Assessment of Recreation and Ecological Damages from Green Tides in Jiaozhou Bay

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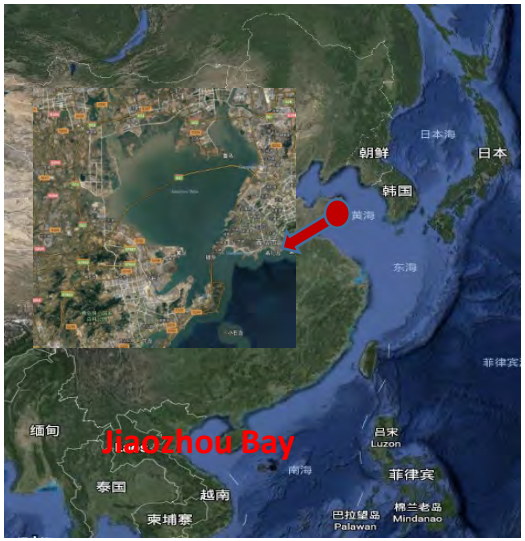
CONTENTS

Background

In 2008, the sudden massive arrival of green algae on the shore of the coastal city Qingdao, stirred the world attention.

It is estimated that about 1 million tons washed up on the coast, and that two additional million tons sunk.



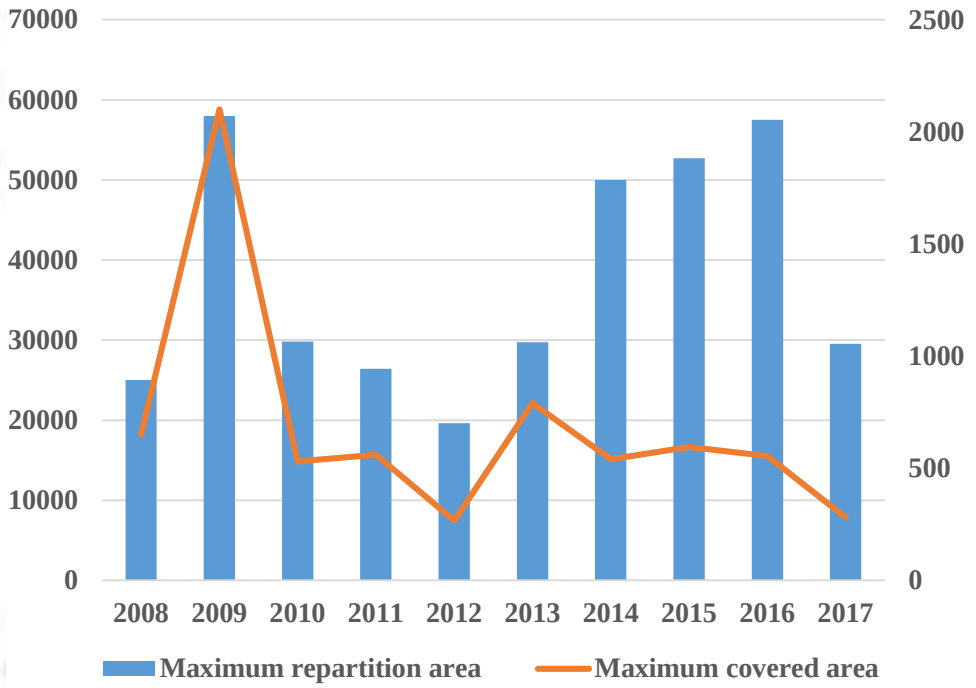
Background

Since 2008, green tides have occurred in Yellow sea each year, with a varying intensity.

Yellow Sea green tides: Maximum repartition and covered area, 2008-2017

Year	Maximum repartition area(km²)	Maximum covered area(km²)
2008	25000	650
2009	58000	2100
2010	29800	530
2011	26400	560
2012	19610	267
2013	29733	790
2014	50000	540
2015	52700	594
2016	57500	554
2017	29522	281

Source: SOA, China maritime disasters bulletin, 2008-2017



Background

Damages caused by Green Tides Bloom

Damages caused by Green Tides

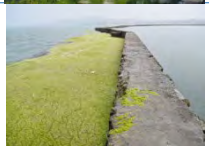
Fishing & Aquaculture

* Increase mortality in farms growing sea cucumbers, scallops, clams, and jellyfish

Tourism & Recreational activities

* Affect aquatic activities
* Damage coastal landscape
* Emit stench of the decayed algae

Marine ecosystems



* Water quality
* Marine creature
* Marine biodiversity

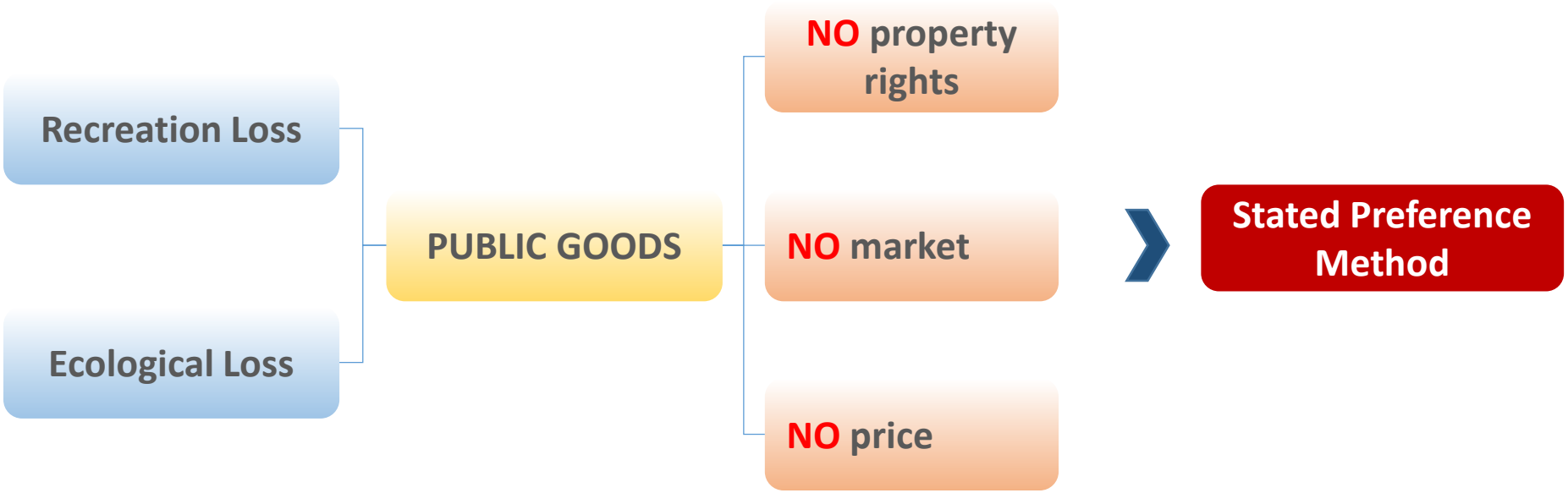
Background

Question proposing

- **What** is the social and economic impacts of green tides bloom?
- **How much** is the recreation loss caused by green tides bloom?
- **How much** is the ecological loss caused by green tides bloom?
- **Who** should pay to restore the beach?

The loss of ecological and social value must be translated into monetary terms involving an economic assessment.

Methodology & data



Method

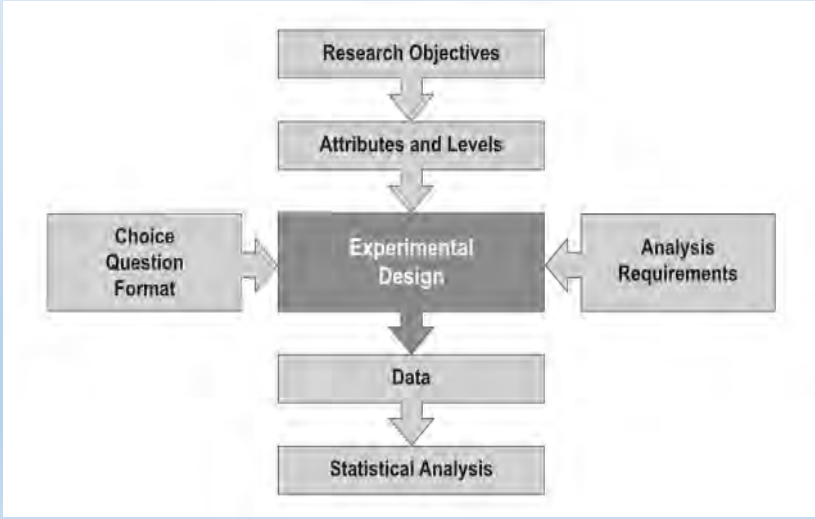
Stated Preference Method

Contingent Valuation

Contingent valuation is a survey approach designed to create the missing market for public goods by determining what people would be willing to pay (WTP) for specified changes in the quantity or quality of such goods or what they would be willing to accept (WTA) in compensation for well-specified degradations in the provision of these goods

Choice Experiment

Choice Experiment is a stated choice methods elicit the preferences of citizens for environmental goods that do not have a market price. In a choice experiment study, the respondents are asked to choose among alternative policy options all characterized by attributes of environmental change.



Method

Questionnaire design

Recreation loss : CVM

- **INTRODUCTION:** the situation of green tides in Jiaozhou Bay
- **ATTITUDE:** the respondent's attitude towards green tides and marine environment
- **WTP:** the willingness to pay to govern the green tides to recover the coastal recreation function.
- **Socioeconomic characteristics:** gender, education, income…

Ecological damage: CE

- **INTRODUCTION:** the situation of green tides in Jiaozhou Bay
- **ATTITUDE:** the respondent's attitude of green tides and marine environment
- **CHOICE SET:** 2 restoration scenario and 1 no change scenario
- **Socioeconomic characteristics:** gender, education, income…

Recreation and ecological damage assessment from green tides in Jiaozhou Bay

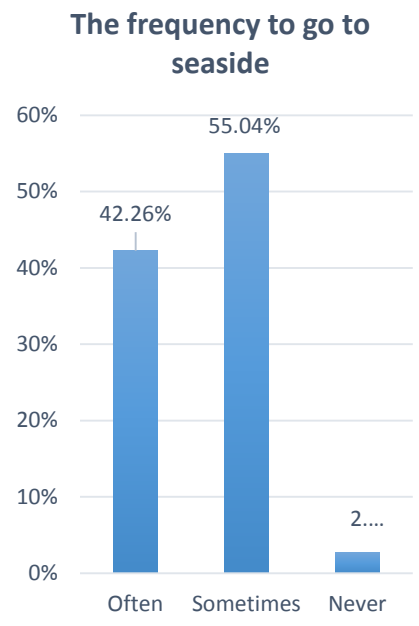
Survey and data

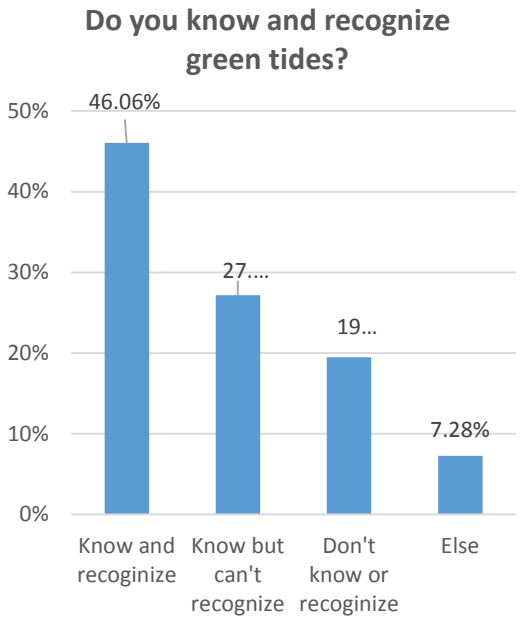
CATEGORY	Recreation Loss	Ecological Loss
Valuation method	CVM	CE
Questionnaires	2149	420
Effective rate	97.28%	95.66%

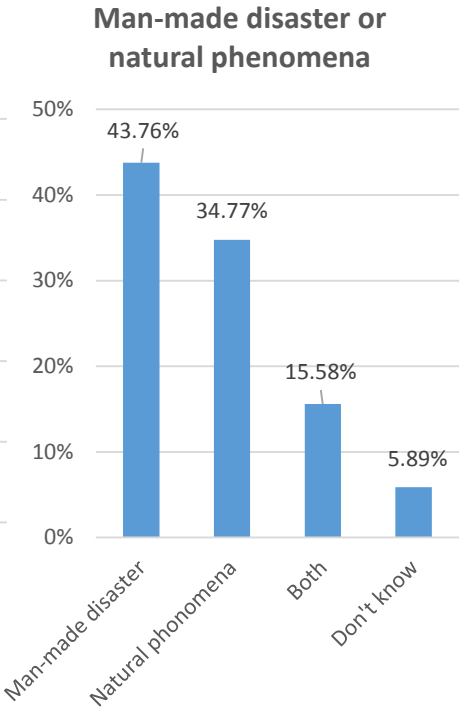
Recreation and ecological damage assessment from green tides in Jiaozhou Bay

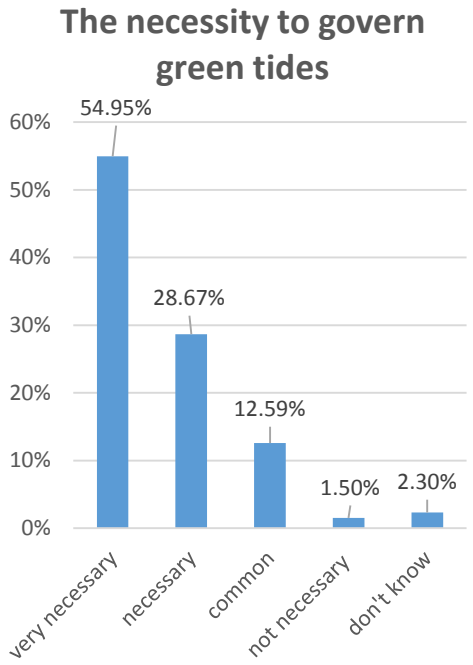
Recreation Loss

The respondents' attitude to the green tides









Recreation Loss

Core question

In order to govern the green tides of your city such that the recreation function of ocean become good, how much are you willing to pay annually for the government and firms to govern the green tides?

Elicitation format

Payment card (PC)

Double-bounded dichotomous choice (DBDC)

Some measures to control the bias of CVM in the valuation of recreation loss

Bias in CVM	Control measures
Information effect bias	Implement the survey **during the period of green tides,** which will help respondents quickly build intuitions about green tides.
Hypothetical bias	Use **Cheap Talk** scrip to remind the respondents of the limited budget and ask them to choose the cost of zero if they are not really pay for the amount they choose. Use **certainty calibration** to better align stated and actual willingness to pay values.
Bias caused by investigator	Train the investigator before investigation.
Starting point bias	Implement pilot survey to know respondents' **possible range of WTP** for the governance of green tides and then set starting point and interval which can simulate approximate distribution of the WTP

Result

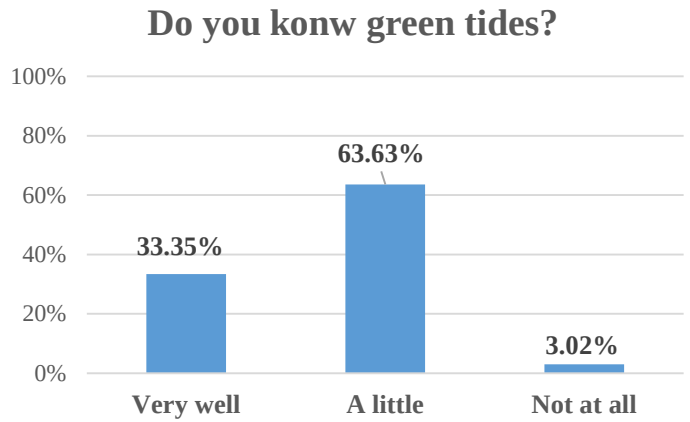
TYPE	Elicitation format	Mean WTP/WTA (Yuan)	Total WTP/WTA (Billion Yuan)	Recreation loss (Billion Yuan)
WTP	PC	36.96	0.34	0.34
	DBDC	68.10	0.63	0.63
WTA (supplement)	PC	252.33	2.32	2.32

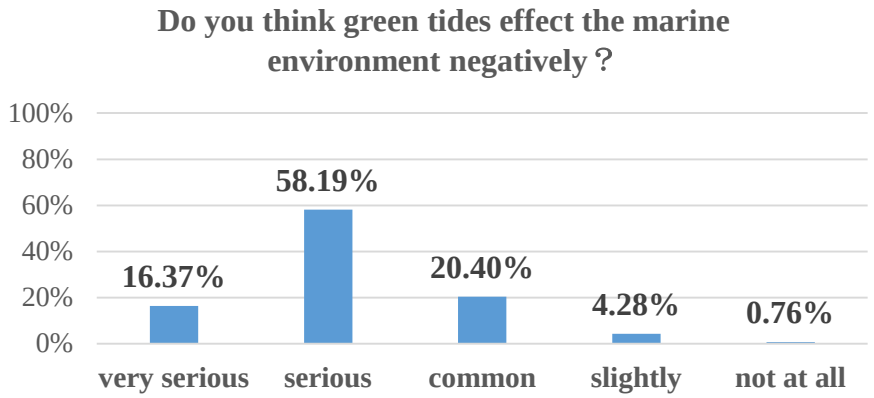
The recreation loss caused by green tides is 0.34-0.63 billion yuan a year.

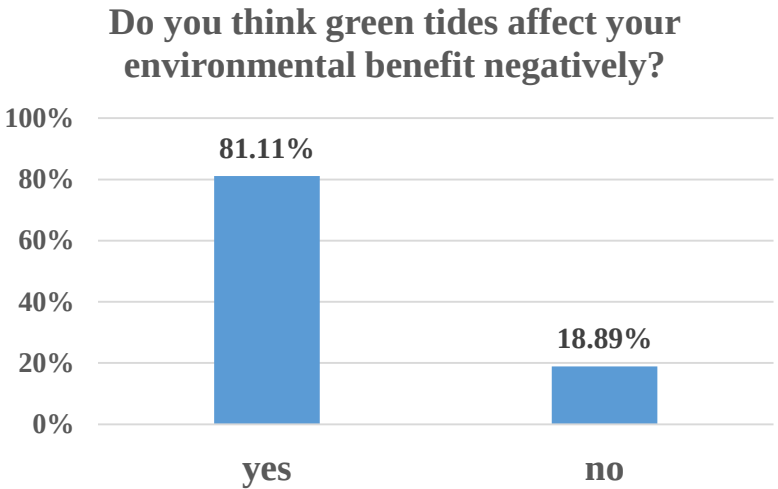
Tourism and ecological damage assessment from green tides in Jiaozhou Bay

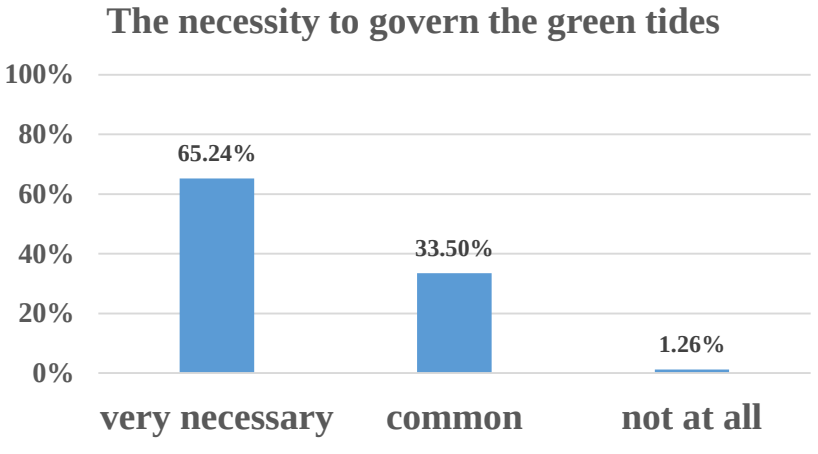
Ecological Loss

The respondents' attitude to the green tides









Recreation and ecological damage assessment from green tides in Jiaozhou Bay

Ecological Loss

Attributes and levels

Attributes	Levels	Explanation
Coastal water quality	Return to the primary level	All the green tides have been salvaged before corruption and the coastal water quality is fully restored as the primary level.
	Slightly decline	A few of green tides sank and the coastal water quality declines slightly.
	Worse*	The effect of governance is bad and lots of green tides sank and the coastal water quality declines significantly.
Marine creature	Return to the primary level	The quality and quantity of affected marine creature such as fishes and shrimps has been improved through governance program and are fully restored as the primary level.
	Slightly decline	The quality and quantity of affected marine creature such as fishes and shrimps has been improved through governance program but are still worse than the primary level.
	Significantly decline *	The effect of governance is bad and the quality and quantity of affected marine creature has declined significantly.
Marine biodiversity	Return to the primary level	The species abundance of marine creature has improved significantly through governance program and are fully restored as the primary level.
	Slightly decline	The species abundance of marine creature has improved slightly through governance program but are still worse than the primary level.
	Significantly decline *	The effect of governance is bad and the species abundance of marine creature has declined significantly.
Willingness to pay	0*, 50,100,200	The willingness to pay for the governance of green tides.

Recreation and ecological damage assessment from green tides in Jiaozhou Bay

An example of a choice set

Attributes	A	B	C
Coastal water quality	Worse	Worse	Worse
Marine creature	Significantly decline	Slightly decline	Significantly decline
Marine biodiversity	Return to the primary level	Slightly decline	Significantly decline
Willingness to pay/Yuan	200	50	0
I choose			

In the case of this study, a full factorial design would have had 3*3*3*4=108 combinations of attributes. Through the use of efficient design principles, we get 15 choice tasks, and separated them into three sets of five tasks per respondent and respondents were randomly allocated one of the three blocks. Each choice task contains a ‘no change’ option at zero cost and two alternative management plans (‘change options’) at positive cost.

Recreation and ecological damage assessment from green tides in Jiaozhou Bay

Ecological Loss

Random Parameters Logit model Results

Variables	Coefficient	Standard errors
X1	0.736***	0.067
X2	0.577***	0.053
X3	0.643***	0.064
Y	-0.004***	0.0006
σX1	0.860***	0.085
σX2	0.465***	0.084
σX3	0.489***	0.124
log likelihood	-1669.430	
Pseudo R^2	0.234	

Implicit price of attributes

Attributes	Implicit price
Coastal water quality	84.92
Marine creature	43.17
Marine biodiversity	49.34

$$CS = -\frac{1}{\beta_p}[\ln(\sum \exp(V^1)) - \ln(\sum \exp(V^0))]$$

Based on the equation above, the ecological damage is 2.8 billion yuan a year.

PUBLICATION:

Application of the choice experiment to the evaluation of willingness to manage Enteromorpha prolifera disasters from the perspective of attribute cut-offs[J]. *Resources Science*,2018,40(10):1943-1953.

Starting Point Bias and its Correction in Double-bounded Dichotomous Contingent Valuation Method——An Application to the Evaluation for the Ecological Damage of Enteromorpha Prolifera Blooms in Jiaozhou Bay[J]. *Statistics& Information Forum*, Forthcoming.

Conclusion

- Green tides bring passive impact on human activities and ecological ecosystem.
- An important purpose of assessment is to give an economic signal to make the responsible party to consider the cost of environmental damage when decisions.
- There are still some bias for the valuation and the correction of these bias is worth further studies.

Acknowledgement
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Thank you !