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Anexos

Anexo 1. Artigos Completos Publicados Durante o Desenvolvimento da Tese

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Environmental Pollution 154 (2008) 98–106
ENVIRONMENTAL POLLUTION
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Total mercury, organic mercury and selenium in liver and kidney of a South American coastal dolphin

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Received 1 December 2007; accepted 24 January 2008

This study presents some useful data on the bioaccumulation of Hg, organic Hg and Se, and their inter-element relationships in a Brazilian small cetacean.

Abstract

Selenium and total and organic mercury were determined in the liver and kidney of franciscana dolphin (*Pontoporia blainvillei*) incidentally caught in fishing nets along two Brazilian coastal areas (southeast and south). Regional differences in the concentrations of these contaminants were observed in *P. blainvillei*. Liver showed the highest organic and total mercury. In general, samples of individuals collected at the southern of Brazil had the highest concentrations of selenium and total and organic mercury. No significant gender differences were observed. Growth stage influenced the accumulation of these contaminants in both organs, and hepatic concentrations increased with the body length, according to the sampling area. Molar mercury and selenium concentrations in liver were significantly correlated, with a Se:Hg ratio close to 4. The among-site differences we found may be related to differences in preferred prey, bioavailability in the marine environment, environmental conditions, or these individuals may belong to distinct populations.

Keywords: Brazilian coast; Franciscana dolphin; Trace elements; Organic mercury; Ecological and biological factors

1. Introduction

Mercury is an exogenous and harmful metal, which accumulates in the tissues of higher food web organisms (such as marine mammals) as they grow (Caurant et al., 1994; Haraguchi et al., 2000; Kunito et al., 2004; Feroci et al., 2005). Conversely, selenium is recognized as an essential element (WHO, 1987) for metabolic activity of aquatic mammals, acting as a protective agent against the toxicity of exogenous metals such as mercury (USA/EPA, 1998; Feroci et al., 2005). Studies have shown that selenium may reduce the availability of mercury, as methylmercury, blocking it in insoluble compounds (Feroci et al., 1997; Sasakura and Suzuki, 1998).

In the southwestern Atlantic some studies have documented trace element concentrations in the tissues of franciscana, *Pontoporia blainvillei* (Marcovecchio et al., 1994; Gerpe et al., 2002; Lailson-Brito et al., 2002; Kunito et al., 2004; Seixas

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doi:10.1016/j.envpol.2008.01.030

Analytical Letters, 41: 1691–1699, 2008

ISSN: 0003-2719 print/1532-236X online
DOI: 10.1080/00032710802122677

CHEMICAL SPECIATION

Different Species of Mercury in the Livers of Tropical Dolphins

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Abstract: Four kinds of mercury species (inorganic mercury (Hg_{inorg}), methylmercury (MeHg), total organic mercury (ΣHg_{org}), and insoluble mercury, deemed to be mercuric selenide (HgSe), were determined in the livers of dolphins from the Brazilian coast. The MeHg was identified and quantified in the toluene layer on a Gas Chromatograph with an Electron Capture Detector (GC-ECD). The ΣHg_{org} was isolated by acid leaching (H_2SO_4-KBr-$CuSO_4$) and then extracted into CH_2Cl_2. The ΣHg_{org} and Hg_{inorg} were determined by Cold-Vapor Atomic Absorption Spectroscopy (CV-AAS). The MeHg was the smallest fraction of Hg_{tot}, with a median of 9%, whereas the highest fraction of the Hg_{tot} was as HgSe, corresponding to 53%. The fractions of Hg_{inorg} and ΣHg_{org} corresponded to 30% and 39%, respectively. The lowest fraction of MeHg and the highest fraction of HgSe in the liver of all animals are related to different capacities or strategies of detoxification of methylmercury in this organ.

Keywords: Inorganic mercury, insoluble mercury, liver, methylmercury, total organic mercury, tropical dolphin

Received 11 October 2007; accepted 28 February 2008.
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Available online at www.sciencedirect.com
ScienceDirect
Science of the Total Environment 385 (2007) 208–220
Science of the Total Environment
www.elsevier.com/locate/scitotenv

Ecological and biological determinants of trace elements accumulation in liver and kidney of *Pontoporia blainvillei*

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Received 28 November 2006; received in revised form 23 June 2007; accepted 26 June 2007
Available online 31 July 2007

Abstract

The present work tested whether ecological and biological variables have an influence on the assimilation of trace elements by the tissues of a cetacean from the Western South Atlantic Ocean. No significant differences were observed in the concentrations for both sexes. As individuals from the two sampling areas belong to distinct genetic and morphological populations, animals of similar body length were older on the southeastern than on the southern coast. The liver showed the highest concentrations of mercury, whereas the highest levels of cadmium were found in the kidney. Hepatic mercury, cadmium and selenium in individuals from the south coast were about four times as high as those from the southeast coast. However, arsenic in the liver and kidney were similar in both coastal areas. Hepatic mercury, cadmium and selenium concentrations increased with body length in individuals from the southeastern coast, although no significant correlations ($P>0.05$) were observed between body length from either area and the renal and hepatic As concentrations. A significant positive linear relationship was observed between molar concentrations of Hg and Se in the liver of all individuals from both areas ($r^2=0.93$; $P<0.001$), presenting Se:Hg ratios close to 4. Differences found among the concentrations of Hg, Cd and Se in dolphins from both areas were probably due to the preferred prey, bioavailability of elements in each marine environment, and environment variables (water temperature, net primary production). As a consequence, concentrations of trace elements in the tissues of this species can be considered to be a result of the surrounding environment.

Keywords: Mercury; Cadmium; Arsenic; Selenium; Franciscana; Latitudinal gradient; South Atlantic

1. Introduction

Marine mammals are very sensitive to environmental changes and have been considered good bioindicators of environmental contamination (Capelli et al.,

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doi:10.1016/j.scitotenv.2007.06.045

Quim. Nova, Vol. 30, No. 3, 554-559, 2007

Artigo

DISTRIBUIÇÃO DE SELÊNIO EM ORGANISMOS MARINHOS DA BAÍA DE GUANABARA/ RJ

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Recebido em 1/2/06; aceito em 3/7/06; publicado na web em 19/1/07

DISTRIBUTION OF SELENIUM IN MARINE ORGANISMS FROM GUANABARA BAY/ RJ. The study assessed selenium concentrations in the muscle tissues and liver samples of three fish species and in the soft tissues of a mussel species. The samples were analyzed by GF-AAS using Zeeman background correction. Selenium in the muscle samples was higher in carnivorous fish. The liver of all studied fish species presented higher selenium concentrations than the muscle. The fish species presented a high positive correlation between their total length and selenium concentration. A significant correlation was observed between the selenium concentration in the mussel soft tissues and the condition index.

Keywords: total selenium; fish and mussel; Guanabara Bay.

INTRODUÇÃO

O selênio (Se) é conhecido como um micronutriente essencial para a maioria dos animais, porém em concentrações elevadas é considerado tóxico[1,2]. Estudos vêm mostrando que a morte de algumas espécies de organismos mais susceptíveis ao selênio é observada em ambientes aquáticos cuja água apresentou concentração de Se na faixa de 0,06 a 0,6 μg g^{-1} [2]. Para o ser humano, o Se é considerado como essencial em concentrações que variam de 0,04 a 0,1 μg g^{-1} [2]. Entretanto, para os organismos marinhos, como os peixes, o selênio se torna tóxico a partir de 3,0 μg g^{-1} [3]. Há um grande interesse em se entender o comportamento do Se nos organismos marinhos, devido a sua importância fisiológica e toxicológica. Existem poucos trabalhos dedicados ao metabolismo e à acumulação do Se no meio ambiente aquático e seu ciclo biogeoquímico é parcialmente conhecido[4]. Alguns estudos relacionados ao metabolismo do Se nos produtores primários[5,6] e acumulação do Se pelos consumidores[7] forneceram algumas informações básicas a respeito da importância e do papel deste elemento para a biota marinha. Os bivalvos e os peixes são reconhecidamente empregados como biomonitores de Se em ambientes aquáticos[1]. Peters e colaboradores[8] concluíram que a cadeia alimentar bentônica é uma importante fonte de Se para os peixes e que a principal rota para a bioacumulação é via cadeia alimentar. Porém, uma variedade de parâmetros abióticos e bióticos pode influir na eficiência com que os organismos aquáticos acumulam os metais pesados e o selênio em seus tecidos e órgãos[9]. A concentração de Se nos detritos orgânicos dos sedimentos é mais importante para a contaminação da cadeia alimentar aquática que a concentração de Se dissolvido na coluna d'água[8]. Estudos vêm mostrando que a contaminação dos sistemas aquáticos por Se pode causar sérios danos à biota, inclusive a mortalidade de peixes[10].

Neste trabalho foram determinadas as concentrações de selênio total em tecido muscular e fígado de três espécies de peixes bentônicos com diferentes hábitos alimentares (*Mugil liza* – tainha, peixe planctívoro; *Bagre* spp. – bagre, peixe onívoro e *Micropogonias furnieri* – corvina, peixe carnívoro) e nos tecidos moles de uma espécie de mexilhão (*Perna perna*), coletados na Baía de Guanabara.

A Baía de Guanabara (22ºS, 43ºW) é um estuário de aproximadamente 400 km², localizada no estado do Rio de Janeiro, na região sudeste brasileira (Figura 1). É uma importante área com relação à produção pesqueira, porém recebe impactos na forma de esgotos domésticos e efluentes industriais não tratados, que são provenientes de uma área densamente povoada, com aproximadamente 10.000 indústrias, além de uma intensa atividade portuária e um complexo pólo petroquímico[11]. Sua bacia de drenagem pode ser considerada como uma região bastante impactada por matéria orgânica, óleo e um grande número de outros compostos, incluin-

Figura 1. *Locais de coleta na Baía de Guanabara, estado do Rio de Janeiro*

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O SELÊNIO NO MEIO AMBIENTE

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RESUMO

O selênio é conhecido como um elemento de grande importância fisiológica e ecotoxicológica, uma vez que é um micronutriente essencial para a maioria dos organismos, mas também torna-se tóxico em concentrações elevadas. Por esta razão, há um grande interesse em se entender o comportamento deste elemento no meio ambiente. Nesta revisão, alguns aspectos importantes com relação a este elemento são apresentados.
Palavras-chave: Selênio; papel fisiológico; deficiência; efeito protetor; toxicidade.

ABSTRACT

SELENIUM IN THE ENVIRONMENT. Selenium is known as an element of great physiological and ecotoxicological importance due to it is an essential micronutrient for some organisms, but it is also toxic at elevated concentrations. For this reason, there is an increasing interest in understanding the behavior of selenium in the environment. In this review, some important aspects related this element is described.
Key-words: Selenium; physiological role; deficiency; protector effect; toxicity.

INTRODUÇÃO

O selênio (Se) é conhecido como um micronutriente essencial para a maioria dos organismos (Chatterjee *et al.* 2001), porém, este elemento possui uma ambigüidade biológica em que: (1) em concentrações traço é necessário para o crescimento e desenvolvimento normal do organismo; (2) em concentrações moderadas pode ser armazenado e mantém as funções homeostáticas e (3) em concentrações elevadas pode resultar em efeitos tóxicos (Hamilton 2004). Dentre os elementos essenciais, o selênio é considerado o mais tóxico uma vez que a diferença existente entre a dose essencial e a tóxica é muito pequena (Chapman 1999). As crescentes atividades antropogênicas têm aumentado a liberação e o emprego do selênio de suas fontes naturais (rochas e solos), tornando-o disponível principalmente para o meio ambiente aquático e consequentemente para o homem; uma vez que a principal via de exposição tanto do homem quanto dos organismos aquáticos ao selênio é através da dieta alimentar. Há várias décadas o "quebra-cabeça" chamado selênio vem sendo aos poucos montado tanto no campo biológico, quanto no campo ecotoxicológico. A cada estudo são atribuídas mais funções biológicas importantes a este elemento traço. A função protetora e antagônica que este elemento desempenha contra a ação tóxica de certos metais (Hg, Cd, Pb) e metalóides (As) é uma delas. Porém, seu mecanismo é complexo e ainda não foi totalmente elucidado. Somente para o mercúrio (Hg) esta interação parece já estar um pouco esclarecida. Estudos realizados com mamíferos marinhos (Wagemann *et al.* 1998, 2000) mostraram, através de um mecanismo hipotético, que o selênio através das selenoproteínas proporciona a demetilação do metilmercúrio (MeHg) por meio da formação de grânulos inertes de seleneto mercúrico (HgSe) no fígado desses organismos. A seguir serão apresentados alguns pontos relevantes a respeito deste elemento de grande importância fisiológica e ecotoxicológica.

O SELÊNIO E SEUS COMPOSTOS NO AMBIENTE

O selênio é um metalóide que foi isolado e identificado em 1817 pelo químico sueco Jöns Jacob Berzelius (1779-1848) quando este observou um depósito vermelho sobre as paredes de uma câmara de chumbo usada para produzir ácido sulfúrico (Foster & Sumar 1997, Barceloux 1999). Este elemento pertence ao grupo 16 da tabela periódica, e está localizado entre o enxofre e o telúrio. Ambos

SETAC – Brazil

J. Braz. Soc. Ecotoxicol., v. 1, n. 1, 2006, 21-25

JBSE

Selênio em Tecidos de Organismos Marinhos da Baía de Guanabara, Brasil

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RESUMO

Neste estudo foram determinadas as concentrações de selênio total (TSe) no tecido muscular e no fígado de três espécies de peixes e, também, nos tecidos moles de uma espécie de bivalve. As amostras sofreram um tratamento ácido, e o TSe foi determinado por Absorção Atômica com forno de grafite (GF-AAS) equipado com corretor Zeeman. As concentrações de Se no tecido muscular foram mais elevadas no peixe carnívoro. O fígado foi o órgão que apresentou as maiores concentrações de Se para todas as espécies de peixe. Nos peixes, a concentração de Se no tecido muscular apresentou correlação significativa e positiva com o comprimento total. Os mexilhões apresentaram correlação significativa (Spearman) entre a concentração de Se nos tecidos moles e o índice de condição (IC). Todas as espécies estudadas apresentaram concentração de TSe no tecido muscular e nos tecidos moles dentro dos limites aceitáveis pela OMS (1,5 $\mu g.g^{-1}$ em peso úmido) para o consumo humano.

Palavras-chave: selênio total, peixes e mexilhão, Baía de Guanabara, hábito alimentar.

ABSTRACT

Selenium in tissues of marine organisms of Guanabara Bay, Brazil

This study assessed total selenium concentrations in the muscle tissues and liver samples of three fish species and also in the soft tissues of a bivalve. The samples were digested with concentrated acid and analyzed by GF-AAS using Zeeman background correction. Concentrations of selenium in the muscle tissue samples were higher in carnivorous fish. The liver samples of all studied fish species presented the highest total selenium concentration. The fish species presented a high positive correlation (Spearman) between their total lengths and total selenium concentration. A significant correlation was observed between the selenium concentration in the mussel soft tissues and the condition index (IC). All studied species presented the selenium concentrations in the muscle tissue and in the soft tissue below the safety limit established by WHO for human consumption (1.5 $\mu g.g^{-1}$ in wet weight).

Key words: total selenium, fish and mussel, Guanabara Bay, feeding habit.

INTRODUÇÃO

O selênio (Se) é conhecido como um micronutriente essencial para a maioria dos animais, porém em concentrações elevadas é considerado tóxico (Chatterjee & Bhattacharya, 2001). Há grande interesse em entender o comportamento do Se nos organismos marinhos devido a sua importância fisiológica e toxicológica. São poucos os trabalhos dedicados ao metabolismo e à acumulação do Se no meio ambiente aquático, e seu ciclo biogeoquímico é parcialmente conhecido (Pelletier, 1985). Alguns estudos relacionados ao metabolismo do Se nos produtores primários (Fries, 1982; Price *et al.*, 1987) e à acumulação do Se pelos consumidores (Fowler & Benayoun, 1976) forneceram algumas informações básicas a respeito da importância e do papel desse elemento para a biota marinha. Os bivalves e os peixes são reconhecidamente empregados como biomonitores de Se em ambientes aquáticos (Chatterjee & Bhattacharya, 2001). Peters *et al.* (1999) concluíram em

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SELÊNIO EM TECIDOS DE QUATRO ORGANISMOS MARINHOS DA BAÍA DE GUANABARA-RJ

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Recebido: 13/05/2005
Aceito: 09/09/2005

RESUMO

As concentrações de selênio foram determinadas em tecidos de diferentes organismos marinhos coletados na Baía de Guanabara, entre 2000 e 2003. Foram analisados o tecido muscular e o fígado de 79 indivíduos de peixe com diferentes hábitos alimentares, *Micropogonias furnieri*, *Bagre* spp., *Mugil liza*, (carnívoro, onívoro e iliófago) e os tecidos moles de 40 indivíduos de mexilhão, *Perna perna*, (filtrador). As amostras sofreram uma digestão ácida e foram analisadas por Absorção Atômica com forno de grafite (GF-AAS) equipado com corretor Zeeman. O fígado foi o órgão que apresentou as maiores concentrações de selênio para todas as espécies de peixe. As concentrações de selênio no tecido muscular foram mais elevadas no peixe carnívoro (0,12-1,25 $\mu g.g^{-1}$ p.u.). As espécies de peixe onívoro e iliófago apresentaram concentrações de selênio no tecido muscular similares, na faixa de < 0,05-0,18 $\mu g.g^{-1}$ p.u., e estas foram similares às encontradas nos tecidos moles do mexilhão (0,16-0,21 $\mu g.g^{-1}$ p.u.). O tecido muscular mostrou ser o único tecido a sofrer influência direta do hábito alimentar. Os peixes carnívoro e iliófago apresentaram uma correlação significante (Spearman) e positiva entre a concentração de selênio no tecido muscular e o comprimento total dos indivíduos. O peixe carnívoro foi a única espécie que apresentou uma correlação significativa entre as concentrações de selênio nos dois tecidos analisados (músculo e fígado). O mexilhão apresentou uma correlação significativa entre a concentração de selênio nos tecidos moles e o índice de condição (IC). Não foram observadas diferenças significativas *($p<0,05$)* entre as concentrações de selênio nos tecidos moles dos mexilhões entre os diferentes locais de coleta dentro da baía. As espécies estudadas apresentaram concentrações de selênio em seus tecidos semelhantes às encontradas em ecossistemas considerados não impactados.

Palavras-chave: selênio, peixes, mexilhão, Baía de Guanabara, hábito alimentar.

ABSTRACT

Selenium In Tissues Of Four Marine Organisms From Guanabara Bay/Rj

Selenium concentrations were measured in different marine organisms collected at Guanabara Bay in different periods between 2000 and 2003. The muscle tissues and the liver of a

Anexo 2. Artigos Submetidos e Aceitos para Publicação

J. Braz. Chem. Soc., Vol. 00, No. 00, 1-10, 2009.
Printed in Brazil - ©2008 Sociedade Brasileira de Química
0103 - 5053 $6.00+0.00

Article

Trace Elements in Different Species of Cetacean from Rio de Janeiro Coast

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Neste estudo avaliou-se a influência de alguns parâmetros ecológicos e biológicos sobre a acumulação dos elementos-traço (As, Cd, Cu, Pb, Se e Ag) no fígado de três espécies de cetáceos, sendo duas de hábito costeiro (*Pontoporia blainvillei* e *Sotalia guianensis*) e uma de hábito oceânico (*Stenella frontalis*), que foram acidentalmente capturados na costa norte do estado do Rio de Janeiro. Diferenças inter-espécies foram observadas no padrão de acumulação dos elementos-traço, Cd e Pb (5,12 ± 0,74 μg g^{-1} e 21,25 ± 1,35 μg g^{-1}, respectivamente). Entretanto, as três espécies de cetáceo, *S. guianensis*, *P. blainvillei* e *S. frontalis* apresentaram concentrações hepáticas de As, Cu e Ag similares. O sexo dos indivíduos não influiu na bioacumulação dos elementos. O comprimento total influenciou na acumulação dos elementos-traço no fígado de acordo com a espécie de cetáceo. *S. guianensis*, que co-habita o mesmo ambiente que a espécie *P. blainvillei*, apresentou uma diferença significativa na concentração hepática de selênio (20,70 ± 32,22 μg g^{-1} e 3,24 ± 2,02 μg g^{-1}, respectivamente). A partir dessas observações pode-se concluir que condições ambientais e parâmetros biológicos, tais como comprimento total e principalmente a preferência alimentar, influenciaram significativamente a acumulação de elementos traço no fígado dessas espécies de cetáceos.

The present work tested whether ecological and biological parameters have an influence on the accumulation of trace elements (As, Cd, Cu, Pb, Se and Ag) by the liver of three cetaceans species: two species of coastal habit (*Pontoporia blainvillei* and *Sotalia guianensis*) and one of oceanic habit (*Stenella frontalis*), that were incidentally caught in fishing nets along the north of Rio de Janeiro coast. Inter-species difference was observed on the accumulation of Cd and Pb (5.12 ± 0.74 μg g^{-1} and 21.25 ± 1.35 μg g^{-1}, respectively). However, the three cetacean species, *S. guianensis*, *P. blainvillei* and *S. frontalis* presented similar hepatic concentrations of As, Cu and Ag. No gender differences were found on the bioaccumulation of trace elements. Hepatic trace element accumulation was influenced by body length, according to the cetacean species. *S. guianensis*, which co-habits the same coastal marine environment that *P. blainvillei* species, presented a significant difference between hepatic selenium concentration (20.70 ± 32.22 μg g^{-1} and 3.24 ± 2.02 μg g^{-1}, respectively). Based on these results, it is possible to conclude that, not only the different environmental conditions, but also total length and mainly the feeding habit influenced the accumulation of trace elements by the liver of these cetacean species.

Keywords: trace elements, liver of marine dolphin species, biological parameters, Rio de Janeiro coast, GF-AAS

Introduction

The industrial and urban development observed in the last decades greatly increased the fluxes of various chemical contaminants and pollutants, such as, organic matter, oil and also a great number of others compounds, including trace elements, to the marine environment.[1,2] Some elements such as selenium, arsenic and copper are of ecological and biological interest because they are required as essential nutrients in low concentrations for marine organisms and

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MPB 3981
30 December 2008 Disk Used
ARTICLE IN PRESS
No. of Pages 6, Model 5G

Marine Pollution Bulletin xxx (2008) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Essential (Se, Cu) and non-essential (Ag, Hg, Cd) elements: What are their relationships in liver of *Sotalia guianensis* (Cetacea, Delphinidae)?

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Cetaceans are very sensitive to environmental changes and have been considered good bioindicators of environmental contamination (Capelli et al., 2000). The analysis of tissues from different species of whales and dolphins has been used as a tool for the assessment of marine pollution by trace elements (Caurant et al., 1994; Woshner et al., 2001; Kunito et al., 2004; Seixas et al., 2007a). These organisms have high potential for accumulating some trace elements, such as selenium (Se), copper (Cu), silver (Ag) mercury (Hg) and cadmium (Cd), since they have relatively long life spans, and generally occupy a high trophic level in the marine food chain (Woshner et al., 2001; Kunito et al., 2004). They present high hepatic concentrations of these elements that are related to the role played by the liver in terms of pollutant bio-transformation, metabolizing nutrients and essential elements as well as removing some non-essential elements and toxins from the bloodstream (Frodello et al., 2000).

Selenium and copper are recognized as essential elements for the normal growth and metabolism of aquatic mammals (Eisler, 2000). Conversely, silver, cadmium and mercury are exogenous and harmful elements, which accumulate during growth (Feroci et al., 2005). Selenium is reported to have an antidotal action on the toxic effects of some heavy metals, e.g. mercury, cadmium, and copper. Although silver is not currently a major concern with regard to toxicity in mammals, it has been of some interest due to its interaction with selenium. The interaction of Ag with Se differs from other selenium–metal interactions in that silver can induce symptoms of selenium deficiency (Becker et al., 1995). Until now, most studies have focused on the contamination status of Se, Cu, Hg and Cd in liver of cetaceans (Caurant et al., 1994; Capelli et al., 2000; Gerpe et al., 2002; Kunito et al., 2004; Seixas et al., 2007a). However, few data are reported concerning the concentrations of silver in cetaceans (Becker et al., 1995; Woshner et al., 2001; Kunito et al., 2004; Dehn et al., 2006). Furthermore, extensive studies of Se, Cu, Hg, Cd and Ag concentrations in cetaceans have been carried out in the Northern Hemisphere (Caurant et al., 1994; Becker et al., 1995; Dietz et al., 1996; O'Shea, 1999; Woshner et al., 2001; Roditi-Elasar et al., 2003; Ikemoto et al., 2004; Dehn et al., 2006; Stockin et al., 2007) but relatively little is known about contaminant levels in Southern Hemisphere cetaceans (Gerpe et al., 2002; Bustamante et al., 2003; Kunito et al., 2004; Seixas et al., 2007a, 2008; Lavery et al., 2008).

The objectives of this study were to: (1) evaluate concentrations of essential (Se, Cu) and non-essential (Ag, Hg, Cd) elements in liver; (2) assess their hepatic inter-element relationships; and (3) determine whether these hepatic element concentrations differ with gender and body length in 19 individuals of *Sotalia guianensis* (estuarine dolphin) incidentally caught in fishing nets along the Northern Rio de Janeiro (Brazil) (~21°S to 22°S) between 1998 and 2005 (Fig. 1).

The biological characteristics of *S. guianensis* are presented in Table 1. The classification of *S. guianensis* individuals into three classes of age, calves, young and adults, was based on data concerning their body length (Table 1), as it was not possible to determine the age of all individuals in the basis of the growth layers of teeth. According to Di Beneditto and Ramos (2004), the average length at birth of these dolphin individuals occurs when they present a body length between 86.0 and 117.5 cm. However, estuarine dolphins from the northern Rio de Janeiro reach asymptotic length when they are approximately 6-years-old and 180 cm (males) or 6-years-old and 160 cm long (females) (Di Beneditto and Ramos, 2004). In this study, only three individuals were classified as calves as they presented body lengths up to 117.5 cm. Individuals of estuarine dolphins with a body length up to 160 cm (females) and 180 cm (males) were classified as young, while females longer than 160 cm and males longer than 180 cm were classified as adults.

Liver samples from 19 individuals of estuarine dolphins were supplied by the Biological Specimen Banking from the Bioscience and Biotechnology Center (UENF). After dissection, samples were stored in identified individual polyethylene bags and kept frozen (−20 °C) until the freeze-drying process. They lost around 70% of their water content.

In homogenized dry samples Cu, Cd, Se, Ag and total mercury (Hg) were determined by atomic absorption spectrometry techniques. Aliquots of liver samples (~100 mg dry wt.) were acid

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0025-326X/$ - see front matter © 2008 Published by Elsevier Ltd.
doi:10.1016/j.marpolbul.2008.12.005

Please cite this article in press as: Seixas, T.G. et al., Essential (Se, Cu) and non-essential (Ag, Hg, Cd) elements: What are their ..., Mar. Pollut. Bull. (2008), doi:10.1016/j.marpolbul.2008.12.005

Anexo 3. Comunicações e Resumos Publicados em Anais de Congressos ou Periódicos (completo)

1. BARBOSA, S. C. T., COSTA, M., BARLETTA, M., DANTAS, D. V., KEHRIG, H. A., **SEIXAS**, **T. G.**, MALM, O. Mercúrio tatal em peixes *Centroppomus undecimalis* (centropomidae), *Mugil curema* (mugilidae) e *Achirus lineatus* (achiridae) do estuário do rio Goiana (nordeste do Brasil). In: XII Congresso Latino-Americano de Ciências do Mar - XII COLACMAR, 2007, Florianópolis. **XII Congresso Latino-Americano de Ciências do Mar**, 2007.

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Anexo 4. Comunicações e Resumos Publicados em Anais de Congressos ou Periódicos (resumo)

1. KEHRIG, H. A., **SEIXAS**, **T. G**., DI BENEDITTO, A.P.M., SOUZA, C. M., MALM, O. Mercury species and selenium in dolphin liver. In: SETAC Europe 17th Annual Meeting, 2007, Porto. **Abstract book of SETAC Europe 17th Annual Meeting**. Brussels: SETAC, p.201 – 201, 2007.

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