F.A.O projet

TCP/JAM/2251

Marine cage fish farming

March 1993

Amended september 1993

The present document has been established after a mission to Jamaica, taking place between september 28, 1992 and october 9, 1992. During this mission contacts have been established with the Ministry of Agriculture, Aministrations, Research Institutes, private fish farmers and fishermen groups or individuals, under the coordination and with the efficient assistance of the FAO regional office of Kingston.

Contributors are :

P. ESPEUT(1), **Y. HARACHE** (2), **G. LEMARIE** (3) and **J.M. RICARD** (4)

under the coordination of **J.M. RICARD**

(1) University of the West Indies, Institute of Social & Economic research, Kingston, JAMAICA
(2) IFREMER, Centre de Brest, FRANCE. Coordinator of fin fish Research Programs
(3) IFREMER, Station de Palavas FRANCE
(4) IFREMER Regional Director for the West Indies, Le Robert, MARTINIQUE

SUMMARY

1. INTRODUCTION

1.1 MOTIVATION OF THE PROJECT : *(FAO Documents 19/07/1991)*

BACKGROUND and JUSTIFICATION

Marine capture fisheries in Jamaica is primarily artisanal in nature ansd is conducted maiinly by fishermen operating from canoes. Approximately 95% of these fishermen operate on the coastal shelf and its associated banks. The commercial species harvested comprise bottom-dwelling, coral reef species and free swimming species of finfish. Other fishery resources of commercial value include marine shrimp, conch and lobsters. Catch statistics are not available for all species, but the Department of Fisheries reports a slight decline in fishery production with production decreasing from 16 milion lbs in 1990, despite the fact that fishing efforts have doubled. Over this period the number of registered fishermen has grown from 12 000 to 16 000, al of whom are engaged in full-time fishing. There arealso part-time fishermen who are not registered.

The decline in fish catch is accompanied by a decrease in fish size and quality, suggesting that the fisheries are under pressure and have already exceeded optimum production in relation to vailable resources. As a result the economic returns to fishermen are declining. There are also other problems, such as high incidence of conflicts among fishermen at sea, the high cost of purchasing boats, outboard engine fuel, and equipment, with together with the dangers involved in fishing offshore (piracy, and praedial larceny) create serious social ans economic difficulties for fishermen. Notwithstanding, there is an apparent move on the part of the fishermen to leave the industryor to seek alternative forms of employment. In fact, the Department ofFisheries reports that it is still reciving applications for new licences to operate fishing boats. This is probably due to the fact that where the basis of a community is fishing, it becomes difficult to introduce alternative forms of employment, such as cottage industries, village crafts and other trades.

In 1987 the Jamaica Department of Fisheries prepared a Management plan which proposed several conservation measures to promote the efficient use of fisheries resources and to control the development of the Fishery in such a way that the country would receive highest benefits. Adequate attention was given to limitations on fishing gear, institution of closed seasons and related legislation. Strategies to diversify the marine fishing were also proposed. The 1990 five year Devlopment Plan for marine fisheries also focuses on proper resource management in order to reverse trends associated with the overexploitation of marine resources. According to the plan, emphasis will be placed on inland fisheries and mariculture in order to reduce pressure on the fisheries. Inland fisheries in the form of freshwater fish farming has expanded significantly over the past 10 years with production increasing from less than 0,5 million lbs. in 1980 to in excess of 6.0 million lbs. in 1989. However, some freshwater fish farmers are already experiencing serious competition for water usage and, to a lesser extent for land from crop-producing farmers.

The Ministry of Agriculture is of the view that marine cage culture technologically has the potential for introduction in Jamaica . This technologyhas been successfully developed in Norway and the technology is currentlty being experimentally utilized in several countries in the area. The technology, if widely utilized in Jamaica, couls significantly reduce pressure on fisheries, making fishing more cost effective and improve the economic returns to fishermen. Already there exist some technical and institutional capabilities in Jamaica to support commercial development of marine cage culture. The Department of Fisheries has highly trained personnel in aquaculture and marine fisherie, some of whom are directly responsible for the success of freshwater fish farming. In adition, the Marine Laboratory at the Univesity of the West Indies (UWI) is caarying research on hatchery facilities for marine cage farming. The Department of Fisheries will seek the collaboration ofg the marine unit at UWI which could provide fingerlings of selected marine species for cage culture. One the main thrusts of the research programme of this Unit is the promotion of local species which appear to have potential for aquaculture with a view to either developingnew systems for their culture or on adapting already existing systems to that purpose. The UWI facility is strategically located at Port Royal, one of the older fishing villages in the country.

1.2 OBJECTIVE OF THE ASSISTANCE AND WORKPLAN *: (FAO document 19/07/91*

A. Objective of the assistance

The main purpose of the assistance is to carry out the preparatory work for and the formulation of longer term projects that will aim to the feasibility of marine cage fish farming in Jamaica in order to find a socially and economically acceptable alternative to artisanal fishing and thereby reduce pressure on local fisheries.

The specific objectives are :

to evaluate possibilities to develop marine cage fish farming in Jamaica and elaborate proposals for experimental and pilot projects that will permit an avaluation of the potential for marine cage farming as an economically viable activity in the country.

to evaluate the scope of UWIS Marine Laboratory participation, in particular its capacity to provide adequate hatchery facilituies for a meaningfu marine cage fish farming programme with potential for growth.

to evaluate the capacity of the Department of Fisheries to carry out a marine cage fish farming programe and to establishand maintain linkages with appropriate supprt institutions ;

to facilitate the preparation by the Government of requests for obtaining external funding for assistance to the above experimental and pilot cage fish farming programme in Jamaica.

B. Workplan

In order to achieve the above objectives, the following activities will be undertaken :

an assessment of potential sites for marine cage fish farming. Special consideration wil be given to commercial fishhing beaches and to fishing communities whose regular fishing grounds are under severe pressure ;

recommandations for environmental practices which should be observed and or introduced in order to maintain the desired quality of the sites ;

an assessment of the social and economic implications of widespread applicationsof this technology at local and national levels (employment, incomes, availability of protein) the impact of widespread practice on rehabilitation of fisheries and the possible implications for consumer acceptance of the species selected;

an assessment of technical and physical conditions offered by thr Marine Laboratory at Port Royal to provide support for marine cage farming and formulation of the necesary improvements ;

an assessment of the institutional capacity of the Department of Fisheries to manage the programme and to provide the necessary promotional and extension services ;

preparation of a proposal for a longer-term pilot project to encourage widespread practice of marine cage fish farming ;

the conduct of a workshop or similar training activity to introduce the technology to fishermen and fisheries extension officers.

The above activities should involve not only government institutions, but also fishermen, fishing cooperatives, and the private sector. The UWI's Marine Laboratory at Port ROYAL will also be associated to some of these activities.

1.3 Methodology and workplan used

The mission visit to Jamaica as well as the preparation of the final report were driven by three main concerns:

A. The Relevance of the Mission Report to the local context:

This Mission Report would not be useful if it was not based on the most accurate information about the local context. Relevant biological, technical, economic, legal, and social data for Jamaica were integrated into the analysis and the proposals.

B. A full awareness of the present state of knowledge and practice of marine aquaculture worldwide:

A distinction was made between those technologies still in the research phase and those technically and economically established. This permits a better assessment of the risks inherent in each option, and a better estimation of the timetable for the achievement of each objective.

C. The Method of Transferring to Jamaica the necessary knowledge and technology:

The recommendations in this report involve the transfer of technology and technical information to Jamaicans. The methods by which this may be achieved were analyzed in the light of the local context.

Within this framework, the following procedure was established, which is reflected in the presentation of the report.

Step 1: An analysis of the background to the FAO request. This involves an analysis of the present status of fishing and aquaculture in Jamaica, and of its positive and negative aspects.

Step 2: A description of the major world trends in finfish aquaculture development, with special attention given to cases of both success and failure. This step provides adequate information to identify the potential and limits of aquaculture development in any given environment.

Step 3: An analysis of the potential for marine cage fish rearing in Jamaica including an analysis of constraints and the main factors conditioning the activity: the existence of suitable mariculture sites, but also the legal environment, the availability of juveniles, capital and human resources.

Step 4: With regards to all these previous elements, the elaboration of proposals permitting the achievement of the objectives set out in the terms of reference of the mission.

These proposals have been developed with two main considerations:

- they are to take a holistic approach covering all aspects of initiating this new primary production activity: initial and continuous training, scientific and technical advice and cooperation, technical assistance and local site operations.

- they have been formulated to assist local authorities in Jamaica to make appropriate choices between:

  - *short, middle or longer term operations*
  - *the nature of the actions to be undertaken (research or development)*
  - *basic actions (initial training), and instantaneous pragmatic actions (immediate trials).*

2. THE FISHERY SECTOR IN JAMAICA
(Fishing and Aquaculture)

2.1 CONSUMPTION OF AQUATIC PRODUCTS

Table 1 outlines the source and consumption of fish and fish products in Jamaica, between 1977 and 1991. The *per capita* consumption of fish appears to be relatively stable, varying by about 25% over the period. The domestic marine catch has been relatively constant and inland fisheries relatively low (although increasing); the aggregate estimate of the annual consumption of fish has been relatively constant over the period.

Table 1:

SOURCE AND CONSUMPTION OF FISH, JAMAICA, 1977-1991

Year	Estimated domestic marine catch (mt)	Total imports of fish (mt)	Farmed Tilapia (mt)	Estimated total fish consumption (mt)	Estimated per capita consumption (kg/cap)
1977	7,956.9	11,600.0	2.2	19,559.1	9.48
1978	8,094.0	15,250.9	37.8	23,382.7	11.20
1979	7,988.1	19,177.3	25.3	27,190.9	12.87
1980	7,893.3	15.295.5	20.3	23,209.7	10.88
1981	7,772.1	16,588.2	32.4	24,392.7	11.28
1982	7,974.6	17,195.5	129.9	25,300.0	11.50
1983	8,134.4	13,113.6	147.4	21,395.4	9.55
1984	8,070.0	14,854.5	339.1	23,263.6	10.20
1985	7,967.5	11,876.4	727.7	20,571.8	8.90
1986	8,057.3	13,281.5	1,441.9	22,780,7	9.75
1987	8,346.2	14,962,2	2,180.0	25,062.9	10.64
1988	6,804.0	16,904.3	2,741.3	26,107.8	11.07
1989	7,257.6	17,124.8	3,055.3	27,165.2	11.36
1990	7,200.0	15,000.0	3,363.8	25,564.6	n.a
1991	7,200.0	n.a	3000,1	n.a	n.a

Sources: Planning Institute of Jamaica, 1987 ; Ministry of Agriculture, 1986. Inland Fisheries Unit; Livestock and Feed Statistics 1979-1991; External Trade 1987-89.

2.2 FISH PRODUCTION

2.2.1 Marine catch

The relative paucity of bigger fish on the coastal shelves (and more recently on the offshore banks), a reduction in catch size in real terms, and a change in species composition towards more trash fish, is strong evidence that the stock is not being regenerated. An increase in fishing effort and changes in fishing practices are depleting the fishery, possibly past the point of sustainability.

Table 2 :

Estimated fish production, Jamaica, 1945-1981

years	estimated production (million pounds)	year	estimated production (million pounds)
1945	12.0	*1962*	24.2
1950	11.0	*1968*	14.6
1955	14.5	*1970*	13.8
1956	17.0	*1971*	16.1
1957	20.0	*1973*	15.9
1958	22.6	*1981*	15.4
1959	21.8	*1983*	15.4
1960	22.7		

Source: Ministry of Agriculture (1963), page 3 ; Sahney (1981), page 10 ; Livestock and Feed Statistics 1981-91)

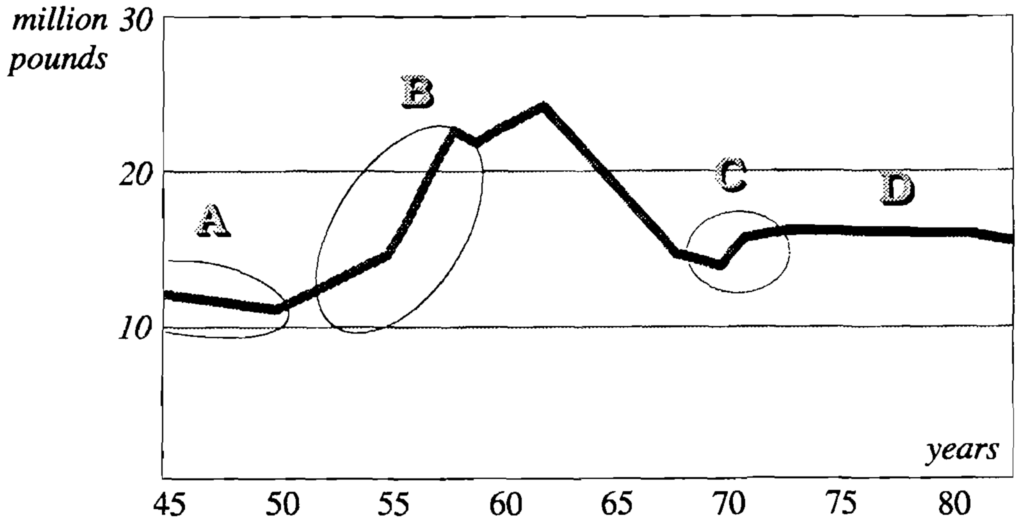


Figure 1 : **Evolution of the marine fishery catch in Jamaica**

Figure 1 *is a plot of the data in* ***Table 2****. The area labelled A represents the tail end of the pre-mechanization period where catches were falling due to overfishing on the coastal shelves. The rapid mechanization of the Jamaican canoe fleet through the "Boat Mechanization*

Scheme" (1956), as well as improved equipment and new techniques, led to a doubling of the volume of fish caught between 1950 and 1958 (labelled B). Larger boats and improvements in navigational skills meant that fishers could further exploit the coastal shelf and also could reach the banks. This dramatic increase in production was not ecologically sustainable, and the decade of the 1960s saw massive reduction in fish catches (especially on the coastal shelf), and a near return to pre-mechanization production levels (area C). Fishing in three non-territorial offshore banks resulted in slight increases in fish catches (area D); the appearance of stability in catch is misleading as Jamaican fishers have had to roam further afield to obtain the same catch. One can predict that with the expiration of the Treaty with Columbia in 1986 there would have been a further decline. Poaching -- especially of lobster -- by vessels from Central America has also reduced Jamaica's catch.

Unless the fisheries resources (and their exploitation) are effectively managed, one can predict a rapidly worsening situation in the capture fishery. Considering the need to increase the availability of fish protein to Jamaica's increasing population, sources other than the capture fishery will have to be explored.

2.2.2 Existing aquaculture production in Jamaica

The production of red Tilapia in freshwater has known a rapid expansion over the last decade, with excellent results. The present limitations are linked to the availability of aditional surface water allowing to extend the existing acrage of ponds, with severe competition with other users of the water resource and agricultural land. In the other hand, it could be observed that the market potential of this species is high, and may provide interesting opportunities for local consumption and export on the european market.

Tables of production are available from the Livestock statistics. A text, commenting on these data, recent evolution of the activity, problems encountered, market characteristics, and a discussion of the future potential of this sector was to be provided by the Fisheries Division. It has not been possible to obtain this chapter in spite of repeated requests.

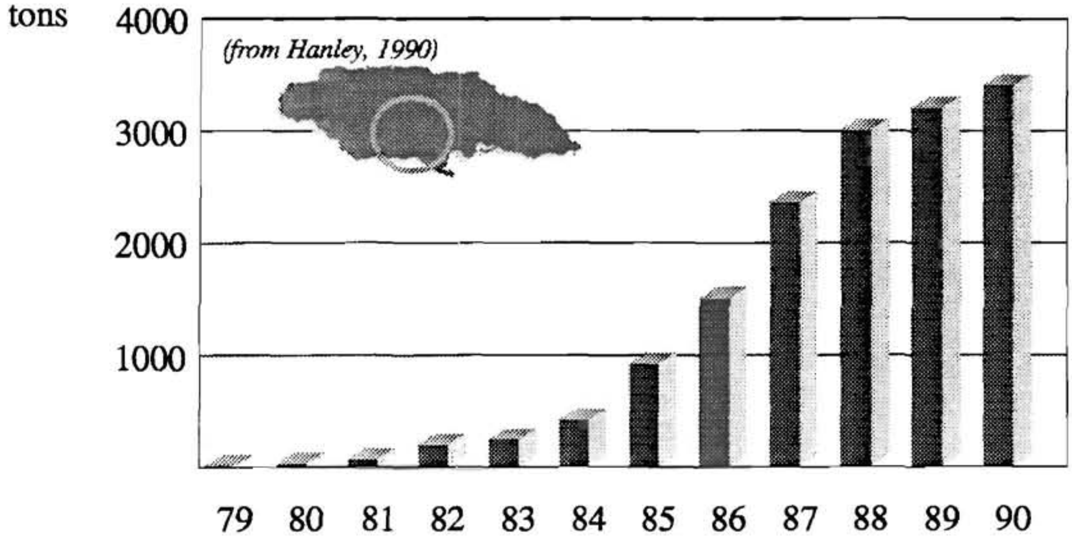


Figure 2 : **Production of red Tilapia in Jamaica**

2.2.3 Imports and exports

In 1990; (the most recent data available), Jamaica imported 15,000.8 tons of fishery products from 17 countries at a value of J$227,517,480; at the same time, she sold 1,093.3 tons of fishery products worth J$23,808,635 to 20 countries.

TABLE 3 :

Imports, exports and re-exports of fish and fishery products, by country, Jamaica, 1990

Quantity: kilos, Value: J$

COUNTRY	IMPORTS		EXPORTS F.O.B		RE-EXPORTS F.O.B	
	quantity	*value*	*quantity*	*value*	*quantity*	*value*
Antigua & Barbuda			3	68		
Argentina	29139	739032				
Bahamas			49	836		
Barbados			238	14151		
Belize	214091	8079933	2841	35737		
Canada	5312576	77267878	4979	290016		
Cayman Islands			40103	2466414		
Chile	14322	156296				
China	224328	2077983				
Dominican Republic			31045	167335		
France			19998	571494		
Guadeloupe			38133	629263		
Guyana	506561	10131412				
Haiti			1207	14490		
Hong Kong	735	23206				
Iceland	47496	1207903				
Japan	252403	2495268				
Martinique			51722	1309444		
Netherlands	94512	486254	227	8000		
Norway	3913240	83089665				
Panama			43	743		
Poland	236189	2803982				
Puerto Rico			275019	1748461		
Spain	4	25	68	4802		
St Martin (Fr.)			18182	680400		
Switzerland			2253	169249		
Thailand	1804889	16708751				
Trinidad & Tobago	109035	2646009	6356	109627		
UK	68	6982	42025	1498819		
USA	2241222	19596901	558812	16089286		
Total	***15000810***	***227517480***	***1093303***	***23808635***		

Sources: Calculated from External Trade 1990, STATIN, 1991.

In dollar terms, Jamaica bought 36.5% of its fishery products from Norway, 34% from Canada and 8.6% from the USA. ***Cod*** was the largest single species imported in 1990, with ***Sardines*** second, ***Mackerel*** third and ***Herring*** fourth. Despite the fact that there is no local source, the consumption of cod is firmly rooted in Jamaican culture (it is a main constituent of Jamaica's National dish: Ackee and saltfish). Imported tinned fish (or locally tinned bulk-imported fish) is one of the cheapest sources of animal protein, and a major component of the diet of the lower socioeconomic groups. Increases in local fresh fish production are unlikely to replace all fish imports.

Table **4** :

Imports & exports by quantity and value of items, january to december 1990

Quantity: kilos, Value: J$

Item SITF revised Classification	IMPORTS C.I.F Quantity	IMPORTS C.I.F Value	EXPORTS F.O.B Quantity	EXPORTS F.O.B Value
Salmon, Trout, Halibut Sole and Plaice	53684	727927	873	14863
Snapper, Shark, Croaker Grouper, Dolphin Bangamary, Sea Trout	592442	10879116	14141	398149
Kingfish	113884	705812	91	2000
Cod	4747453	105178003	114	3155
Mackerels	2471738	24190728	50201	464027
Herring	679430	7248164	1022	10516
Alewives	143978	1276890		
Salmon	2452	213451		
Trout	336	31880		
Sardines	3138806	49716412		
Other fish	2908063	18969341	93112	3038148
Shrimp	125234	75724795	45	1200
Lobster	5173	309712	75783	5007993
Other crustaceans, molluscs	17003	922695	857570	14869329
Caviar, caviar substitutes	599	57388		
Total	***15 000 810***	***227 517 480***	***1 093 303***	***23 808 635***

2.3 CAN FIN FISH AQUACULTURE BE AN ADDITIONAL RESOURCE? A SOCIOECONOMIC ANALYSIS

Jamaica's demand for fish and other marine products far exceeds the local supply; the quantity of marine products imported largely exceeds local production. Even if successful fishery management measures are initiated, the severe depletion of marine finfish stocks renders unlikely any dramatic improvement in the harvest from the territorial capture fishery in the near future.

The alternatives to imports are well known:

a. Extend the reef capture fishery beyond Jamaica's EEZ;
b. Develop Jamaica's pelagic fishery in the EEZ;

c. Develop capability to harvest pelagics out of EEZ;
d. Expand land-based aquaculture activities;
e. Develop marine cage culture capability;
f. Reduce the demand for fish and fish products.

These options are not mutually exclusive; a choice for one does not preclude the selection of another. However, each has its own special problems. Extending the reef fishery beyond Jamaica's EEZ has its own logistical problems and requires the negotiation of unilateral fishing treaties. The extent of Jamaica's pelagic resources is not known, and the development of a capability in this area carries high capital costs. There is evidence that Jamaica's fresh water resources are being substantially exploited and that this factor will limit further expansion of freshwater aquaculture, or would require the exploration of new modes of exploitation necessitating a higher control of the production parameters. Attempts to change consumer tastes cannot be expected to yield quick results if any.

The option of marine cage culture is attractive because it does not requires substantial land and freshwater resources and does not depend (in the long run) on the status of the capture fishery or pelagic resources. Marine cage culture can therefore function as a fisheries resource complementary to the wild stocks.

But marine aquaculture is not without its own drawbacks. As the technology does not yet exist for the culture of local species, some period of research and development will be necessary. The cost in time and money will be worth the effort if a workable technology emerges, and Jamaica may play a leading role in tropical finfish aquaculture.

Like in most other countries, it is likely that carnivorous fish species suitable to the consumers' tastes, will be selected for culture; these will require a more elaborate diet than Tilapia (a herbivorous species). The relatively expensive fish meal which will be required will, at first, have to be imported, which will raise significantly the cost of production. On the other hand, the artificial production of juveniles remains a costly operation. The cost of production of the **Red Drum** (***Sciaenops ocellata***) in Martinique using state-of-the-art technology is US$12/kg (J$264/kg in October 1992) for a hatchery and growing farms producing 50 tons of fish/year. If the problems encountered by cage culture of Jamaican marine species are comparable, it will be unwise to expect substantial local demand at that price. If research determines that a market exists in Europe or the USA for Caribbean species, then export sales may pay for imports of cod or other species. Subsequently, an important area of research will be identifying sources of fish meal which will reduce production costs (such as Tilapia unsuitable for sale and/or shark meat which is not consumed in Jamaica).

N.B.: a substantial part of this chapter, especially sections 2.1 and 2.2.1 are basically extracted from a previous FAO report on the Socioeconomics of fishing in Jamaica (P. ESPEUT and S. GRANT).

3. SPECIES AND TECHNOLOGIES AVAILABLE FOR MARINE CAGE FISH FARMING

3.1 SOME GENERAL CHARACTERISTICS OF MARINE AQUACULTURE

The possibility of emergence emergence of a profitable aquaculture industry, especially in sea water, relies on the simultaneous satisfaction of five major requirements :

A. the existence of a species, whose biological characteristics are fitted to captivity, and which can be considered to be well adapted to the existing environment (chiefly temperature and salinity). Juveniles must be available either through a "punction" of wild animals issuing from natural stocks or through artificial production in hatcheries.

B. the capacity to provide adequate fish food for commercial production wether with a strategy to use local products or foreign imports.

C. significant market demand with high initial prices so that the cost of rearing may be covered.

D. meeting certain geographical (the availability of suitable rearing sites), socio-economic (the existence of persons willing to do cage farming, the aptitude to organize the development, the general economic environmnent), and legal criteria (a framework allowing the fast development of the activity). This has to be evaluated with respects to concurrent mid and long term productions destined to the same markets.

E. local capability to solve the biological problems (nutrition, pathology), which will undoubtly appear in the research/development phase.

A critical analysis of how Jamaica matches up these requirements follows, but it might help to recall some major biological and economic considerations.

3.1.1 Biology

1. As opposed to terrestrial animals, organisms living in aquatic environments have no mechanisms to regulate their internal temperature and body fluids. Consequently they are highly sensitive toe environmental conditions which l regulate all major biological functions : respiration, excretion, growth, and reproduction. Each species is thus characterized by optimal environmental conditions, especially for temperature and salinity, under which physiological comfort will be maximum, and energy expenditure will be minimum. Under these conditions, the growth rate will be optimal, and morbidity will be low. This explains why each species is found only in specific types of environment, and are not suited for culture under other conditions. Although for each species there is a "tolerable" range of temperature, there will be significant differences in growth rate under different temperature regimes. For instance, the European **Sea bass** will reach the market size of 450 g in 14 months in southern Greece (18-26°C) but only after 20 to 24 months on the french mediterranean coast (14-23°C).

2. When compared to animal husbandry which involves only a limited number of species "domesticated" over many centuries, aquatic species remain "wild animals", and not all of them are suited

to captivity. At present, very few species have proved to be rearable, and there is wide variability within a given species between geographic strains or races, as has been proven with salmon.

3.1.1 Market value and production cost

1. Any production has to be planned with its potential market in mind, and markets are sensitive to specific characteristics such as size, color, quality and price, which in the initial phase of development approximately correspond to the characteristics of the equivalent wild product.

2. The cost of production has to be significantly lower than this market price in order to allow profitability. Moreover, when production increases, the market price decreases, and only the most competitive systems of production survive. An aquaculture system has to be planned with projections well into the futur, in order to ensure long term profitability.

3. Two factors represent the majority of the production cost : juveniles and food. There respective proportions may vary considerably depending on the choices made with respect to the following alternatives :

   a. extensive production at low density (a part of the energy being provided by natural food), or intensive rearing at high density (all feed being provided by the grower). Marine cage farming implyes the second choice.

   b. the use of wild young fish (caught), or of fingerlings artificially produced in a hatchery. In the later case, the present state of the art for hatchery-reared juveniles leads to production costs in the range of US $ 0.40 to 1.80 per unit (1 to 5g). More extensive methods for producing fry may provide some cheeper opportunities, which are generally associated with more variability in quality.

Table **5** :

Evaluation of farm gate production costs for various aquaculture fish

(in US$/kg, october 1992)

Species	**Trout**		**Salmon**		**Sea Bass**		**Red Drum**		**Tilapia**		**Tilapia**	
country	France		Norway		France		Martinique		Martinique		Jamaica	
weight range (g)	4-250		50-3000		1-400		4-700		2-350		1-285	
duration (m)	15		18		26		7		7		5.5	
rearing system	HD- pond		HD - cage		HD - cage		HD - cage		HD- pond		LD - pond	
sea/ freshwater	FW		SW		SW		SW		FW		FW	
costs	US$	%	US$	%	US$	%	US$	%	US$	%	US$	%
juvenile	0.05	2.	0.71	14	1.5	14	2.1	20	0.8	18	0.37	21
food	1.33	56	2.12	42	2.5	22	2.1	20	2.0	45	0.92	54
labour	0.43	18	0.41	8	3.0	28	2.6	25	0.6	14	0.13	8
capital amort	0.18	7	0.50	10	2.0	18	1.6	15	0.4	9	0.11	7
miscellaneaous	0.41	17	1.35	26	2.0	18	2.1	20	0.6	14	0.17	10
total	**2.40**		**5.09**		**11.0**		**10.5**		**4.4**		**1.70**	

HD = high density intensive production, LD = low density extensive production. *Compiled from various sources including BJORNDAHL (1990), HANLEY, 1991 updated, 1992.*

Table **6** :

Indicative beach landing price of various fish in the Lesser Antillas

(in US$/kg, october 1992)

Cat	Species	Gren	St Vi	St Lu	Anti	St Ki	Nevis	VirgI	Barb
1	*Tuna,Dolphin Shark Swordfish*	3.35	3.34	3.43	5.30	5.59	5.00	3.47	5.60
2	*Skipjack Bonito Kingfish Carangidae*	3.22	3.24	3.36	6.05	5.42	4.09	2.39	
3	*Snappers Groupers Hind (Serran) RedFish (Lut)*	3.19	3.24	3.66	5.53	4.18	3.8	2.19	7.7
4	*Cavalli,Gar Big eye jack*	2.83	2.77	3.28	5.45	3.18	3.00	2.00	2.13
5	*Dodger Spratt ,Bala Robin*	1.69	3.94	2.15	4.62	2.62			
6	*Anchovy Sardine*	1.27	1.68	1.42	4.67	1.50			
7	*combination fish*	3.06	2.10	3.41	4.28	3.22	3.05	2.06	

Grenada, St Vincent, St Lucia, Antigua, St Kitts, Nevis, Virgin Is. Barbuda. (*Source* : IFREMER)

Table **7** :

Estimation of the beach landing prices in Jamaica

(US$Kg, october 1992)

Category 1	*Snapper Kingfish*	10,00
Category 2	*Grunt Snook Red Drum*	4.00
Category 3	*Mullet Snapper*	3.20
Category 4	*Parrot fish*	2.70
Category 5	*"soup fish"*	1.80

source : P.D. BUNTING, pers. comm, 1992)

3.2 GENERAL STEPS FROM RESEARCH TO DEVELOPMENT

Any attempt to establish an aquaculture activity with a new aquatic species (or even with an introduced species reared elsewhere) must go through four major stages (whether th actor is government or private industry) :

a. a **preliminary phase**, in which the objectives and the means to achieve them are determined precisely.

b. an **initial exploration phase**, which is extremely important. The aquaculture technology is tried and tested with rigour and method at a small scale in order to solve the technical problems which will undoubtly arise ; a "standard rearing method" is developed.

c. a "**pilot**" or "**demonstration**" phase, during which the findings of the exploratory phase are "validated" at a larger scale. The volumes used and quantities produced will be the standard for the development phase. The future fish farmers should be associated or at least informed in detail during the pilot, and operators should receive training in the application of the techniques.

d. a **development phase**, during which appropriate policies facilitating a smooth and gradual takeoff of the activity should be in place, in order to avoid major problems such as : shortage of juveniles (leading in turns to an increase of their price) or too rapidly increasing production with regards of the target markets (leading to an abrupt decrease of price).

3.3 EXAMPLES OF AQUACULTURE HAVING REACHED COMMERCIAL DEVELOPMENT

3.3.1 An example of cage farming relying on the capture of wild juveniles : Yellowtail (*Seriola quinqueradiata*) in Japan.

Japanese **Yellowtail** farming was initiated in Japan in the 1960s, and reached the industrial development phase in the 1970s. Breeding is difficult in captivity when compared to the many other species reared in Japan, and larval rearing is extremely difficult. On the other hand, juveniles are very hardy and grow rapidly at high densities when reared in the appropriate environment with specially adapted food. Japanese fishermen and the National Fisheries authorities were aware of the nursery areas where juveniles are gathering, and national policy allowing the capture of a certain number of juveniles, with careful management of the resource, allowed a very profitable aquaculture activity to emerge (now stable at about 150 000 tons per year), without affecting the wild catch (stable around 60 000 tons).

3.3.2. Existing aquaculture production relying on hatchery produced fry.

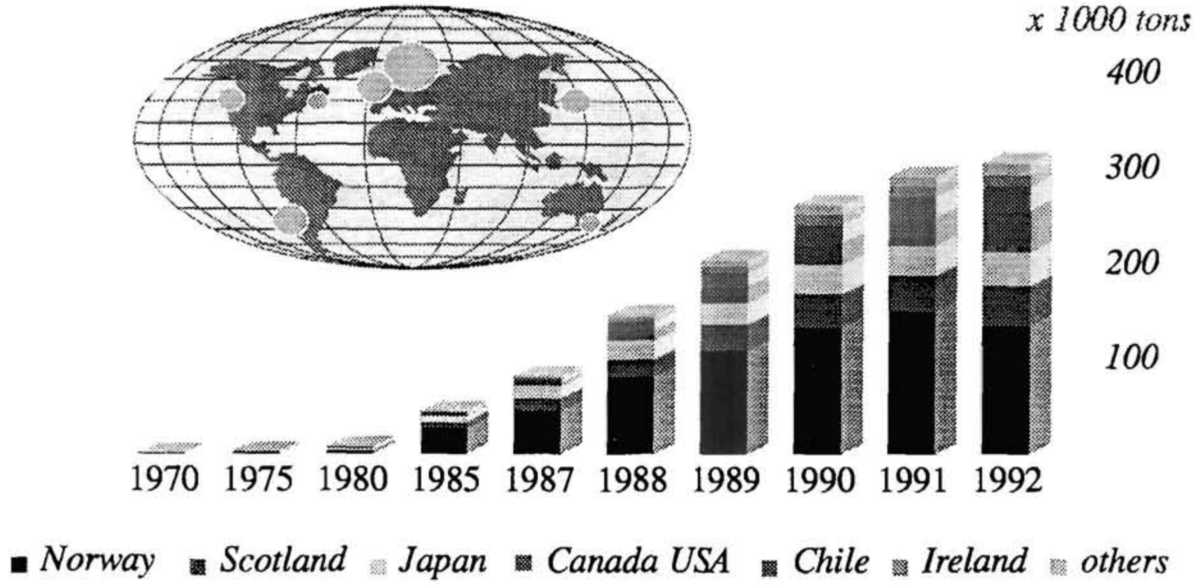
3.3.2.1. *With temperate species*

Twenty years ago, the only species being reared industrially where trout (*Oncorhynchus mykiss*) and catfish (*Clarias sp.*), both of which being produced in fresh water, either through extensive farming in earthen ponds, or intensive culture in concrete raceways. The former, originally being found only in the west part of North America, has been widely introduced all over the world, and has given birth to fruitfull aquaculture ndustries. The latter, also native to the North American continent has been developed only in U.S.A, and most attempts to farm it in different environments have failed.

The marine cage culture of salmon, initiated in Norway at the end of the 1960's (100 tons produced in 1970), was still a pre-industrial activity in 1980 (4000 tons in Norway), then very rapidly expanded, both with the Atlantic species (*Salmo salar*) and the Pacific ones (*Oncorhynchus kisutch* and *O. Tschawytscha*). The technology, and the well adapted strains, have been spread over many countries, leading to a world production reaching 250 000 tons in 1992, among which Norway alone produced 135 000 tons. Availability of juveniles (smolts), produced in fresh water hatcheries, has been the major bottleneck in the development phase, the shortage of juvenile conditionning the advancement of production.

figure **3** :

Evolution of salmon farming production

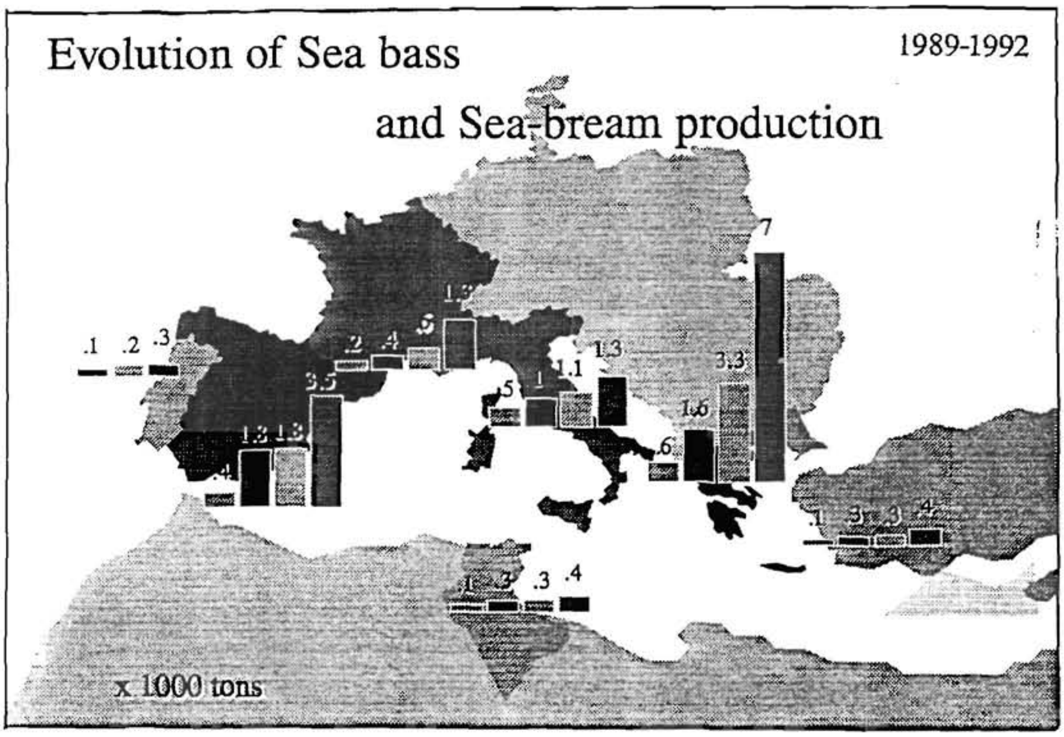


The cage culture of marine species has expended over the last ten years, both in Japan, with the culture of new species such as the **Japanese imperial bream** or red-snapper (*Pagrus major*) and **Japanese halibut** (*Paralychtis olivaceus*), and in Europe, with Mediterranean or Atlantic species.

Sea-bass (*Dicentrarchus labrax*) and **sea bream** (*Sparus aurata*) culture in Mediterranée (Greece, France, Spain, Italy) is expanding rapidly, with a production of about 14 000 tons in 1992, with projections of 20 000 tons by 1995 . In both cases, production takes place mostly in sea cages (though part of the production occurs in shore based ponds and raceways), with juveniles (1 to 2 g) produced in hatcheries using basically two techniques : intensive production in clear water (France, Greece) or at lower densities in green water ponds (Spain). The grow-out period (up to the commercial size of 350-450 g) takes from 14 to 24 months according to the rearing temperatures.

3.3.2.1. ***With tropical species***

Numerous tropical species have been investigated for aquaculture, and have generated significant research effort. Among these, only the Asian tropical sea-bass or **Barramundi** (*Lates calcarifer*) has resulted in significant production, mainly in **Thaïland** (about 3000 tons in 1991). Production begins with juveniles, either from wild adults collected during the spawning season, or from captive brood stock. The juveniles are



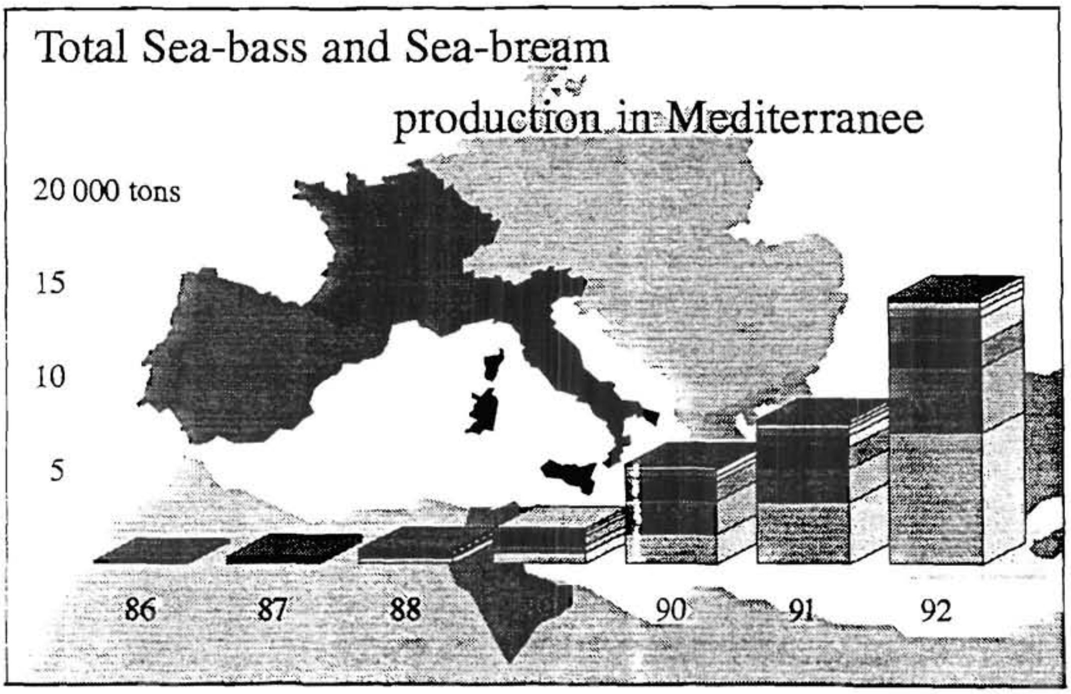


Figure 4 : **Evolution of sea bass and sea bream production in Europe**

obtained either through extensive production in earth ponds, or in hatcheries at a higher density. The occurence of a *picorna virus*, identified in 1988 has been a major difficulty in the production of fry . The species has been introduced to the French territory of **Tahiti**, where it has demonstrated excellent potential for growth at temperatures of 28-30°C (average market size of 600 g reached after 6-8 months from first feeding).

Production of **Grouper**, the fry of which is particularily difficult to produce, is also showing some interesting results in South East Asia. All other attempts with other species are still at research level, or at best in the pilot-demonstration phase.

3.4 AN EXEMPLE OF TROPICAL FIN-FISH AQUACULTURE HAVING REACHED THE PILOT PHASE : THE RED-DRUM (*Sciaenops ocellata*) IN MARTINIQUE.

As part of a program , aiming at the selection of potential candidates for marine fish culture in the Caribbean area initiated in 1981 (see § 3.5.2 for more details), the **red drum** was introduced from Texas in 1987. The species showed an excellent aptitude to grow rapidly with dry pellets (commercial size of 600g obtained 8 months after first feeding), reproduce in captivity, and provide viable outputs through the larval rearing phase. After an initial research phase, allowing to define a "standard method" for larval rearing to be defined, the program entered the pilot phases, both for larval rearing and grow-out, which will be completed by the end of 1992.

The technology has been transferred to the local association in charge of development (ADAM), with the appropriate training for all phases. The economic assessment will be completed in 1993, and possibly lead to a development phase.

3.5 OTHER TROPICAL MARINE SPECIES PRESENTLY INVESTIGATED (research level), WITH SPECIAL REFERENCE TO THE CARIBBEAN AREA.

3.5.1. Selection of finfish species for aquaculture in French Polynesia

A program for selecting finfish species suitable for aquaculture in French Polynesia was undertaken by IFREMER betxeen 1983 and 87, (FUCHS et al., 1989), to identify the most suitable species for aquaculture. A litterature review, based on the economic interest of each species and the existence of previous research in Tahiti or abroad, led to the selection of four local (Carangidae, Coryphanidae, Serranidae, Siganidae) and two introduced families (Centropomidae, Cichlidae) from south east Asia.

In a second step, species were selected according to the following criteria : growth rate potential, acceptance of dry pelleted food, reproduction and spawning in captivity, larval rearing and fry production, pathology and resistance to stress, economic interest on the local market. A classification in 3 groups has resulted from the trial :

- species with a very high potential for aquaculture, permitting development in the short term : the tropical **sea bass** (*Lates calcarifer*, Centropomidae), originating from S.E. Asia.
- species with potential, but presenting some drawbacks, such as difficulties with larval rearing like **grouper** (*Epinephelus microdon*, Serranidae) and **dolfin fish** (*Coryphaena sp.*, Coryphaenidae), or affected by pathological problems during the grow-out phase in marine cages such as a red Tilapia strain (*Oreochromis sp.*).
- species considered as difficult to rear and not under further consideration, like the **rabbit fish** *Siganus argenteus*, **Siganidae** (poor economical value and unsuccessfull larval rearing), or *Caranx ignobilis*, **Carangidae** (no acceptance of dry feed).

The results of these trials are synthetized in the following table **8**. The sea bass (*Lates calcarifer*) was undoubtly the most promizing species for marine aquaculture in the area.

Table **8** :

Synthesis of selection of the most suitable species for aquaculture in French Polynesia

	SPECIES	SEABASS	RED TILAPIA	GROUPER	DOLPHIN FISH	RABBIT FISH	JACKFISH
Growth	A > 500 g B > 300 < 500	A	B	B	No Trial	B	B
Adaptation Dry Pellet	A = easy B = progressive C = impossible	A	A	B	No Trial	A	C
Maturation Spawning	A = natural B = induced C = no obtained	B	No Trial	A	A	A	C
Larval rearing Fry Production	A = easy B = feasible C = unsuccessfull	B	No Trial	C	C	C	No Trial
Pathology	A = resistant B = sensitive	A	B (salinity)	A	B	A	B
Price/Kg	A = high B = medium C = low	A	B?	B	B	C	C
Group 1. : High Potential Group 2. : Drawback Group 3. : No retain.		group 1	group 2	group 2	group 2	group 3	group 3

(From Aquacop, J. FUCHS, G. NEDELLEC and E. GASSET, 1989)

3.5.2 Selection of finfish species for aquaculture in Martinique

Since 1981, a similar program has been conducted in Martinique (THOUARD et al., 1989) to assess the aquaculture potential of the following species

- **palometa**	(*Trachinotus goodei*)
- **permit**	(*Trachinotus falcatus*)
- **yellowtail snapper**	(*Ocyurus chrysurus*)
- **mutton snapper**	(*Lutjanus analis*)
- **school master**	(*Lutjanus apodus*)
- **lane snapper**	(*Lutjanus synagris*)
- **gray snapper**	(*Lutjanus griseus*)
- **red drum**	(*Sciaenops ocellata*)
- **red Tilapia**	(*Oreochromis sp.*)

Zootechnical and socio-economic constraints have led to the choice of three species either endemic or introduced : the **Palometa, Red Drum** and **red Tilapia hybrid for further trials :**

Palometa showed good growth performances (400g after 7 months from 17g juveniles), accepts dry pellets and showed a high resistance to disease. However, the obtention of maturation and spawning either natural or injection induced appeared difficult. For two years, 88 females received an hormonal injection, only 43, 000 viable eggs were released, not permitting serious larval rearing trials. A reliable technology remains to be developed for this species.

Red drum, an exotic species from the Gulf of Mexico, introduced from Texas and Florida stocks, gave encouraging results, facilitated by the extensive research done in the USA. The best survival rates after two months reached 17% (2-5 g fry), and the growth allowed to reach an average weight of 300g and 600g respectively six and 7 months after hatching.

Red *Tilapia* was introduced in Martinique in 1986. The srtrain reared was the red Florida hybrid, imported from Jamaica. Broodstock, larvae and fingerlings were reared in brackisk water (19 ppt), and grow out was conducted in tanks (with recirculated fresh ans seawater), and in net cages in the sea. Various problems were encountered in cage rearing in full seawater. These two species were considered as the mostt appropriate candidates for allowing a possible development of their production in the Lesser Antilles

Table **9** :

Synthetic results of the grow-out phase of selected species in Martinique
(From E. THOUARD, P. SOLETCHNIK and J.P. MARION, 1989)

SPECIES	Origin	Growth experiments period	Number of fish (g/ month)	Growth from fingerlings	Pathology
Trachinotus goodei	Wild	10/81-11/84 05/85-8/86 06/86-12/86	60 50 120	300/6	Parasitism
Trachinotus falcatus	Wild	10/81-11/84	40		
Ocyurus chrysurus	Wild	10/81-01/85 10/85-9/86 06/86-12/86	20000 500 500	300/18	Nutritional disease
Lutjanus *analis* *griseus* *apodus* *synagris*	Wild	10/81-4/84	1000	350/12 370/24 250/24 140/21	Nutritional disease
Sciaenops ocellata	Hatchery	07/87-1/88 08/88-1/89	4000 [illegible]	500/6	No
Oreocnromis	Hatchery	Since 1987		350/6	Parasitism in full sea water

3.5.3 Status of other species investigated in the Caribbean area

In a complete review, (World Aquaculture, march 1991), TUCKER stated that "most marine fish culture in the Caribbean is experimental and there are few commercial operations. "Ornamental fish" have been raised commercially since the early 1970's, but the only "food fish" being raised commercially in salt water on a reasonable (but relatively small) scale are **Tilapia** and **red-drum**, with two other candidates having reached pre-commercial size : **mutton snapper** (*Lutjanus analis*) and **white mullet** (*Mugil Curema*). Table 10 gives a synthesis of the existing investigations in 1991.

Table 6. Some fish with potential for farming in the Caribbean region				
Common name	Scientific name	Types	Units	Locations
	FOOD FISH			
FAMILY CICHLIDAE				
Tilapia	*Oreochromis* sp	C H; E H	P C T	Bahamas, Bonaire, Colombia, Cuba, Curaçao, Dominican Republic, Florida, Haiti, Jamaica, Martinique, Puerto Rico.
FAMILY SCIAENIDAE				
Red drum	*Sciaenops ocellatus*	C H; E H	P C T	Alabama, Bahamas, Florida, Louisiana, Martinique, Mississippi, Panama, South Carolina, Texas,
Spotted seatrout	*Cynoscion nebulosus*	E H	P T	Alabama, Florida, South Carolina, Texas
Whitemouth croaker	*Micropogonias fumieri*	E H	T	
FAMILY CORYPHAENIDAE				
Dolphin	*Coryphaena hippurus*	E H	C T	Bermuda, Florida, North Carolina
FAMILY CARANGIDAE				
Florida pompano	*Trachinotus carolinus*	E H W	C T	Alabama, Bahamas, Dominican Republic, Florida, Venezuela
Palometa	*Trachinotus goodei*	E H W	C T	Martinique, Venezuela
Permit	*Trachinotus falcatus*	E W	C T	Florida, Martinique, Venezuela
FAMILY PERCICHTHYIDAE				
European sea bass*	*Dicentrarchus labrax*	E H	C T	Martinique
FAMILY CENTROPOMIDAE				
Common snook	*Centropomus undecimalis*	E H	P T	Brazil, Colombia, Florida, Venezuela
FAMILY SERRANIDAE				
Nassau grouper	*Epinephelus striatus*	E H	T	Cuba, Florida, Grand Cayman
Red grouper	*Epinephelus morio*	E	T	Florida, Mexico
Garoupa-verdadeira	*Epinephelus guaza*	E		Brazil
Jewfish	*Epinephelus itajara*	E W	C T	Florida, Venezuela
Gag	*Mycteroperca microlepis*	E H	T	Florida
Black grouper	*Mycteroperca bonaci*	E W	C T	Venezuela
Sand perch	*Diplectrum formosum*	E H	T	Venezuela
Black sea bass	*Centropristis striata*	E H	T	Florida, North Carolina
FAMILY LUTJANIDAE				
Gray snapper	*Lutjanus griseus*	E H W	C T	Cuba, Florida, Martinique
Lane snapper	*Lutjanus synagris*	E H W	C T	Cuba, Florida, Martinique
Mutton snapper	*Lutjanus analis*	C W; E W	C T	Florida, Martinique, Venezuela
Red snapper	*Lutjanus campechanus*	E H	T	Alabama, Texas
Schoolmaster	*Lutjanus apodus*	E W	C T	Martinique
Yellowtail snapper	*Ocyurus chrysurus*	E H	C T	Florida, Grand Cayman, Martinique
FAMILY SPARIDAE				
Sheepshead	*Archosargus probatocephalus*	E H	P T	Florida
Sea bream	*Archosargus rhomboidalis*	E H W	P	Florida, Venezuela
Gilthead sea bream*	*Sparus auratus*	E H	C T	Martinique
Porgies	*Calamus spp*	E W		Venezuela
FAMILY EPHIPPIDAE				
Atlantic spadefish	*Chaetodipterus faber*	E H W	C	Venezuela
FAMILY GERREIDAE				
Striped mojarra	*Diapterus plumieri*	E H W	T	Cuba, Venezuela
FAMILY ELOPIDAE				
Tarpon	*Megalops atlanticus*	A W	P	Colombia
FAMILY MUGILIDAE				
Striped mullet	*Mugil cephalus*	F	P	
White mullet	*Mugil curema*	C W; E H	P	Brazil, Cuba, Venezuela
Liza	*Mugil liza*	E H W	P	Brazil, Cuba
	Mugil spp	C W	P	Brazil, Colombia, Mexico, Venezuela
FAMILY ARIIDAE				
Crucifix sea catfish	*Arius proops*	E W	P	Colombia
New Granada sea catfish	*Arius bonillai*	E W	P	Colombia
Pemecou sea catfish	*Arius herzbergii*	E W	T	Venezuela

TABLE **10** : (From TUCKEY, World Aquaculture, March 1991)

3.6 SOME DOCUMENTED CASES OF FAILURE IN AQUACULTURE DEVELOPMENT

Off all theattempts to domesticate and farm aquatic species, only a few can be called "successes", and several may definitely be called failures due to different causes : biological or behavioural characteristics not conforming to aquaculture practices, environment maladaptation or lack of competitiveness in the market places.

3.6.1 Biological and behavioural factors : the european **Dover Sole** (*Solea solea*)

This demersal flat fish, high priced on the european market (US $ 15/kg), reproduces normally in captivity, and mass production of juveniles in hatchery has proved to be relatively easy to achieve. However, during the grow-out phase, after weaning to artificial feed, the animal have specific behavioural requirements, which makes economical rearing almost impossible.

The fish need tanks with sandy bottom allowing a normal burrying behaviour, and do not easily accept concrete or plastic surfaces (injuries, necrosis etc...). Moreover, while larvae and young fry were actively feeding on live prey and after weaning to artificial feeds, fingerlings and adults are not attracted by the food, and feed only at night very slowly on food particles settled on the bottom of the tanks. Subsequently, specific nutritional problems (leeching of soluble matter and vitamins), and slow growth have been observed.

3.6.2 Environmental maladaptation : **Salmon** in southern Europe, **Peneid shrimp** in France, **Seabass** and **Seabream** in Martinique.

Salmon and **trout** grow very rapidly in winter in coastal waters of southwestern europe, but face some difficulties during summer months (mortalities due to "environmental pathology"). Subsequently, global technical performances (survival, growth, feed conversion factor) remain inferior to that observed in northern Europe (Norway, Scotland), and consequently production costs are higher. This allows profitable aquaculture for a time, but when world production increases, and market prices decline significantly, it becomes extremely difficult for French enterprises to remain competitive. Consequently, the production has not really developed and remains stable around 1000 tons.

At the opposite, temperatures have proved to be too cold for farming successfully the most temperate species of **peneaid shrimp** (*Peneus japonicus*) on the Atlantic or mediterranean french shore : growth is slow, which makes market size difficult to attain aftre the summer months season, not allowing to benefit from the extremely high price of the product on the french market.

Sea bass and **sea bream** were introduced in **Martinique** for cage culture in 1981, by a private french company (AQUAMAR) . The species was alleged to grow faster in tropical waters (26-30°C) than in the French Mediterranean 14-24°C). The expected production (500 tons) was supposed to be shipped to Europe where market prices are high. The first trials were conducted with fry purchased from French hatcheries, and a hatchery was established to develop local production. The project reached a maximum production of 15 tons (in floating cages), and a serie of technical and pathological problems were encountered, including virulent outbreaks of viral disease (picornavirus) affecting fish during the growout phase then during fry and fingerling stage. The owners of the project withdrawned in 1986, after bankrupcy (US $ 2 million loss), and the project ended.

3.6.3 Lack of competitivity on international markets : the freshwater prawn (*Macrobrachium rosenbergii*) in French Guyana

Production of post larvae is well mastered by french research scientists, and hatcheries established in the French territories of Cayenne and Guadeloupe are fully operational with excellent results. However, the best cost of production attained for the grow-out phase remains extremely high due to local economic factors (price of land, high salaries costs). Consequently production costs are much higher than in parallel operations in South east Asia, and the products are not competitive on international markets, including France. The attempts to improve the rearing performances having failed , the product remains destined for local consumption only with limited markets (a few tenth of tons) per area, and this production has not developed significantly.

3.7 CONCLUSIONS

The emergence of profitable aquaculture production, especially in sea water, relies on the simultaneous satisfaction of four major issues :

- *the existence of a species, whose biological characteristics are compatible with captivity, and which is welle adapted to the existing environment (chiefly temperature and salinity) can be considered as well adapted or ideal. Juveniles must be available either as a "punction" of wild animals or through a controlled reproduction in hatcheries.*

- *the capacity to provide adequate food to allow the development of production (after a choice between the strategi of using local products vs imports of raw material.*

- *high initial market pricescovering the cost of rearing, taking into account the potentialprice decrease when production increases.*

- *geographical (sites), socio-economic (existence of economic actors, aptitude to organize the development, general economic environmnent), and legal framework allowing fast development of the activity. This has to be evaluated with regards to potential parallel operations competing in the same markets.*

- *local capacity to solve the biological problems (nutrition, pathology), which will undoubtly appear in the research/development phase.*

At present, these conditions are not all satisfied in Jamaïca, and the emergence of fish marine cage farming will require a preliminary research/development phase before profitable marine aquaculture can emerge. Significant favorable factors exist, but the most negative factor at present the lack of a species which rearing technology has been mastered under local conditions.

On the other hand, *Tilapia* culture has proven to be a profitable aquaculture activity, well applicable to the socioeconomic context of Jamaica. Ways of expanding the production by entering new environments (brackish waters) and techniques (intensive pond farming in freshwater) should be explored to rapidly expand the existing production.

4. THE CONTEXT FOR CAGE CULTURE OF MARINE FISH IN JAMAICA

4.1. SITE AVAILABILITY

4.1.1 Site selection criteria:

Many variables have to be taken into consideration when assessing the suitability of a marine site for cage farming (a detailed list of selection criteria is given in annex). Among these, shelter from rough open sea conditions is one of the first criteria to take into consideration. The most sheltered sites allow the use of the simplest and cheapest cage technology, but more exposed locations can also be considered, where high resistance surface structures or submersible cages may be suitable. The experience of other countries suggests that where protected sites exist, it is wise to use them before looking to other areas requiring more elaborate technology.

We recommend that the establishment of finfish cage culture activity in Jamaica utilize very simple floating cage technology able to stand reasonable surface wave action (no more than 2 meters amplitude), with relatively low structural costs. For this reason, selected sites should preferably be well sheltered against open sea rough conditions and heavy oceanic swell.

Under hurricane conditions (last major hurricanes were in 1988, 1951), practically no site would offer satisfactory protection to floating cages of any type. This fact should be considered a major risk with respect to future marine aquaculture. Its probability should be introduced in the economic analysis preceding the development phase.

4.1.2 Methodology:

Existing maps and charts have been examined, and a site survey has been conducted using two different approaches:

- **by road**: the Eastern and North-Eastern coasts of Jamaïca as far as Discovery Bay have been visited (Port Royal, Morant Bay, Port Morant, Manchioneal, Port Antonio, Annotto Bay). Where possible, information about depth and sea conditions have been obtained through discussions with fishermen on the fishing beaches.

- **by air**: the entire coast line of Jamaïca has been surveyed using a rented plane (2 hours and 40 minutes), and aerial photographs of most of the potential sites were taken; these provide general information on protection, water depths and water quality aspects, as well as on surrounding activities. This survey was made with the participation and assistance of R. MOO YOUNG, former Director of the Fisheries Division, Aquaculture Branch, Ministry of Agriculture.

4.1.3 Results

Among 67 sites preselected after an examination of existing charts and after discussions with Jamaican experts (P. ESPEUT, V. RODNEY, P. BUNTING); after examination by aerial survey, 17 have been retained as the most suitable.

Information on all these 17 locations are provided in *table 11*, including shelter, water depth, road access and water quality. Where available, magnified parts of the relevant marine charts are contained in annex .

A certain number of sites appear suitable for surface cage fish farming. Port Morant (Bowden) appeared to be the most appropriate for running a pilot scale cage project: unpolluted waters, slightly lower salinity, closeness to Kingston, existing land based facilities (the oysterculture project), make it very favorable.

It is important that a large surface area be available and would theoretically allow a large production if used. A rough estimation based upon the experience from other countries shows that an annual yield of 20-50 tons/hectare is a conservative figure. However, among the sites listed, there will undoubtedly be competition with other uses, making the site unavailable for cage farming. Moreover, the protection of rearing structures and reared fish from poaching or praedial larceny appears to be a major constraint in the Jamaican context. A legal status for this new activity should be established (see 4.5).

Table 11

Detailed list of potential sea water fish farming sites (cages or ponds) located during the survey

The following sites have been identified and observed by air or by road. They are cited in the order observed during the clockwise flight around the Jamaican coastline starting from Kingston:

1	Port Royal (in/out)	21	***Hedonism***	41	***Port Maria***
2	Fort Clarence	22	***Orange Bay***	42	***Annotto Bay***
3	Wreck Point	23	***Green Island***	43	Golden Grove coast
4	Manatee Bay	24	***Davis Cove***	44	Burlington's Coast
5	Cabarita Point	25	Lances Bay	45	Port Antonio West
6	Great Goat Island	26	***Lucea Harbour West***	46	***Port Antonio East***
7	Old Harbour Bay	27	***Lucea Harbour East***	47	Sax San Bay
8	Galleon harbour	28	***Mosquito Cove***	48	Dragon Bay
9	***Port Esquivel***	29	Round Hill Bluff W	49	Priestman's river estuary
10	***Salt River***	30	Montego bay	50	***Manchioneal***
11	***Rocky Point 1***	31	Montego Freeport	51	***Happy Grove***
12	***Dolphin Island***	32	Salt Marsh	52	***Bowden***
13	Portland Bight NE	33	Falmouth	53	***Port Morant***
14	Rocky Point 2	34	Trelawny Beach	54	Prospect Point East
15	Rio Minho estuary	35	***Rio Bueno***	55	Prospect Point West
16	Port Kaiser	36	***Discovery Bay W***	56	***Salt Ponds***
17	Calabash Bay	37	***Discovery Bay E***	57	Bull Bay Coast
18	Savannah la Mar	38	St Ann's Bay		
19	Cabarita point	39	Ocho Rios		
20	Negril	40	Oracabessa		

(*) sites with an interesting potential are quoted in ***italics***

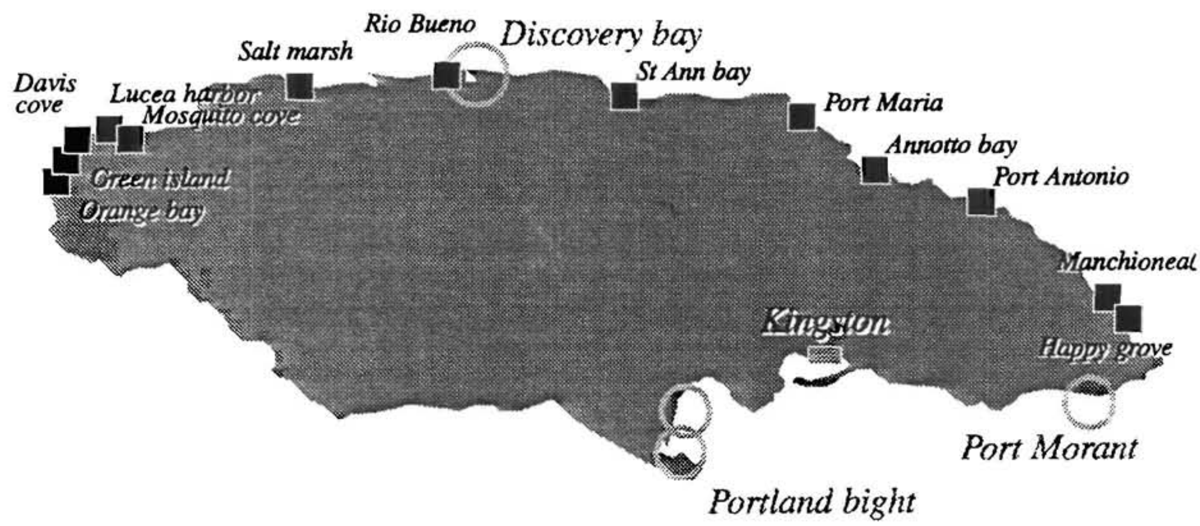


figure **6**

Repartition of the potential sites identified

Table **12** :

Characteristics of selected sites for marine cage farming in Jamaica

N°	**Location**	**Characteristics**					**Environment**						**Water quality**		**Chart**
		shelter			**surf**	**Depth**									
		G	*F*	*B*	**acres**	**(m)**	*Ci*	*Ro*	*Hw*	*Ind*	*Tou*	*Aqu*	*Tur*	*Riv*	
	South coast														
	Portland Bight														
1	**Port Estivel**	x			290	4-6		x		x			**VT**	x	x
2	**Salt river**	x			270	5-8				x			**VT**		x
3	**Main Bay**		x		12,000	10-20				x			**T**	x	x
4	**Port Morant**	x			320	7-10		x	x			x	**LT**	x	x
5	**Port Royal (south)**		x		1,100	25	x	x	x	x			**LT**		x
	West coast														
6	**Orange bay**			x	100	5-8		x					**C**	x	
	North coast														
7	**Green Island**		x		70	5-10	x	x				x	**LT**		
8	**Davis Cove**		x		20	5-10		x					**LT**	x	
9	**Lucea Harbour**		x		210	3-10	x	x	x	x	x		**C**	x	x
10	**Mosquito Cove**		x		20	4-10							**C**	x	x
11	**Rio Bueno**			x	20	10-100							**C**	x	x
12	**Discovery Bay**		x		95	10-45	x	x	x	x	x		**C**	x	x
	East coast														
13	**Port Maria**		x		40	5-20	x	x			x		**C**	x	
14	**Annotto Bay**			x	300		x	x	x			x	**C**	x	
15	**Port Antonio (East H.)**		x		60	5-20	x	x	x		x		**C**	x	x
16	**Manchioneal**	x			20	5-10	x	x					**C**	x	
17	**Happy Grove**		x		10	10-30		x					**C**		

Legend

Shelter : **G** = good , **F** = fair , **B** = bad

Environment : **CI** = city ; **RO** = road access ; **HW** = harbourg, wharf
IND = industry ; **TOU** = tourism ;
AQU = aquaculture (oysters, sea weeds)

Water quality : **TUR** = turbidity : **(VT)** very turbid; **(T)** turbid ;
(LT) low turbidity ;
(C) clear, **RIV** = river estuary

Chart : **x** = existing (see annex)

4.2 AVAILABILITY OF JUVENILES

The culture of the freshwater fish **Tilapia** is well advanced in Jamaica and juveniles are readily available for growth trials in cages within the marine environment: preliminary research having indicated that this species is highly adaptable. The type, distribution and quantities of the juveniles of marine species are poorly known. Anecdotal information suggests that some species demonstrate a seasonality normally coinciding with the rainy season, although relatively large schools have been located outside this season in estuarine waters. Preliminary investigations will have to be done in order to determine species distribution with regards to quantities and seasonality. Concerning the removal of juveniles from the marine environment, section 9 of the **Wildlife Protection Act 1945** prohibits the capture of juvenile fish; however, the act does not define juvenile. Section 14 however allows the Minister to make regulations controlling the capture of juveniles.

4.3 HUMAN RESOURCES

4.3.1 Agents of development: private enterprises or fishermen's cooperatives?

Fundamentally, there are two courses that the development of marine cage culture of fish in Jamaica can take: the industry could develop as large-scale operations owned by a few individuals or companies and employing the necessary labour; or it could develop as small-scale operations owned and operated by many small fish farmers or co-operatives.

Each option has its own rationale:

Smaller-scale cage fish farming	will diversify the rural coastal economy and may provide an alternative to capture fishing, thus reducing fishing effort.
Larger-scale farms	may develop economies of scale, thus reducing the cost of production and making the products cheaper and more price competitive.

Large-scale corporate operations can be expected to obtain their own financing, while credit may have to be provided for small-scale farms through special schemes. A corporation will purchase the management and technical expertise it needs, while substantial extension services will probably have to be provided for smaller farms. Purchasing and marketing will be vertically integrated into the corporate structure, but small operators will have to make co-operative or other arrangements.

Although the management of many small individually-owned units may be expected to be weak relative to large-corporately managed farms, the model of many smaller-scale farms has the advantage of generating more rural income leading to a more valid rural development. The operations of these small-scale units may be improved through the provision of management training, and by the introduction of co-operation in some management, purchasing and marketing operations.

In the early stages, these options are mutually exclusive and may not be pursued concurrently; the technology developed during the research phase will favour either one option or the other.

The main domestic competition for fresh cultured marine fish will be fresh fish from the local artisanal capture fishery which has relatively low production costs but suffers from declining stocks (numbers and sizes) of the favoured species. What cage culture can offer is good-sized high quality marine species at prices much higher than would obtain in the local capture fishery. Local demand for these (high priced) marine cultured fish will be low, and production for export will have to be the main thrust. This will require further processing and storage capability and export contacts, best done by one central agency.

Since a workable technology for marine cage culture is not yet available, a **Research Phase** of several years prior to the **Development phase** is called for. This period will allow time for the necessary development planning. However, the choice of the type of future aquaculture activity, and its general characteristics (including the level of technology required) will be influenced by the type of development expected. It is thus important to answer these questions at an early stage.

4.3.2 Programme Administration

The human resources available for the administration of the research program are limited. Some resources exist in the **Fisheries Division,** Ministry of Agriculture; in **the Marine Science Unit** of the Faculty of Natural Sciences at the University of the West Indies, Mona; in the **Scientific Research Council**; and in the **private sector.**

4.3.2.1 The Fisheries Division, Ministry of Agriculture.

The **Fisheries Division** (FD) has suffered from staff attribution due to low salaries and "restructuring" under IMF conditionalities. It is headed by a Director and a Deputy Director (both currently acting in their posts), and although there are six (6) posts for Fisheries Officers, all have been vacant for some time[2]. The current staff resources of the FD -- Already stretched to their limit -- will not be able to effectively administer a Marine Cage Culture Programme; and more retrenchment is expected.

The **Aquaculture Branch**, (FD) has technical capability in fresh-water Tilapia production (hatcheries and pond culture), as well as in the marine cultivation of oysters (*Crassostrea rhyzophorae*), and seaweed (*Gracilaria spp.*). It has a Head, a Research officer[3] and other staff. The spat collection facility of the oyster culture project[4] located in Bowden, St Thomas, is staffed by a farm manager and an assistant[5]. As currently staffed, the Aquaculture Branch does not have the capability to administer a Marine Cage Culture Programme.

4.3.2.2 The Marine Sciences Unit, University of the West Indies.

The Marine Science Unit (MSU), of the Faculty of Natural Sciences (FNS) at the University of the West Indies (UWI), Mona, has a Director, one Research Fellow, and several Associate Fellows from the Departments of Zoology, Botany, Chemistry and Geology in the FNS, and from the Institute of Social and Economic Research in the Faculty of Social Sciences. Associated with the MSU are the two UWI Marine Laboratories at Port Royal and Discovery Bay.

At present neither the Zoology Department nor the MSU conduct research into the cage culture of marine finfish species, and no current staff member has practical experience in this field. Several graduate students are currently investigating the marine cage culture of the red hybrid of Tilapia[6]. These are supervised by the same member of staff, currently on leave[7].

4.3.2.3 The Scientific Research Council

The Scientific Research Council (SRC) is a statutory body established by the Jamaican government in 1960. The Scientific Research Council act of 1960 states that the duty of the SRC is:

> *"To foster and co-ordinate Scientific Research in the island and to encourage the application of the results of such research to the exploitation and development of the resources of this island."*

The functions of the SRC are conducted in three main Divisions: research and Development; Technical Information and Co-ordination; Administration; and Finance.

---

2 Others staff include fisheries wardens, clerical , janitorial, kitchen and security wardens. Also on staff are "fisheries instructors" who sell subsidized gas oil at central fishing beaches across the Island, and captain and crew for the Division research vessel "blue fin".
3 Other staff include clerks, drivers attendants , pond operators and casual labourers.
4 Funded by the International Development Centre (IRDC) Canada.
5 There is also an extension officer and three watchmen.
6 A hybrid of T. mossambica and T. nilotica.
7 Dr Dunbar STEELE

The Research and Development Division is comprised of six departments: Agro-industry; Analytical Services; Engineering and Energy; Microbiology/Biotechnology; Food Science and Technology; and Mineral Resources. The achievements of this Division are numerous. Biological projects include: the development of technology for the cultivation of mushrooms under tropical conditions; the development of tissue culture technology for the Irish potato, yams and anthuriums; the development of the culture technology for *Artemia* (brine shrimp) in ponds; and the development of a project for biological nitrogen fixation.

The SRC has the capability to administer a research programme to develop a technology for the cage culture of marine fish.

4.3.2.4 The Jamaican Private Sector

The **Jamaican Private Sector**, has developed substantial capability in the pond aquaculture of *Tilapia*, and has identified considerable unfulfilled market capacity. As the exploitation of Jamaica's water resources approaches its limits, continued expansion of freshwater operations will be severely constrained. Considerable interest has been shown by the private sector in the marine culture of marine species *and of Tilapia*.

Traditionally, the Jamaican private sector has shown a preference for off-the-shelf technology and has kept its research efforts to a minimum. Nevertheless, several companies possess the staff capability to manage a major research programme in marine cage culture. They can be expected to be committed to the development of large-scale cage culture technology.

4.3.3 Research

The human resources available for marine aquaculture research in Jamaica are severely limited, as there are no experts or specialists in marine fish rearing in the island at present. If existing human resources are to be used, they will have to receive some training and exposure to cage culture methods as applied to marine species, and the necessary provisions will have to be made.

Resources exist in the **Scientific research Council**; in the **Marine Science Unit** of the Faculty of Natural Sciences at the University of West Indies, Mona; and in the private sector. There are no human resources available in the **Fisheries Division**, Ministry of Agriculture, or its Aquaculture Branch, to conduct this type of specialized research.

4.3.3.1 *The Scientific Research Council*

The SRC, located next to the Ministry of Agriculture, is devoted to Jamaica's economic growth through technological development. Human resources of the SRC include biologists, physicists, civil engineers, biochemists, microbiologists, chemists, food technologists, food scientists, nutritionists and geologists. In addition, the SRC plant includes laboratory facilities.

Although it has no marine fish aquaculturist on staff, the SRC has the human resource capability to conduct research in marine cage culture, and should have no difficulty in procuring any additional expertise needed.

4.3.3.2 *The Marine Science Unit, University of the West Indies*

Associated with the MSU are the two Marine Laboratories at Port Royal (PRML) and Discovery Bay (DBML). The DBML is staffed and equipped for research in coral reef ecology, and has an enviable reputation in that field; it has no facilities for aquaculture research. The PRML has facilities for both freshwater and marine aquaculture research, and indeed, investigations into both freshwater and brackish water culture of *Tilapia* are in progress there. Aquaculture research at the PRML is conducted by graduate students -- mostly training for master's degrees -- under the supervision of the Department of Zoology of the FNS.

Research into the cage culture of marine fish by the MSU/UWI could be approached in two ways: graduate students could be funded to do the research towards a higher degree; or research staff with higher degrees could be hired to conduct the research. The former approach would be cheaper but the research will take years to complete and supervision will be a problem. The latter approach would be much more expensive, but should produce results in a shorter time. If time is of the essence then the latter option should be selected.

At present the MSU/UWI does not possess the human resources to conduct research into the cage culture of marine fish, but if funding were provided, research staff could be hired and located there.

4.3.3.3 *The Jamaican Private Sector*

The Jamaican private sector (JPS) at present does not have human resource capability in the cage culture of marine fish. Some companies have hired fisheries experts at the Ph.D and Master's levels, and although they would be able to supervise a research program, their regular duties would not permit time for a concentrated effort at performing the research itself. If grant funds were available to the private sector, the necessary expertise could be hired and based in the private sector. The JPS is unlikely to fund marine cage culture out of its own resources.

4.3.3.4 *Participatory Research Techniques*

If a choice is made to develop small-scale labour-intensive cage culture technologies suitable for adaptation by coastal dwellers, then techniques which will allow rural folk to participate in the research should be used. Such an approach is likely to facilitate a smooth transfer of the technology.

4.4 AVAILABILITY OF LOCAL CAPITAL FOR RESEARCH

Considered in this section is the availability of local capital for research, and the availability of local capital for development.

4.4.1 The availability of local capital for Research

Very little of the research conducted by the **University of West Indies** or the **Scientific Research Council** is funded out of the recurrent budget of these organizations. They depend almost exclusively on grants to fund the research they conduct. The Jamaican government does not, as a rule, provide funds from general revenue for research purposes.

The funds required to conduct a serious research programme in marine cage culture are likely to be extensive, and no one private sector company is likely to want to provide funding. An approach could be made to all pond culture interests in the private sector to jointly fund the necessary research. Although some funding might be obtained from this source, it is likely that much more will be required, and overseas sources will have to be sought.

4.4.2 The availability of local capital for Development

Both the **University of the West Indies** and the **Scientific Research Council** conduct research into new technologies, but once completed, they normally choose to hand over their findings to others for development. Judging from past performance, the Jamaican private sector tends to be more prepared to adopt already researched technologies and to adapt them to local conditions, than to fund and conduct research of its own. It is likely that sufficient development capital can be sourced locally by the private sector once the technology is developed.

If the technology that is developed is small-scale and labour-intensive, a loan scheme and other support to assist the transfer of the technology to rural coastal dwellers, will be required. There are a number of non-governmental organizations which have the expertise and experience to be able to handle this sort of operation. Funding for this type of rural development activity should be easily available from overseas.

4.5 THE LEGAL ENVIRONMENT

Marine aquaculture is a novel idea in Jamaica, and specific legal instruments which might facilitate, regulate or protect such operations do not exist at present. Having said this, there are laws currently on the books which may impact upon cage culture operations.

The **Beach Control Act** (enacted June 1, 1956) vests "all rights in and over the foreshore[8] of this Island and the floor of the sea" in the crown [Section 3.1]. The Minister responsible has the authority to declare :

> *"any part of the foreshore and the floor of the sea defined in the order together with the water lying on such part of the floor of the sea to be a protected area for the purposes of this Act;"* [Section 7.1 (a)]

Certain activities may be prohibited within a protected area, including fishing, "the use of boats other than boats propelled by wind or oars", the disposal of rubbish, water-skiing, dredging, the removal of flora and fauna, and treasure hunting. No mention is made of prohibition of entry or trespass.

Commercial activity may not take place on or over the foreshore and the floor of the sea without a license:

> *"From and after 1st of June, 1956, no person shall encroach on or use, or permit any encroachment on or use of, the foreshore or the floor of the sea for any public purpose or for or in connection with any trade or business, or commercial enterprise, or in any other manner (whether similar to the foregoing or not) ... without a license granted under this act."* (Section 5.1).

But even if a licence is applied or granted the licensee does not appear to have the right to exclude others from the area; which is important, as if cage culture operators were to be given licenses, they could not prevent fishermen or others from approaching or sailing/rowing between their cages. If deliberate damage to cages were to be committed, one would have to catch the offender in the act to be sure of conviction, and the cage operator could not fence off the sea or declare a prohibited area as a precaution.

The **Harbours Act** and the **Marine Board Act** are silent on usage of sea areas not used for navigation. Shipping lanes should not be obstructed by racks, anchored rafts or floating cages.

If marine aquaculture is to have a future in Jamaica, then there is the need for legislation which will encourage and protect the activities. At the very least, marine fish farmers should be able to prevent human intruders (above and below water) from encroaching on those parts of the sea in which their farms are located.

---

8 The foreshore is defined as the strip of land exposed between high tide and low tide.

Annex to the chapter 4

- site selection criteria

- detailed charts concerning the sites with an interesting potential for marine cage culture

CRITERIA FOR SELECTING A SITE FOR CAGE CULTURE

To set up such an activity, it is common to analyse each following criteria and check if the parameters stands inside the limits.

1 - Technical characteristics

1.1 - Waves :

Characterizable by their height and period. A long period is less defavorable than a short one. The following limits are generally considered for a site selection :

- 1 m : maximum limit for working on floating cages
- 2-3 m : maximum limit of resistance for simple floating structures
- 8 m : maximum limit of resistance for specific off-shore structures.

The magnitude of waves on a given site, which depends upon wind exposure and strength, fetch fistance, and depth of water can be predicted. Two examples, for wave amplitude and swell refraction are provided.

1.2 - Currents :

A weak and continuous current stream is favorable to bring oxygen and remove wastes in a cage. Long periods without current implies to select cage of limited volume of cages and low density of fish inside. Strong currents may damage floating structures or cages, and recuce the cage usable volume, due to the deformations of the net. The size and cost of moorings and anchor lines are directly linked to the current speed. The limits are :

-. minimum : 0,1 knot,
-. maximum : 1,5 to 2 knots.

1.3 - Tide

Very often, tide and currents are linked (see 1.3). Limited tide amplitudes are generally preferable. The varying depth of water due to the tide implies specific problems for anchors and moorings, maximum : 5-8 m (though cages may operate in stronger tide conditions, at an increased cost.

1.4 - Wind

Wind ??? waves (see 1.1) and also currents (see 1.3). Up-??? effects due to moderate winds can be profitable by the reserval of water.
Strong winds induce perturbations on daily work on cages (feeding, fishing, etc...) or cage structures (nets or shadow-canvas) and implies heavier moorings.
Maximum 30-40 Km/h.

1.5 - Depth

Shallow bays with limited depth of water under cages, are not favorable for water renewal and generally favor the settling of wastes. On the other hand, important depth of water requires expensive moorings (?). A depth of 15 to 30 m at low tide may be considered as ideal conditions. Depths inferior to 10 m require the use of shallow nets, in order to avoid interaction with the sea floor (chemical and bacterial interactions, net damage, crab and bottom organisms predation...). Depths inferior to 5 m, are considered as less favorable to cage farming, and special care should be given to the observation of the sediment evolution. Periodic displacement of the cage site should be considered.

1.6 - Bottom shape and composition

Mud or rocks bottom may cause difficulties for a safe and reliable anchorage. A sandy or gravel bottom is generally looked for.

2 - Criteria of water quality

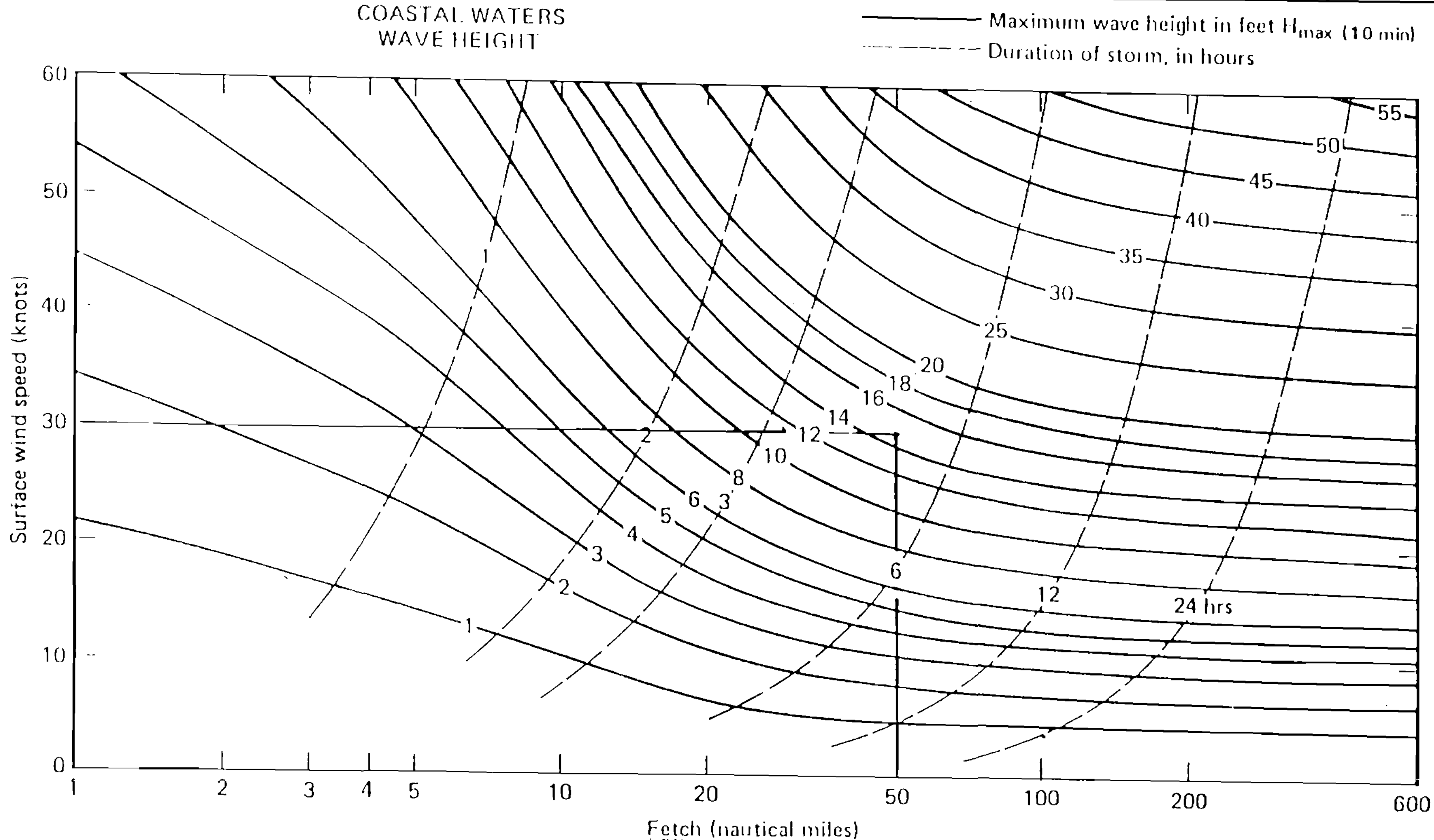
Criteria quality for rearing waters have been established in Japan in 1983 by the*Resources Fisheries Department. Criteria for marine fisheries*. They are summerize in table 1. They is no established maximum concentrations authorized by law but data concerning perturbation levels for a toxic effect can be observed on marine organisms are available. Different species are living in varging marine environments and each organism can have a different sensivity to the toxics. So, one recongnizes the difficulty to establish some ??? criteria of water quality. These criteria are based both on scientific results and on cumulative knowledge by aquaculturists. Although these criteria do not exist as legal regulations, they can be considered as indications for the wildlife protection and safe aquaculture practices.

Wastes from aquaculture can be reduced by avoiding over-feeding and over crowding in cages. The water quality in properly managed aquaculture areas must stay constant and convenient for that purpose for long periods. Water quality is necessary for the health and growthof the reared species.To restore a polluted aquaculture area is difficult and requires time, so a substantial effort is necessary to check, manage and maintain water quality from the start of the activity on a site. One does not forget that a good water quality and clean sea bed allow the development of wild life (nursery of fishes, crustaceans and so on...) and healthy leasure areas for human being.

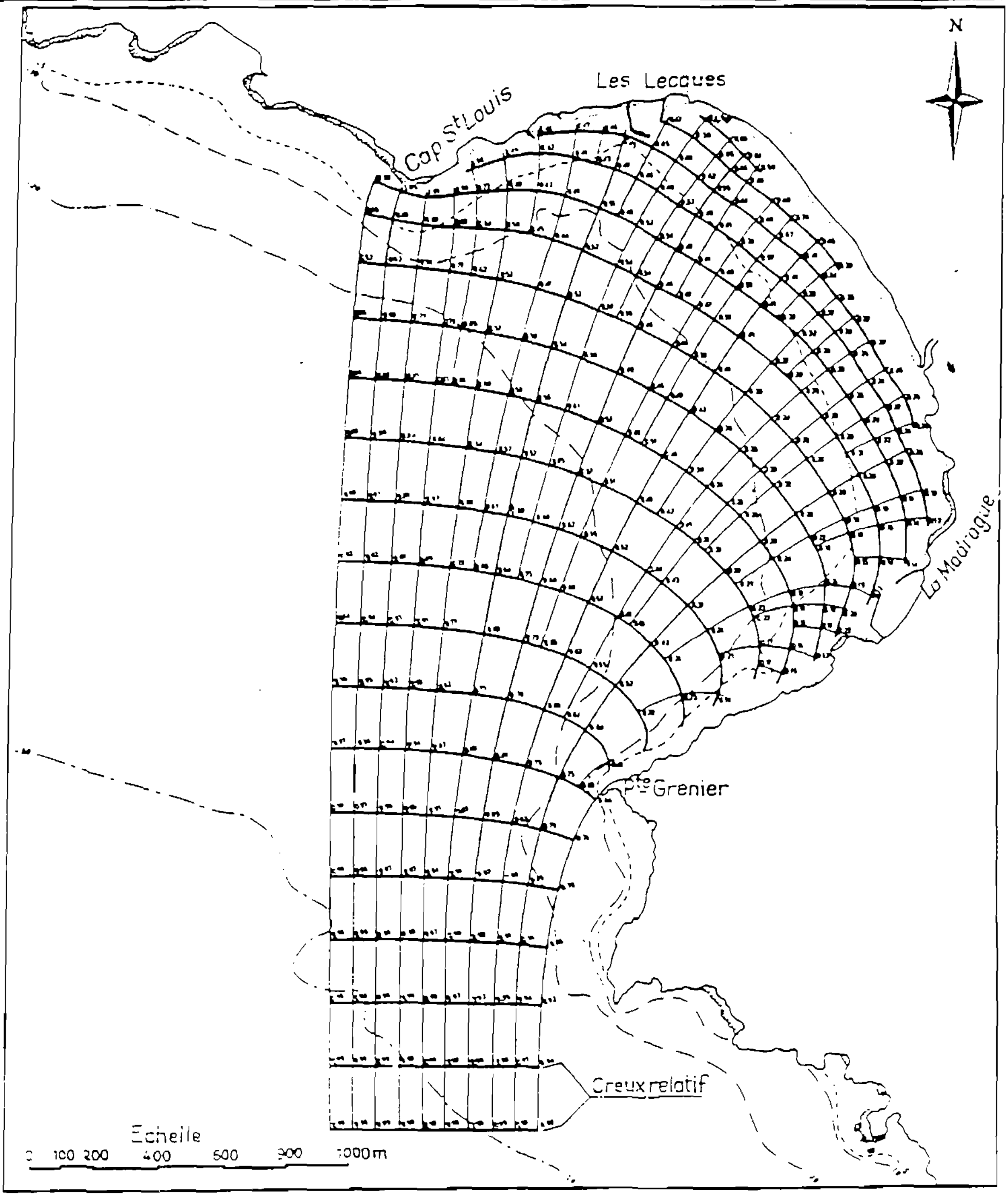
Water quality criteria for marine life and aquaculture

(compiled from various sources)

Salinity	25-40 pour mille, avoid abrupt change
pH	7.8-8.4, avoid abrupt change
Temperature	no abrupt change
Dissolved oxygen	> 6 mg/l
Chemical oxygen demand	< 1 mg/l
Algae culture demand	< 2 mg/l
Total inorganic nitrogen	< 0.1 mg/l
Ammonia (NH_4 + NH_3)	< 1 mg/l for pH=8
Dry suspended matter	< 2 mg/l
Transparence (yearly mean)	< 5 m
Colour	no abnormal behaviour of the fish
Oil	no iridescence in surface
Faecal coliforms	< 1000/100 ml
Rearing oyster coliform	< 70/100 ml
Total inorganic phosphorus	< 0.015 mg/l
Chlorine	< 0.02 mg/l
Total mercurey	< 0.05 mg/l
Sead	< 0.1 mg/l
Copper	< 0.02 mg/l
DDT	< 0.025 mg/l



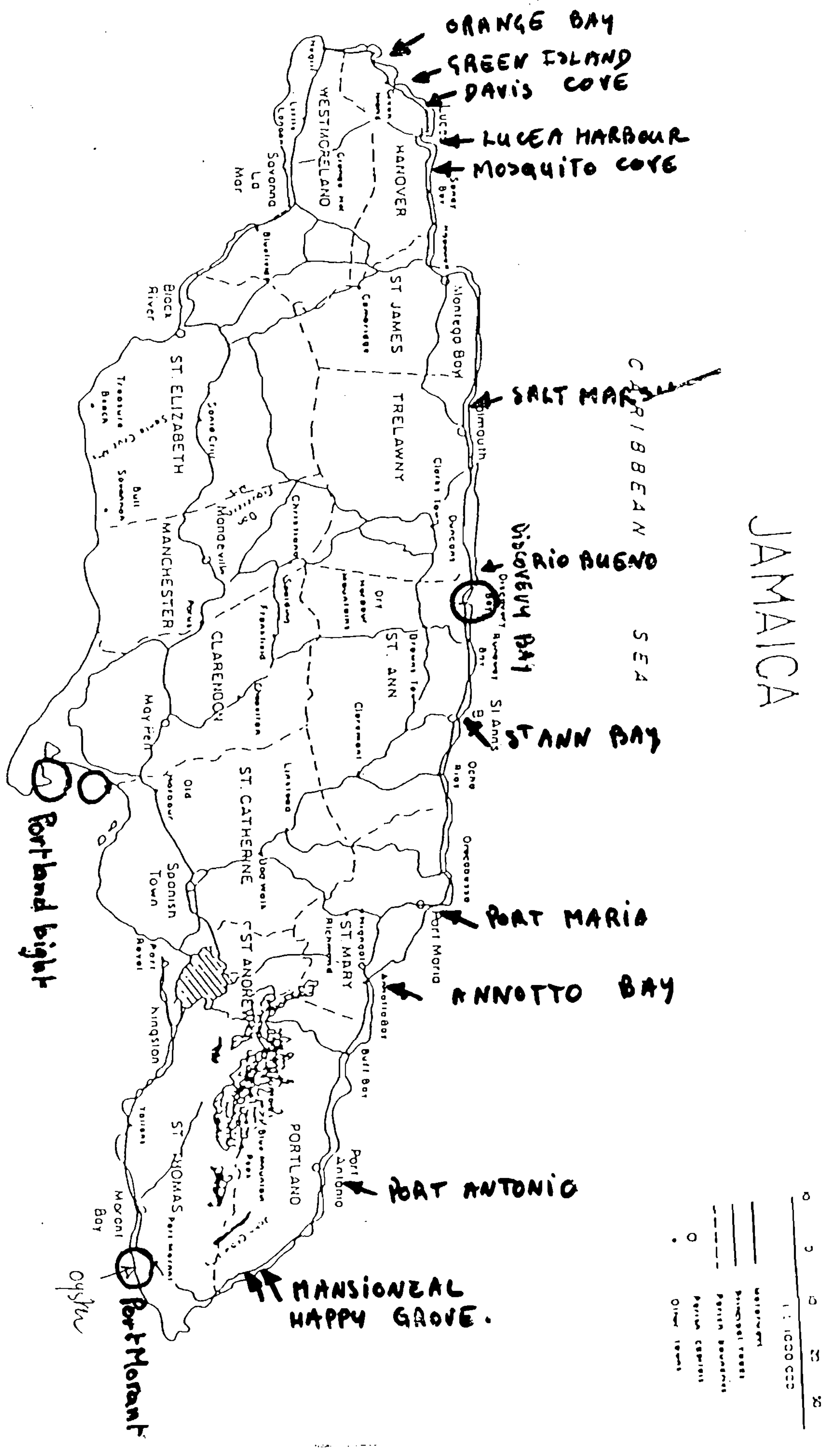
Hauteur des vagues générées par le vent



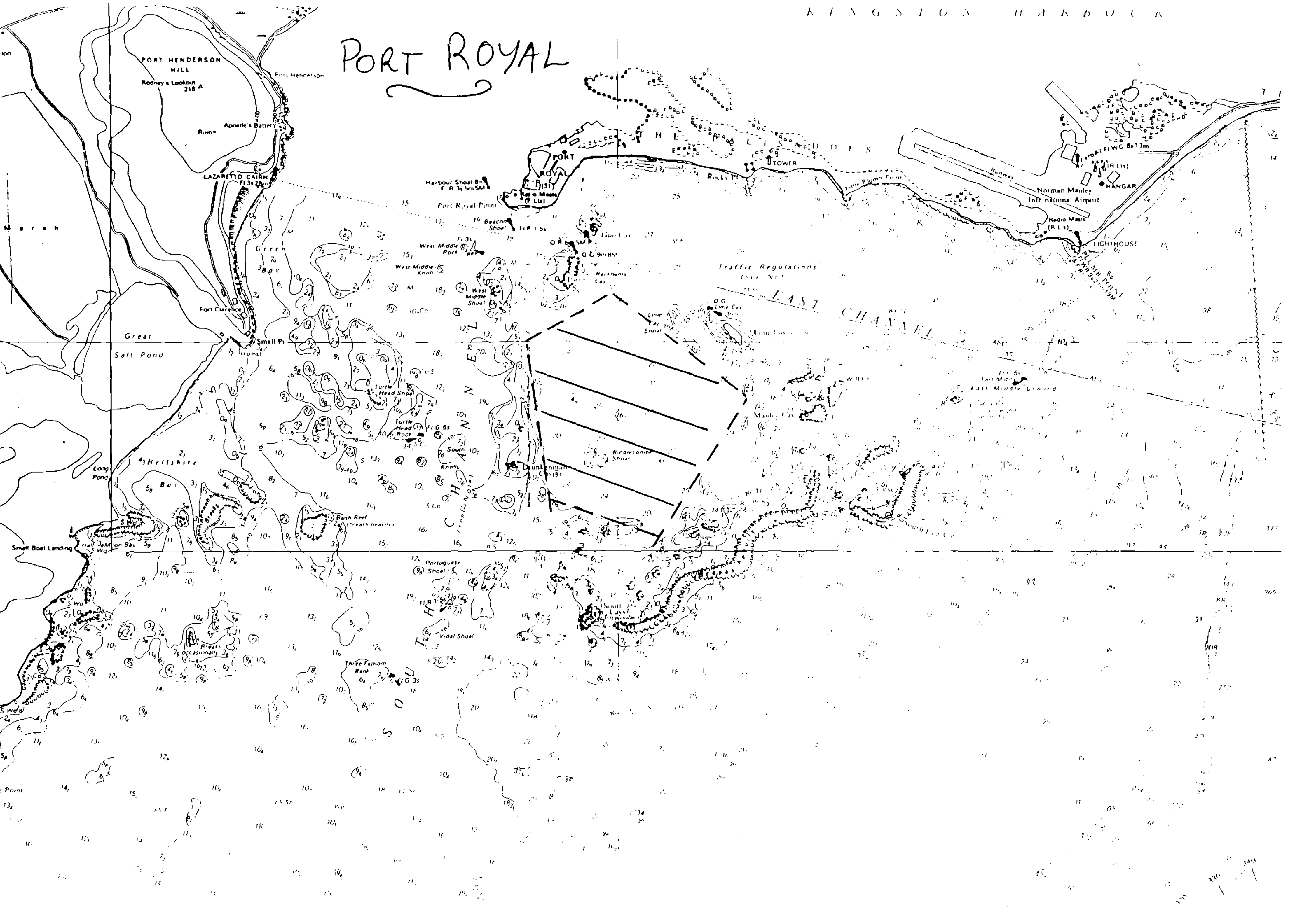
$$\alpha = \text{Arc}\sin(\text{th}(kd)\sin(\alpha o))$$

$$Kr = \sqrt{(\cos\alpha o/\cos\alpha)}$$

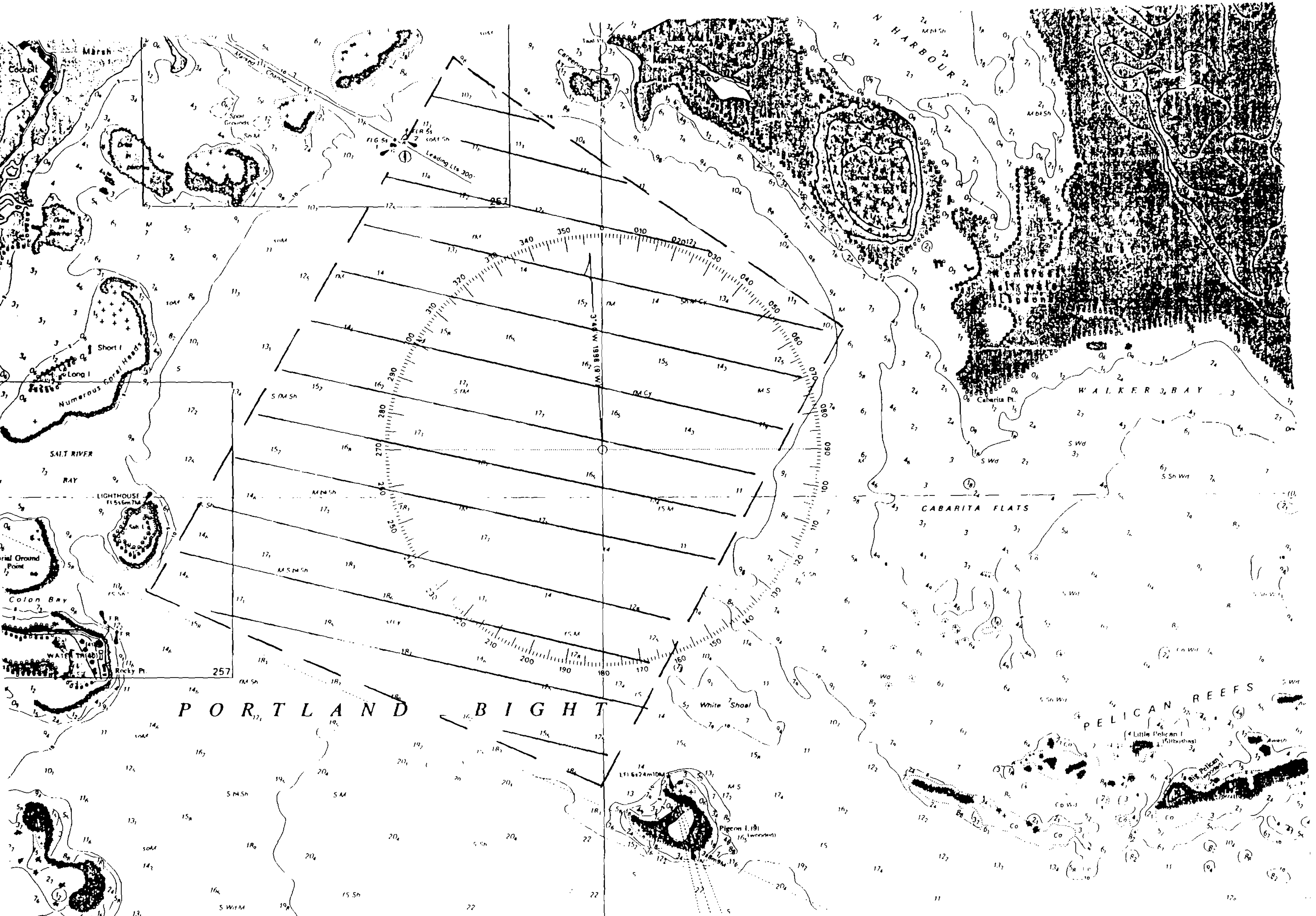
Réfraction de la houle

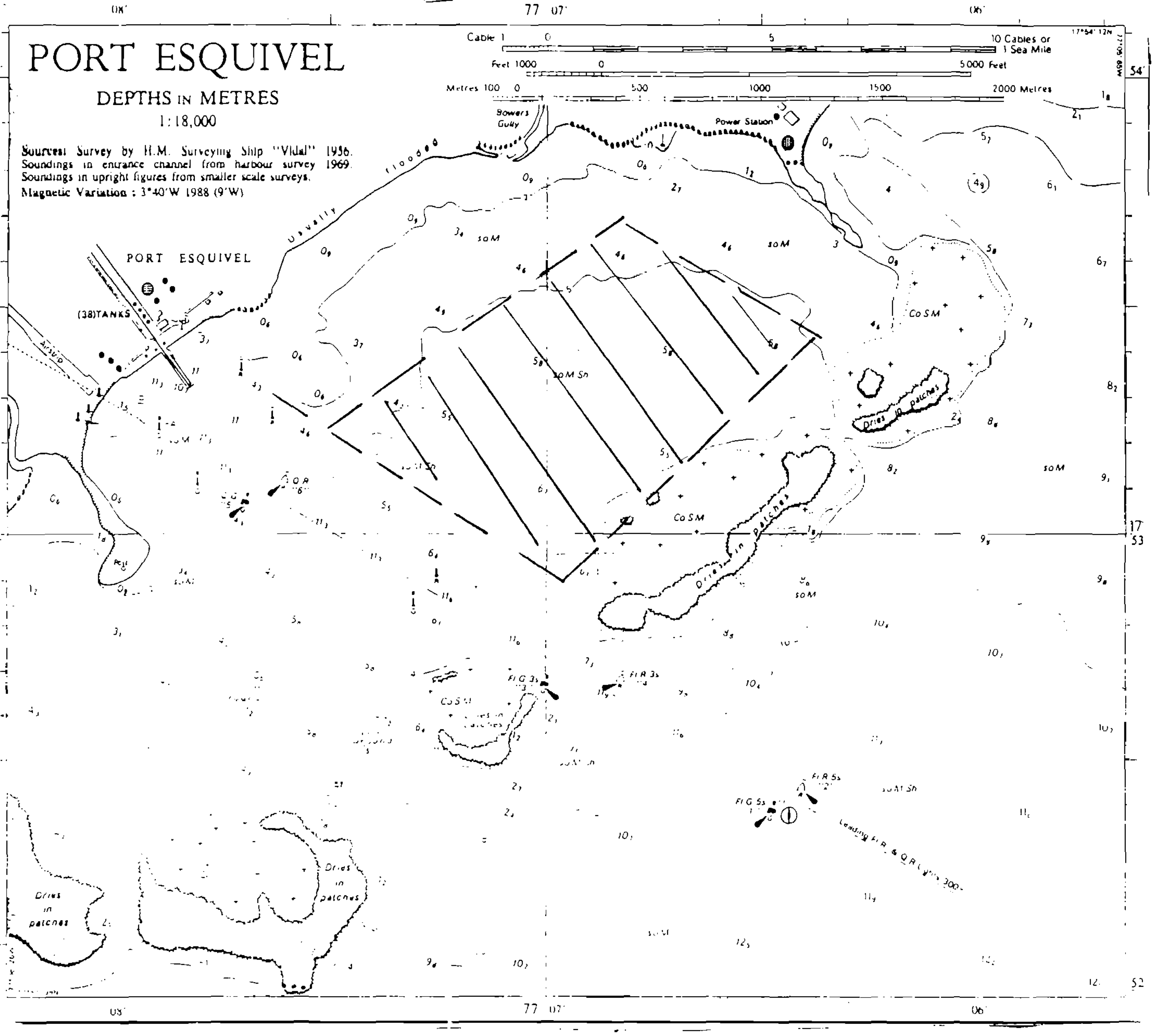


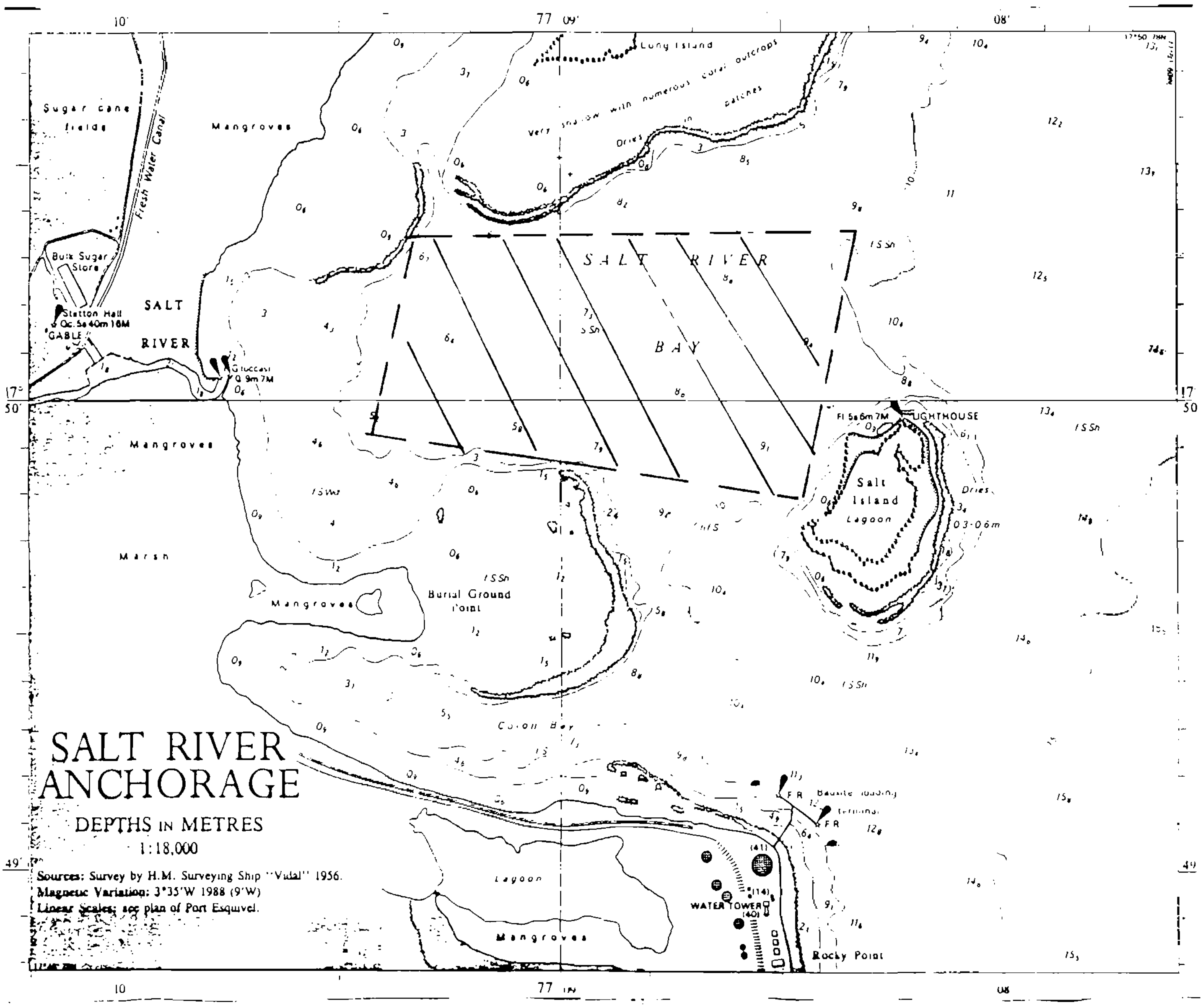
JAMAICA
CARIBBEAN SEA
CARIBBEAN SEA
ORANGE BAY
GREEN ISLAND
DAVIS COVE
LUCEA HARBOUR
MOSQUITO COVE
SALT MARSH
RIO BUENO
DISCOVERY BAY
ST ANN BAY
PORT MARIA
ANNOTTO BAY
PORT ANTONIO
MANSIONZAL
HAPPY GROVE.
Portland bight
Port Morant
WESTMORELAND
HANOVER
ST JAMES
TRELAWNY
ST. ELIZABETH
MANCHESTER
CLARENDON
ST. ANN
ST. CATHERINE
ST. MARY
ST ANDREW
PORTLAND
ST THOMAS
Savanna La Mar
Black River
Montego Bay
Falmouth
Mandeville
May Pen
Spanish Town
Kingston
Port Royal
Morant Bay
Port Antonio
Annotto Bay
Port Maria
Ocho Rios
St Anns Bay

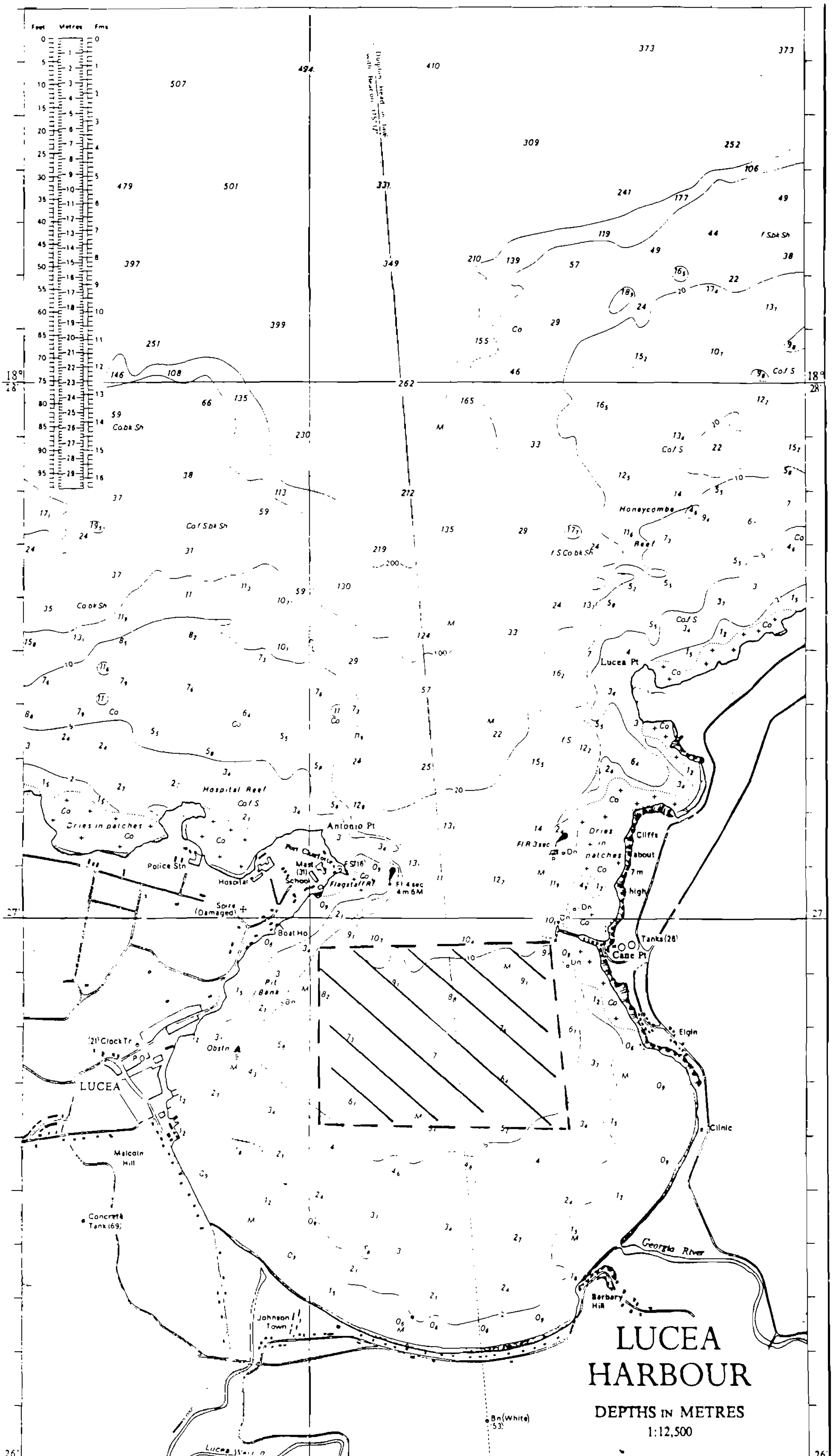


KINGSTON HARBOUR
PORT ROYAL
PORT HENDERSON HILL
Rodney's Lookout 218
Port Henderson
Apostle's Battery
Ruin
LAZARETTO CAIRN
Fort Clarence
Great Salt Pond
Small Pt
Long Pond
Hellshire
Green Bay
Small Boat Landing
Harbour Shoal Bn
Port Royal Point
Beacon Shoal
West Middle Rock
West Middle Knoll
West Middle Shoal
Turtle Head Shoal
Turtle Head Rock
South Knoll
Bush Reef
Portuguese Shoal
Vidal Shoal
Three Fathom Bank
Dunkenman
Rackham Cay
Gun Cay
Lime Cay
Maiden Cay
South Cay
Rinderconner Shoal
East Middle Ground
EAST CHANNEL
SOUTH CHANNEL
Traffic Regulations
THE PALISADOES
TOWER
LIGHTHOUSE
Radio Mast
Norman Manley International Airport
HANGAR
Runway
Little Plumb Point

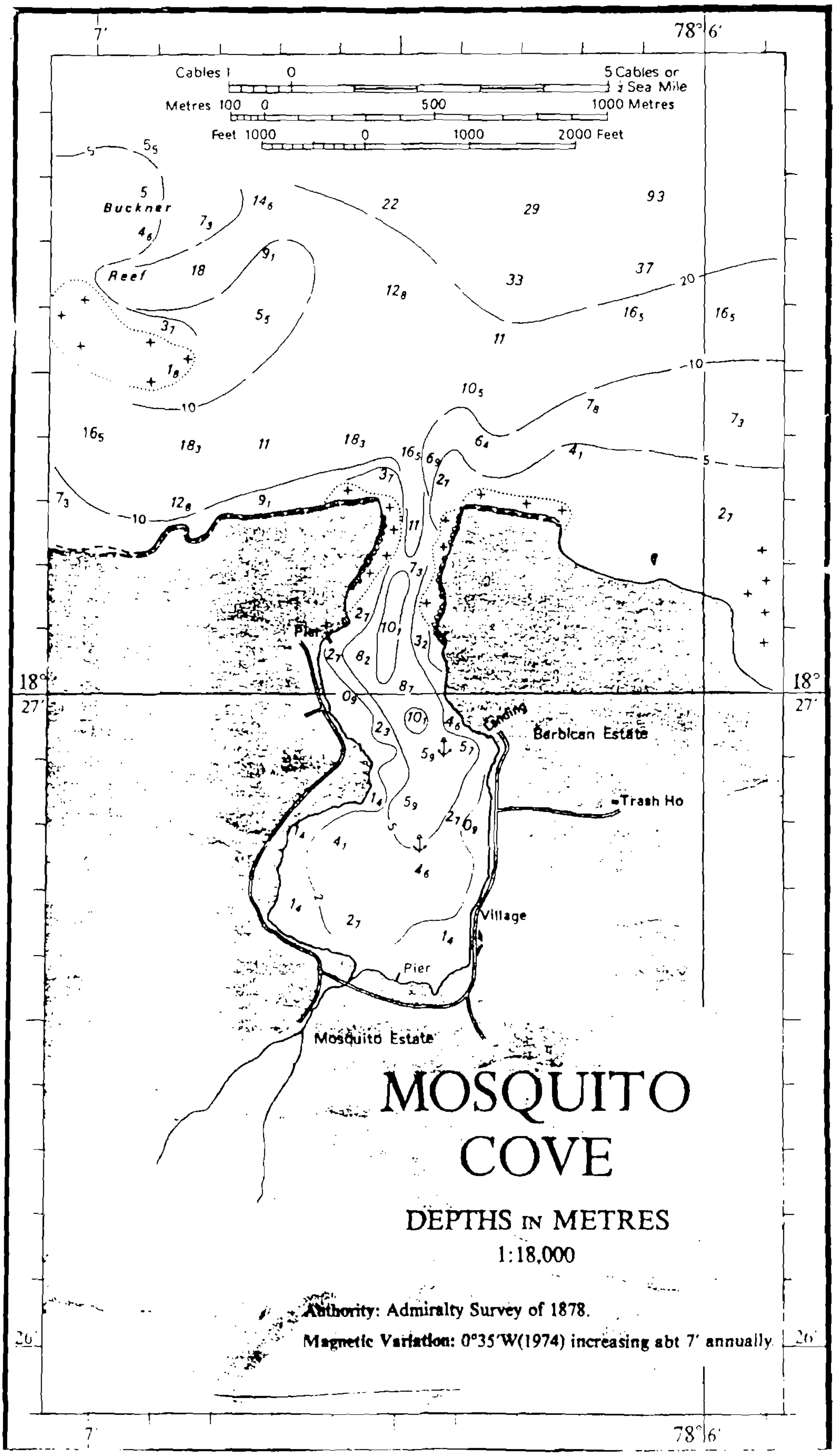

PORTLAND BIGHT
PELICAN REEFS
CABARITA FLATS
WALKER BAY
N HARBOUR
SALT RIVER
BAY
Colon Bay
LIGHTHOUSE
White Shoal
Cabarita Pt.
Pigeon I.
Little Pelican I.
Big Pelican I.
Short I
Long I
Numerous Coral Heads
Rocky Pt.
Careening
Leading Lts 300°
Salt Marsh
257
3°40'W 1998 (9'W)


PORT ESQUIVEL
DEPTHS IN METRES
1:18,000
Sources: Survey by H.M. Surveying Ship "Vidal" 1956.
Soundings in entrance channel from harbour survey 1969.
Soundings in upright figures from smaller scale surveys.
Magnetic Variation : 3°40'W 1988 (9'W)
Cable 1 0 5 10 Cables or 1 Sea Mile
Feet 1000 0 5000 Feet
Metres 100 0 500 1000 1500 2000 Metres
PORT ESQUIVEL
(38)TANKS
Bowers Gully
Power Station
Dries in patches
Co S M
so M
so M Sh
Fl G 3s
Fl R 3s
Fl R 5s
Fl G 5s
Q R
Leading Fl R & Q R Lts
08'
77 07'
06'
54'
53'
52'

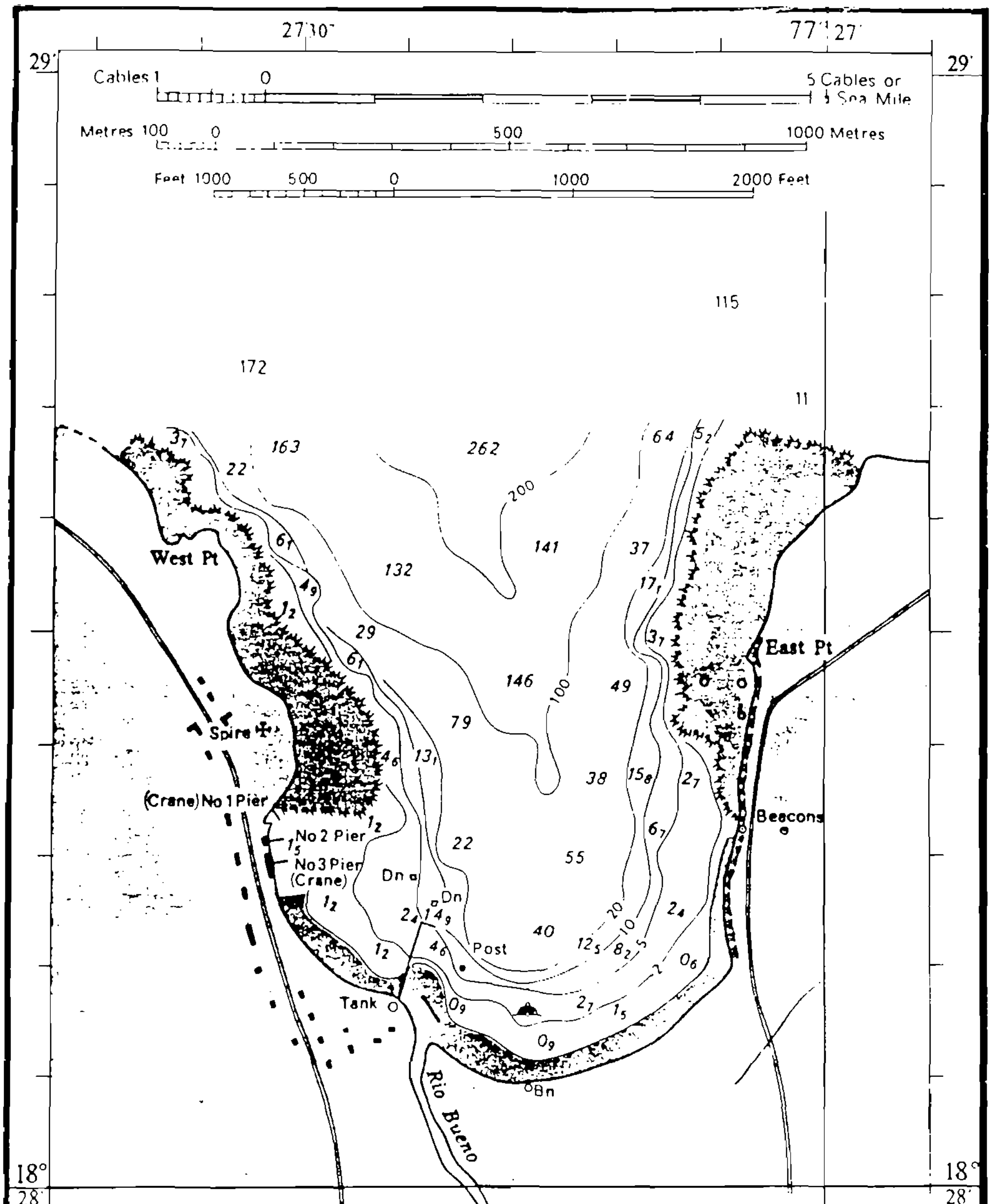

SALT RIVER ANCHORAGE
DEPTHS IN METRES
1:18,000
Sources: Survey by H.M. Surveying Ship "Vidal" 1956.
Magnetic Variation: 3°35'W 1988 (9'W)
Linear Scales: see plan of Port Esquivel.
Sugar cane fields
Fresh Water Canal
Mangroves
Bulk Sugar Store
Statton Hall Oc.5s40m16M
GABLE
SALT RIVER
Long Island
Very shallow with numerous coral outcrops
Dries in patches
SALT RIVER BAY
Fl 5s6m7M LIGHTHOUSE
Salt Island
Lagoon
Dries
0.3-0.6m
Marsh
Burial Ground Point
Colon Bay
Bauxite loading terminal
F R
WATER TOWER
Rocky Point
Lagoon
Mangroves
77 09'
10'
08'
17° 50'
49'



Authority: Survey by H.M.S. "Vidal" 1965.



MOSQUITO COVE
DEPTHS IN METRES
1:18,000
Authority: Admiralty Survey of 1878.
Magnetic Variation: 0°35′W(1974) increasing abt 7′ annually
Buckner Reef
Pier
Landing
Barbican Estate
Trash Ho
Village
Mosquito Estate
Cables 1 0 5 Cables or ½ Sea Mile
Metres 100 0 500 1000 Metres
Feet 1000 0 1000 2000 Feet
78° 6′
7′
18° 27′
26′



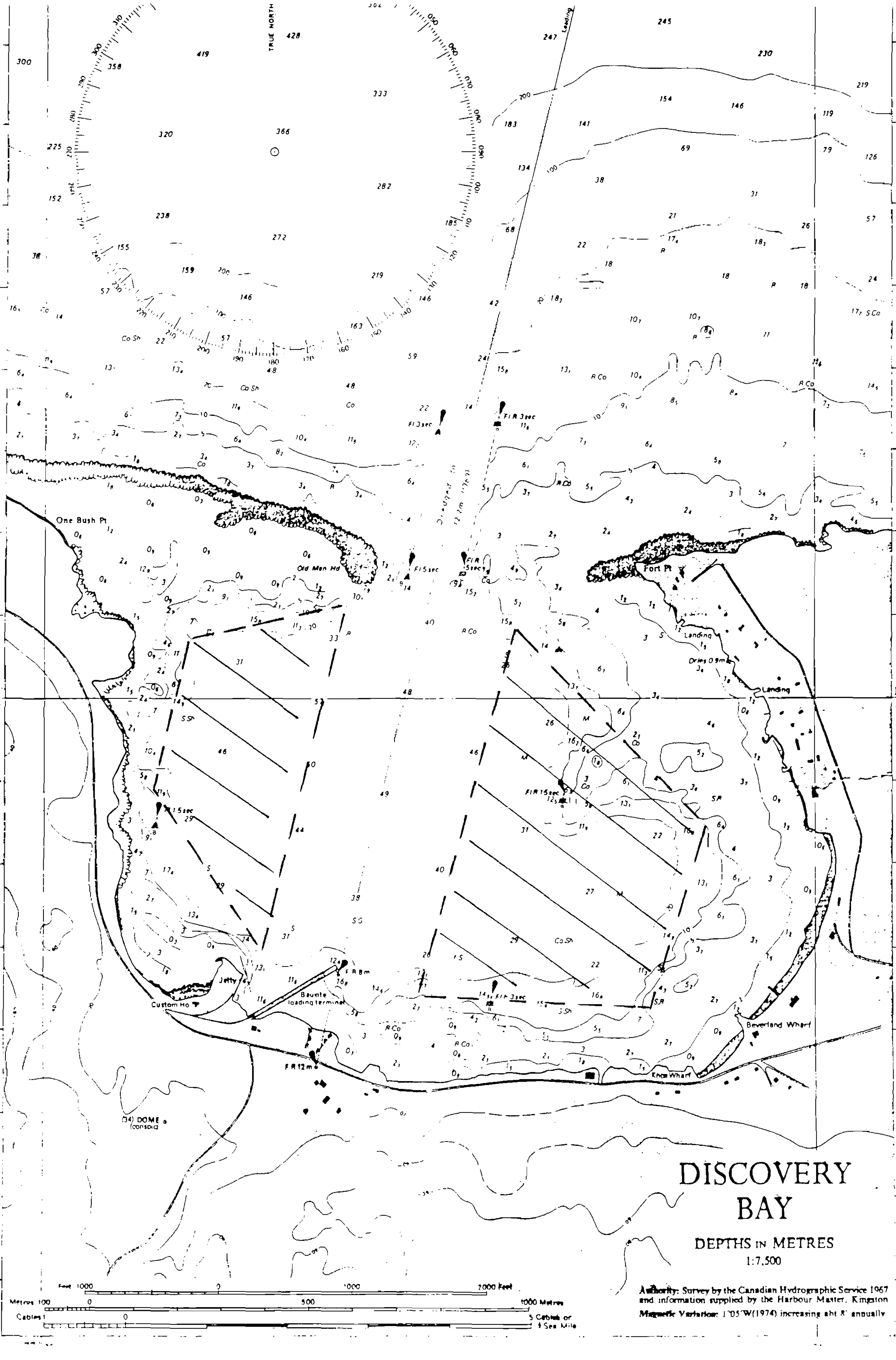
RIO BUENO

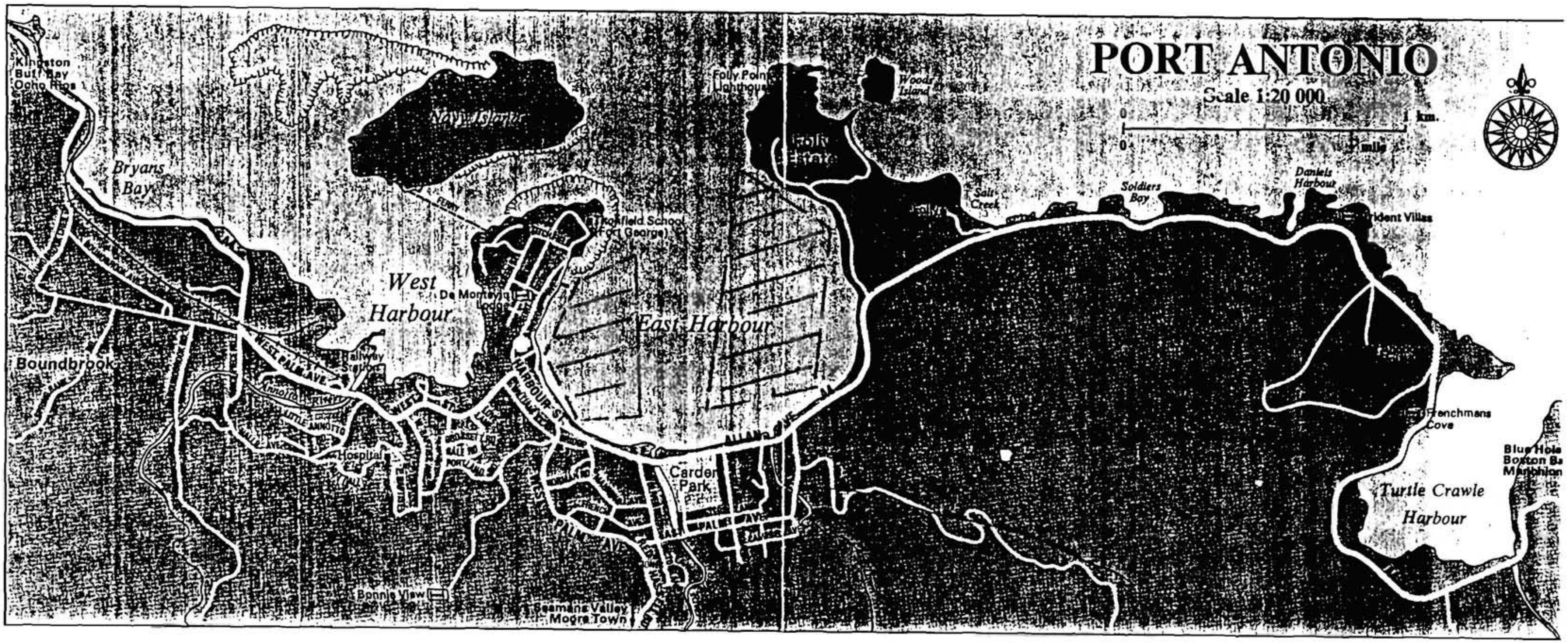
DEPTHS IN METRES

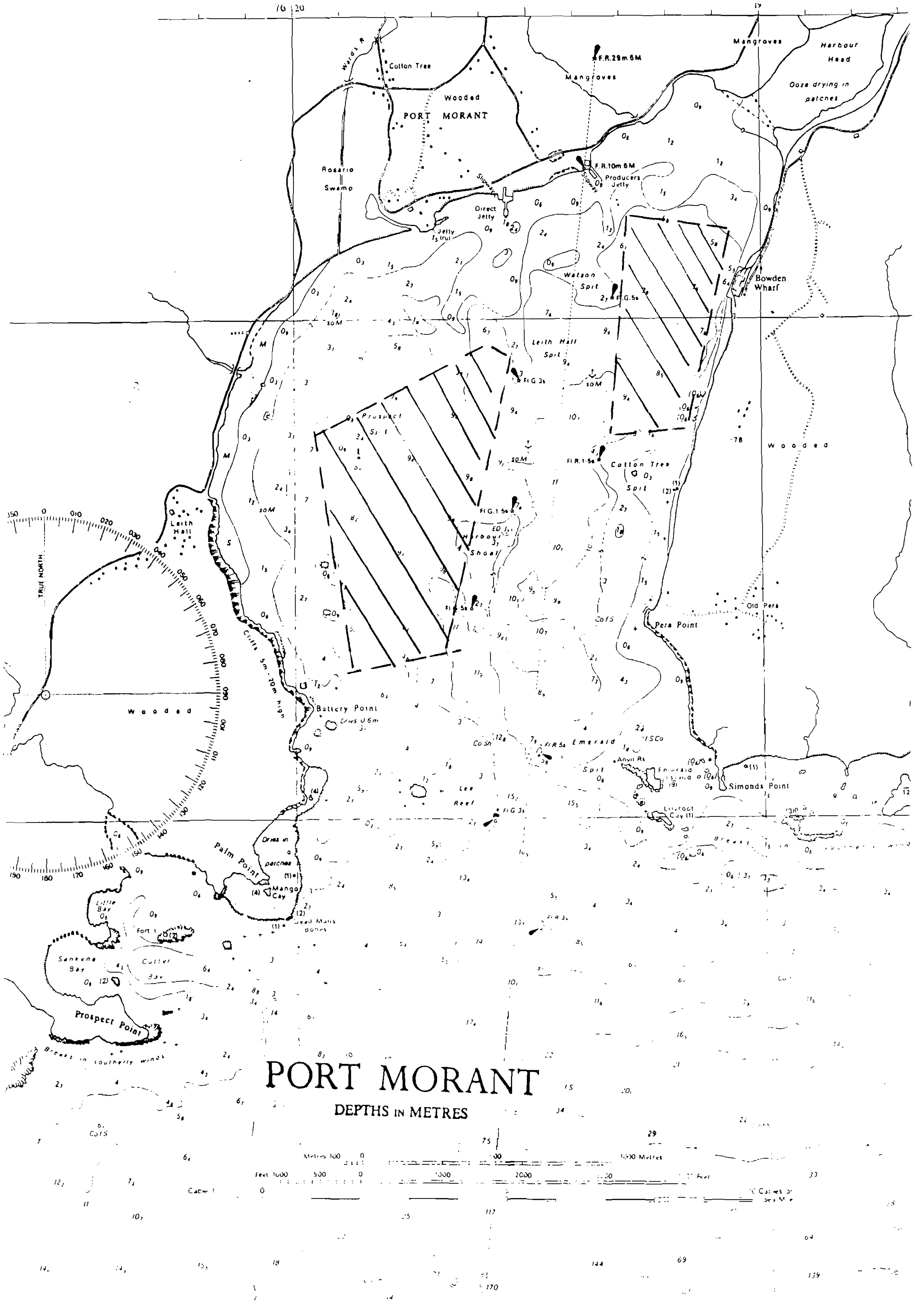
1:12,500

Authority: Survey by H.M.S. "Vidal" 1965.

Magnetic Variation: 1°05'W(1974) increasing abt 8' annually.


DISCOVERY BAY
DEPTHS IN METRES
1:7,500
Authority: Survey by the Canadian Hydrographic Service 1967 and information supplied by the Harbour Master, Kingston
Magnetic Variation: 1°05'W(1974) increasing abt 8' annually
TRUE NORTH
Leading
One Bush Pt
Old Man Hd
Fort Pt
Landing
Custom Ho
Jetty
Bauxite loading terminal
Beverland Wharf
Knox Wharf
(34) DOME (conspic)
Fl 3sec
Fl R 3sec
Fl 5sec
Fl R 15sec
F R 8m
F R 12m
Feet 1000 0 1000 2000 Feet
Metres 100 0 500 1000 Metres
Cables 1 0 5 Cables or ½ Sea Mile


PORT ANTONIO
Scale 1:20 000
0
1 km.
0
mile
Kingston
Buff Bay
Ocho Rios
Bryans Bay
Navy Island
West Harbour
East Harbour
Boundbrook
Folly Point Lighthouse
Woods Island
Folly Estate
Salt Creek
Soldiers Bay
Daniels Harbour
Trident Villas
Frenchmans Cove
Turtle Crawle Harbour
Titchfield School
Fort George
De Montevin Lodge
Railway Station
West Palm Ave
Harbour St
Hospital
Carden Park
Bonnie View
Seamans Valley
Moore Town


PORT MORANT
DEPTHS IN METRES
Port Morant
Cotton Tree
Wooded
Mangroves
Harbour Head
Ooze drying in patches
F.R.29m 6M
F.R.10m 6M
Producers Jetty
Rosario Swamp
Direct Jetty
Jetty
Watson Spit
Fl.G.5s
Bowden Wharf
Leith Hall Spit
Fl.G.3s
Prospect Spit
Fl.R.1·5s
Cotton Tree Spit
Fl.G.1·5s
Harbour Shoal
Leith Hall
TRUE NORTH
Old Pera
Pera Point
Cliffs 5m-20m high
Battery Point
Dries 0.6m
Emerald Spit
Fl.R.5s
Anvil Rk
Emerald Island
Simonds Point
Lee Reef
Fl.G.3s
Palm Point
Dries in patches
Mango Cay
Dead Mans Bones
Little Bay
Fort
Sankene Bay
Cutter Bay
Prospect Point
Breaks in southerly winds
Metres 100
1000 Metres
Feet 1000
500
1000
2000
Cables
10 Cables or Sea Mile

5. PROPOSALS

5.1 SHORT, MEDIUM AND LONG TERM APPROACHES

For many countries aquaculture may present interesting opportunities for developing new coastal enterprises, providing employment, and protein either for local consumption or for export. This is specially applicable to the Caribbean area, for which a better integration of fishery exploitation and aquaculture adapted to local possibilities and needs would be highly beneficial.

However, many examples (and our own experience of some successes and many failures) show that successful aquaculture activities very rarely develop spontaneously with immediate or short term results, without the support of a carefully planned phase of research preceding industrial development. The establishment of these activities requires the simultaneous satisfaction of many conditions: biological, technical and socioeconomic. Many projects, having overlooked or underestimated these conditions, have resulted in drastic failures or severe disillusionment, often discouraging local authorities and entrepreneurs for many years.

Rearing wild marine animals is a very recent activity, and provides limited opportunities for a rapid and cheap transfer of technology. Aquatic animals are very strictly dependent upon the surrounding environment which regulates all physiological functions. This recently established technology remains complex, and in most cases is still under rapid evolution, and its transfer to new environments (hydrological and human) always require some adjustments.

Short term: when the technology is available and reproductible, when the objectives and organization of the project are clearly established, a transfer of technology from scientist to farmer can be operated **rapidly**. It often represents only a part of the aquaculture process, which by itself, is not always sufficient to ensure a the success of the operation (for example the establishment of a hatchery producing fry of a given species).

Medium term: when the technology does not exist, or requires significant improvements, several years of research are generally required to bring together the knowledge necessary to promote the development. Usually this process requires a minimum of **3 to 5 years** to allow commercial application to take place at a reasonable cost.

Long term: rearing a species which has potential, but for which the process of domestication has not started, faces severe difficulties; major research is necessary, and may provide applicable results only in the long term (**10 years**). Over the same time period, significant improvements can be made to rearing processes when applying modern scientific technology such as genetics.

5.2 EDUCATION AND TRAINING

This proposal for action has been designed by the expert team in order to provide to the Jamaican authorities and potential farmers (decisionmakers, administrators, scientists and technicians) both the background and a discussion of the elements necessary for the development of a marine cage fish rearing industry with the minimum of risks. Broadly two activities are recommended:

- a short term operation, allowing Jamaican observers to visit IFREMER facilities in Martinique and to meet with experienced aquaculture scientists and technicians.
- a medium-term operation allowing IFREMER scientists (or other foreign experts) to participate in the training and education of marine biology and aquaculture students.

5.2.1 UWI, FW, and NSF staff to visit IFREMER facilities. Specific short training courses in finfish aquaculture.

A. ***Objective***: to provide in a short period of time a full course in marine cage culture, allowing an immediate start of trials in the cage rearing of marine fish.

B. ***Program***: (10 days)

- full explanation and hands-on training with all the tools and technologies, permitting the establishment of trials in the rearing of marine fish in cages: cage structure, building and handling, changing nets, feeding fish, collecting, mortalities etc.
- analysis of how the techniques may be adapted to Jamaican conditions by the trainees themselves.
- a discussion of and a search for solutions to technology adaptation problems, if necessary.

C. ***Participants:*** Jamaican scientists and/or technicians in charge of the rearing trials; staff of IFREMER Martinique.

D. ***Products***: Joint preparation of a manual presenting in detail the different stages of the program at a practical level, allowing the rapid commencement of the first tests.

5.2.2 Organization of a specific session on marine aquaculture at UWI or other institutions in 1993 or early 1994, with possible participation of IFREMER scientists

A. ***Objectives***: Insert in the aquaculture and marine biology syllabuses a component devoted to marine aquaculture, allowing them to participate in research and development programs in the area.

B. ***Program***: 3 full days + site visits

A program should be designed by UWI staff (discussed with foreign experts), to identify key areas where foreign experts may participate (2-3 speakers from Martinique and France). It may include:

- lectures, seminars, debates, films, slides.
- present status of finfish aquaculture in the world.
- strategies for development
- present status of specialized research in Europe
- tropical finfish aquaculture
- adaptation to the context of the Caribbean area.

C. ***Co-operators***:

- the staff in charge of teaching this field at UWI (biology, economy, technology)
- Jamaican experts in aquaculture and potential farmers (state, services, banks, managers, operators)
- 2 to 3 French experts from Martinique or other IFREMER laboratories and associated research Institutes.

D. ***Products***: the development of a set of written documents, videos, slides in advance or prepared during the session, and presented to UWI staff for further use.

5.2.3. The possibility of a special workshop in marine fish aquaculture sciences and technology to be organized by FAO. (1994)

A. ***Objectives***: Analysis of the assets and constraints to the development of this industry in the Caribbean, based on the present state of research and world aquaculture production particularly those set in the tropical zone; if possible establishing concrete projects of scientific and technical cooperation between the different countries in the Caribbean, including the French islands of Martinique and Guadeloupe.

B. ***Program***: (one week)

B.1 ***Global Finfish Aquaculture: present status and perspectives***

- *Fishing and aquaculture: complementary or competing activities*
- *Different strategies for development*
- *Structuring field operations: research, technical assistance, development*
- *The legal framework for marine aquaculture*
- *Aquaculture and the environment*
- *Tropical aquaculture: the experience of South east Asia and Oceania.*

B.2 ***Aquaculture in the Caribbean area***

- *state of the art and present situation of development*
- *constraints for development*
- *proposals for coordinated actions between countries.*

C. ***Operators and Participants***:

- Organizer and convenor: FAO
- All Directors of Fisheries interested in aquaculture in the Caribbean, UWI staff
- Experts from the Caribbean area, and additional foreign expertise to be requested by FAO.

D. ***Products***:

- proceedings of the conferences to be published by FAO
- concrete proposals for an international research project in the Caribbean, including trends for international co-operation with European countries.

5.2.3 Caribbean nationals to obtain higher academic degrees and training in marine aquaculture.

A. ***Objectives***: to ensure a high level of education in this field in the area.

B. ***Program***: a long-term programme (5-10 years) providing education and training for aquaculture specialists and educators able to ensure a high level of education in this field; this will provide full capability for assessing, initiating or operating Research and Development projects in the Caribbean at a management level.

C. ***Operators***: Persons in charge of aquaculture education in the Caribbean countries.

D. ***Products***: the multiplication in the Caribbean area of national experts in this sector, allowing a long term regional policy of research and development for a new economic activity.

5.3. TECHNICAL ASSISTANCE

The development of new aquaculture activities will require significant effort to acquire the appropriate knowledge, to apply it to actual operations and to solve the problems which will undoubtedly appear in the transfer and development process. All ways of making existing know-how available to potential Caribbean farmers, as well as problem-solving technical assistance, should be utilized in order to enhance the chances of success. The existence of IFREMER's fully equipped laboratory (15 scientists and technicians) in Martinique, able to provide scientific and technical assistance in fisheries assessment and management as well as aquaculture, should not be overlooked as it may represent significant support for a regional project.

A. ***Objectives***: improvement in the existing experimental facilities at Port Royal.

B. ***Program***: mission to Port Royal of 1-2 IFREMER experts for the design and use of state-of-the-art equipment and plant for applied research in finfish aquaculture, followed by another mission to evaluate and modify the experimental tools.

C. ***Operators:*** local project scientists, 2 experts from IFREMER. Funding to be sought through international or bilateral cooperation.

D. ***Products***: programme modifications, budget estimation, operations schedules, implementation.

5.4. SHORT TO MEDIUM TERM TILAPIA AQUACULTURE EXTENSION

5.4.1 Intensive Freshwater Farming

Traditionally, Tilapia culture is an extensive or semi-extensive mode of production. The main characteristics are low density and limited renewal of freshwater. The management of primary production in the ponds (phyto and zooplankton) provides part of the food and oxygen required by the fish. The amount of energy required is limited, but large flat land surfaces are necessary. The cost of construction and maintenance of ponds, canals, and access is significant. The potential for expansion of the freshwater farmed Tilapia industry using this extensive method appears limited, due to the unavailability of further water resources in the areas where production has been developed (large alluvial plains of the South).

On the other hand, the aerial site survey conducted showed important quantities of running surface water, mainly in the East and North-East part of the island, but in areas where flat land is limited. This raises the possibility of the use of these water resources in more intensive farming techniques, allowing higher density production in farms of smaller surface area, basically with an application of trout-farming technologies.

Such technologies are in the pilot phase in **Martinique,** where a commercial scale intensive farm is in operation. This operation, situated in the Northern part of the island (Morne Capot), uses a concrete raceway structure with gravity fed fresh water at an exchange rate of 100-200% per hour. Due to the limited amount of running surface water on the site (21-24°C), and the extremely high densities used, additional oxygen must be introduced to the system by mechanical aerators (8 x 0,25 hp), allowing an adequate level of oxygen in the ponds to be maintained. All food is provided by the farmer: a 30% protein dry pellet, twice a day (food conversion ratio of 2:1). The fish are reared at densities ranging from 3-75 kg/m^3, and reach market size after a rearing period of 7 months (starting with 2g fry). The pond surface of 90 m^2 provides an annual harvest of 12 tons. The product is very well accepted by consumers, because fish produced that way never have the taste of "mud or soil". Information about production costs is summarized in table 5.

The opportunity of developing this technology in the Eastern part of Jamaica should be viewed with great interest by Jamaican scientists and entrepreneurs.

5.4.2 Brackish Water Pond Culture

The feasibility of red Tilapia farming in brackish water (10-15 ppt) has been demonstrated at several locations, with growth performances comparable to that obtained in freshwater. In **Jamaica**, several farms are located in the immediate vicinity of river estuaries, and some areas where brackish water is available could be used for Tilapia farming. Providing salinities remain at moderate levels, no major difficulties in developing Tilapia pond farming should be observed under such conditions. Limited extra costs might be faced due to the shorter life of some equipment in salt water (pumps, aerators, vehicles), and special attention should be given to the possible infestation by marine pathogens such as Vibrio.

The persons able to explore these two ways of extending Tilapia culture in **Jamaica** -- intensive freshwater culture and brackish water pond rearing -- exist in Jamaica. They have excellent knowledge of the requirements and rearing procedures in pond culture, and probably the financial capability of exploring these new opportunities, requiring only limited research effort with good chances of short term application.

5.5 CAGE FARMING OF TILAPIA IN MARINE WATERS (longer term)

Several attempts to cultivate red Tilapia in pure marine waters have been made on several occasions, either in land-based ponds or floating cages. Some positive results have been obtained, but after facing significant difficulties. More research is needed to identify a suitable animal and a profitable rearing technology. On the other hand, the development of such opportunities should be of major interest to the Caribbean as a whole; the marine aquaculture of tilapia would lead to an increase in fish production (for those countries already having an industry and large amounts of freshwater and land space), and the development of new aquaculture opportunities (for Caribbean countries having marine cage sites, but no freshwater (lesser Antilles).

This has led IFREMER to embark on a comprehensive research program, with major activities being concentrated in **Martinique**, but networking all the expertise existing among French Institutes specializing in fish culture research (INRA, CEMAGREF, CIRAD, ORSTOM). This program, initially called "***GETIDOM***" will focus mainly on the development of strains and rearing technologies for Tilapia farming in full seawater. It will generate new programs in the fields of:

- *genetics*: developing pure strains of red Tilapia, with improved body conformation and fillet yields, and a higher seawater tolerance.
- *stress resistance, physiology of adaptation* in relation to the change of environment, using chiefly the scientific approach developed for salmonids.
- specific *nutritional requirements* in seawater, and specific *pathologies*.

All together, more than 30 highly specialized scientists will be involved in this new program. Additional expertise will be welcome, both from other European Institutes, and also from local experts in the Caribbean area, especially at The University of West Indies at Mona, and the Institute of Marine Affairs in Trinidad. The program will be finalized in 1993, for a practical start-up in 1994.

5.6 ASSESSMENT OF THE POTENTIAL OF LOCAL MARINE SPECIES FOR MARINE CAGE FARMING

Concerning the development of the aquaculture of new marine species, and considering the strong interest of Jamaican authorities in developing activities in that field, we recommend that the following program composed of four phases be undertaken:

1. ***Preliminary investigations***
2. ***Field experimentation***
3. ***Pilot phase***
4. ***Development***

5.6.1 Phase 1: Preliminary Investigations

Objectives:

Acquisition of basic data for estimating the availability (species, characteristics, quantities) of naturally produced fry to be captured for aquaculture operations.

Duration:

This step should be conducted over an 18 month period, in order to obtain continuous data over more than a calendar year, and two successive natural annual broods and spawning periods. This would also reduce the risks of misestimating the aptitude of a given species due to abnormal conditions.

Execution:

After an exhaustive updating of the bibliography covering all aquaculture experiments in the area (biology, rearing trials), three or four candidate species should be selected as possible options for the experimental program. A survey of potential juvenile collection sites should be conducted, after a preliminary evaluation of the sites including discussions with fishermen's cooperatives and individuals.

It is proposed that three sites be carefully chosen from among the possible locations. On each of them a regular (monthly?) fishing research programme, with a standardized procedure using adapted fishing equipment (fixed traps, seine) should be conducted for 18 months (species, number, size, etc.). Such a programme could be developed in collaboration between the Fisheries Division and UWI (research subject for a graduate student?). For the establishment of the details of the protocols, contact should be established with the authors of the program in Annotto Bay, as well as with other structured fisheries research teams in the Caribbean area (including the IFREMER laboratory in Martinique).

The juveniles collected should be released after taxonomy, counting and measuring (using chemical anesthetics such as Phenoxy-ethanol), but in the event the abundance of a species is considered interesting, the juveniles should be collected and trucked to a stocking location such as either Port Royal or Bowden. The different stocks could be grouped in cages and adapted to dry pellet feed, to be used at a later stage for more precise experiment.

Practical aspects:

human: The study could be conducted by a research student, under joint supervision of Dr. Dunbar STEELE (UWI) and the Fisheries Division. Additional help should be provided for each fishing trial (either by the Fisheries Division or UWI).

equipment: availability of a four wheel-drive vehicle with a 200-400 liter fuel tank, the assistance of a boat on each site when necessary (rental?).

fishing equipment, with appropriate data collection equipment: metre rule, battery-operated balance (0.1g), thermometer, salinometer, photographic camera.

fish handling and transportation equipment (insulated transportation tank (200-400 l), buckets, hand nets, oxygen bottle and diffusion apparatus, chemical anesthetics).

Planning: Initiation of Phase 1 at T=0, after finalization of the agreement between different partners, including the allocation of budget:

T0 ***T19***

1 month	**18 months**
site inventory and selection	***experimental fishing, data collection on the three sites selected***

Financial cost (if necessary to acquire new equipment)

- fish capture equipment: US $ 2,000
- monitoring devices: US $ 3,000
- rental fishing boat: (3 days/week x 78 weeks)
- road transportation: (3 days/week x 78 weeks)

5.6.2 Phase 2: FIELD EXPERIMENTATION

Objective:

This phase should permit the evaluation of the rearing potential (reaction to captivity, handling and acceptance of dry pellets) of the juveniles of the three candidate species collected from the wild. It will also provide rough indications about gross nutritional requirements. These experiments should run for 12-18 months, at the UWI experimental facility at Port-Royal. Several steps may be identified:

Execution:

Step 1

1. The improvement of existing research facilities and equipment to match the needs of the experimentation phase. This could be conducted with the assistance of an expert from IFREMER. Possibilities of funding this assistance has been sought through the French embassy in Kingston. (T_0 + 2 months).
2. Improvement and modification of the structures: (+ 3 months).

Step 2

1. Collection of the juveniles, accustom to captivity.
2. Survival and growth assessment, with careful collection of environmental data (temperature, salinity, pH, dissolved oxygen), with tests of two different diets for each species (Tilapia food compared to a "high protein diet" (Sea-bass type) manufactured locally (formulation guidelines provided by IFREMER). The following information will be collected: daily mortality, feed consumption, specific growth rate, food conversion factor.
3. Appropriate sanitary control of the stocks should be maintained by a veterinarian experienced with the fish culture industry.

Staff requirements: The rearing program should be undertaken by the present staff of the Port Royal facility, with the addition of one graduate student.

An ideal solution would be to provide additional expertise in the field of marine fish rearing and pathology through French-Jamaican bilateral co-operation (for instance a veterinary student completing his civil service, after adequate in an appropriate laboratory in the Carribean (possibly IFREMER). Such an eventuality has been discussed with the French embassy.

A Jamaican veterinarian familiar with fish pathology should be contracted (Hi-PRO?).

Equipment: After *Step 1*, 12 tanks (1 m^3) will be necessary (3 species x 2 feeds x 2 (in duplicate), with the appropriate rearing equipment.

Costs:

- Staff	external expertise	international cooperation (*)
	veterinarian expertise	HI-PRO ?
	rearing staff	UWI
rearing equipment		UWI
experimental food		contract with local feed company

(*) possibility of VSN through French embassy ?

Planning

T0 -T0+2 months	expertise
T0+2 - T0+5 months	modification of Port Royal facilities
T0+6 months	start of the experiment
T0+6 - T24/26 months	end of experiment, completion of report

5.6.3 Phase 3: PILOT PHASE

Objectives :

Demonstration of the technical feasibility of marine cage culture in Jamaica with juveniles collected from the wild, at a scale allowing a real economic assessment of the potential and of the market response.

This phase can be initiated before Phase 2 is completed, but will rely partially on the results obtained. It consists of two steps, both of which should ideally be located in the bay of Port Morant, if possible using the existing land base, possibly modified or improved according to recommendations from **Phase 1**, which will also identify the necessary equipment. This will necessarily include:

- a set of experimental cages with anchors and lines, nets and covers.
- a light service boat, with outboard engine.
- a land vehicle able to transport live fry, food and harvested fish.
- the minimum rearing equipment.
- the access to diving equipment and divers to control anchors and nets.

Execution:

Step 1:

Its aim is to assess the possibilities of rearing wild caught fry in small floating net cages (8 to 10m^3), and to define gross rearing standards, to be used during the second step, towards a later exploitation phase.

The experimental cages should be made of the cheapest material available: used plastic 100 l tanks for flotation, bamboo poles, leads made of concrete inserted into used tyres etc., or any other material compatible with the available budget. The structures should be dimensioned to resist sea conditions not exceeding a wave height of 1,5 m. Nylon net cages should be imported to the following specifications:

- number of cages : 6, with 27 nets (3 species x 2 cages x 3 nets/2 cages, 3 mesh)
- dimensions : 2 x 2 x 2,5 meters.
- mesh sizes : 5, 10 and 20 mm

(several addresses of European manufacturers can be provided)

Fry would be made available by the team working on phase 1. About 1,500 juveniles of each species will be necessary for each trial (total of 4,500 fish). Assuming an average size of 500g at the end of the experiment, a final density of 20 kg/m^3, and a survival of 50%, approximately **4,500 kg of dry food will be necessary** (the general characteristics of which will be defined during the initial phase of the programme).

During the trial, the following data should be collected:

- physico-chemical characteristics of water (daily temperature and salinity)
- weight sampling every two weeks, allowing the determination of the daily conversion ratio, and subsequent zootechnical parameters (daily growth rate, daily food consumption, food conversion index.
- daily mortalities.

Harvesting and sales of the first fish (960 kg) should be used to adequately observe the response of buyers and consumers of the product.

Step 2:

The objectives are

1. to confirm the preliminary results of Step 1 and their replicability.

2. to test larger rearing structures (frames and floats, nets, anchors), prototypes of the cages used for further development.
3. to verify the production technology in a pilot scale operation.

This phase would ideally start 6 months after the beginning of phase 1, but will be contributory to its results, and also to the results of the study of **availability of wild fry** for aquaculture. The general characteristics of this phase can be summarized as follows:

- 4 cages of 50 m^3 each.
- 16,000 fry introduced
- food requirement of 8,000 kg.
- expected production: 4 tons
- duration of the cycle: 12 to 18 months.

For this pilot phase, additional resources will be necessary, as follows:

staff:
- one qualified aquaculturist, possibly through international cooperation (VSN French Embassy?)
- permanent or temporary assistance of 2 additional workers on site.

equipment:
- service boat with adequate engine, vehicle
- cages, nets and miscellaneous: estimated at US$4,000 for phase 1 and US$5,000 for Phase 2.
- scientific equipment: scales, laboratory apparatus, etc. (US$5,000)

5.6.4 *Development phase*

Each phase of the proposed procedure must be carefully evaluated at regular intervals, allowing appropriate decisions to be taken for the following steps. In the event of the success of the preliminary and pilot phases, decisions concerning the possible development of commercial production will have to be made at an early stage and the appropriate policy defined. This will necessarily include the **legal framework** for aquaculture, a **development plan** corresponding to the social and economic objectives defined by Jamaican authorities, and possibly the establishment of a **hatchery** able to provide the fry the farms need. For these different steps, scientific and technical assistance should be mobilized through international institutions in order to offer adequate training to Jamaican interests, or additional research support to solve biological bottlenecks which may arise. The results of this programme, if undertaken, will most certainly have an important impact on the evolution of finfish aquaculture activities in the Caribbean area.

Atelier de reprographie
IFREMER - Centre de Brest
B.P. 70 - 29280 PLOUZANE
Tél. : 98. 22. 40. 40.

- OCTOBRE 1993 -