

学校编码: 10384
学号: 22420111151362

密级_____

廈門大學

硕士学位论文

基于 REA 的近岸海域溢油对海洋生态系统服务功能损害评估

**Assessment of Damage of Marine Ecosystem Services
Caused by Offshore Oil Spill Based on REA**

黄文怡

指导教师姓名: 蔡明刚 教授

专业名称: 海岸带综合管理

论文提交日期: 2014 年 5 月

论文答辩时间: 2014 年 5 月

2014 年 5 月

厦门大学学位论文原创性声明

本人呈交的学位论文是本人在导师指导下,独立完成的研究成果。本人在论文写作中参考其他个人或集体已经发表的研究成果,均在文中以适当方式明确标明,并符合法律规范和《厦门大学研究生学术活动规范(试行)》。

另外,该学位论文为()课题(组)的研究成果,获得()课题(组)经费或实验室的资助,在()实验室完成。(请在以上括号内填写课题或课题组负责人或实验室名称,未有此项声明内容的,可以不作特别声明。)

声明人(签名):

年 月 日

厦门大学学位论文著作权使用声明

本人同意厦门大学根据《中华人民共和国学位条例暂行实施办法》等规定保留和使用此学位论文，并向主管部门或其指定机构送交学位论文（包括纸质版和电子版），允许学位论文进入厦门大学图书馆及其数据库被查阅、借阅。本人同意厦门大学将学位论文加入全国博士、硕士学位论文共建单位数据库进行检索，将学位论文的标题和摘要汇编出版，采用影印、缩印或者其它方式合理复制学位论文。

本学位论文属于：

1. 经厦门大学保密委员会审查核定的保密学位论文，
于 年 月 日解密，解密后适用上述授权。

2. 不保密，适用上述授权。

（请在以上相应括号内打“√”或填上相应内容。保密学位论文应是已经厦门大学保密委员会审定过的学位论文，未经厦门大学保密委员会审定的学位论文均为公开学位论文。此声明栏不填写的，默认为公开学位论文，均适用上述授权。）

声明人（签名）：

年 月 日

目 录

摘要.....	I
ABSTRACT.....	III
缩略词表	VI
图目录.....	VII
LIST OF FIGURES	VIII
表目录.....	IX
LIST OF TABLES	XI
第一章 引言	1
1.1 全球石油污染概述	1
1.2 研究背景和意义	3
1.3 本文主要工作	4
1.3.1 研究目的.....	4
1.3.2 研究内容.....	4
1.3.3 研究方法与技术路线.....	5
第二章 溢油对海洋生态系统的影响及生态损害研究动态	7
2.1 溢油对海洋生态系统影响概述	7
2.1.1 溢油对海洋环境的影响.....	7
2.1.2 溢油对海洋生态系统的影响.....	10
2.2 溢油生态损害研究进展	12
2.2.1 国外研究进展.....	12
2.2.2 国内研究进展.....	14
2.2.3 小结.....	15
第三章 海洋生态系统服务功能内涵及其损害评估方法	17
3.1 海洋生态系统服务功能内涵	17
3.1.1 海洋生态系统服务功能的定义.....	17

3.1.2 海洋生态系统服务功能的分类.....	18
3.1.3 海洋生态系统服务功能识别.....	21
3.2 溢油对海洋生态系统服务功能损害评估方法.....	23
3.2.1 NRDA 方法体系.....	23
3.2.2 “塔斯曼海”轮溢油生态价值损失评估.....	25
3.2.3 经验公式法.....	26
3.2.4 人工神经网络法.....	26
3.2.5 货币评估法.....	27
3.3 典型海洋生态服务功能损害评估方法比较分析.....	27
第四章 基于 REA 的近岸海域溢油生态系统服务功能损害模型建立	
.....	31
4.1 近岸溢油对海洋生态系统服务功能损害的识别.....	31
4.2 REA 方法探讨.....	32
4.2.1 估算生态系统服务功能损害 (debit).....	34
4.2.2 估算补偿修复项目的环境收益 (credit).....	35
4.2.3 测定修复工程的规模.....	36
4.3 REA 方法的工作基础—环境敏感区.....	36
4.4 溢油对海洋生态系统服务功能受损程度界定.....	38
4.4.1 油类对海洋浮游植物的半最大效应浓度.....	39
4.4.2 确定海洋浮游植物生长抑制率.....	40
4.4.3 海洋生态系统服务功能损失率.....	44
4.5 海洋生态系统的平均公益价值.....	45
第五章 基于 REA 方法之案例分析	47
5.1 案例选择依据.....	47
5.2 案例分析 1—渤海湾“塔斯曼海”轮溢油案例.....	47
5.2.1 案例研究背景及数据来源.....	47
5.2.2 事故概述.....	47
5.2.3 事故海域概况.....	51

5.2.4 事故海域生态系统服务功能损害评估.....	53
5.2.5 评估结果评价.....	57
5.3 案例分析 2—兴化湾新加坡籍集装箱船“BARELI”轮搁浅.....	58
5.3.1 案例研究背景及数据来源.....	58
5.3.2 事故概况.....	65
5.3.3 事故海域概况.....	67
5.3.4 事故海域生态环境现状.....	71
5.3.5 事故海域生态系统服务功能损失评估.....	76
5.4 小结.....	78
第六章 近岸溢油污染的管理对策和建议.....	79
第七章 论文总结.....	81
7.1 研究结论.....	81
7.2 创新点.....	82
7.3 不足与展望.....	82
7.3.1 不足之处.....	82
7.3.2 展望.....	83
参考文献.....	84
攻读硕士学位期间发表论文.....	91
会议摘要.....	92
致谢.....	93

LIST

Abstract (In Chinese).....	I
Abstract (In English).....	III
Abbreviations.....	VI
List of Figures (In Chinese).....	VII
List of Figures (In English).....	VIII
List of Tables (In Chinese).....	IX
List of Tables (In English).....	XI
Chapter 1 Introduction.....	1
1.1 OVERVIEW OF GLOBAL OIL POLLUTANT.....	1
1.2 RESEARCH BACKGROUND AND SIGNIFICANCE.....	3
1.3 MAJOR WORK OF THIS STUDY.....	4
1.3.1 Research objectives.....	4
1.3.2 Research contents.....	4
1.3.3 Methodology.....	5
Chapter 2 Impact of oil spill on marine ecosystem and research progresses on ecological damage.....	7
2.1 OVERVIEW OF IMPACT OF OIL SPILL ON MARINE ECOSYSTEM.....	7
2.1.1 Impact of oil spill on marine environment.....	7
2.2.2 Impact of oil spill on marine ecosystem.....	10
2.2 RESEARCH PROGRESSES ON ECOLOGICAL DAMAGE OF OIL SPILL.....	12
2.2.1 Research progresses overseas.....	12
2.2.2 Research progresses domestically.....	14

2.2.3 Summary	15
Chapter 3 Marine ecosystem services contents of its function and damage assessment.....	17
3.1 CONTENTS OF MARINE ECOSYSTEM SERVICES	17
3.1.1 Definition of marine ecosystem services	17
3.1.2 Classification of marine ecosystem services.....	18
3.1.3 Identification of marine ecosystem services	21
3.2 ASSESSMENT METHOD OF DAMAGE OF OIL SPILL ON MARINE ECOSYSTEM SERVICES	23
3.2.1 Methodology of NRDA	23
3.2.2 Assessment of ecological value loss-Case of “Tasman Sea”oil spill event .	25
3.2.3 Empirical formula method	26
3.2.4 ANN method	27
3.2.5 Monetary assessment method	27
3.3 COMPARISON OF TYPICAL ASSESSMENT METHODS OF DAMAGE ON MARINE ECOSYSTEM SERVICES.....	27
Chapter 4 Modeling of damage of oil spill on marine ecosystem services in the coastal areas based on REA.....	31
4.1 DAMAGE OF COASTAL OIL SPILL ON MARINE ECOSYSTEM SERVICES AND IDENTIFICATION	31
4.2 EXPLORATION OF REA METHOD	32
4.2.1 Quantification of damage on marine ecosystem services (debit)	34
4.2.2 Quantification of environmental benefits of repair and compensation (credit)	35
4.2.3 Determination of extent of repair.....	36
4.3 BASIC OF REA-ENVIRONMENTAL SENSITIVITY AREA	36
4.4 DEFINITION OF DAMAGE OF OIL SPILL ON MARINE ECOSYSTEM SERVICES	38

4.4.1 Half effective concentration of oil for marine phytoplankton	39
4.4.2 Determination of GIR of marine phytoplankton.....	40
4.4.3 Quantification of damage on marine ecosystem services	44
4.5 MEAN COMMONWEAL VALUE OF THE MARINE ECOSYSTEM	45
Chapter 5 Case based on REA method	47
5.1 CHOICE OF THE CASES.....	47
5.2 CASE 1- OIL SPILL OF “TASMAN SEA” IN BOHAI BAY	47
5.2.1 Research background and data.....	47
5.2.2 Overview of the event.....	47
5.2.3 Overview of the area.....	51
5.2.4 Assessment of damage on marine ecosystem services	53
5.2.5 Assessment result	57
5.3 CASE 2- BEACHING OF SINGAPORE SHIP “BARELI” IN XINGHUA BAY	58
5.3.1 Reserch background and data	58
5.3.2 Overview of the event.....	65
5.3.3 Overview of the area.....	67
5.3.4 Ecological environment of the area	71
5.3.5 Assessment of damage on marine ecosystem services	76
5.4 SUMMARY.....	78
Chapter 6 Management strategy and suggetion of coastal oil spill	79
Chapter 7 Conclusion and outlook	81
7.1 CONCLUSION	81
7.2 INNOVATIONS.....	82
7.3 DEFICIENCY AND OUTLOOK	82
7.3.1 Deficiency	82
7.3.2 Outlook	83
References	84

Publications	91
Conference Paper	92
Acknowledgement	93

厦门大学博硕士学位论文摘要库

摘要

人类对海洋石油资源的开发与利用日益扩大,频繁的海上运输和海上油田勘探开发导致石油泄漏事故屡屡发生。近年来石油污染正逐渐成为我国海洋环境中的主要污染物,且污染量呈上升趋势,其中近岸海域溢油事件频繁发生,且近岸海域生态系统敏感度高,故人类活动造成的溢油事故对近岸海域生态系统造成重大压力。海洋溢油事件所引发的生态损害之技术问题,已成为国内外该领域研究和政府管理部门制定相关规范的重大需求。然而,在中国目前完成的海洋溢油损害赔偿案例中,所获赔偿仍多集中于清污、渔业资源损失等直接费用,生态系统损害等间接影响则仍处于研究层面,研究内容则鲜少涉足生态系统服务功能损失评估。因此,开展近岸溢油对海洋生态系统服务功能损失评估的科学研究迫在眉睫。

本文运用海洋环境化学、海洋生态学、环境经济学、海洋生态系统管理等多学科交叉的相关理论与方法,结合国内外文献查阅、相关资料收集、理论分析、比较分析以及模型与案例相结合的手段进行研究,归纳总结生态系统服务功能概念的历史演化,概括评述海洋溢油生态系统服务功能损失评估方法,修正资源等价分析方法(Resource Equivalency Analysis, REA),通过评述和分析,为我国海洋溢油管理的研究与实践提供参考,以期能推进溢油海洋生态系统服务功能损失评估的科学研究。本文主要取得以下几个方面的研究成果:

(1) 溢油影响海气交换,降低海洋初级生产力,危害生物生存和人类健康,破坏海滩休养地及风景区的景观。本文调研得出,目前我国油污损害相关立法及规程与国际水平仍有一定差距,缺乏健全的相关溢油损害法律法规体系,针对海洋生态系统服务功能损害的相关法律相对较少。国内外溢油生态损害影响研究中,大多研究关注的是溢油对海洋环境损害,渔业资源等的直接影响,鲜少涉足海洋生态系统服务功能等长时间尺度损害的评估,从而提出开展海洋生态系统服务功能损害评估工作的必要性。

(2) 对海洋生态系统服务功能定义相关理论及其历史演化进行了总结,探讨其内涵,海洋生态系统服务功能是指人类从海洋生态系统中获得的收益与功能,其分为供给服务、调节服务、文化服务和支持服务,并对海洋生态系统服务

功能进行分类及对各项服务进行识别。

总结国内外关于生态系统服务功能的评估方法，包括自然资源损害评估（Natural Resources Damage Assessment, NRDA）方法体系：生境等价分析（Habitat Equivalency Analysis, HEA）、REA、或然价值法（Contingent Valuation Method, CVM）；神经网络法模型、华盛顿评估公式模型、佛罗里达评估公式模型等、“塔斯曼海”轮溢油生态价值损失评估模型；货币化评估及基于经济学的各类评估手段。在各类方法优缺点进行比较分析，提出确定 REA 为近岸溢油生态损害评估方法的主要依据。通过国内外对溢油污染生态系统服务功能损失评估方法的调研，对典型溢油生态损失评估方法进行优缺点对比分析，最终确定运用 REA 作为本文针对近岸海域溢油污染的生态系统服务功能损害评估的主要方法。

(3) 笔者发现在大多 REA 方法对海洋生态系统服务功能损失进行评估过程中，海洋生态系统损失程度（I）的选取多仅通过假设来确定，其参数确定并未有明确的规定。本文对 REA 方法进行修正和改进，确定不同溢油情况下 REA 公式中的不同参数：海水中油类浓度为 0-0.005 mg/L, I 为 0, 浓度为 0.005-0.03 mg/L, I 为 5%，浓度为 0.03-0.05 mg/L, I 为 30%，浓度为 0.05-0.3 mg/L, I 为 50%，浓度为 0.3-0.5 mg/L, I 为 60%，浓度为 0.5 mg/L, I 为 80%，大于 1 mg/L, I 为 100%。通过海水中油类浓度来界定海洋生态系统服务功能损害的程度，从而确保公式中的参数更具科学意义。

(4) 将 REA 评估方法应用于“塔斯曼海”轮溢油事故案例的研究，对该溢油事故造成的海洋生态系统服务功能损失进行评估，结果显示：海洋生态系统服务功能损失的总价值约为 1.286 亿元，并与其他该案例评估结果进行比较，验证修正后 REA 方法的合理性。同时，将运用 REA 对 2012 年发生在福建省兴化湾一起溢油事故进行评估，结果显示：该海域海洋生态系统服务功能损失的总价值约为 1 267.27 万元。

(5) 在对案例分析的基础上，针对近岸溢油污染管理方面提出相关对策和建议，为今后研究及政府决策提供科学依据。

ABSTRACT

The development and utilization of offshore oil resources are enlarging increasingly, because of the frequent maritime transport and oil exploration, the oil spill accidents occur frequently. Petroleum have become the main contaminant in seawater in China and the oil pollution is getting worse and worse. Among the oil spill accident, most of which occurred in coastal waters. Due to the highly sensitive nature of the coastal marine ecosystem, Oil pollution is stressful for coastal waters. Thus it has become a commonly concerned topic all around the world to assess ocean ecosystem damage which caused from oil spill. However, among the claims of oil spill damage, most of assessment of losses of oil focus on the assessment of direct losses, including the loss of fishery resources, the cost of the rack cleaner, etc.; among the studies of oil spill damages, ecological damage, ecological value loss, etc. have been concerned, but not ecosystem service loss. So the research of the oil spill occurred in coastal is urgently needed.

This paper studies the ecological losses caused by oil spill in coastal based on the multiple disciplines of Ocean Chemistry, Marine Ecology, Environmental Economics, Integrated Coastal Zone Management and so on., as well through reference research, information-gathering, theoretical analysis. It summarizes the historical evolution of the concept of ecological services and the assessment method of the loss of marine ecosystem services, also revises the Resource Equivalency Analysis (REA). It provide some reference value for the management and policy making.

This paper achieves the following goals:

(1) Oil spill brings severe environmental impact, such as destroying air-sea exchange, decreasing the marine primary productivity, being dangerous to human health and destroying landscapes and habitats. While we still have a certain gap in law-making of oil pollution and lack a sound supervision system and regulations in China. Most of assessment of losses of oil focus on the assessment of direct losses, including the loss of fishery resources, the cost of the rack cleaner, etc. A lack of

assessment of marine ecosystem services. So it is necessary to assess marine ecosystem services.

(2) The paper summarizes and also discusses the definition of marine ecosystem services. Marine Ecosystem Services is the incomes which humans gain from marine ecosystem, and then we classifies marine ecosystem service and its sub-services, it is classified into four categories: provisioning service, regulating service, cultural service and supporting service.

Sums up the evaluation method of ecosystem services at home and abroad, including the NRDA method system: HEA, REA, CVM; Artificial neural network model; Washington assessment formula model; Florida assessment formula model; “Tasman sea” ecological value of oil spill damage assessment; Monetization assessment and other kinds of evaluation methods. Through comparative of the advantages and disadvantages of the various kinds of method, we determine REA as the main method of assessment of offshore oil spill.

(3) Through discusses REA method, the author found that the determination of parameter I (Marine ecosystem damage degree) just by assumption in most research which using REA method to assess the loss of marine ecosystem services, its parameters is not clearly defined. We have corrected and improved the REA method, it determine the different I under different concentrations of PAHs: The concentrations range is 0-0.005 mg/L, I=0; the range is 0.005-0.03 mg/L, I=5%; the range is 0.03-0.05 mg/L, I=30%; the range is 0.05-0.3 mg/L, I=50%; the range is 0.3-0.5 mg/L, I=60%; the concentration is 0.5 mg/L, I=80%; concentration above 1 mg/L, I=100%.Using the oil concentration in seawater to definition of Marine ecosystem services damage degree, which can ensure that the parameters in the formula is more scientific.

(4) REA method was applied to the “Tasman sea” vessel oil spill accident to assess the marine ecosystem services loss of this case, the results show that the total value of Marine ecosystem service loss is about 128.6 million RMB, and comparing with other cases to prove REA which under corrected is scientific and rational. At the same time, we use REA to assess the marine ecosystem services loss of “BARELI” oil

spill accident occurred at in XingHua bay in Fujian province in 2012. The results show that the total value of the Marine ecosystem services loss is about 12.6727 million RMB.

(5) Through theoretical analysis and case study, the paper intends to supply experience and reference to the relevant policy making department and related studies.

关键词：资源等价分析；生态系统服务；损失评估；溢油

Keywords: Resource Equivalency Analysis; Ecosystem Services; Damage Assessment; Oil Spill

缩略词表

- PAHs: 多环芳烃 (polycyclic aromatic hydrocarbons)
- MEA: 千年生态系统评估小组 (Millennium Ecosystem Assessment)
- NRDA: 自然资源损害评估 (Natural Resources Damage Assessment)
- HEA: 生境等价分析 (Habitat Equivalency Analysis)
- REA: 资源等价分析方法 (Resource Equivalency Analysis)
- CVM: 或然价值法 (Contingent Valuation Method)
- EC₅₀: 半最大抑制浓度 (Concentration for 50% of Maximal Effect)
- ESA: 环境敏感区 (Environmental Sensitive Area)
- WTP: 支付意愿 (Willingness to Pay)
- WTA: 受偿意愿 (Willingness to Accept)

Degree papers are in the "[Xiamen University Electronic Theses and Dissertations Database](#)". Full texts are available in the following ways:

1. If your library is a CALIS member libraries, please log on <http://etd.calis.edu.cn/> and submit requests online, or consult the interlibrary loan department in your library.
2. For users of non-CALIS member libraries, please mail to etd@xmu.edu.cn for delivery details.

廈門大學博碩士論文摘要庫