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UNION SEA LAND PROPERTY AND THE RELATIVE 1831 SEA LEVEL AT BARRA DO UNA BEACH

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ABSTRACT. Measurements of relative sea level have been performed at Barra do Una (BU) located on the Southern Brazilian coast near the Island of São Sebastião, in São Paulo State, Brazil, relative to the sea level in 1831, as established by law n. 9760, 1946. The estimate took into account three plausible hypotheses about the change in global relative sea level from 1831 to the present and allowed to establish the "Terrenos de Marinha" on BU. The motivation behind this work, the hypotheses and the methods used are described, along a brief history of the "Terrenos de Marinha". The discussion of the results reveals the need to reactivate the national network of sea level gauges, bearing in mind the clear evidence of relative sea level increase nowadays, on the Brazilian coast and the consequent need of defining legal standards for its use according to the law.

Keywords: sea land property, Barra do Una, Southern Brazilian coast, relative sea level, global warming.

RESUMO. Foi feita a medição do nível relativo do mar (Barra do Una, BU) situada na região Sudeste do Brasil, próximo à Ilha de São Sebastião no Estado de São Paulo, referido ao nível médio relativo do mar do ano de 1831, conforme estabelece a lei n. 9.760 de 1946. A estimativa se fez através de hipóteses plausíveis sobre a variação do nível global do mar desde 1831 até o presente e permitiu estabelecer a materialização do "Terreno de Marinha" em BU, ao longo dos termos da lei. A motivação deste trabalho, as hipóteses e os métodos utilizados são descritos juntamente com um breve histórico sobre os "Terrenos de Marinha". A discussão dos resultados revela a necessidade de ser reativada a rede nacional de medidores de Nível do Mar, tendo em vista as claras evidências de aumento, nos dias atuais, do nível relativo do mar nas Costas Brasileiras e a consequente necessidade de definição de normas legais adequadas para a sua utilização.

Palavras-chave: terrenos de marinha, Barra do Una, costa brasileira sudeste, nível relativo do mar, aquecimento global.

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INTRODUCTION

The reason behind this study resulted from several inquiries made by several land owners at Barra do Una (BU), in São Paulo State, who were reportedly having difficulties to regularize their properties since they have no standard procedures for determining on the land the relative mean sea level of the High Tides in the year 1831, as established by law n. 9760, 1946. Their main question was whether it is possible to comply with the law "verbatim", once the mean relative sea level at BU in 1831 is known (Fig. 1).

The raised question has no easy answer nowadays because, although the records obtained in 1831 for the purpose of defining the mean relative sea level for the entire Brazilian coast are well kept in the Museu da Diretoria de Hidrografia e Navegação da Marinha do Brasil, in Niterói, Rio de Janeiro State, no information is available about the reference level (RL), fixed to the ground, in relation to which the relative sea level data were referred to in 1831. For this reason the relative sea level mentioned in the 1946 law cannot be materialized and it is not possible to apply "ipsis litteris" the law.

Aiming to contribute to the solution of the problem, the following study describes the origin of the term "sea land property", Barra do Una beach and measurement program conducted at the beach. The leveling and positioning equipment, sea level gauge used at BU, as well as the method used to obtain the relative sea level of the average high tide in 1831 are also described.

The results indicate that the used methods worked well to solve the problem, leading to a discussion where the current Global Changes, as well as the need to reactivate the national network of sea level gauges and related services for solving legal problems like the one aforementioned, are put in perspective.

MATERIAL AND METHODS

Sea land property

Union sea land property started to be defined in the XVIII century in Brazil. The first record mentioning the concern of the authorities with the buildings being constructed on these areas dates back to October 21, 1710, when the Royal Order of Portugal asked the governor of Rio de Janeiro State to inform about the buildings being built on sea land property or on the beaches of the city (SPU, 1999).

The first sea level measurements in the Lands of Santa Cruz were performed at Guanabara Bay, near the bar, by Sanches Dorta, from 1781 to 1782.

During the period after the Portuguese court moved to Brazil in 1808, a Decree from January 1809 ordered "the sea lands of the Gamboa and Saco do Alferes suitable for warehouses and wharfs, to be rented/aforada" (decree that the land belonged to the Union). A notice from November 18, 1818 stated that "15 fathoms of the sea water line and its coast are reserved for public use and that everything that touches and grows in the seawater belongs to the nation".

A decree from September 13, 1820 enabled the Navy to grant any portion of the beach, at all ports.

After 1822, during the first Empire, a law from October 15, 1831 budgeted a revenue and a fixed expenditure for the 1832-1833 financial year and a budget law that expressly addressed the Union sea land placed these lands at the disposal of the Municipal Councils and allowed the presidents of the provinces to appraise and establish the value of the Union sea lands. Sea land property was defined by Instruction number 348.

The first records of systematic measurements of Sea Level date back to 1831, and aimed at defining on the ground, the mean relative sea level in the port city of Rio de Janeiro. There are no records that these measurements were performed longer than one year.

In 1889, the Republic of the United States of Brazil was proclaimed and new horizons opened in the political scenario of the former Island of Vera Cruz. However, there was nothing that indicated great changes in contributions. In 1905, the first attempt to organize a systemized observation service of the sea level was made. This service was the responsibility of the Secção de Hidrografia da Inspetoria Federal de Portos Rios e Canais, which maintained permanent measurement stations in all major ports of Brazil, from Chuí to Oiapoque.

Some progress was achieved in the construction and operation of a network of permanent measurement stations of the Relative Sea Level along the 8,000 km of the Brazilian coast in the Southern New Republic. Stations were set up in Rio de Janeiro, in 1905; Fortaleza, in 1910; port of Santos, in 1920; Pelotas, in 1930; Laguna, in 1906; São Francisco do Sul, in 1923; Florianópolis, in 1923; Itajaí, in 1922; Paranaguá, in 1928; Vitória, in 1917; in Salvador from 1918; Aracaju, in 1935; Recife, in 1935; Natal, in 1939 and Belém, in 1935. In these places, the records were rated for the highest and the lowest air temperatures and atmospheric pressure, at Portobras, the company responsible for the deployment and operation of permanent stations for observation of Sea Level in the ports.

In the 50s, the Universidade de São Paulo (1934) installed and still operates through the Instituto Oceanografico, permanent measurement stations of the relative sea level in the coastal cities of Cananeia and Ubatuba, São Paulo State.

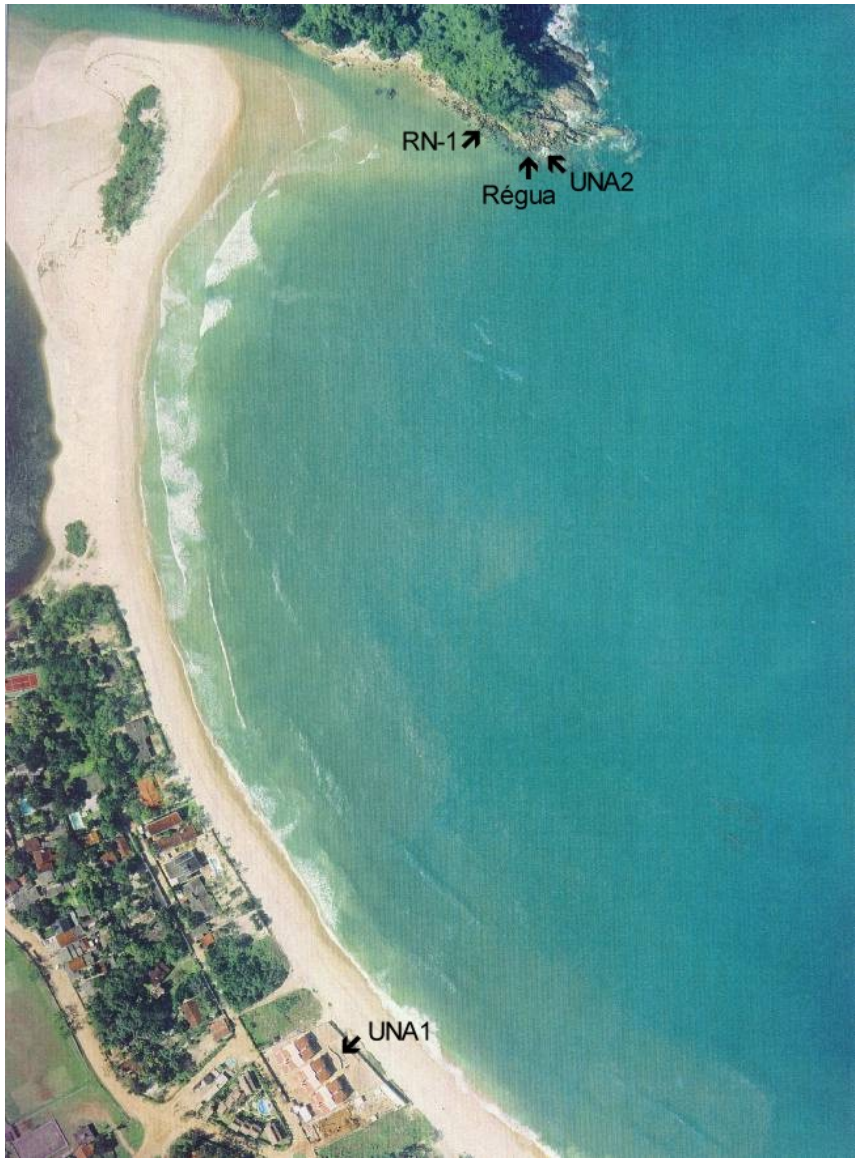

Figure 1 – Aerial photograph of Rio Una beach showing where the landmarks for georeferencing and positioning were set up (UNA1- UNA2- RN1 and metal ruler).

Law n. 9769 from 1946, in Section II, Article 2 regulates the legal matter of defining the "Union Sea Land Property" and establishes that it should be measured against the mean high tide of 1831. Records of relative sea level on which this law was based are in the Museu da Diretoria de Hidrografia e Navegação da Marinha do Brasil, Niterói, Rio de Janeiro State; "however, there is no information about the reference levels (RLs), for which the records were reported" (Santos[1], 1999).

Thus, it is not possible to materialize the mean relative sea level in 1831 in order to enforce the law. For this reason, a portion of this work is devoted to defining plausible hypotheses that would allow the materialization of mean relative sea level in 1831 at Barra do Una beach.

Barra do Una – BU

Barra do Una (BU) beach is located on the northern coast of São Paulo State and part of it is shown in Figure 1, where the Una river meets the sea.

[1]Eng. José Antônio dos Santos (1999). Instituto Nacional de Pesquisas Hidroviárias, Rua do Caju, Rio de Janeiro, RJ (personal communication).

Figure 2 – Equipment N3 Wild with Mira Invar used to level Barra do Una. The survey was done with UNA1 and UNA2 stations georeferenced as base for measurement departure and arrival. The equipment used is a ZEIS Elta R50, precision 5" for angular and 5 mm $\pm$ 3 ppm distance measurements. Linear precision reached was 1:18000.

Leveling and surveying

Leveling was done using precision level N3 Wild with Mira Invar (Fig. 2) according to existing specifications for high precision leveling, meeting the recommendations of the Instituto Brasileiro de Geografia e Estatística (IBGE), based on norm 13133 from the Associação Brasileira de Normas Técnicas (ABNT).

Georeferencing

The georeferencing of the land was performed using a GPS positioning system (Fig. 3). The equipment used was a TRIMBLE, model 4000 SSI with frequencies L1, L2 and codes C/A and P. The data were processed using the GPSURVEY software that allows processing of multiple stations by the static method. We used ephemeris transmitted, based on the stations of the Rede Brasileira de Monitoramento Contínuo (RBMC) UEPP and PARA located in Presidente Prudente (São Paulo State) and Curitiba (Paraná State), respectively. The stations were materialized by concrete milestones and brass plates set up on the beach (UNA1) and on the rocks (UNA2), as shown in Figure 1.

Sea level measurements

The equipment used for permanent measurement of sea level was the AOTT sea level gauge made in Germany (Fig. 4) that belongs to "Clarimundo de Jesus" research center of Instituto Oceanográfico of the Universidade de São Paulo (IOUSP) in Ubatuba Base (UBA), whose database spans about 40 years of nearly continuous measurements. The equipment and its georeferencing at the time are described in the publication Tides and Tide Gauges of Cananeia and Ubatuba, by Mesquita & Harari (1983).

The Ubatuba relative sea level data collected at Clarimundo de Jesus (UBA) research center was used to determine current long term (LT) mean sea level in BU, as well as deviations from current mean long term (LT) high tide in UBA, which are representative of the corresponding deviations to BU with very good approximation.

Following these observations, a graduated metal ruler (cm) was tightly concreted into the rocks near to Una River (Fig. 1) as shown in Figure 5.

The Reference Level (RL) was established close to the graduated ruler. The measurements performed using the ruler have an estimated uncertainty of 5 cm. The estimated uncertainty while transferring the ruler quota to the RLs is 0.8 cm.

Figure 1 shows UNA1, another reference level additionally installed at Una beach and also the terrain configuration on which the study is based on.

Additionally, measurements of the hypotenuse, the distance connecting the current fence position shown in Figure 9 to the high tides that occurred during March/April 2001 at Una beach, were performed using a measurement tape during one month in March/April.

Figure 3 – Equipment GPS (Global Positioning System) used for georeferencing at Barra do Una.

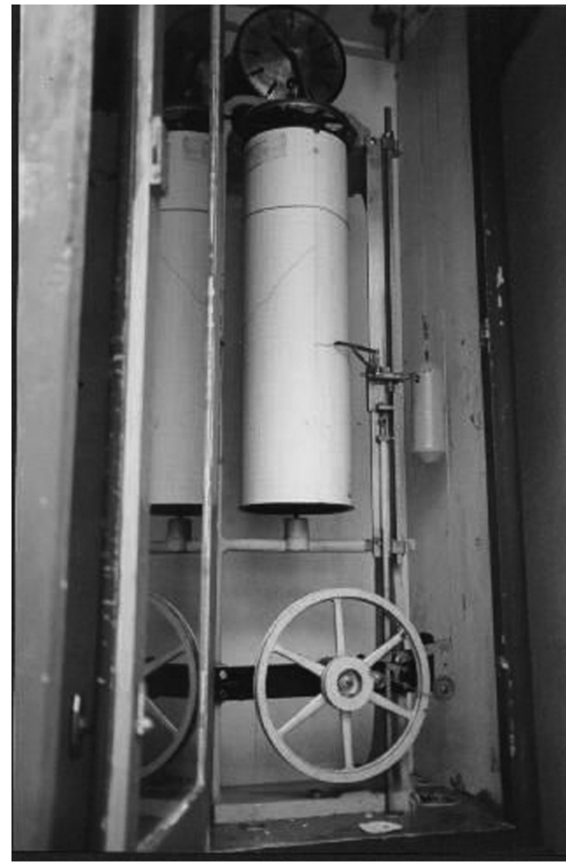

Figure 4 – Sea level gauge AOTT from Clarimundo de Jesus Research center of IOUSP.

Figure 5 – Positioning of the metal ruler used to measure sea level on the rocks at Barra do Una indicated in Figure 1.

RESULTS

Long term (LT) Relative Sea Level at Barra do Una – BU in 1831

The first studied hypothesis assumes that the long term (LT) relative sea level in 1831 at Barra do Una (BU), changed at the same rate of the relative sea level in Brest, France, whose configuration between 1822 and 2001 is shown in Figure 6. Other two reasonable hypotheses were also investigated, relative sea level changes according to the IPCC (Intergovernmental Panel for Climate Changes) and the relative sea level in Cananeia.

Figure 6 shows that long-term (LT) Sea Level Difference in Brest between 1831 and 2001 was about = XXXXXXX = 0.16 m.

The basic plausible assumption that must be accepted is that sea level increased at the same rate in Barra do Una (BU) between 1831 and 2001, that is, the variation rate in Barra do Una (BU) was equal to Brest = 0.94 mm/year.

As we do not know where the mean relative sea level is in BU, the on-site measurements for this purpose were conducted during 5 cycles of the semidiurnal tides; syzygy tide on days 6, 7 and 8/04/01, and neap tide on 17, 18, 19/06/01, at approximate 15-minute intervals. Mean sea level measurements determined by visual reading on the metal ruler only on the 3 days of syzygy tide is shown in Figure 7.

The mean value during syzygy at BU = YYYYYYYYY = 0.97 m $\pm$ 0.01 m, corresponds to the mean during the same period calculated from the data obtained simultaneously at Ubatuba Base (UBA).

The mean during the same period at UBA = ZZZZZZZZZ = 1.40 m $\pm$ 0.01 m, obtained simultaneously from the permanent sea level gauge AOTT records at Clarimundo de Jesus research center in UBA.

Although the two figures have different values, they represent the level of the same sea that washes onto BU and UBA. This is another reasonable assumption given the geographical proximity of these two sites on the Southeast coast, as shown in Figure 7.

Since both measurements are referred to the terrain due to the proximity between BU and UBA and the characteristics of hourly, diurnal and seasonal variations in the Southeast (Franco & Mesquita, 1986), the level measured at each location has the same characteristics throughout the region and corresponds at each moment to the same geoid surface and consequently to the same sea level, (Fig. 8).

Mean high tide at Barra do Una in 1831

Taking into consideration the above hypothesis, the levels measured every 15 minutes correspond to its Mean in the period, that is, the deviations of BU and the ones obtained simultaneously at UBA, referred to its mean, were used to estimate their absolute values (AV) during the measurement period as follows:

Average Absolute Deviation for the period April 6, 7 and 8 at BU = 0.34 m and UBA = 0.32 m, results in the ratio:

$$\frac{\text{Average absolute deviation BU}}{\text{Average absolute deviation UBA}} = \text{XZYYZX} = 1.06 \text{ m} \pm 0.01 \text{ m}$$

The XZYYZX ratio was then used to estimate long term (LT) mean high tide at BU from the already known values for UBA. The Long Term mean high tide for UBA is given by the sea level records from 1995 to 2000 and the deviation from the long term (LT) mean at UBA is:

Mean deviation of (LT) high tides in 2001 UBA = ACACAC = 0.332 m $\pm$ 0.007 m, obtained by multiplying ACACAC by XZYYZX, the deviation in BU. Therefore, average deviation of (LT) high tides 2001 in BU = XZYYZX (1.06 m $\pm$ 0.01 m) $\times$ ACACAC (0.332m $\pm$ 0.007 m) = AZAZQZQ = 0.352 m $\pm$ 0.007 m.

LT mean level at BU in 2001

Long term (LT) mean sea level at BU in 2001 is given by the difference between mean level at UBA in the period April 6, 7, 8 and LT mean sea level at UBA in 2001, between 1995 and 2000. This mean was calculated from the tide gauge station records at UBA and is given by: LT mean at UBA in 2001 = 1.43 m $\pm$ 0.02 m.

Therefore, mean level difference during the measurement period in UBA = mean sea level in the period at UBA (1.40 m) – LT mean 2001 at UBA (1.43) = – 0.03 m. This difference should be algebraically added to the BU average in the period (0.97 m), in order to obtain LT average level at BU, under the reasonable assumption that the sea level is the same in both places. It follows: LT mean sea level in 2001 at BU = means in the measurement period in BU (0.97 m) – difference SL in the period in UBA (–0.03 m) = 1.00 m $\pm$ 0.02 m. Therefore: LT.SL.2001.BU = 1.00 $\pm$ 0.02 m. From this value, it is obtained the LT mean high tide level in 2001 and 1831, as well as the LT relative mean sea level at Barra do Una (BU) in 1831.

Mean high tide at BU in 2001

The value obtained above (1.00 m $\pm$ 0.02 m), determined through the RLs set on the rocks at BU, represents mean sea level in 2001, to which the LT mean high tide deviation (AZAZQZQ) should be added to obtain the LT high tide level in 2001 at BU as follows:

LT.HT.L.2001.BU = LT mean level 2001 in BU (1.00) + AZAZQZQ (0.35) = 1.35 m $\pm$ 0.02 m. The value 1.35 m $\pm$ 0.02 m defines the htl (average high tide line in 2001) along the beach,

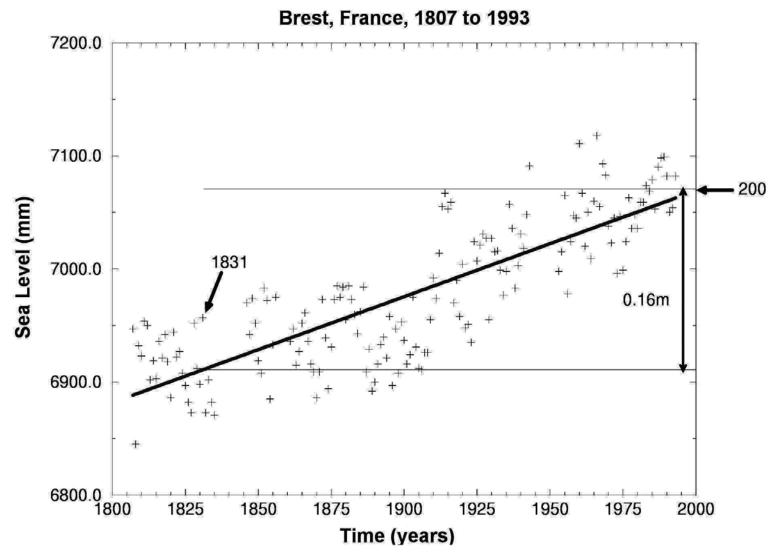

Figure 6 – Data series of annual sea level measurements in Brest (France), located in the English Channel, from 1807 to 2000. Note that in the period between 1831 and 2000, sea level increased 0.16 m PSMSL (Permanent Service for the Mean Sea Level). IAPSO (International Association for the Physical Sciences of the Oceans).

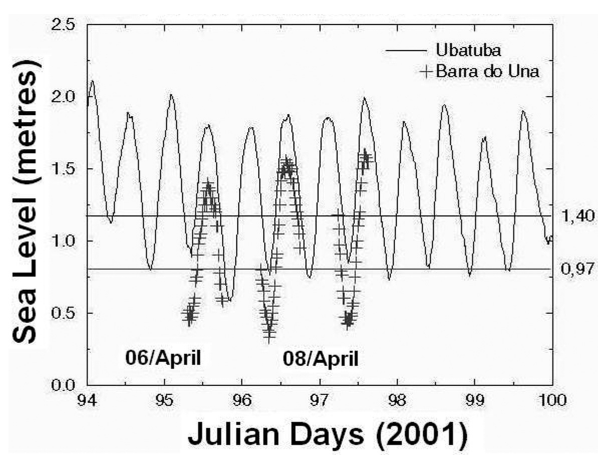

Figure 7 – Simultaneous measurements of sea level realized from April, 6 to 8, 2001, in Barra do Una (BU) and at the research center of the IOUSP (UBA).

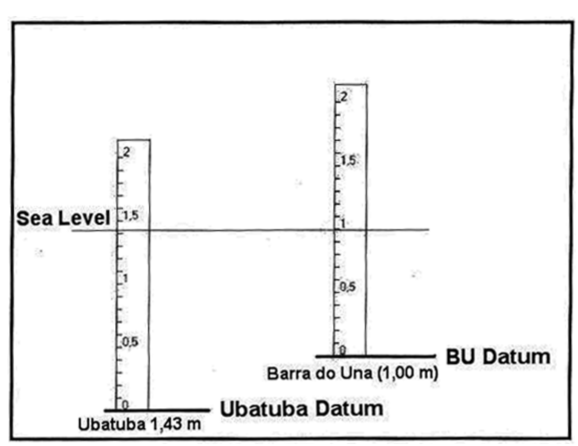

Figure 8 – Sea level indication, basic hypothesis for the transfer of the sea level recorded in BU and UBA.

from which 33 m should be measured inland in order to define the geographic position of the Union sea land property in Barra do Una (BU).

LT mean high tide at BU in 1831 – Brest Hypothesis

Assuming that the sea levels in Brest, France, are representative of global sea level variations in the period from 1831 to 2001, then according to law n. 9769, 1946, the value XXXXX = 0.16 m should be subtracted from the LT high tide of 2001 in order to estimate the corresponding mean high tide at BU in 1831.

The Long Term Mean High Tide at BU in 1831

$$\text{(LT.M.HT.BU1831)} = \text{LT.M.HT.BU2001 (1.35 m)} - \text{XXXXXX (0.16 m)} = 1.19\text{ m.}$$

This value (1.19 m) was referred to the RLs set on the rocks in BU, as shown in Figure 9. By accepting this value, we also accept the plausible hypothesis that the proportionality ratio XZYYZX = (1.06 m ± 0.007 m) remained constant during the 1831-2001 period.

Mean high tide at BU in 1831 – IPCC hypothesis

Assuming the hypothesis that the relative sea level varied between 1831 and 2001 according to the rate established by the IPCC, XXXXX = 0.31 m, the following value is obtained: LT.M.HT.BU2001 (1.35 m) – XXXXXX (0.31 m) = 1.04 m. This value (1.04 m) was referred to the reference ground through the RLs fixed in BU, as indicated in Figure 1.

LT mean high tide at BU in 1831 – Cananeia hypothesis

Assuming the hypothesis that relative sea level changed according to the variation rate of 0.004 m per year determined for Cananeia port by Mesquita et al. (1996), between 1831 and 2001, we obtain XXXXX = (0.69 m), thus: LT.M.HT.BU2001 (1.35 m) – XXXXXX (0.69 m) = 0.66 m. This value (0.66 m) was referred to the ground through the RLs in BU, as shown in Figure 1.

The LT relative mean sea level at BU in 1831 can, then, be obtained from R.M.SL.BU2001 (1.00 m ± 0.02 m), by subtracting the RSL variation values in the period from 1831 to 2001, thus yielding according to the hypotheses: Brest (0.16 m), IPCC (0.31 m) and Cananeia (0.69 m) and the following LT.M.SL.BU1831 for Brest = 0.84 m; IPCC = 0.69 m; and, Cananeia = 0.31 m, all results with 0.02 uncertainty relative to the metal ruler of Figure 6.

Establishing the Union Sea Land property in BU

The outline and geographic position of the area shown in Figure 9 was determined by global positioning system (GPS) with respect to the high tide line, in order to establish the Union Sea Land property in Barra do Una (BU).

The correspondence of the ruler levels for the area in Figure 1 was made by leveling the ruler RL (Fig. 5) with UNA2 established in the indicated area. This reference level (RL) became the basis on which the three hypotheses were used to determine the LT.M.HTL (Long-Term Mean High Tide level/line) in the period from 1831 to 2001. The three LT.M.HTL.BU in 1831 were according to the hypotheses: Brest (1.19 m), IPCC (1.40 m) and Cananeia (0.66 m).

Therefore, the LT.MRSL.BU1831 was determined according to the hypotheses as follows: (0.84 m ± 0.02 m) Brest; (0.69 m ± 0.02 m) IPCC and (0.31 m ± 0.02 m) Cananeia, in relation to the ruler zero (Fig. 8). Figure 9 and 9A show the high tide lines in 2001 (indicated by 2000 in the figures) either with or without the action of the waves, as well as the high tide lines in 1831 according to the three hypotheses, Brest, IPCC and Cananeia, respectively. It is also noted the position of the wire fence and the width in meters (19.58 m) of lot M8, where high tide lines due to the waves were measured using a measuring tape during March/April. It is also observed that from the width of lot M8, in scale, the distance from the fence to the high tide line in 2001 with the waves, is about 50 meters. Therefore, the lots do no overlap Union sea land property, since the distance required by law n. 9760, 1946, is only 33 meters above the mean high tide line of 1831. As shown in Figure 9A, all estimates based on all three hypotheses, Brest, IPCC and Cananeia, yield distances higher than 50 meters between the mean high tide line of 1831 and the lot M8 in Barra do Una (BU).

DISCUSSION

The first concern of the Portuguese Crown with the constructions built on the beaches dates back to the eighteenth century, in colonial Brazil and is related in some way to the current regulations about the use of sea land property. Government fees known as "Laudemio" were thus established in 1846, followed by the designation of Sea Land property in 1868 that gave the population free access to the coastal areas, all during the Second Empire, which lasts until the present day in Brazil Republic (SPU, 1999).

Sea Land property was defined during the Republic in 1932, by Instruction 348 and Decree Law n. 9760, 1946, that formally established the mean high tide level and, therefore, also the

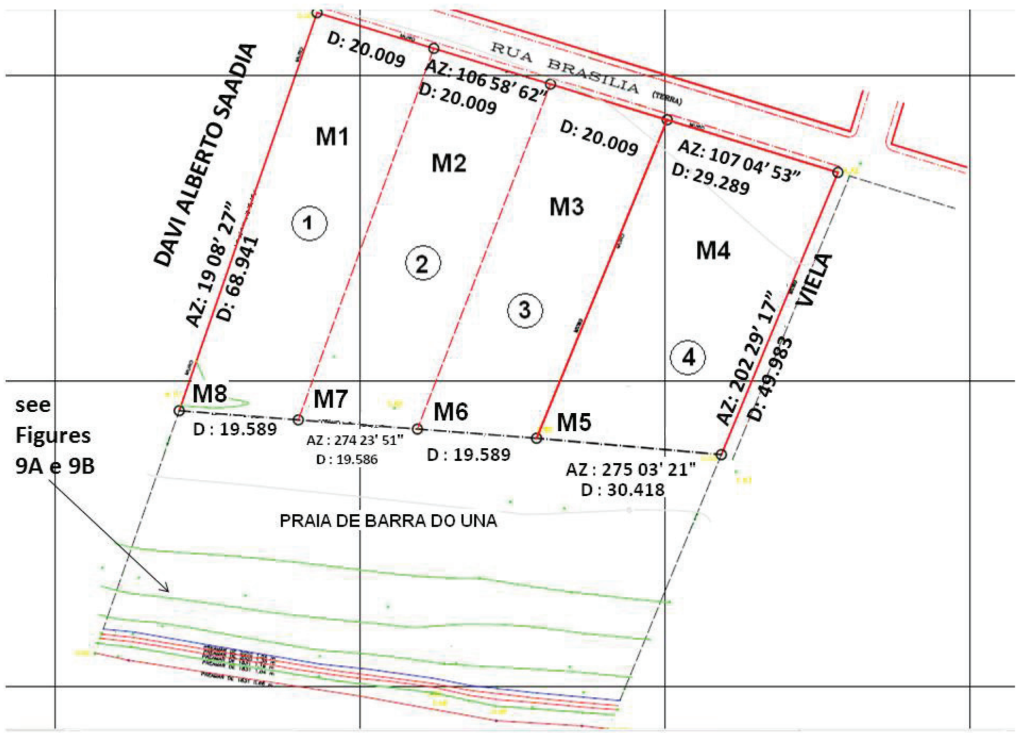

Figure 9 – Plan indicating the positions, in order, of the mean high tide line at BU, with wave action, 1) from April/March, 2001, measured with measuring tape from the fence, to the left side of the figure, 1.54 m, 2) LT.M.HTL at BU (2001), 1.35 m and LT.M at Bu in 1831, according to the three hypothesis: 3) Brest, 1.19 m, 4) IPCC, 1.04 m and 5) Cananeia, 0.66 m.

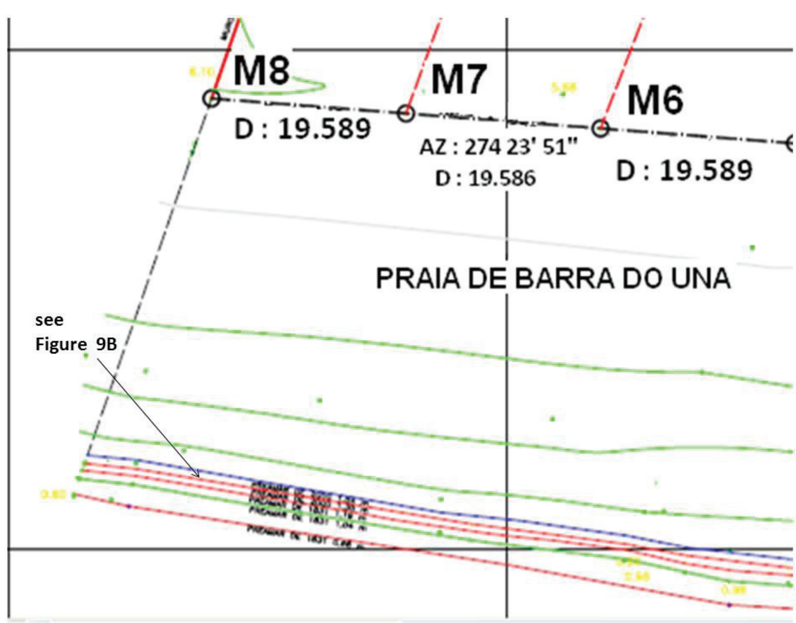

Figure 9A – Figure 9A has been increased from Figure 9 so as to reach lot M8, which reads lot width 19.589 m. Hence, the scale of the figure can be estimated by the reader to check that the distance from the lot fence to the high tide line is about 51 m and the slope of about 6 degrees indicates that the horizontal distance is approximately 50 m; far beyond the limit of 33 m required by law 9760, 1946. Note in Figure 9 that lot M8 is the closest to the high tide lines.

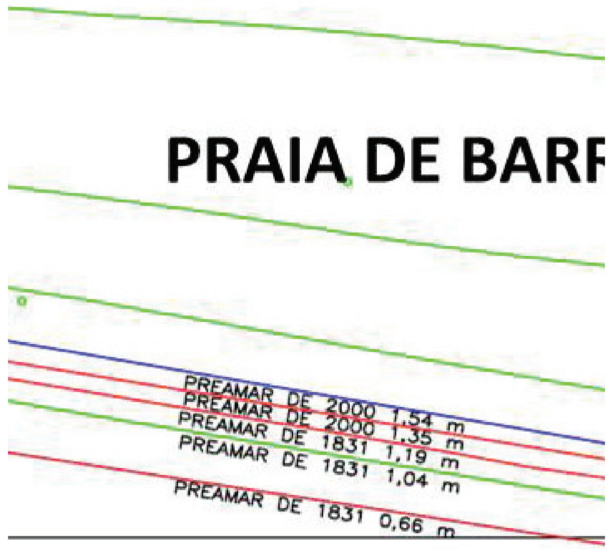

Figure 9B – Barra do Una beach – Atlantic Ocean.

relative mean sea level in 1831 as the reference to determine the Sea Land property that belongs to the Union.

From 1820 to 1840, the Long Term (LT) relative sea level (the level measured over the period regression line, as seen in Fig. 6) remained relatively constant and the relative mean sea level of 1831, established as reference, fulfilled satisfactorily its function as geodesic mark for the implementation of Decree Law 9760. In fact, there was a small increase of sea volume and air temperature that led to a slight increase of sea level, which began in the last 15,000 years IGBP (1996), as summarized by Mesquita (1998), which for being small, did not lead to any concern.

In 1822, the basic tool to analyze the tide phenomenon had been developed by Fourier and understood by Isaac Newton in 1670. The industrial revolution began thereafter and lasted into the twentieth century, with increasing production of greenhouse gases. The increasing air temperature warmed up the poles, producing polar ice melt and consequent increase of relative sea level, followed by cooling of the crust beneath the polar ice caps, Peltier (2000).

In the opposite direction to the cooling (consequent decrease of ice load on Earth crust), it is felt the effect of the changing obliquity of the Earth angular momentum vector, Chao (1999), causing the Tropics of Cancer and Capricorn to approach the Equator, producing new glaciation and therefore, increasing the polar ice load on the crust, while limiting the incidence of perpendicular sunrays on Earth to a smaller band around the Equator, during the seasonal cycle. This effect lasts about 41 K years, the Milankovitch period (IGBP, 1996).

In opposite directions move also the two indices for measuring sea level, namely, the relative sea level in the tropical zone and global relative sea level that includes both zones, the tropics, where it increases and the polar caps, where it decreases due to the cooling of the crust (Mesquita, 1994).

Only measurements of Absolute Sea Level in the tropics and in the poles can establish exactly how relative sea level adjusts itself on every continent throughout the different latitudes. At the IO research center in Cananeia and Ubatuba, these measurements are being conducted by GPS (Global Positioning System) (vertical direction), as well as relative and absolute gravity meter, Franco (2000).

Notwithstanding the uncertainties related to the indices, which are currently being investigated through more accurate measurements, it is quite likely that the relative sea level, not only in Cananeia, but along the Brazilian coast is increasing at the rate of 0.41 cm/year, or 40 cm/century, Mesquita et al. (1996). These data alone are sufficient to point out the need to establish fair and appropriate procedures to enable the application of Law 9760, 1946, by defining Union land own limits that take into account these variations in sea level.

The legislature of 1946 based on the mean sea level of 1831, as geodesic mark to define and determine Union Sea Land property, did not take into account the body of knowledge that has been built from 1822 to 1946, until the present day, 2001, about the glaciation phenomenon and global warming, among others, thus changing the boundaries of Union property that were previously considered unchangeable.

The procedures used in this study acknowledge such boundary mobility and, by varying the relative sea level according to the hypotheses Brest, IPCC and Cananeia, take into account the most important influences on the determination of reference sea level at Barra do Una (BU) in 1831 (plus or minus) during the 1831-2001 period.

To make all this possible, it was necessary to set up a permanent station to measure Long-Term (LT) relative sea level, relatively close, as the Clarimundo de Jesus Research center in Ubatuba, whose measurement records allowed to estimate the high tide and LT relative mean sea level at Barra do Una (BU), hypothesizing that the physical level of the sea is the same at both locations (Fig. 8). It was also necessary to make sure that the seasonal and diurnal variations of the sea level in the basin that contain Barra do Una (BU), were similar, so that this hypothesis could be safely adopted when transferring these levels.

Figures 9 and 9A, based on these procedures, clearly indicate that independent of the procedure adopted, the boundaries of Union sea land property in Barra do Una (BU) now determined are far from reaching the official boundary shown in this figure, the 33 m limit from the mean high tide line in 1831, of Law 9760, 1946.

Such inaccuracies to determine Union sea land property boundary according to Decree Law 9760, 1946, may be occurring throughout the Brazilian coastline, which to be corrected require the re-installation of the entire network of sea level gauges. This network was disabled years ago and it needs to be reactivated in order to cover the entire national territory and enable the application of a measurement methodology, such as the one presented in this study so that these corrections become possible.

CONCLUSION

The measurement of relative sea level on the beach at Una River, Barra do Una (BU) referred to the relative mean sea level in 1831, according to law n. 9760, 1946, by assuming plausible hypothesis about the varying global sea level since 1831 to the present day, allowed to establish the boundary of Union sea land at BU.

Three measurable and plausible hypotheses were tested in this referencing. The relative sea level at Barra do Una (BU) varied during the 1831-2001 period according to: 1) the changing rate of the measured sea level at the port of Brest, France; 2) the changing rate of Global Relative sea level estimated by Intergovernmental Panel for Climate Changes (IPCC); and 3) to the changing rate of relative sea level recorded so far in Cananeia, São Paulo State.

The results indicate that, in any of these assumptions, the current official boundaries of the Union sea land used until now in BU are in disagreement with the law of 1946.

The measurements from the fence up to the high tide lines, shown in Figure 1 and Figures 9 and 9A, during April/March, 2001, obtained in this study compared to current official measurements (in the deed) confirm that discrepancies were found, whatever the hypothesis investigated (Brest, IPCC or Cananeia).

The discussion of these results shows the need to reactivate the national network of sea level gauges in view of the clear evidence of the current increasing relative sea level and therefore, its mobility along the Brazilian coast and consequent need to define appropriate legal standards for its use, based on similar measurements.

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