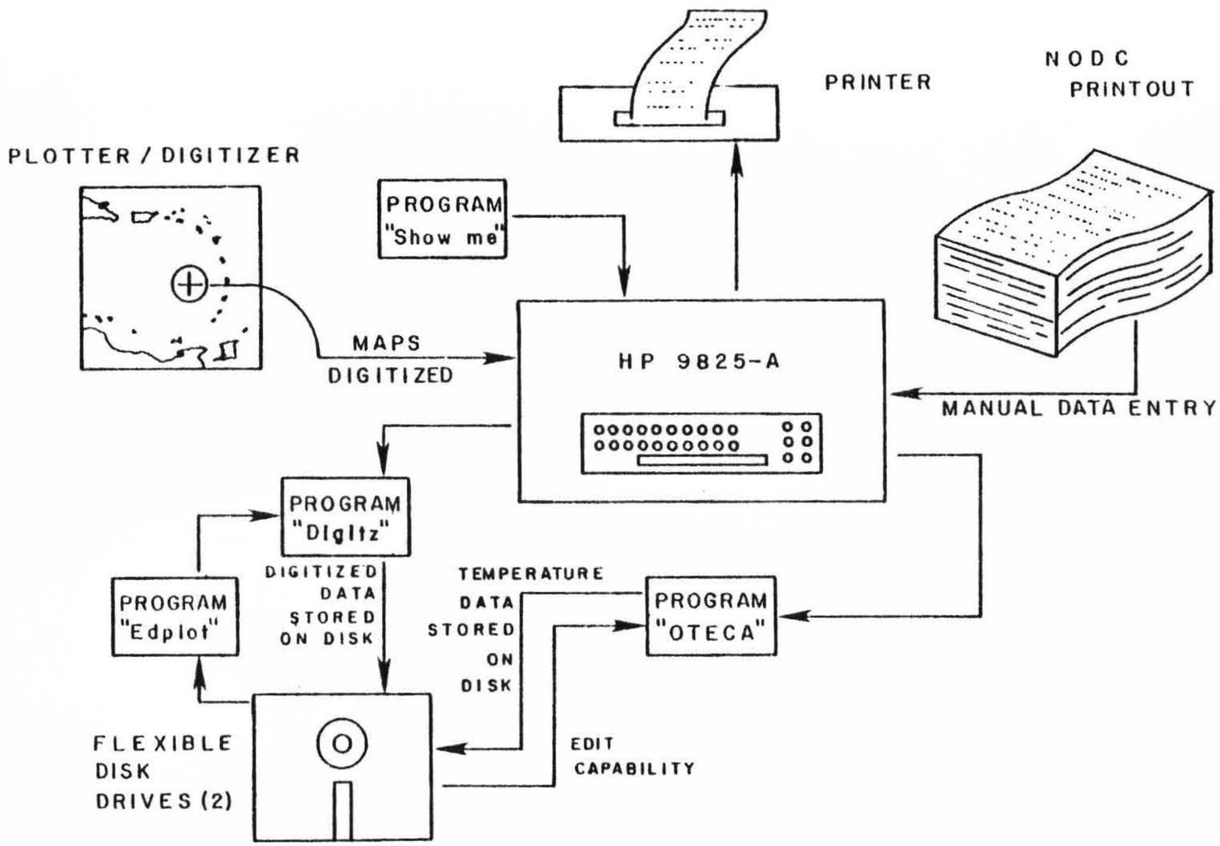


Figure V-9: Flowcharts of computer programming system to store, retrieve and display OTEC-related hydrographic data: (A) Data input sequence

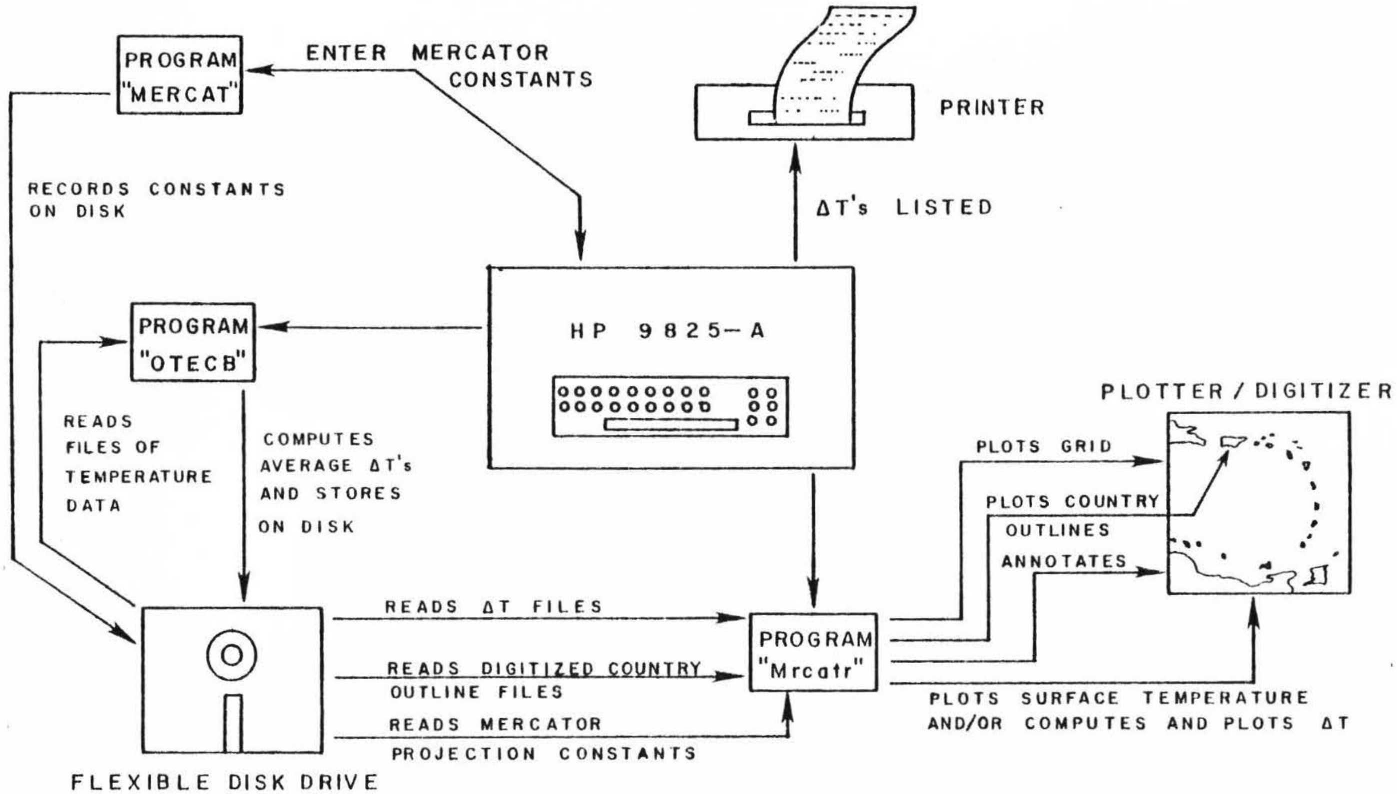


Figure V-9: Flowcharts of computer programming system to store, retrieve and display OTEC-related hydrographic data: (B) Data output sequence

TENTATIVE RESULTS AND RECOMMENDATIONS

The capability has been developed of examining potential OTEC site characteristics on a global scale and also in more detail in selected regions. Most of the data base has been obtained except for bathythermograph records, and specialized bathymetric data that may reside in private data banks and exploration company files. Methods have been developed to store, retrieve and display ΔT information and evaluate the data files for quality control. Certain indices of OTEC suitability such as "pseudo-gradient", and "hypsothermal" curves, have been developed and show promise for further evaluation of OTEC sites.

It is recommended that in any phase II of this project, the collection of the pertinent data bases be completed and a thorough study of suitable sites be done from both the ΔT and bathymetric viewpoints. For this study, some attention should be given to demography and economics before doing a detailed study on any specific area.

Sites that have already been subjected to preliminary study (e.g., in the Caribbean) might be selected for more intense survey.

Our preliminary studies have shown that in certain regions pipelines need only reach 400-500 m to reach water that has an average annual temperature difference from surface water of 20° C. In the Caribbean, the islands of St. Lucia, St. Vincent, Tobago and the Grenadines show the greatest promise. On St. Vincent, off the town of Waterfalls on the north coast the distance to 500 m water depth is $\simeq$ 0.55 miles. A pipeline to reach this depth from shore and provide a year-round ΔT of 20° C would only have to be 1000 m long. There are many other sites with a potential of having deep water even closer to shore, especially in the Philippines, Indonesia and Oceania. It is recommended that more detailed investigations be done on these regions.

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CHAPTER V

SITE SELECTION

APPENDIX

PROGRAMS AND PRINTOUTS

```
0: "Edplot":
1: dim A$[6],X[10],Y[10],P[10]
2: files *
3: ent "ENTER 6-CHARACTER FILE NAME",A$
4: asgn A$,1
5: "START":
6: ent "ENTER FILE #",N
7: rread 1,N,X[*],Y[*],P[*]
8: ent "LINE # TO BE EDITED",L
9: if L=0;jmp 2
10: ent X[L],Y[L],P[L];jmp -2
11: -1→J
12: for I=1 to 5
13: J+2→J
14: fmt 1,2f7.2,f3.0,4x,2f7.2,f3.0,5x,f3.0
15: wrt 6.1,X[J],Y[J],P[J],X[J+1],Y[J+1],P[J+1],N
16: next I
17: fmt /;wrt 6
18: rprt 1,N,X[*],Y[*],P[*]
19: gto "START"
20: end
*21395
```

PROGRAM "Edplot" EDITS DIGITIZED DATA TO CORRECT ERRORS AND RE-RECORDS ON DISK.

```
0: "Showme":
1: dim A$[6],X[10],Y[10],P[10]
2: ent "ENTER 6-CHARACTER FILE NAME",A$
3: asgn A$,1
4: "START":
5: ent "ENTER START & END FILE #s",M,N
6: for L=M to N
7: rread 1,M
8: sread 1,X[*],Y[*],P[*]
9: -1→J
10: for I=1 to 5
11: J+2→J
12: fmt 1,2f7.2,f3.0,4x,2f7.2,f3.0,5x,f3.0
13: wrt 6.1,X[J],Y[J],P[J],X[J+1],Y[J+1],P[J+1],L
14: next I
15: fmt /;wrt 6
16: next L
17: gto "START"
18: end
*28136
```

PROGRAM "Showme" LISTS DIGITIZED DATA.

X	Y	P	X	Y	P	RECORD NUMBER
-0.10	14.87	0	0.26	14.39	1	1
0.53	14.39	1	0.84	14.03	1	1
1.52	14.02	1	2.16	14.29	1	1
2.49	14.71	1	2.31	15.24	1	1
2.10	15.74	1	1.96	16.19	1	1
1.85	16.50	1	1.25	16.33	1	2
0.70	16.21	1	-0.09	16.21	1	2
-0.09	16.93	1	-0.09	17.71	1	2
-0.17	20.11	1	-0.17	21.49	1	2
0.69	21.18	1	1.10	20.84	1	2
1.41	20.60	1	1.84	19.69	1	3
1.93	19.14	1	1.93	18.32	1	3
2.14	17.65	1	2.31	17.07	1	3
2.39	16.79	1	2.51	16.22	1	3
2.87	15.62	1	3.31	14.68	1	3
4.09	14.32	1	4.80	14.73	1	4
5.66	14.73	1	6.60	14.73	1	4
7.30	15.12	1	8.33	14.72	1	4
9.02	14.58	1	9.99	14.11	1	4
10.89	14.22	1	11.58	14.22	1	4
12.38	13.62	1	13.10	13.22	1	5
13.81	12.83	1	14.66	12.40	1	5
15.59	11.61	1	16.17	11.17	1	5
16.79	10.30	1	17.23	9.50	1	5
17.67	8.90	1	17.34	8.27	1	5
16.79	8.13	1	16.92	7.35	1	6
17.28	6.65	1	17.56	6.01	1	6
18.01	5.43	1	18.46	4.89	1	6
19.12	4.89	1	19.70	4.89	1	6
20.33	4.77	1	21.10	4.77	1	6
22.14	4.91	1	23.10	5.08	1	7
24.21	5.16	1	25.02	5.29	1	7
26.18	5.39	1	27.28	5.54	1	7
28.38	5.61	1	29.37	5.94	1	7
30.41	6.13	1	31.88	6.21	1	7

SAMPLE OUTPUT FROM "Showme": X = X-COORDINATE OF POINT; Y = Y-COORDINATE; P = PEN COMMAND (0 = LIFT PEN BEFORE MOVING; 1 = LOWER PEN BEFORE MOVING).

```
0: "OTECA":
1: dim T[5],B$[240],A$[6],C$[80]
2: "1         10        20        30        40        50        60"→C$
3: "          70"→C$[62]
4: fmt 2,2/,3fz2.0,":",fz2.0,":",fz2.0,2/
5: dev "clock",716
6: wtb "clock","C"
7: red "clock",T;1→I
8: 100frc(T/100)→T[I];int(T/100)→T;jmp (I+1→I)=6
9: wrt 6.2,"Date: ",T[4],"/",T[5],"/1978 ; Time: ",T[3],T[2],T[1]
10: files *
11: ent "ENTER 6-CHARACTER FILE NAME",A$
12: asgn A$,1
13: ent "0 TO ENTER, 1 TO EDIT, 2 TO LIST",I
14: if I=1;gto "EDIT"
15: ent "ENTER RECORD #",N
16: "LOOP":
17: rread 1,N;if I=2;sread 1,B$
18: fmt 2,"RECORD #",f4.0
19: wrt 6.2,N;wrt 6,C$
20: -79→J;0→K
21: for L=1 to 3
22: J+80→J;K+80→K
23: if I=2;jmp 3
24: ent "ENTER 80 COLUMNS OF DATA",B$[J,K]
25: if B$[J,J]="x";"0"→B$[J,240];sprt 1,B$,"end";gto "EDIT"
26: wrt 6,B$[J,K]
27: next L
28: if I#2;sprt 1,B$
29: wrt 6," "
30: N+1→N
31: gto "LOOP"
32: "EDIT":
33: ent "FILE # TO BE EDITED",N
34: rread 1,N
35: sread 1,B$
36: ent "LINE #?",J,"COLUMN #?",K,"# OF CHARACTERS?",L
37: if J=0;jmp 2
38: ent B$[(J-1)*80+K,(J-1)*80+K+L-1];jmp -2
39: rread 1,N;sprt 1,B$
40: fmt 3,"EDITED RECORD #",f4.0
41: wrt 6.3,N;wrt 6,C$
42: -79→J;0→K
43: for L=1 to 3
44: J+80→J;K+80→K
45: wrt 6,B$[J,K]
46: next L
47: wrt 6," ";gto "EDIT"
48: end
*12003
```

PROGRAM "OTECA" ENTERS NODC TEMPERATURE, AVERAGED STATION DATA FROM KEYBOARD ONTO DISK FILE. ALSO EDITS DATA TO CORRECT ERRORS.

```
RECORD #    7
1        10        20        30        40        50        60        70
21 3 261 129 078 04921 4 274 135 078 05221 6 270 000 000 00021 7 281 129 076 051
2911 284 157 087 0512912 275 000 000 00030 1 264 134 076 05130 2 265 152 078 053
30 3 270 132 085 05130 4 275 141 085 05230 5 273 000 000 00030 6 275 000 000 000

RECORD #    8
1        10        20        30        40        50        60        70
30 7 281 139 083 05230 8 285 145 076 05130 9 288 155 080 0513010 283 139 083 053
3011 287 143 082 0003012 273 000
31 3 270 128 084 04731 4 272 138 080 00031 5 271 000 000 00031 6 285 142 088 000

RECORD #    9
1        10        20        30        40        50        60        70

EDITED RECORD #    3
1        10        20        30        40        50        60        70
 6 8 243 000 000 000 7 1 217 000 000 000 7 3 255 000 000 000 7 8 268 142 084 000
 711 269 142 000 00010 1 264 135 077 04910 2 264 134 071 05210 3 268 120 078 000
10 4 280 130 080 05110 5 271 000 000 00010 6 272 122 078 05010 7 275 112 068 052

EDITED RECORD #    4
1        10        20        30        40        50        60        70
1011 279 148 054 0531012 270 133 077 05214 1 243 120 076 04814 2 258 145 079 046
14 3 242 131 075 00014 4 243 147 090 00014 5 261 132 078 00014 6 245 147 000 000
14 8 252 151 084 04814 9 281 161 084 0001410 275 142 082 0001411 281 152 083 048

EDITED RECORD #    7
1        10        20        30        40        50        60        70
21 3 261 129 078 04921 4 274 135 079 05221 6 270 000 000 00021 7 281 129 076 051
2911 284 157 087 0512912 275 000 000 00030 1 264 134 076 05130 2 265 152 078 053
0

EDITED RECORD #    6
1        10        20        30        40        50        60        70
21 3 261 129 078 04921 4 274 135 078 05221 6 270 000 000 00021 7 281 129 076 051
21 8 281 141 076 00021 9 295 137 000 0002111 285 142 079 00027 1 258 130 071 048
27 2 262 140  083 05027 3 257 131 000 00027 8 272 129 081 05027 9 281 131 000 00
```

TYPICAL OUTPUT OF "OTECA": KEY TO DATA COLUMNS (REPEATED FOUR TIMES IN EACH LINE): (a) = 1° SQUARE NUMBER; (b) = MONTH; (c) = SURFACE TEMPERATURE; (d) = TEMPERATURE AT 250 m; (e) = TEMPERATURE AT 500 m; (f) = TEMPERATURE AT 1000 m.

```
0: "OTECB":
1: dim B$[240],A$[6],T[100,4]
2: files *
3: ent "ENTER 6-CHARACTER FILE NAME",A$
4: asgn A$,1
5: ent "ENTER RECORD #",N
6: ent "0 TO LIST,1 FOR NO LIST",L
7: on end 1,"OUTPUT"
8: "LOOP":
9: rread 1,N
10: sread 1,B$
11: if F=0;val(B$[1,2])→S→X;1→F
12: -19→J;-14→K;-10→M;-6→O;-2→P
13: for I=1 to 12
14: 20+J→J;20+K→K;20+M→M;20+O→O;20+P→P
15: "TEST":
16: if X=0;gto "OUTPUT"
17: if val(B$[J,J+1])#S;gto "AVGE"
18: val(B$[P,P+2])+T[X,4]→T[X,4];if val(B$[P,P+2])#0;r4+10→r4
19: val(B$[O,O+2])+T[X,3]→T[X,3];if val(B$[O,O+2])#0;r3+10→r3
20: val(B$[M,M+2])+T[X,2]→T[X,2];if val(B$[M,M+2])#0;r2+10→r2
21: val(B$[K,K+2])+T[X,1]→T[X,1];if val(B$[K,K+2])#0;r1+10→r1
22: gto "SKIP"
23: "AVGE":
24: if r1#0;T[X,1]/r1→T[X,1]
25: if r2#0;T[X,2]/r2→T[X,2]
26: if r3#0;T[X,3]/r3→T[X,3]
27: if r4#0;T[X,4]/r4→T[X,4]
28: if L=1;gto "NOLIST"
29: fmt 3,"DELTA T's for 1Deg. square",f3.0;wrt 6.3,S
30: fmt 4," SURF.",f6.1," -----"
31: fmt 5,"   250",2f6.1
32: fmt 6,"   500",2f6.1
33: fmt 7,"  1000",2f6.1,/
34: wrt 6.4,T[X,1]
35: wrt 6.5,T[X,2],T[X,1]-T[X,2]
36: wrt 6.6,T[X,3],T[X,1]-T[X,3]
37: wrt 6.7,T[X,4],T[X,1]-T[X,4]
38: "NOLIST":
39: val(B$[J,J+1])→S→X;0→r1→r2→r3→r4;gto "TEST"
40: "SKIP":
41: next I
42: N+1→N
43: gto "LOOP"
44: "OUTPUT":
45: files *
46: ent "ENTER 6-CHAR.OUTPUT FILE NAME",A$
47: asgn A$,1
48: sprt 1,T[*]
49: end
*31394
```

PROGRAM "OTECB" READS DATA FILES FROM "OTECA", COMPUTES <u>ANNUAL</u> AVERAGE TEMPERATURE IN EACH 1^{o} SQUARE, RECORDS $T_{(surf)}$, $T_{(250)}$, $T_{(500)}$ AND $T_{(1000)}$ ON NEW DISK FILE. COMPUTES AND PRINTS OUT ΔTs FOR EACH 1^{o} SQUARE.

```
Date: 06/21/1978 ; Time: 09:04:42

DELTA T's for 1Deg. square  4
 SURF.  25.1 -----
   250  17.4   7.8
   500  17.1   8.1
  1000  17.0   8.2

DELTA T's for 1Deg. square  5
 SURF.  26.4 -----
   250  17.4   9.0
   500  17.0   9.4
  1000  16.9   9.4

DELTA T's for 1Deg. square  6
 SURF.  25.2 -----
   250   0.0  25.2
   500   0.0  25.2
  1000   0.0  25.2

DELTA T's for 1Deg. square  7
 SURF.  25.2 -----
   250  14.2  11.0
   500   8.4  16.8
  1000   0.0  25.2

DELTA T's for 1Deg. square 10
 SURF.  27.1 -----
   250  12.9  14.2
   500   7.3  19.9
  1000   5.1  22.0

DELTA T's for 1Deg. square 14
 SURF.  25.8 -----
   250  14.3  11.5
   500   8.1  17.7
  1000   4.8  21.1

DELTA T's for 1Deg. square 16
 SURF.  27.0 -----
   250  14.2  12.9
   500   8.0  19.0
  1000   5.0  22.0
```

OUTPUT FROM "OTECB" LISTS _IN_ _SITU_ TEMPERATURE AND ΔT.

```
0: dim A[81]
1: files MERCAT
2: ent "0 TO LOAD FILE,1 TO EDIT",N
3: if N=1;gto "EDIT"
4: for I=1 to 81
5: ent A[I]
6: A[I]/10000→A[I
7: fmt 1,"A[",f2.0,"]=",f7.4
8: wrt 6.1,I,A[I]
9: sprt 1,A[I]
10: next I
11: "EDIT":
12: files MERCAT
13: for I=1 to 81
14: sread 1,A[I]
15: next I
16: "START":
17: ent "RECORD #? ",N
18: if N=0;gto "RECORD"
19: ent A[N];gto "START"
20: "RECORD":
21: files MERCAT
22: for I=1 to 81
23: sprt 1,A[I]
24: next I
25: end
*27021
```

PROGRAM "MERCAT" LOADS MERCATOR/LINEAR MAP SCALE CONVERSION FACTORS ONTO DISK FILE.

```
A[ 1 ]= 0.9933
A[ 2 ]= 0.9937
A[ 3 ]= 0.9943
A[ 4 ]= 0.9952
A[ 5 ]= 0.9964
A[ 6 ]= 0.9980
A[ 7 ]= 0.9998
A[ 8 ]= 1.0020
A[ 9 ]= 1.0045
A[10 ]= 1.0073
A[11 ]= 1.0105
A[12 ]= 1.0139
A[13 ]= 1.0170
A[14 ]= 1.0219
A[15 ]= 1.0264
A[16 ]= 1.0313
A[17 ]= 1.0365
A[18 ]= 1.0421
A[19 ]= 1.0481
A[20 ]= 1.0545
A[21 ]= 1.0613
A[22 ]= 1.0686
A[23 ]= 1.0752
A[24 ]= 1.0843
A[25 ]= 1.0928
A[26 ]= 1.0109
A[27 ]= 1.1114
A[28 ]= 1.1215
A[29 ]= 0.1320
A[30 ]= 1.1431
A[31 ]= 1.1548
A[32 ]= 1.1671
A[33 ]= 1.1801
A[34 ]= 1.1937
A[35 ]= 1.2079
A[36 ]= 1.2229
A[37 ]= 1.2388
A[38 ]= 1.2552
A[39 ]= 1.2726
A[40 ]= 1.2909
A[41 ]= 1.3101
A[42 ]= 1.3303
A[43 ]= 1.3515
A[44 ]= 1.3739
A[45 ]= 1.3875
A[46 ]= 1.4121
A[47 ]= 1.4482
A[48 ]= 1.4758
A[49 ]= 1.5049
```

```
A[50 ]= 1.5356
A[51 ]= 1.5681
A[52 ]= 1.6024
A[53 ]= 1.6388
A[54 ]= 1.6774
A[55 ]= 1.7185
A[56 ]= 1.7621
A[57 ]= 1.8085
A[58 ]= 1.8580
A[59 ]= 1.9108
A[60 ]= 1.9674
A[61 ]= 2.0280
A[62 ]= 2.0932
A[63 ]= 2.1633
A[64 ]= 2.2389
A[65 ]= 2.3208
A[66 ]= 2.4096
```

PRINTOUT FROM "MERCAT". THE INDEX OF VARIABLE A IS EQUIVALENT TO DEGREES LATITUDE.

```
A[67 ]= 2.5062
A[68 ]= 2.6118
A[69 ]= 2.7275
A[70 ]= 2.8547
A[71 ]= 2.9954
A[72 ]= 3.1516
A[73 ]= 3.3261
A[74 ]= 3.5222
A[75 ]= 3.7440
A[76 ]= 3.9924
A[77 ]= 4.2822
A[78 ]= 4.6189
A[79 ]= 5.0145
A[80 ]= 5.4863
A[81 ]= 6.0580
```

```
Date: 25/06/1979   Time: 21:20:29


0: "Mrcatr":
1: dim A$[6],X[10 ,Y[10],P[10],B[160],A[81],B$[50]
2: dim D[100],T[4
3: files MERCAT
4: for L=1 to 81
5: sread 1,A[L]
6: next L
7: ent W,E,S,N
8: E-W→D;if D<=0; +360→D;W+D→E
9: 0→B[1];S→A
10: for J=2 to N- +1
11: A+1→B
12: if abs(A)-abs B)<=0;B[J-1]+A[int(abs(B))]→B[J];jmp 2
13: B[J-1]+A[int( bs(A))]→B[J]
14: B→A
15: next J
16: files *,CS100:;ent "ENTER 6-CHARACTER FILE NAME",A$
17: "LOOP":
18: pclr;scl 0,10 S,S+B[N-S+1]
19: 0→J
20: ent "0 TO PLO  TEMPS,1 FOR DELTAS",r1
21: for P=1 to 10
22: if J#0;gto "PLOT"
23: if r1=1 and P 26;gto "PLOT"
24: pen# 3
25: wrt 705,"TL10 "
26: for L=2 to N- +1
27: yax 0,B[L]-B[ -1],S+B[L-1],S+B[L]
28: next L
29: xax S,1,0,10
30: csiz 2,1.5,2/ ,0;fxd 1
31: ent "LABEL",B ;plt 1,S+B[11],1;csiz 3,1.5,2/3,0;cplt 1,.5;lbl B$;""→B$
32: plt -1,S-.5,1
33: for I=1 to 11
34: plt I-1,S-.5, ;cplt -1,0;fxd 0;lbl W-I+1,"W"
35: next I
36: for I=1 to 11
37: plt -1,S+B[I] 1
38: cplt 0,0;fxd ;lbl S+I-1,"N"
39: next I
40: asgn A$,1
41: scl 0,100,0,1 0
42: pen# 4
43: for L=1 to 25
44: if type(1)=3; mp 6
45: rread 1,L,X[* ,Y[*],P[*]
46: for I=1 to 10
47: plt X[I],Y[I] P[I]+1
48: next I
49: next L
50: pclr;scl 0,10 S,S+B[N-S+1]
51: "PLOT":
52: pen# 2
53: csiz 2,1.5,2/ ,0;fxd 1
54: sread 2,T[*]
55: for K=1 to 4
56: J+1→J
57: if T[K]=0;gto "END"
58: if P<26 and r =1;T[K]→D[J];gto "END"
59: int(J/10)→Y;J int(J/10)*10→X
60: if P>25 and r =1;D[J]-T[K]→T[K]
61: plt 9-X,S+B[Y 1],1
62: cplt 1,1;lbl  [K]
63: "END":
64: next K
65: if J=100;0→J; tp
66: next P
67: gto "LOOP"
68: end
*2255
```

PROGRAM "Mrcatr" PLOTS MAP OF A 10^{o} SQUARE REGION, ANNOTATES GRID, ADDS HEADER, DRAWS COUNTRY OUTLINES OR BATHYMETRIC CONTOURS, PLOTS <u>IN SITU</u> TEMPERATURE AND ΔT.