Journal of Integrated Coastal Zone Management / Revista de Gestão Costeira Integrada 18(2):103-109 (2018)
http://www.aprh.pt/rgci/pdf/rgci-n149_Rocha.pdf | DOI:10.5894/rgci-n149

GESTÃO COSTEIRA INTEGRADA
Journal of Integrated Coastal Zone Management

Analysis of the evolution of Brazilian ports' environmental performances

Análise da evolução do desempenho ambiental dos portos brasileiros

Carlos Henrique Rocha[1], Gladston Luiz Silva[2], Lucijane Monteiro de Abreu[3]

[1] *Professor Associado na Universidade de Brasília. Email: chrocha@unb.br*
[2] *Professor Adjunto na Universidade de Brasília. Email: gladston@unb.br*
[3] *Professor Adjunto na Universidade de Brasília. Email: lucijanemonteiro@gmail.com*

ABSTRACT: Worldwide, communities living near ports and environmentalists put pressure on port authorities to mitigate their environmental impacts with the major ones being water and air pollution. In 2011, Brazil, through the National Agency of Waterway Transportation (ANTAQ), advanced towards monitoring and environmental control in national ports. ANTAQ signed a cooperation agreement with the Interdisciplinary Center for Transport Studies at the University of Brasilia (CEFTRU/UnB) to develop a methodology to calculate the environmental performance of port facilities. The result of this cooperation is the Environmental Performance Index, known as IDA, which assumes values between zero and one ($0 \leq IDA \leq 1$). Optimum port environmental performance is reached when the index is equal to 1. ANTAQ computes IDA for thirty Brazilian ports located in the North, Northeast, South and Southeast and administered by federal, state or local agencies. This paper analyzes the evolution of the environmental performance in Brazilian ports and investigates whether environmental performance differs between them. The study comprises the period between the first semester of 2012 and the first semester of 2016 (2012.01-2016.01). The application of tests for means comparison to the data revealed that: a) environmental performance was lower in the ports managed directly by the federal government when compared to the environmental performance of the delegated ports; b) the environmental performance of the ports of the macro-regions South/Southeast was higher than in the ports of the macro-regions North/Northeast. The paper is not dedicated to understanding the reasons for the differences in port environmental performance during the period considered. That should be the subject of additional research.

Keywords: Environmental performance index, environmental performance analysis, Brazilian ports, comparison of means, Duncan's test.

** Submission: 20 OCT 2017; Peer review: 24 NOV 2017; Revised: 2 JUN 2018; Accepted: 29 SEP 2018; Available on-line: 9 NOV 2018*

RESUMO: As comunidades residentes nas proximidades dos portos e os ambientalistas exercem pressões sobre as autoridades portuárias para atenuar os impactos ambientais das suas atividades, que poluem especialmente a água e o ar. Em 2011, o Brasil, por intermédio da Agência Nacional de Transportes Aquaviários (ANTAQ), deu um importante passo na direção do monitoramento e controle ambiental nos portos nacionais. A ANTAQ assinou um termo de cooperação com o Centro Interdisciplinar de Estudos em Transportes da Universidade de Brasília (CEFTRU/UnB) para desenvolverem uma metodologia de cálculo do desempenho ambiental de instalações portuárias. Como resultado desta cooperação foi criado o índice de desempenho ambiental, denominado IDA, que assume valores entre 0 e 1 ($0 \leq IDA \leq 1$), inclusive. A plenitude de desempenho ambiental portuário é atingida quando o índice for igual a 1. O IDA tem sido calculado para trinta portos brasileiros localizados nas regiões norte, nordeste, sul e sudeste e administrados por órgãos federais, estaduais ou municipais. Este artigo analisa a evolução do desempenho ambiental nos portos brasileiros e investiga se o desempenho ambiental diferiu entre portos. O estudo compreende o período entre o primeiro semestre de 2012 e o primeiro semestre de 2016. A aplicação de testes de comparação de médias revelou que: a) o desempenho ambiental foi inferior nos portos administrados diretamente pelo governo federal quando comparado com o desempenho ambiental dos portos delegados; e b) o desempenho ambiental dos portos da macrorregião sul/sudeste foi superior ao dos portos da macrorregião norte/nordeste. Com o presente artigo não se pretende analisar as razões das diferenças no desempenho ambiental portuário, no período considerado, as quais deverão ser objeto de pesquisas adicionais.

Palavras-chave: Índice de desenvolvimento ambiental, análise do desempenho ambiental, portos brasileiros, comparação de médias, teste de Duncan.

1. INTRODUCTION

In a modern globalized world, more than ever before, a country's economic performance depends on efficient goods distribution networks, where ports play an outstanding role (Reveley and Tull, 2008; Talley, 2009). The competitiveness of national products in world markets depends on the speed, reliability and costs of port services with environmental responsibility duly guaranteed. All over the world, ports greatly boost trade, but they also face serious environmental challenges.

Like any other activity that could potentially harm the environment, ports depend on prior environmental licensing in order to operate and consequently they are liable to environmental impact assessments in addition to being obliged to recuperate any damage eventually caused to the environment.

Negative impacts on the environment tend to increase with the volume of cargo being handled. According to Bailey and Solomon (2004) and Boer and Verbraak (2010), water and air pollution are the major environmental impacts of ports. Port water can become polluted in innumerable ways. Talley (2009) lists some of the possibilities: spills of waste materials during changes of ballast water, elimination of waste by the vessels, use of anti-encrustation paints on the hulls of vessels, dredging operations and oil spills from vessels. Martins and Vegas (2013) report that the use of anti-encrustation paints on the hulls of vessels can have long-lasting effects on aquatic organisms. Ships also pollute the air when they are in port in the moment they activate their engines to generate electricity on board. The fossil-fuel burning engines of locomotives and trucks, while they are within the port area, and the equipment installed in the port itself, all exacerbate air pollution (Bailey and Solomon, 2004). Atmospheric pollution levels in port areas are a source of concern all over the world as Boer and Verbraak (2020) and many other authors have pointed out. Worldwide, communities living near the ports and environmentalists put pressure on port authorities to mitigate their environmental impacts (CCA, 2017; Talley, 2009).

The response of the port operators around the world has been in the form of management practices for environmental monitoring and control. In continental Europe, for example, at least 150 ports and terminals have formed a network with the aim of harmonizing their environmental management (Kitzmann and Asmus, 2006). In the 1990s, the United Kingdom launched a series of initiatives in order to measure physical-chemical and biological parameters in ports and to identify the vulnerability and sensitivity of habitats in relation to port operations, making use of biological indicators such as the occurrence of certain species as well as using diversity and richness of species indexes (Rodrigues, 2014).

By means of its National Agency of Waterways Transportation (ANTAQ), Brazil took an important step in 2011 towards achieving environmental monitoring and control in its ports. ANTAQ signed a Cooperation Agreement with the University of Brasília's Interdisciplinary Center for Transport Studies

(*Centro Interdisciplinar de Estudos em Transportes da Universidade de Brasília* - CEFTRU/UnB) for the purpose of developing a methodology that would enable a calculation of the environmental performance of port installations.

That cooperation led to the creation of an environmental performance index (índice *de desempenho ambiental* - IDA). In a synergic perspective, the index considers the social, environmental and economic dimensions of sustainable development. It works with values ranging from 0 to 1, as such $0 \leq IDA \leq 1$. A port reaches the maximum environmental performance if it achieves an index value of 1.

The IDA has been computed for thirty Brazilian ports located in the North, Northeast, South and Southeast macro-regions, managed by federal, state or municipal bodies. Table 1 presents the distribution of the ports discriminated by regions and by the type of port administrating authority.

Table 1 - Distribution of 30 Brazilian ports with IDAs calculated.

Tabela 1 - Distribuição dos 30 portos brasileiros com IDAs calculados.

By region			
North	Northeast	South	Southeast
5	12	6	7
By types of port administration			
Federal		State/Municipal	
16		14	

This paper analyzes the evolution of environmental performance in Brazilian ports to discover whether there are any significant differences among their IDAs. The sampling period was from the first semester of 2012 to the first semester of 2016. The data were submitted to the Duncan's test for comparing means.

After this introduction, section 2 presents a brief description of ANTAQ's environmental performance index. Later, section 3 presents the tests of comparison of the average IDAs among the Brazilian ports and section 4 presents the conclusions.

2. ANTAQ'S ENVIRONMENTAL PERFORMANCE INDEX

2.1 Composition of the ANTAQ Environmental Performance Index

The IDA was obtained considering four aspects of environmental conditions: economic-operational, sociocultural, physical-chemical and ecological-biological conditions (Rodrigues, 2014). Each category was decomposed into sub-categories and finally into alternatives. The weight attributed to a sub-category is the sum of the weights of the corresponding alternatives. The weights were obtained using software that works on the basis of dominance principles or hierarchies after prior consultations with experts on port environments.

Accordingly, the environmental performance index has the branching structure of a tree as is usual with the application of hierarchical analysis methods (Costa, 2006).

2.2 Environmental Performance of Brazilian Ports

Being well aware of the new technical and management trends in the world, ANTAQ approved the monitoring and control of environmental management in port installations by means of the environmental performance index (ANTAQ's Resolution 2.659/2012).

The IDA may trigger effects such as obligations, rewards and recognition for port managements in addition to creating considerable technical information flows to enable knowledge and understanding of environmental management as practiced in Brazilian ports. It can safely be stated that the environmental performance index has become consolidated and is considered an advance in regulatory practices.

The environmental performance indexes that ANTAQ has published for Brazilian ports are set out in Table 2. Considering the period from the first semester of 2012 to the first semester of 2016 (2012.1-2016.1), the most outstanding differences in the IDAs over that period are those of the port of Natal in the state of Rio Grande do Norte and the port of Paranaguá in the state of Paraná. The ports of Salvador in the state of Bahia and Imbituba in the state of Santa Catarina registered the biggest drops in their IDAs over that period.

Still referring to Table 2, it can be seen that some ports have IDAs that are notably higher than the rest especially in the case of Itajaí/Santa Catarina and São Sebastião/São Paulo, in the half-year of 2015. In contrast to that, the ports of Porto Velho in Rondônia and Porto Alegre in Rio Grande do Sul have IDAs that are notable lower than the others. On the other hand, taking the average of all the values from 2012.1 to 2016.1, there was an overall positive evolution in the environmental performance index.

3. MATERIAL AND METHODS

3.1 Objectives and Test Selection

Tests were conducted to detect any differences among the IDAs for ports according to: year, state, region and

Table 2 - Brazilian Ports and their Environmental Performance Indexes (2012.1-2016.1).

Tabela 2 - Portos brasileiros e seus Índices de Desempenho Ambiental (2012.1-2016.1).

Ports	2012.1	2012.2	2013.1	2013.2	2014.1	2014.2	2015.1	2015.2	2016.1
	Environmental Performance Indexes (%)								
Angra dos Reis/RJ	68	68	68	66	70	70	70	99	99
Aratu/BA	49	36	37	40	42	42	45	94	98
Belém/PA	63	63	68	62	62	60	64	89	84
Cabedelo/PB	44	47	47	47	47	57	50	81	82
Forno/RJ	33	33	58	60	63	64	56	83	95
Fortaleza/CE	71	71	72	72	72	82	85	84	88
Ilhéus/BA	36	34	32	39	44	47	47	61	61
Imbituba/SC	70	70	49	57	58	57	57	74	75
Itaguaí/RJ	61	61	61	62	61	61	61	77	70
Itajaí/SC	92	97	93	93	90	93	96	71	71
Itaqui/MA	71	71	72	72	72	82	85	64	68
Macapá/AP	35	49	38	29	34	37	40	58	67
Maceió/AL	40	57	60	49	41	39	45	66	69
Natal/RN	41	54	61	65	63	68	79	52	52
Niterói/RJ	70	68	68	68	67	67	67	51	49
Paranaguá/PR	47	34	58	61	80	81	80	54	54
Porto Alegre/RS	33	14	12	18	20	20	17	62	61
Porto Velho/RO	22	25	32	31	31	27	27	63	63
Recife/PE	46	54	56	43	53	53	57	61	61
Rio de Janeiro/RJ	49	49	56	58	52	52	52	65	65
Rio Grande/RS	77	73	73	73	72	71	71	50	51
Salvador/BA	60	48	35	39	43	43	45	52	61
Santarém/PA	66	66	71	73	65	64	64	41	32
Santos/SP	64	71	62	63	60	64	64	56	62
São Francisco do Sul/SC	63	76	75	75	74	62	72	46	45
São Sebastião/SP	67	73	73	87	90	96	98	44	41
Suape/PE	49	71	71	71	71	73	79	37	37
Terminal Pecém/CE	67	66	69	69	65	66	66	37	28
Vila do Conde/PA	63	63	68	62	62	60	64	22	33
Vitória/BA	47	34	41	43	44	44	46	13	28
Means	55	57	58	58	59	60	62	60	62

Source: ANTAQ Internet Page (Select: Meio Ambiente/IDA). IDA numbers are times 100.

macro-region. It was also verified whether there were any statistically significant differences between ports whose administration is delegated to states, municipalities or public consortia and the federally managed ports. The delegated ports are: Cabedelo/Paraíba; Forno/Rio de Janeiro; Imbituba/Santa Catarina; Itajaí/Santa Catarina; Itaqui/Maranhão; Macapá/Amapá; Paranaguá/Paraná; Porto Alegre/Rio Grande do Sul; Porto Velho/Rondônia. Recife/Pernambuco; Rio Grande/Rio Grande do Sul; São Francisco do Sul/Santa Catarina; São Sebastião/São Paulo; Suape/Pernambuco.

Duncan's test is used for multiple comparisons of means (Vieira, 2006). Among the other well-known tests most used for that same purpose are the Tukey test and the applied *t* test. According to Vieira (2006), the Tukey test and Duncan's test have some similarities, but Duncan's test is less conservative so that it presents significant differences more readily, while the Tukey test is more accurate and has a 95% probability of not identifying as significant, a difference that is actually null among all the means of the treatments.

In the case of the *t* test, which is equivalent to the Fisher (1950) test when the sample sizes are equal, the level of significance for experiments becomes very high because tests comparing means are carried out two by two. The Duncan's test was selected because it establishes a half-way condition between the accuracy of the Tukey test and the limitations of the *t* test.

3.2 The Duncan's Test

To proceed with Duncan's test, the first step is to organize the values (in this case the means of the IDA values) in decreasing order. Then the minimum significant difference (between the highest and the lowest means) is calculated. Note that there are *k* means situated between the highest and the lowest means. The significant minimum difference is obtained from the following equation:

$$s.m.d = z\sqrt{\frac{MSR}{r}} \qquad (1)$$

where *z* is the value of the statistic to the pre-determined level of significance for the number of means in the interval being analyzed and for the number of degrees of freedom of the variance analysis residue (Harter, 1960), *MSR* is the mean square residual of variance analysis and *r* is the number of repetitions (in this case, the number of semesters used to compute the means).

The second step is to verify whether the compared means are statistically significant to the established level. Whenever two means are not significant, the interval between them is underscored. For example, consider the mean values A, B, C and D, Figure 1. Panel 1 shows that the means are not statistically different from one another. Panel 2 shows that the means A, B and C are not statistically different from one another but they are from D. Panel 3 shows that the means A and B do not differ statistically but they do differ from the means C and D and that the means B, C and D are not significant.

Panel 1	Panel 2	Panel 3
A B C D	A B C D	A B C D

Figure 1 - Duncan's test example.

Figura 1 - Teste de Duncan: exemplo.

The usual presentation for the variance analysis of a factor of interest is done as set out in Table 3.

Table 3 - Variance analysis for a simple factorial experiment.

Tabela 3 - Análise de variância para uma experiência fatorial simples.

Source of Variation	Degrees of Freedom	Sum of the Squares	Mean Square	F_0[1]
Treatments	$(a - 1)$	$SS_{Treatment}$	$MS_{Treatment}$	$\frac{MS_{Treatment}}{MS_{Error}}$
Error	$a\,(n - 1)$	SS_{Error}	MS_{Error}	
Total	$a\,(n - 1)$			

[1]F_0 is the calculated value of the statistic *F*. $MS_{Error} = MSR$ in equation (1).

4. RESULTS AND DISCUSSION

4.1 Variance Analysis

Table 4 sets out the variance analysis of the Environmental Performance Indexes of ports discriminated by macro-regions and by administrative authorities.

Table 4 - IDA Variance Analysis (2012.1-2016.1).

Tabela 4 - Análise de Variância do IDA (2012.1-2016.1).

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F	P-value
Modelo	23	65,709.13	2,856.92	34.50	<.0001
State	14	47,861.11	3,418.65	41.29	<.0001
Region	3	8,743.44	2,914.48	35.20	<.0001
Macro-region	1	7,398.06	7,398.06	89.35	<.0001
Delegated Port	1	648.82	648.82	7.84	0.0055
Year	4	1,057.68	264.42	3.19	0.0140
Error	246	20,369.41	82.80		
Total	269	86,078.54			

Based on the values set out in Table 4 it is possible to calculate the Coefficient of Determination (R^2) which in this case is equal to 0.763. This means that approximately 76% of the variation registered in the IDAs of Brazilian ports during the period of study can be explained by the variables related to the model. The Coefficient of determination is defined (Vieira, 2006) by,

$$R^2 = \frac{SS_{Model}}{SS_{Error}} \qquad (2)$$

where R^2 represents the coefficient of determination, SS_{Model} the sum of the squares for the model and SS_{Total} the total sum of the squares.

4.2 Sate of Location

To verify what differences were found in the IDAs of ports, discriminated by their states of location, the Duncan's test was applied to groups of different sizes (Vieira, 2006) and the results are presented in Table 5.

Table 5 - Duncan's test applied to the means discriminated by states.

Tabela 5 - Teste de Duncan aplicado às médias discriminadas pelos Estados.

Groups – Duncan		Mean	n	State
	A	77.6	9	MA
B	A	75.9	18	SP
B	A	75.4	27	SC
B	A	71.1	18	CE
B	C	68.9	9	PR
D	C	63.4	18	PE
D	C	61.7	27	PA
D	C	61.4	9	RN
D		61.0	45	RJ
	E	50.4	9	PB
	E	46.2	18	RS
	E	44.9	9	AL
F	E	43.0	36	BA
F		36.3	9	AP
	G	27.8	9	RO

Legend: MA = Maranhão; SP = São Paulo; SC = Santa Catarina; CE = Ceará; PR = Paraná; PE = Pernambuco; PA = Pará; RN = Rio Grande do Norte; RJ = Rio de Janeiro; PB = Paraíba; RS = Rio Grande do Sul; AL = Alagoas; BA = Bahia; AP = Amapá; RO = Rondônia

The results of Table 5 show that in the period 2012.1-2016.1:

a) The ports in the states of Maranhão, São Paulo, Santa Catarina and Ceará presented environmental performance indexes significantly higher than those in the other states with IDAs lower than those of the ports in the state of Paraná;

b) The mean IDAs of the ports in the states of Paraná, Pernambuco, Pará and Rio Grande do Norte do not differ significantly from one another but were higher than those presented by ports of states with a mean IDAs lower than those of the State of Rio de Janeiro;

c) The IDAs of the ports in the states of Paraíba, Rio Grande do Sul, Alagoas and Bahia did not differ significantly from one another, but were significantly higher than the IDAs of the port of Porto Velho. Furthermore, the IDA of the ports of the states of Bahia and Amapá did not differ significantly from one another;

d) The IDA of the port of Porto Velho was the lowest one.

4.3 Region

The IDAs of the ports in in the regions South and Southeast do not differ significantly among themselves. The same is true for the ports of the regions North and Northeast (Table 6).

Table 6 - Duncan's Test for the Means of the IDAs by Regions.

Tabela 6 - Teste de Duncan aplicado às médias dos IDAs discriminadas por regiões.

Groups - Duncan	*Mean*	*n*	*Region*
A	65.2	63	Southeast
A	64.6	54	South
B	56.3	108	Northeast
B	49.8	45	North

On the other hand, according to Table 7, the IDAs registered for ports in the South and Southeast regions (SS) were statistically higher than those for ports in the North and Northeast regions (NN).

Table 7 - Duncan's test: comparison of the mean IDA of ports in the south/southeast regions and the north/northeast regions.

Tabela 7 - Teste de Duncan: comparação do IDA médio dos portos nas regiões sul/sudeste e norte/nordeste.

Groups - Duncan	*Mean*	*n*	*Region*
A	64.947	117	SS
B	54.384	153	NN

4.4 Delegated Port

The mean IDAs of the delegated ports were significantly higher than those registered for federally managed ports, Table 8.

Table 8 - Duncan's test: comparison of the mean IDA of federal and delegated ports (2012.1-2016.1).

Tabela 8 - Teste de Duncan: comparação do IDA médio dos portos federais e delegados (2012.1-2016.1).

Groups - Duncan	*Mean*	*n*	*Ports*
A	60.619	126	Delegated
B	57.511	144	Federal

4.5 Year

Statistical differences were found associated to the annual mean IDAs (Table 9). The mean annual IDAs for the years 2015 and 2016 were significantly higher than the means for the first year (when data gathering began). The mean IDAs for the periods 2012-2014 did not showed any significant differences although they did reveal a tendency to increase.

Table 9 - Duncan's test for the annual IDA means.

Table 9 - Teste de Duncan para o IDA anual médio.

Groups - Duncan		*Mean*	*n*	*Year*
	A		30	2016
	A	60.920	60	2015
B	A	59.485	60	2014
B	A	58.076	60	2013
B		55.979	60	2012

5. CONCLUSIONS

In 2011, ANTAQ and CEFTRU/UnB signed a cooperation agreement with the purpose of developing a methodology to calculate the environmental performances of port installations. That cooperation resulted in the development of an index of environmental performance known as the IDA. The Index values may vary from 0 to 1 ($0 \leq IDA \leq 1$). An index of 1 corresponds to the maximum environmental performance. The IDA has been computed for thirty Brazilian ports located in the macro-regions North, Northeast, South and Southeast, some managed by Federal bodies and others by delegated states and municipal bodies or public consortia. It is clear that the average environmental performance of ports has evolved positively since the implantation of the IDA.

This paper investigates the evolution of the Brazilian ports' environmental performance and investigates whether the environmental performances of ports in different national regions and with different types of port management differ significantly. The analysis considers data gathered from the first half-year of 2012 to the first half-year of 2016. Duncan's multiple means comparison test was applied to the data. It must be stated that this paper is not dedicated to gaining an understanding of the reasons for the differences in ports' environmental performances in the period under consideration; that should be the motive for additional studies.

The results obtained by comparing mean values suggested that the environmental performances of the ports in the South and Southeast macro-regions are significantly better than those obtained for ports in the North and Northeast and that the delegated ports present a better performance than those under federal administration. It has been shown that the environmental performance has improved with time because the mean IDAs for 2015 and 2016 are significantly higher than the mean IDAs obtained for the other years embraced by the study sampling.

The port that could serve as a national benchmark is the port of Itajaí in Santa Catarina which obtained a mean IDA of 93.93 for the period 2012.1-2016.1. Furthermore, the ports of São Sebastião in São Paulo, Itaqui in Maranhão, Fortaleza in Ceará, Suape in Pernambuco, Rio Grande in Rio Grande do Sul and São Francisco do Sul in Santa Catarina, could be considered regional benchmarks. On the other hand, the ports of Porto Velho in Rondônia and Porto Alegre in Rio Grande do Sul registered environmental performance indexes well below the others.

REFERENCES

Bailey, D. e Solomon, G. (2004) Pollution prevention at ports: clearing the air. *Environmental Impact Assessment Review*, v. 24, n. 7-8, p. 749-774. DOI: 10.1016/j.eiar.2004.06.005.

Boer, E. and Verbraak, G. (2010) *Environmental impacts of international shipping: a case study of the port of Rotterdam*. Paris: OCDE.

CCA. (2017) *The Value of Commercial Marine Shipping to Canada*. Ottawa: Council of Canadian Academies (CCA).

Costa, H. G. (2006) *Introdução ao método de análise hierárquica*. Niterói: LATEC/UFF.

Fisher, R. A. (1950) *Statistical Methods for Research Workers*. London: Oliver and Boyd.

Harter, H. L. (1960) Critical values for Duncan's new multiple range test. *Biometrics*, v. 16, n. 4, p. 671-685. DOI: 10.2307/2527770.

Kiztmann, D. and Asmus, M. (2006) Gestão ambiental portuária: desafios e possibilidades. Revista de Administração Pública, v. 40, n. 6, p. 1041-60.

Martins, T. L. e Vargas, V. M. F. (2013) Riscos à biota aquática pelo uso de tintas anti-incrustantes nos cascos de embarcações. *Ecotoxicology and Environmental Contamination*, v. 8, n. 1, p. 1-11. DOI: 10.5132/eec.2013.01.001.

Reveley, J. e TULL, M. (2008) Privatisation postponed: convergence and divergence in Australian and New Zeeland port reform. In J. Reveley e M. Tull (Org.) *Port privatisation: the Asia-Pacific experience*. Cheltenham (UK): Edward Elgar.

Rodrigues, J. C. (2014) O índice de desempenho ambiental dos portos brasileiros: panorama e análise crítica. *Terceiro Incluído*, v. 4, n. 1, p. 44-65.

Talley, W. K. (2009) *Port economics*. New York: Routledge.

Vieira, S. (2006) *Análise de variância (ANOVA)*. São Paulo: Atlas.