

## ADAPTATIVE DREDGING AND SEA TURTLE CONSERVATION

*Victor Patiri victorpatiri@bracosocial.com.br, Gustavo G. Lopez gustave.lopez@bracosocial.com.br, Vicente Habib vicente.habib@gasnaturalacu.com.br, Leonardo Santarossa leonardo.santarossa@prumologistica.com.br, João Teixeira joao.teixeira@gasnaturalacu.com.br and Carolina Brandl carolina.brandl@prumologistica.com.br*

---

### 1. ABSTRACT

This is a case study of an adaptive dredging plan for Port of Açu, a recently built offshore port with a 20km navigation channel, on the northern coast of Rio de Janeiro State, Brazil. With an estimated dredging volume of about 32,532,000m<sup>3</sup>, the port is located in an environmentally sensitive area due to the presence of breeding sea turtles between September and March, with peak activity identified between October and January..

After extended negotiation periods, the environmental agency of Rio de Janeiro State (INEA) authorized dredging during the seasonal restriction period, conditioning to the application of current mitigation measures combined with new ones to avoid turtle takes by the dredgers. In order to protect areas with the highest presence of nesting turtles, dredging operations were restricted to areas up to 11km away from the cost at depths up to 17m, between October 2016 and January 2017. The dredging sectorization associated with effective mitigation measures resulted in zero accidents during the seasonal restriction months.

In parallel, a satellite telemetry experimental research was conducted, providing relevant data on sea turtle behavior during reproductive periods. This initiative also highlights the efficiency of dredging sectorization in the area.

**KEY WORDS:** Port of Açu, environmental management, adaptive dredging plan, sea turtle conservation.

### 2. OBJECTIVE

Developing and executing an adaptive dredging plan at a highly sensitive area, due to sea turtle reproductive activity.

### 3. INTRODUCTION

With a privileged location in the geographic center of the Campos Basin, Port of Açu (PdA) is currently the largest private port operating and in development in Brazil. This article reports issues associated with the deepening and widening of the maritime access navigation channel, with a dredged volume of 32,532,000m<sup>3</sup>. The new channel configuration (20km length and 25m depth) has allowed arrival of larger ship categories like VLCC, opening up new operational possibilities. However, PdA is located in an important nesting ground for loggerhead turtles (*Caretta caretta*), characterized as its southernmost nesting area of the South Western Atlantic. The reproductive activity occurs between September and March, when adults migrate from other regions, gathering to mate and nest on local beaches, peak activity between October and January (LIMA, 2012).

In response to environmental constraints, PdA has implemented a robust sea turtle monitoring program on 62km of beaches since 2008. Nesting seasonal distribution and areas of concentration are very well known.

According to literature, loggerhead females typically remain within the vicinity of nesting beaches during the internesting period (i.e. period of time between a successful nest and the next nesting attempt), resting either on the seabed or in mid-water (HART, 2010).

Hopper dredging was first identified as a source of turtle mortality in 1980, when 71 turtle interactions were recorded over a period of five months in Canaveral channel, Florida (DICKERSON,

2004). Subsequently, between 1980 and 2003, 508 turtles have been impacted by dredgers, in 38 different locations throughout the Southeastern United States (DICKERSON, 2004). During active dredging operations, the hopper dredge dragheads are slow-moving and relatively silent while suctioning bottom sediments, thereby potentially causing injuries or death to sea turtles that are entrained (DICKERSON, 1990) (DICKERSON, 2004)(BANKS; ALEXANDER, 1994)(FITZPATRICK, 2006).

In order to prevent incidents, Brazilian regulations forbid dredging near sea turtle breeding areas between October 1<sup>st</sup> - January 31<sup>st</sup>, creating a seasonal restriction (JORDAN-SELLERS; HERSHORIN, 2015; LASALLE, 1991; NATIONAL RESEARCH COUNCIL, 2001).

Negotiations with the State Environmental Institute of Rio de Janeiro (INEA) opened the way for the development of viable alternatives that would conciliate dredging operations and turtle protection during the restriction months.

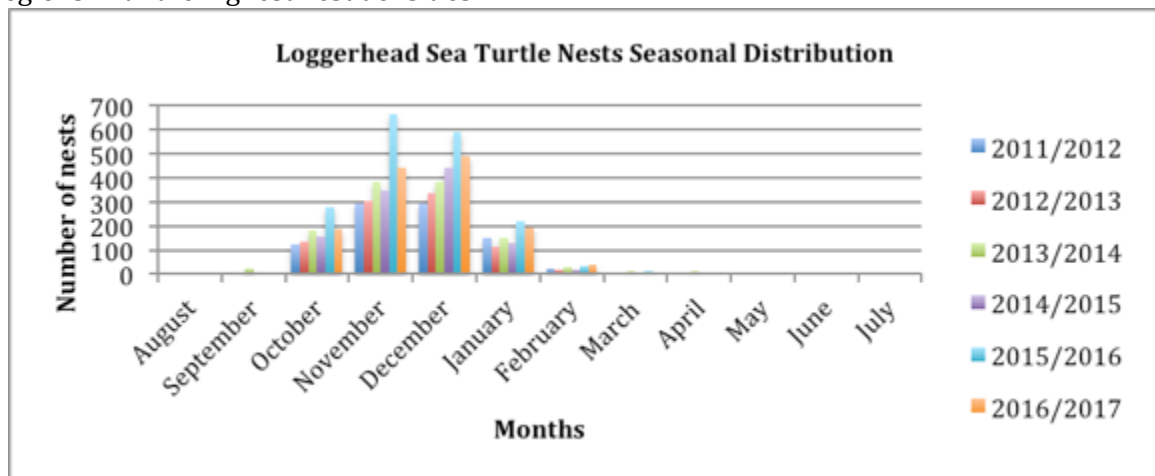
With the initial 12-month dredging operation forecast, PdA was challenged to develop engineering solutions that, would simultaneously make construction economically feasible, (without a stoppage) while ensuring minimal impact on loggerhead turtles, at an extremely important life stage.

#### 4. DEVELOPING AN ADAPTIVE DREDGING PLAN

In order to identify the critical periods and areas with greater potential of interactions occurrence between hopper dredges and sea turtles, the following assessments were prioritized: a) analysis of the reproductive records, b) behavior of same species populations in other regions, and c) related experiences of dredging in sea turtle breeding areas.

##### 4.1. *Analysis of reproductive records in the region:*

Based on the results of the PdAçu sea turtle monitoring program, information on nesting activity from six reproductive seasons was analyzed to observe nesting period, nesting numbers and beach regions with the highest nest densities.



**Graph 1.** Loggerhead nests seasonal distribution at PdA region 2011-2017.

##### 4.2. *Spatial distribution and behavior of same species populations in other regions:*

Information on the use of marine areas by adult animals (males and females) in other regions of the world (East Coast USA, Gulf of Mexico, Greece, Oman and Australia) was accessed to understand spatial distribution and behavior during the reproductive season. Satellite telemetry studies indicate that males are present in marine areas close to nesting beaches, in the beginning of the reproductive seasons, at depths of less than 10m, to increase chances of finding females and mating (ARENDT et al., 2012; SCHOFIELD et al., 2010). Females usually arrive after the males, and lay on average three to four nests each breeding season. During internesting intervals (from 12 to

17 days) they remain resting near the coast, in depths inferior to 20m (HART et al., 2010; HOUGHTON et al., 2002). Despite great variability in areas of use size, both sexes present a preference for areas closer to the coast with a core of permanence at 5 km off the beach line (males and females) and total areas of 20km<sup>2</sup> (SCHOFIELD et al., 2010).

#### *4.3. Related dredging experiences in sea turtle breeding areas:*

Studies on interactions between sea turtles and dredgers in several regions (evaluations and adopted mitigation measures) were reviewed. Studies on loggerhead distribution in the vicinity of navigation channels indicate a greater animal abundance (adults and subadults) in loamy or hard bottoms (VAN DOLAH et al., 1992; VAN DOLAH; MAIER, 1993). Dickerson, in the analysis of bathymetry of six navigation channels in the southwestern coast of US, observed that sectors with highest observation rates varied from 1 - 17m depth. The distance from the coast to the observation limits ranged from 9 to 12 km (DICKERSON et al., 1995).

## **5. RESULTS**

### *5.1. Integrating information and developing solutions:*

Results indicate that the greater the distance from the coast and the deeper the region, the lower the presence of breeding turtles. Loamy bottoms are present in regions closer to the beach line at Port of Açu, and sandy bottoms predominate on areas distant from the coast. This information was relevant to understand how events occur and to develop a new solution, improving mitigation measures.

Specific PdA maps and its channel expansion project were elaborated to visualize the different sectors at distinctive distances from the coast. This tool contributed to visually understand published data and to identify sectors with higher probabilities of loggerhead presence. The maps were then summed to estimate areas of sea turtle high, medium and lower use probabilities. This analysis opened the possibility of subdividing the navigation channel into three regions to minimize associated risks regarding dredging during turtle breeding season:

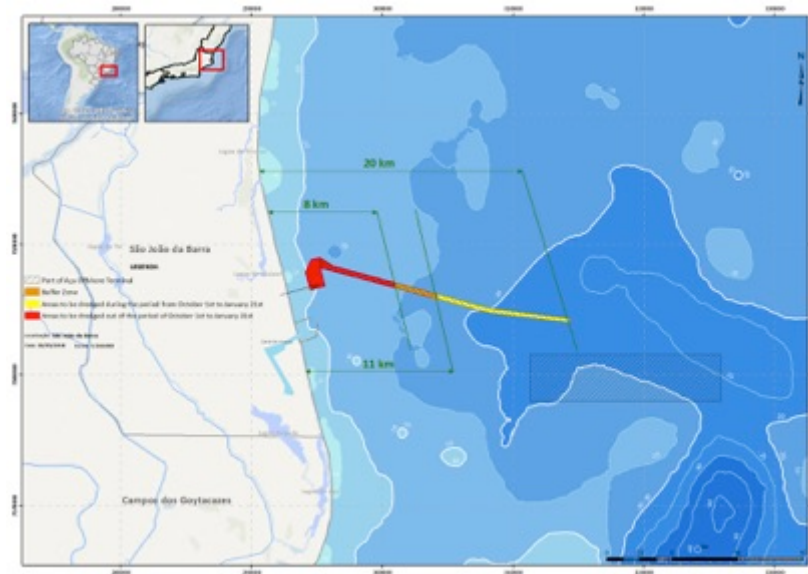
- a) Areas to be dredged outside of the period from October 1<sup>st</sup> - January 31<sup>st</sup> (peak of nesting season) with a distance of up to 8km from the coastline and isobaths of less than 17m;
- b) Areas preferably to be dredged during the period from October 1<sup>st</sup> - January 31<sup>st</sup>, including the adoption of standard mitigating measures: distance from 11km from the coastline, with isobaths greater than 20m, and;
- c) Buffer region (between 8 and 11km from the coastline) where additional measures, such as turtle relocation and day only operations, would be fulfilled in the case of dredging between Oct 1<sup>st</sup> - Jan 31<sup>st</sup>.

The sectorization solution combined with other current mitigation measures (e.g. rigid deflectors, onboard observers, etc.) was presented and approved for implementation and monitoring. Based on this planning, PdA established terms of reference for contracting dredging services, transforming these measures into contractual commitments.

### *5.2. Assessment and Dredging Management:*

A monitoring structure was set up and a management room created to enable information monitoring, decision-making and adoption of complementary measures, if necessary. It was also agreed to forward daily information to INEA on the dredges tracks and records of equipment interactions with sea turtles.

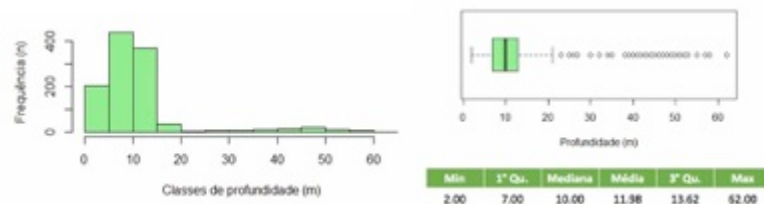
With this organization and coordination among professionals, dredging operations began on December 12, 2016 during nesting peak season, with 2 hopper dredges at the furthest point from the coastline (between 11 and 20km) shown in yellow (**Figure 1**).



**Figure 1.** PdA navigation channel expansion project divided into 3 dredging areas.: 1) Red – No dredging from Oct 1<sup>st</sup> - Jan 31<sup>st</sup>; 2) Yellow – Dredging from Oct 1<sup>st</sup> - Jan 31<sup>st</sup>; 3) Orange – Additional measures added if dredged between Oct 1<sup>st</sup> - Jan 31<sup>st</sup>.

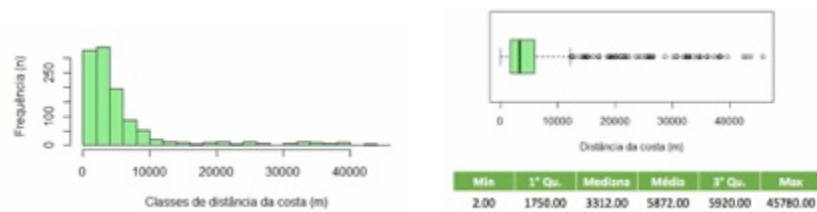
Dredging operations during seasonal restriction started on December 12th with a 15,000m<sup>3</sup> capacity hopper dredge, joined later by another vessel of the same size. Between the starting date and January 31st, last day of peak season, there were no incidents with loggerhead turtles and a total volume of 4,858,300m<sup>3</sup> was dredged, representing 13% of the total amount. . Since there were no more seasonal restrictions dredges then migrated to the channel sectors closer to the beach. Overall, there were four vessels operating simultaneously in different areas of the channel.

Supporting the Adaptive Dredging Plan, a satellite telemetry project was initiated. During the period between December 2016 and January 2017, eight transmitters (model SPOT-Wildlife Computers) were installed in nesting loggerhead turtles. During the interesting period, a higher occurrence frequency was observed at depths of up to 15m and median at 10m (**Graphs 2 and 3**).



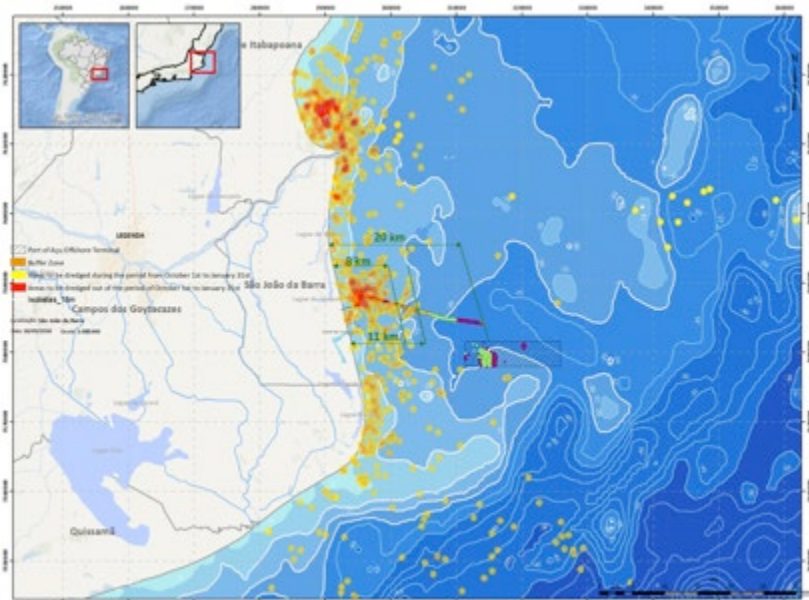
**Graphs 2 and 3.** Depth values distribution. Data Time Series 17-Dec-2016 until 13-Feb-2017. Sample size n = 1135. Number of distinct individuals n = 8. Values from 2 to 62 meters with a median of 10 meters. Sample size n=1135.

A greater frequency of occurrences was observed in coast distances up to the class of 6,000-8,000m, with a median of 3,312m (**Graphs 4 and 5**).



**Graphs 4 and 5.** Frequency distribution of coast distances. Time series of data 17-Dec-2016 until 13-Feb-2017. Sample size n=1135. Number of distinct individuals n = 8. Values from 2 to 45,780m with a median of 3,312 meters. Sample size n = 1135.

The preliminary results obtained up to February 2017 support the proposed model of sectorization for dredging operations suggested by the Adaptive Dredging Plan. It was observed that the largest number of adult loggerhead turtles in the region occurred between October and January, concentrating on distances between 2 and 10km from the coast in bathymetries at less than 20m (**Figure 2**).



**Figure 2.** Satellite telemetry results showing marine habitat use for tagged nesting females during interesting periods. Yellow dots represent positions acquired. Overlaid positions change color towards red.

## 6. FINAL CONSIDERATIONS

Through this experience it was demonstrated the possibility of using scientific information on the behavior of marine species to design and adopt measures that harmonize high impact activities with marine life protection. In this specific case there were no incidents with loggerhead turtles during the critical months which can be considered as a success. The loggerhead turtle behavior predictive model designed to create the dredging plan was strengthened by the satellite telemetry experiment, and results will also support adjustments to regulations and identification of conservation priority areas by the Brazilian government.

The experience of establish and conduct a permanent discussion and decision forum is also a successful achievement towards making decisions that considered turtle behavior and seasonality. It also allowed dredging period to be reduced to 10 months, as dredging equipment was optimized.

It is important to note that this plan was specifically designed for PdA conditions, meaning that other regions and turtle species demand studies based on local features.

## 7. REFERENCES

- ARENDT, M. D. et al. Migration, distribution, and diving behavior of adult male loggerhead sea turtles (*Caretta caretta*) following dispersal from a major breeding aggregation in the Western North Atlantic. **Marine Biology**, v. 159, n. 1, p. 113–125, 2012.
- BANKS, G. E.; ALEXANDER, M. P. **Development and Evaluation of a Sea Turtle- Deflecting Hopper Dredge Draghead** U.S. Army Corps of Engineers. Waterways experiment station. [s.l: s.n.].
- DICKERSON, D. et al. **Dredging impacts on sea turtles in the southeastern USA: a historical review of protection** proceedings of the 17th World Dredging Congress, Hamburg, Germany. **Anais...**2004
- DICKERSON, D. D. et al. Environmental Effects of Dredging. **Technical Note EEDP-09-6**, n. December, p. 14, 1990.
- DICKERSON, D. D. et al. Assessment of Sea Turtle Abundance in Six South Atlantic U.S. Channels. **Miscellaneous Paper EL-95-5**, n. September, p. 44, 1995.
- FITZPATRICK, T. G. et al. **THE EFFECTS OF SEA TURTLE RELOCATION TRAWLING DURING SELECTED COASTAL DREDGING PROJECTS** 23rd International Symposium on Sea Turtle Biology and Conservation, Kuala Lumpur, Malaysia. **Anais...**2006
- HART, K. M. et al. Internesting habitat-use patterns of loggerhead sea turtles: enhancing satellite tracking with benthic mapping. **Aquatic Biology**, v. 11, n. 1, p. 77–90, 2010.
- HOUGHTON, J. D. R. et al. Diving behavior during the internesting interval for loggerhead turtles *Caretta caretta* nesting in Cyprus. **Marine Ecology Progress Series**, v. 227, p. 63–70, 2002.
- JORDAN-SELLERS, T.; HERSHORIN, A. **An Evaluation of Environmental Windows on Dredging Projects in Florida** Florida Shore and beach Technical Meeting, Clearwater Beach, FL Feb 4-6, 2015. **Anais...**2015
- LASALLE, M. W. et al. **A Framework for Assessing the Need for Seasonal Restrictions on Dredging and Disposal Operations**. [s.l: s.n.].
- LIMA, E. P. E et al. Nesting Ecology and Conservation of the Loggerhead Sea Turtle (*Caretta caretta*) in Rio de Janeiro, Brazil. **Chelonian Conservation and Biology**, v. 11, n. 2, p. 249–254, 2012.
- NATIONAL RESEARCH COUNCIL. **Process for Setting, Managing and Monitoring Environmental Windows for**. [s.l: s.n.].
- SCHOFIELD, G. et al. Inter-annual variability in the home range of breeding turtles: Implications for current and future conservation management. **Biological Conservation**, v. 143, n. 3, p. 722–730, 2010.
- VAN DOLAH, R. F. et al. **A survey of turtle populations in the Charleston Harbour entrance channel**. [s.l: s.n.].
- VAN DOLAH, R. F.; MAIER, P. P. The distribution of loggerhead turtles (*Caretta caretta*) in the entrance channel of Charleston Harbor, South Carolina, U.S.A. **Journal of Coastal Research**, v. 9, n. 4, p. 1004–1012, 1993.