Hydrographic Data as Indicators of Physical Development on the Trinidad West Coast

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Key words: Coastal Area Planning, Hydrography, and Environmental Assessment.

SUMMARY

In Trinidad, physical development is concentrated on the west coast along the Gulf of Paria. The development pattern includes a wide range of use including towns and villages, oil and gas development, manufacturing and commercial ports. In order to satisfy the country's need to document the state of its environment, including the marine environment, all available data were reviewed to ascertain the potential of these data to describe, monitor and predict environment change. Hydrographic data are among the data sets reviewed. These data collected mainly by private sector enterprises are generally concentrated on areas of high physical development. They include bathymetry, ship traffic and coastal circulation. While the collection of these data are not designed for or specific to environmental monitoring, they serve to indicate in spatial terms, areas of marine development activity.

For the 156km-long Trinidad West Coast, the review revealed three (3) areas of special attention. The identification of these '*special attention areas*' allows the State to direct limited resources, such as obtains in Small Island Developing States like the Republic of Trinidad and Tobago, towards surveys that can be managed to include specific data collection and reporting regulations.

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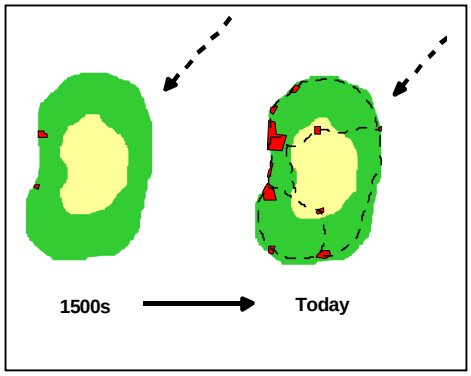
1. INTRODUCTION

European politics and global commerce have over the past 500 years been significant contributors to the present form of Caribbean coastlines. Some researchers in urban planning studies of the region suggest a generalised physical development model in which the growth of settlements is concentrated on the west (leeward) coasts of the region's islands. As development intensifies, the cumulative impact of such a development form is likely to be evident not just in demography and built statistics but in marine coastal measurements (hydrography) along those coasts. Development-associated dredging and reclamation activity, marine resource exploitation, coastal protection works, maritime shipping, marine dumping, increased terrestrial run-off, marine recreation and maritime demarcations can conspire in any number of ways to induce changes to seabed topography, water column structure, circulation, and coastal form.

Figure 1: Model of the development of Carribbean Settlement



The physical results from such activity can be evident not just in the data collected in hydrographic surveys but in the numbers of such surveys performed. Long and short peroid geological, oceanographic and meteorlogical activity can also induce changes hydrographic paramaters thus making reliable association of physical development and hydrographic changes sometimes difficult particularly when the period over which the measurements are made is relatively short. Indeed, it is the determination of this relationship: that between development and the environment, that is at the centre of nearly all environmental studies. That notwithstanding, the ability to collect, analyse and present hydrographic data can offer useful insight into culumative development and environmental state.

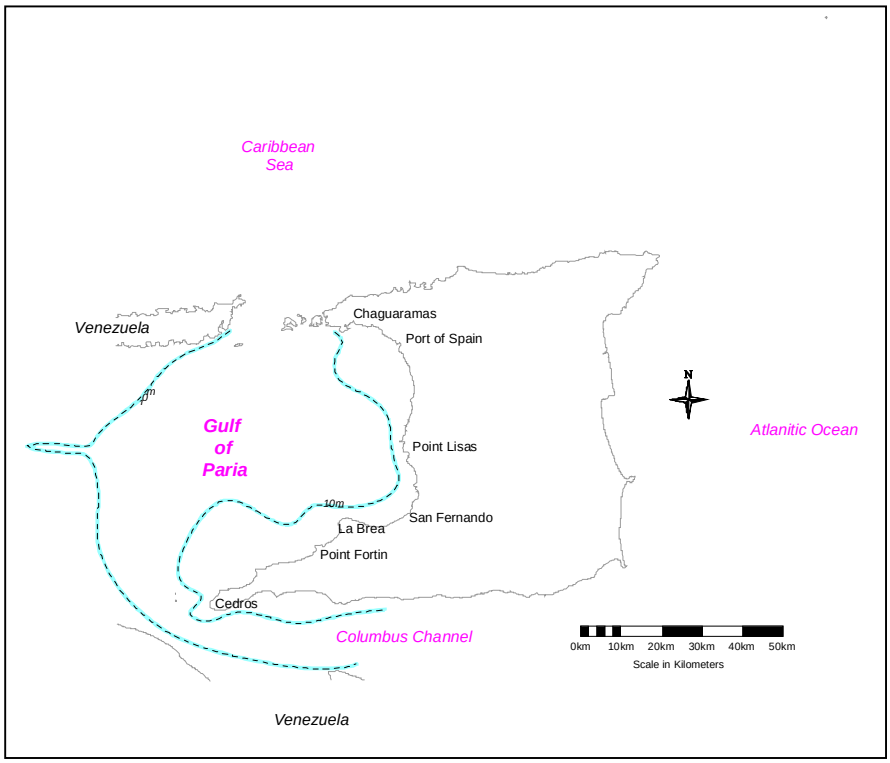
The Gulf of Paria coast of Trinidad in the southern Caribbean is an example of an island whose development subscribes to the settlement model described above. This paper searches

the available hydrographic data for evidence of potential wear on the marine environment as part of a contribution to statements on development. The paper continues a brief review of the physical geography (Section 2) and brief development history (Section 3) of the Gulf of Paria Coast of Trinidad concentrating on those aspects that may have affected the marine spaces. The final section (Section 4) presents the arguments for the use of hydrographic data as one possible indicator of potential environmental change.

2. PHYSICAL GEOGRAPHY

The Trinidad West Coast lies in the Eastern Shore of the Gulf of Paria in the Southern Caribbean. The island of Trinidad, geologically speaking, is part of the South America landmass. The Gulf of Paria separates the Island of Trinidad and The Venezuela mainland. At it widest, it is 120km and at its narrowest, less than 15km. The Gulf is a shallow (37m at its deepest) semi-enclosed sea with a net flow from south to north. During the rainy season (May to November) the flow is increased by high volumes of fresh water from the Orinoco River. This river also transports sediment loads wich are deposited within the Gulf. Current speeds are rarely in excess of 1m s^{-1}. The tides within the Gulf are semi-diurnal in nature with a range of about 1m.

Figure 1: Location Plan showing Trinidad and the Gulf of Paria



In general oceanographic conditions within the gulf are of low intensity, winds are usually less that 25 knots and waves less than 1m. During the passage of storms or hurricane, these

conditions may intensify but the occurance rate is relatively low. Hurricanes, for examples are thought to occur once every twenty-six years.

In general marine conditions within the Gulf of Paria are low energy with marked seasonal variations in hydrographic stucture (temperature and salinity). The coastline is in parts subject to significant erosion and other change, mainly because of the soft sediments along the shore, in particular along southwest peninsula.

The passive and nutrient-rich conditions of the Gulf support an abundant and easily exploited fishery. The beaches while not extensive, support limited local community recreational activity and wider yachting.

3. DEVELOPMENT HISTORY

In 1498, on Christopher Columbus's third voyage to the 'New World,' he made landfall on the south coast of Trinidad and after a brief stop, long enough to claim the island in the name of the Spanish Crown, sailed west and north through the Gulf of Paria to the Caribbean Sea still in search of *El Dorado*. Perhaps the more significant visit came later with the arrival of the English sailor- Sir Walter Raleigh. He reportedly stopped in the southern part of the Gulf of Paria at La Brea to utilise the local natural tar to cork his leaky ships. Not driven by the need to find gold, Sir Francis took time to note the presence of early coastal settlements of indians engaged in fishing and agriculture, something of the coastal form and the development potential of the new colony. The indians were few, perhaps less that a few hundred over the entire 5000 km^2 Trinidad land mass. These natives were soon wiped out, probably the result of subsequent European attempts at colonisation. With development contact and trade with Europe grew, the coastal small village settlements became towns and centres of island Government. Port of Spain, Trinidad's present capital city, was established when the Governor moved his home frorm the ccentre of the island to the north western coast in 1757. Built around a 'Plaza de Armas' square, the town centre was located with 300m of the high water mark with functional wharves and garrisons.

By the 1750 there were only two critical maritime-related matters for any Trinidad Government. The first was a defence of the colony from invading forces, ostensibly the French, the Spanish or the English depending on which European power held Government at the time. This lead to the construction of forts, lookouts, laws and regulations designed to protect the colony against physical invasion. The second was the preservation and encouragement of trade between Europe and the colony. In 1783 the then Spanish Governer convinced the Crown to invite French settlers from neighbouring islands to Trinidad, offering them grants of large tracts of land in the large colony in proportion to the number of slaves that they brought with them. The c*edular* as the proclaiming document came to be called, had the effect encouraging large numbers of settlers and promoting new towns and villages. With this proclamation, development of the colony had in earnest begun and with it came the need for maps as one of a series of measures of control over land, and nautical charts as basis for the needed engineering of the coast to support maritime trade and defence of the colony.

Captain Mallet's Map of 1789, commissioned by Sir Ralph Abercrombie sought to relate coastal form to the agricultural potential of the hinterland behind it. Where possible, Mallet made or compiled (from previous surveys) soundings and descriptions of embayments. He observed and noted sea surface features, recorded anectodotal maritime knowledge and documented coastal settlements and their activities. It is conceivable that the document he produced was at the time the most comphrehensive and perhaps the base map upon which future coastal development was planned and pursued.

The lack of a reliable road transportation network encouraged coastal steamers as the primary transit between the blossoming coastal villages and estates. In turn small wharfs and ports were developed. These facilities were however hampered by the shallow draft conditions, hence lighters were used to carry passengers and goods between the larger coastal packets and the shoreline wharves. By 1900 the need for dredging and reclamation schemes became evident. If trade with Europe was to be made more efficient and profitable, full-scale ports had to be developed and more flat land was required in or near the main coastal towns. In 1920s, the discovery and development of offshore oil reserves in the shallow waters of the Gulf of Paria only served to hasten the introduction of pipelines, modernised shipping and other engineering technology. Ultimately, disputes between England and Spain over the ownership of marine spaces led to agreements (or disagreements) and demarcations within the Gulf of Paria. Other global events such as World War I and World War II (since Trinidad was British Colony until 1962) also contributed to development of the area with the leasing on lands on the coast to the American armed forces. By the time that national independence was achieved in 1962, The Trinidad West Coast was a pivot point of people, produce and power.

4. HYDROGRAPHIC INDICATORS IN THE GULF OF PARIA

4.1 The Externalities of Coastal Development

The externalities of development on the Trinidad West Coast are obvious and many. Some are potentially positive and often centred on economic gains. Dredging for example can be thought of as an increase in singular ship-borne cargo tonnage: a clearly commercial factor, rather than as increased water depth. Regulatory demarcations while they can be driven by maritime safety issues, have in the Gulf of Paria been the result of economic arguments. The 1990 Trinidad /Venezuela Maritime Boundary for instance was mainly the result of living and non-living resource exploitation concerns by the neighbouring states. The demarcation of limits for ports and navi-ways are related to use benefit concerns. Sometimes it can be the form, rights and privileges and other tenure arrangements over these marine spaces bring that give value to the adjacent coastal land space. It is however the negative externalities of coastal marine activity that are of primary concern in this paper. It is the establishment or dispelling of nexus between present or proposed marine activity and environmental changes that is one of larger concerns associated physical development. Once established, mitigation, cost-benefit analysis and negotiation may proceed to shape development. If the state of such a relationship remains uninvestigated, the effects of development remains unsupervised. Prior to the establishment adequate regulatory institutions such as The Town and Country Planning

Division of the Ministry of Planning (in 1965), The Institute of Marine Affairs (in 1976), the Hydrographic Unit of the Lands and Surveys Division (in 1985) and the Environmental Management Authority (in 1998), this may have been the case.

From time to time, it is therefore useful to examine not just the built form but any other data in order to determine any negative effects of physical development. Table I identifies five (5) potential indicators through the effects of coastal marine activity may be evidenced. These are (i) changes in seabed topography, (ii) coastal circulation, (iii) shoreline change and coastal stability, (iv) the location and extent of sources of marine pollution (v) and social/socio-economic displacement. That is not to say that other indicators do not exist. Determination of the chemical content in water and seabed sediment quality or species abundance and diversity in benthic ecology samples are other indicators often used to assess environmental impact. Our examination here is however restricted to hydrographic type data. It is possible to argue that items iv and v on the list of indicators are not hydrographic data. In the case of item iv, pollution sources, those in the Gulf of Paria are often at offshore or shoreline locations. Further, these data can be represented as geographic locations with volumes and chemical properties represented as attribute data in a Geographic Information System, all part of the common tools of the modern hydrographer. Data on social and socio-economic displacement are significantly different from that typically collected by hydrographers, but is it? In Section 3 we referred to Captain Mallet inclusion in his report of data on population and settlement activity in places that he surveyed. Work for the surveyor, arguable as it may be, it provides a clear link and useful between the hydrography and people while underscoring the need for inter-disclipinary research and surveys.

Table I: Potential negative externalities of coastal marine development activity

Indicator⇒ Activity⇓	Seabed topography	Coastal Circulation	Coastal Change/Coastal Stability	Social/Socio-economic Displacement	Pollution Sources
Dredging	■	■	■		
Reclamation	■	■	■	■	
Offshore disposal	■			■	■
Seabed pipelines	■		■		■
Offshore oil and gas installation	■			■	■
Shipping				■	■
Regulatory demarcations				■	
Coastal protection	■	■	■		
Wharves and jetties	■	■	■	■	■

The following sections (Section 4.1.1 to 4.1.5) review the hydrographer data on each of the indicators listed above. No attempt is made to present the actual survey data but instead to discuss the general patterns that can be inferred from the data.

4.1.1 Seabed topography (bathymetry)

Bathymetric measurements are the most frequent form of hydrographic measurements performed in the Gulf of Paria. Older surveys (some surveyed only through the use of leadlines) were completed by the United Kingdom Hydrographer of the Navy as part of surveying missions before 1963. More recent surveys are driven by need to provide data in support of safe navigation and coastal engineering design. While there area areas that have been surveyed using multi-beam instrumentation, in general the available bathymetric surveys are completed using single beam echo-sounding techniques on a single well-understood horizontal Datum. Because of the intensified use, port and harbour approaches are surveyed at higher levels of detail (scale) and frequency than other area. More recently and as a condition of environmental permitting, some marine sites adjacent to large mainly industrial development area are being surveyed as part of post construction monitoring programmes. Other sites such as offshore disposal sites, deep draught lanes and pipeline corridors are regularly surveyed as checks for safe navigation, compliance with permits or as part of site investigation for seabed resource exploration and exploitation. Unfortunately much of these data are not collected in an single archive or repository, nor are they subject quality assurance programmes or third party checks. The application of observed tides, heave, pitch and roll measurements remain undocumented in some of these surveys. Important here is that these data record the occurance of seabed changes, that is dredging, reclamation and offshore dumping and an interest or concern by the party that commissioned the survey.

As might be expected, the locations of dredging projects are the areas of greatest seabed topography change. Hamid[1] in a comphrehensice report identified dredging projects of the Trinidad West coast that ocurred between 1962 and 2003. In excess of 57 million cubic metres of seabed material were dredged – 46 % of it was the disposed of at sea and the rest used for land reclamation. If accumated this volume could create a 11 metre high, 10 m wide embankment along the entire Trinidad Shoreline. Over the past three years, the rate of dredging is in the order of 2 - 4 million cubic metres per year.

4.1.2 Coastal Circulation

Theory suggests that changes in sea bed topography and the construction of coastal works such as sea walls and jetties are significant contributing factors in the changes in coastal circulation. Unfortunately, the practice of conducting coastal circualtion measurements is not prevalent except when the measurements are required for operational features such a navigation. Of the fifteen dredging projects reviewed for this paper only one project included circulation studies as part of the post-dredging surveys. On six of these projects however, observers suggest that post the dredging operations, coastal circulation may have changed significantly and with negative effect.

[1] Hamid. D,. An analyis of coastal development policy in Trinidad with special reference to dredging. Unpublished MSc project Report.

4.1.3 Shoreline change/coastal stability

The Institute of Marine Affairs has pioneered the measurement of coastal change on many parts of the 156km-long Gulf of Paria shoreline. Their 15-year old programme of measurements is supported by data available from historical aerial photography, topographic mapping and more recently satellite imagery. These data indicate large scale changes in shoreline, particularly along the northwestern and southwestern parts of the coastline.

Between Port of Spain and Chaguaramas, nealy 65% of its coastaline in retained by some form of coastal protection structure. The high percentage in this area is reflective of demand driven land reclamation schemes, the up-market values and intensive use of the northwest peninsula rather than high-energy coastal conditions. On the southwestern part of the coastline the reasons for coastal change – mainly erosion are not clear. Long term trends particularly evident along in the Cedros area may be the result of geological time scale activity unrelated to recent coastal development. That notwithstanding, reports suggest that current port construction activity at Point Fortin may be encouraging increased rates of erosion along some sandy beaches. Conclusions however are not yet possible.

4.1.4 Pollution sources

The Institute of Marine Affairs has recently embarked of the identification of sources (or potential sources) of marine pollution for the Gulf of Paria. It hopes ot identify land and marine sources of pollution, including marine oil spills, contaminant input and other land-based pollution sources. Some data on oil-spills is available through oil spill reports logged with Ministry responsible for oil and gas development. The completeness of even these reports is unknown. In an alarming statistic it has been reported that an oil spill occurs every other day in Trinidad and Tobago. The implications of such a frequency is obvious. Any list or report on sources of marine pollution must be prepared based on evidence, due care and sensitivity. Such a list is likely to identify pollutants and polluters aplenty. Included in such a list is likely to be State agencies, public utility companies, private industry and common citizens – at best, a regulator's nightmare.

A review of reports completed as part of environmental impact assessment studies held at the Library of the Environmental Management Agency show elevated levels of heavy metal, and petroleum hydrocarbon concentrations in many parts of the southern Gulf of Paria in the vicinity of oil and gas installations. In some areas close to Port of Spain elevated levels of heavy metal have been reported presumably from leaching from a soild waste disposal site east of the city.

4.1.5 Social/Socio-economic Displacement

Here social and socio-economic displacement represents loss, often based on traditional use, by persons as a result of some demarcation, restriction or other physical development change. Such changes are in many ways inevitable along the Trinidad West Coast. The inevitability of the change is however less severe than the rate at which the changes occur. Continuous

loss of fishing ground or recreational bathing facilities because of demarcation other development scenarios that erode at people and their ability to enjoy traditional use or to earn.

4.2 Hydrographic Data

Some of the data reviewed are representated in Figure 3. The existing population spread is shown in Fig. 3(a), the locations of dredging, land reclamation and offshore dumping are shown in Fig 3(b), the locations of the main offshore marine structures are shown in Fig 3(c) and marine traffic is shown in Figure 3(d) . The figures confirm the trend of intense development and use along the Trinidad West Coast. In particular they identify three direct impact areas. These areas are summariase in Figure 4. Area 1 is centred of the coastaline and offshore areas near the Capital Port of Sapin, Area 2 is near the centre of the coastal stretch where there are large industrial estates, manufacturing concerns and an oil refinery and Area 3 in the southwest where there are offshore oil and gas installations, an LNG plant and port, oil and gas storage and an marine offshore service industry.

Figure 2*:* Graphic representations of (a) population, (b) dredging, land-reclamation & Offshore disposal sites, (c) offshore Oil and Gas installations and (d) Marine Traffic on the Trinidad West Coast

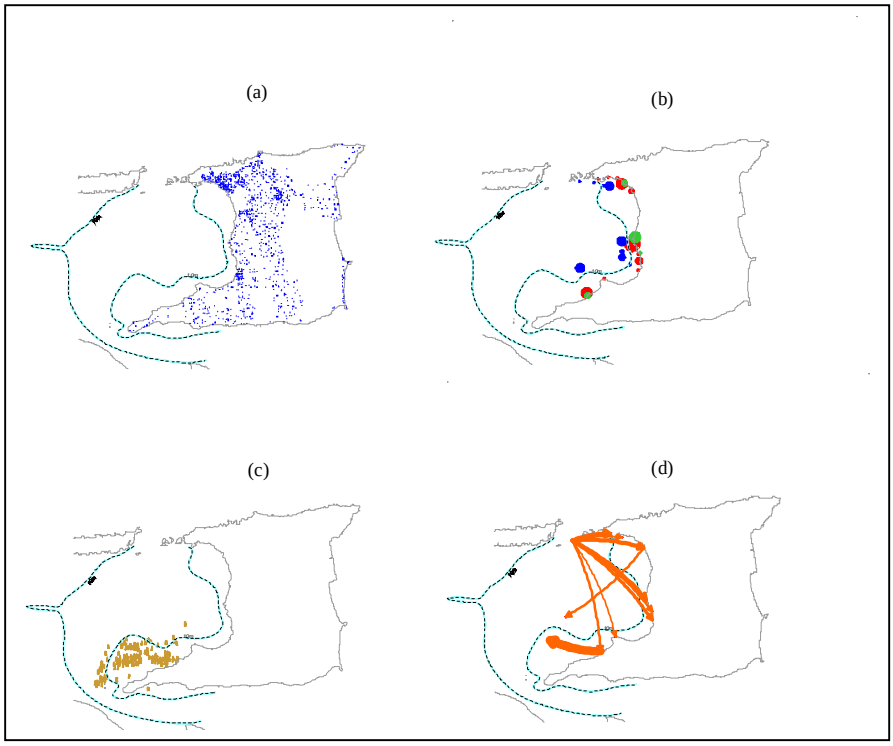
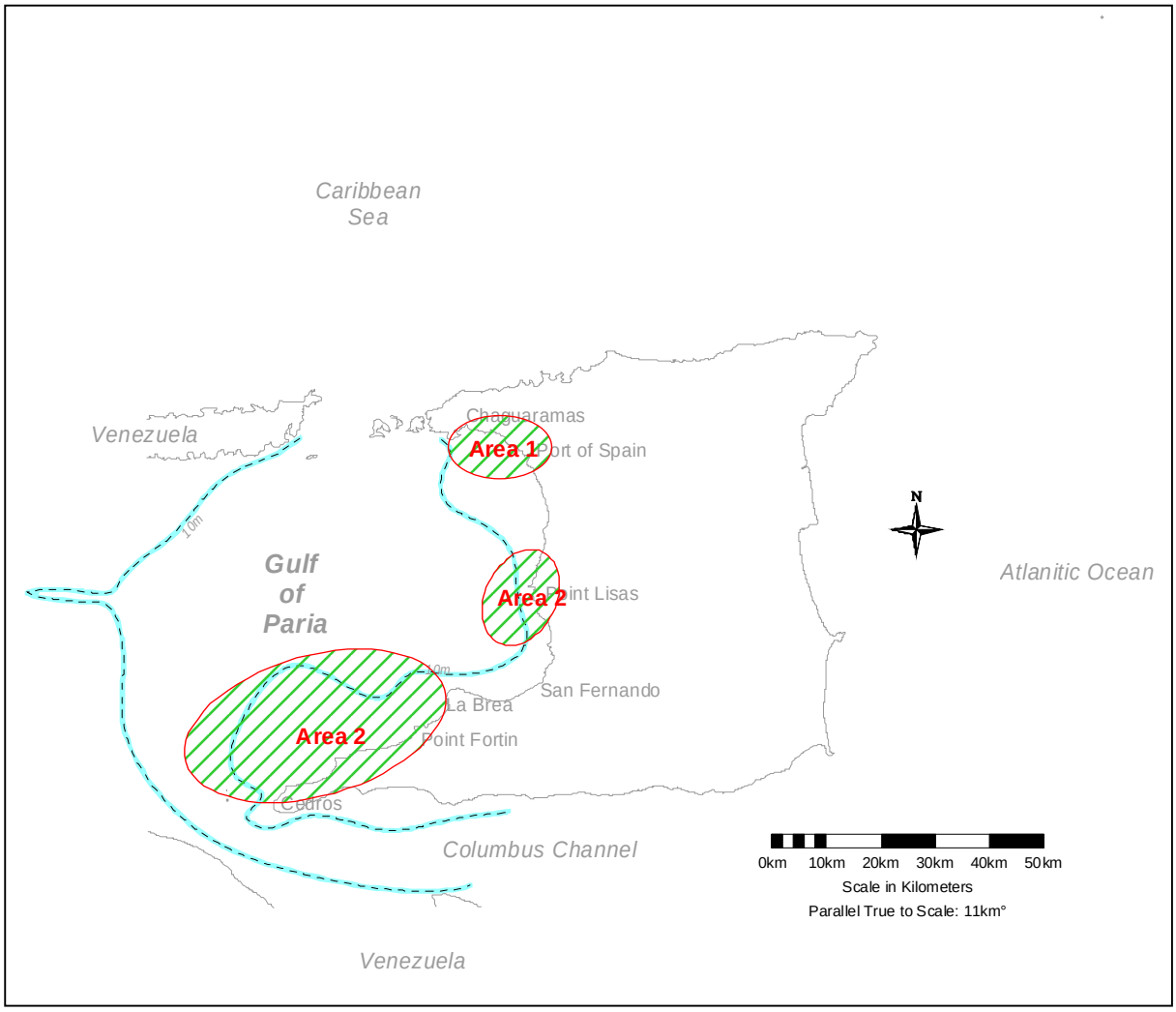


Figure 3: Areas of Special Attention



Not surprising it is within these areas of special attention that the reports of socio-economic displacement emanate. By far the largest group of displaced persons on the Trinidad West coast are fisherfolk who either lose traditional fish landing sites or fishing grounds. Often reports of coastal erosion and shoreline instabilty are associated with these areas. Areas in between and adjacent can be considered are indirect impact areas.

The intent is to use these identified areas as areas of special concern, areas in which the monitoring of hydrographic data (among others) through some formal and managed process may offer a description of envoronmental trends. In a resource constrained Small Island States like Trinidad and Tobago, efforts can be made to direct or redirect efforts at data collection to these areas.

BIOGRAPHICAL NOTES

David Neale is a hydrographer and coastal area planner based in the Republic of Trinidad and Tobago and working throughout the Caribbean. He is a part time lecturer and post graduate student in the Department of Surveying and Land Information at the University of the West Indies.

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