GEF

UNDP/GEF PROJECT ENTITLED "REDUCING ENVIRONMENTAL STRESS IN THE YELLOW SEA LARGE MARINE ECOSYSTEM"

UNDP/GEF/YS/RWG-I.3/9 rev.1
Date: 29 August 2006
English only

Third Meeting of the Regional Working Group for the Investment Component
Dalian, China, 9-12 September 2006

Final Report on Environmental Valuation of Mariculture

The Second Regional Working Group Meeting for Investment Component agreed (Jeju, Korea, 14-17 November 2005) to develop the regional guideline for Environmental Valuation to contribute to the development of the regional Strategic Action Programme (SAP) and the National Yellow Sea Action Plans (NYSAPs). The Meeting also agreed to conduct the study focusing on mariculture and tourism.

Consultants from School of Economics of the Ocean University of China were contracted to prepare a report which includes the following information:

(1) Suggested regional process for valuing the ecosystem services in the Yellow Sea;
(2) A list of ecosystem services of the Yellow Sea ecosystem categorised by the type of economic value;
(3) A list of priority ecosystem services to be valued for calculating the Total Economic Value of the Yellow Sea ecosystem;
(4) Detailed descriptions of valuation methods to measure the priority ecosystem services, i.e., mariculture; and
(5) Regional guidelines for setting discount rates to be used in the calculation of ecosystem values.

The draft final report was prepared by the School of Economics and attached hereafter. During the 3rd RWG-I Meeting, the consultants will present some summary analyses on the collected data and information; highlight major findings, including the ecosystem services to be addressed in order to comprehend the total economic value of the Yellow Sea ecosystem; and provide the valuation methods for the priority ecosystem services, especially those relevant to mariculture.

After reviewing the reports and presentations, participants will discuss the information presented, particularly the valuation methods relevant to mariculture. The participants will be invited to give suggestions on:

(1) How the findings of this implemented Environmental Valuation case study could be used for the development of a regional valuation guideline;
(2) What topics and/or requirements should be discussed in the regional valuation guideline; and

(3) How the Environmental Valuation could be included in the SAP, and the context in which inputs should be included.

Small Contract for Services
Ref. I-6-prc-valuation-72100

Environmental Valuation of the Ecosystem Services in the Yellow Sea: Focus on Mariculture

Final report

August 2006

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1. Introduction

The Yellow Sea Large Marine Ecosystem is an important global resource and an area being densely populated, heavily urbanized and industrialized and intensively exploited in the world. Today the Yellow Sea faces serious environmental problems. To address these problems, the policy maker and researchers in the region have continued extensive discussions and research activities since the late 1990s with the cooperation of the United Nations Development Programme and the Global Environment Facility. At last, UNDP/GEF project entitled" Reducing environmental stress in the Yellow Sea Large Maine Ecosystem" was set up. Valuing ecosystem services in the Yellow Sea is an essential component of the project. It provides an approach to address the issues in the Yellow Sea from socioeconomic perspectives and help the policy maker to set suitable management plans in maintaining sustainable development of the Yellow Sea. The outcomes of ecosystem valuation will provide critical information to the preparation of the Strategic Action Programme (TDA) and the National Strategic Action Projects.

Mariculture as an important anthropogenic activities in the Yellow Sea , is an developing industry that makes a significant contribution to meet human preference in the form of food fish and food protein in respective nation. With the situation of capture fisheries are being exploited to their sustainable limit and beyond in the Yellow Sea, mariculture play an important role in maintain the human need for seafood. In addition, mariculture contribute to the national economy both in terms of income and employment generation in other supporting sectors. However, with the rapid growth of Mariculture around the Yellow Sea, mariculture has become large enough to have significant impacts on the environment and ecosystem services, e.g. water pollution resulting from pond effluents; excessive use of drugs, antibiotics for disease control; negative effects on biodiversity, conflicts with other resource user (Cui Yi, Chen Bijuan 2005)) and a number of concerns have been expressed by both activists and scientists (Dierberg and Kiattisimukul 1996). In order to develop the mariculture resources in a sustainable way, the project entitled Environmental Valuation of the Ecosystem Services in the Yellow Sea: Focus on Mariculture is proposed by PMO. This project will provide a regional guideline for valuation of Yellow Sea ecosystem focus on mariculture as well as a case study. The guideline aims to present a framework and methodology to assess the economics include financial and environmental benefit (cost) generated from mariculture. Using the guideline , a case study will be carry out to provide an empirical analysis for the current mariculture scale to determine the net benefit or not.

2. Ecosystem services of Yellow Sea

According to the definition of ecosystem service by Daily (1997), marine ecosystem services is defined that the conditions and processes through which marine ecosystem, and the species that make them up, sustain and fulfill human life (Chen 2006). Marine ecosystem services include not only goods but also non-mass services provided by marine ecosystem. Marine ecosystem service is different from marine system services. The former must involve in marine living organisms, e.g. seafood and oxygen production, climate regulation. However the later include non-living goods, e.g. petrol and gas exploitation, direct utilization of sea water, cooling of sea water, chemical products, marine energy and so on. Here we are talking are the Yellow Sea ecosystem services rather the Yellow Sea services. Marine ecosystem services are measured with mass unit. When marine ecosystem service is measured with monetary unit and we get its service value.

2.1 Temporal and spatial scale of marine ecosystem service

Marine ecosystem service has its unique temporal and spatial scale. Usually we consider year as temporal scale of ecosystem service. If time duration is too short, some services, e.g. food production can not be finished and therefore it can’t be calculated accurately. The spatial scale of ecosystem service depends mainly on the area of marine ecosystem and available data. Because the some statistical data for service evaluation are summed up by administrative region and usually come from several sea regions. If the study area is too small, it will be very difficult to distinguish how much service are provided by the target area how much from nearby area. We suggest the spatial scale is not usually less than 100 km^2.

2.2 Yellow Sea ecosystem service

Based on the framework of the Millennium Ecosystem Assessment of United Nations (MA 2005), the classification system of the Yellow Sea ecosystem services have been established (Chen 2006), see Fig. 1. It considers the exploitation status of the Yellow Sea and is appropriate to Yellow Sea marine ecosystem.

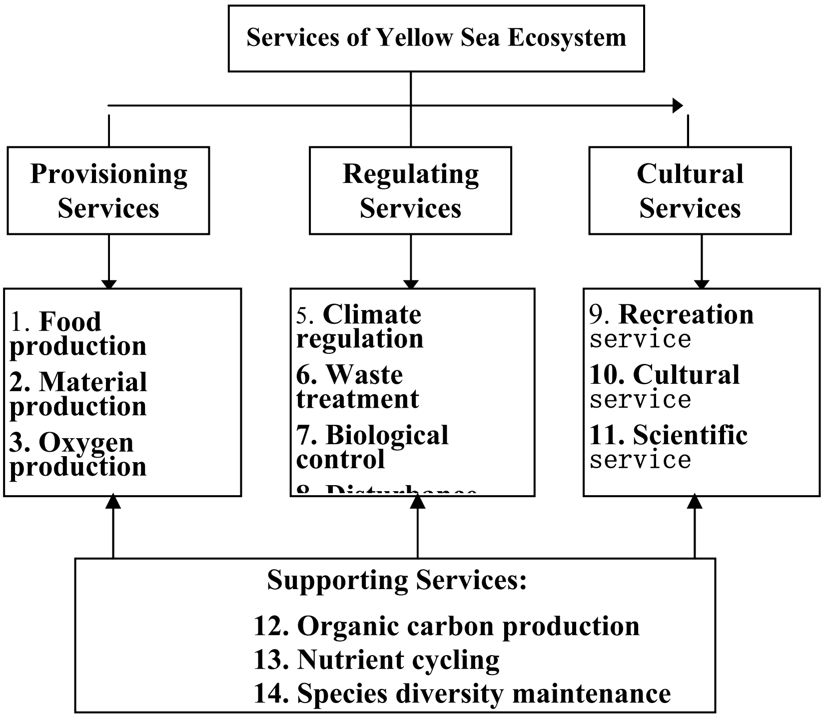

Fig. 1 Framework of ecosystem services of the Yellow Sea

Services of Yellow Sea ecosystem consist of 4 groups and 14 services.

First group is provisioning service. Provisioning service are the products what people obtain from marine ecosystems, which include 4 services:

(1) Food production: production of shellfish, fish, shrimp, crab and kelp etc. through aquaculture and fishing and collecting.

(2) Material production: production of medicine and chemical materials and ornamental material.

(3) Oxygen production: oxygen production finished by marine algae and plant through photosynthesis process.

(4) Provision of genetic resources: wild populations are used to enhance existing cultured species.

Second group is regulating service, which are the benefits people obtain from the regulation of marine ecosystem processes. Including:

(5) Climate regulation: algae may regulate climate through absorbing and emitting of greenhouse gases (CO_2, CH_4).

(6) Waste treatment: the marine living organisms are involved in decomposition and transformation of waste water and waste solid into sea water through river and air deposit.

(7) Biological control: the cultured shellfish feed red tide algae and to reduce the occurrence of red tide events in eutrophicated coastal waters, therefore reduce the damage to people's health.

(8) Disturbance regulation: Coastal wetland can reduce the damage caused by typhoon and storm tide.

Third group is cultural services: which represent the non-material benefits people obtain from ecosystems through spiritual feeling, recreation, tourism, knowledge acquisition and aesthetic experiences.

(9) Recreational value: clean seawater provides places for recreational activities, tourism, swim, fishing, diving etc.

(10) Cultural value: sea provides places for production of movie and TV program, production of music, aesthetic and literary products, educational activities etc.

(11) Scientific value: sea provides places and experimental material for scientific research activities.

Fourth group service is supporting services. Supporting services are the foundational services support for provisioning, regulating and cultural services, including:

(12) Organic carbon production: marine ecosystems fix CO_2 and output organic carbon through algal and bacterial production, which provide material and energy sources for marine ecosystem.

(13) Nutrients cycling: nitrogen and phosphorus into seawater through air and rivers are transformed by marine algae into organic matter, then transfer through food chain, finally go back to the land through the seafood and used by people.

(14) Species diversity maintenance: Some waters function as spawning grounds nursery grounds, overwintering grounds and shelters for many species. These waters maintain the high biodiversity.

3. Economic value of the Yellow Sea ecosystem services

As we know, today the Yellow Sea ecosystem is facing serious environmental problems(the YSLME Project 2000), the major reason for the problems of ecosystem is often the failure to account adequately for ecosystem services's economic value including non-market environmental values in development decisions. So, it is necessary for policy maker, conservation practicer to review the economic value of ecosystem services in marine recourses using and management.

3.1Definition of economic value

Recognising the means of “value” may very from person to person; King and Mazzotta provide a useful summary of the theoretical aspects of economic value. Economic value (or benefits) of a good or a service – for convenience, a service – is measured by the maximum amount of other services that a person is willing to give up in order to have that service. Since it represents how much of all other services that she/ he is willing to give up to obtain the service, the monetary value that the person is willing to pay for that service is commonly used to measure the economic value of the service. In other words, the economic value of the service is measured by the willingness to pay for it.

Detailed definition and measurement of economic value could be found at provisional guideline (UNDP/ GEF YSLME 2006).

So the economic value of an ecosystem service relates only to the contribution it makes to human welfare, where human welfare is measured in terms of each individual's own assessment of his or her well-being.

3.2 Types of economic values (see the Provisional Guideline UNDP/GEF YSLME 2006)

3.3 Economic value of the Yellow Sea ecosystem services

Ecosystem services are valuable because they serve and satisfy human beings. For the Yellow Sea ecosystem, it provide 14 services for human beings(see the figure.1) According to the consensus on the typology of economic values noted in the section 3.2, The economic value focus on the Yellow Sea ecosystem services may consists of the four components as following:

The Direct use value of Yellow Sea ecosystem services: the direct value is the benefits from using the production services and cultural services include the goods (fish, shrimp, raw materials) harvested from the sea and the scenic beauty of a natural view. Note that, the direct use value includes not only consumptive services(fish, raw materials) which are exchanged in markets with price but also non consumptive ones(scenic views), and that the services may or may not be traded in the market. The consumptive services value is generally the easiest to measure by observable quantities and prices of products in a market context. For non consumptive value(scenic views) may be measured by revealed preference approach which will be described in section 5.

The indirect use value of the Yellow Sea ecosystem services: the indirect use value is the benefit from using the regulation services or supporting services of ecosystems. These services include oxygen production, provision of genetic resources, limate regulation, waste treatment, biological control, disturbance regulation and 4 supporting functions. Note that, these services have value without any goods being extracted, produced or harvested, they are only related to economic activities, provide the necessary condition for the production or consumption, their benefits are not exchange in markets. So, the indirect use values are difficult to quantify and are generally ignored in ecosystem management. But environmental economists have developed some valuation techniques for the indirect use value of resource and ecosystem and applied them over many years. Detailed techniques applied in maricultrue will be described in section 5 also.

The option value of the Yellow Sea ecosystem services: the option value reflects the benefits that people receive from holding a future ability to use the ecosystem services. An example is the potential of deriving a cure for cancer from biological substances found on plant or sea mammal. All the direct use value and indirect use value of the Yellow Sea can be seen as the option value for themselves or others(bequest value) future.

The existence value of the Yellow Sea. The existence value is non-use value also.an ecosystem service is non-use but valuable because people place a value on the non-use service for existence. For example, biodiversity became degraded in the Yellow Sea, many people would feel a definite sense of loss. So people would rather to pay for improving or preserving this ecosystem service that they will never use. Non-use value is the most difficult type of value to estimate, since in most cases it is not reflected in production or consumption behavior. But valuation techniques have been developed for non-use value and applied in many cases.

The economic values of Yellow Sea ecosystem services are summarized in table 1.

Table 1 Ecosystem services , type of value and value description of the Yellow Sea

Ecosystem services	Value type	Value description
Food production	Direct use value Option value	The fishery product satisfies the human being need for food. The value can be derived from the actual market directly.
Material production	Direct use value	The raw materials include medicine and chemical materials satisfy the human being need for production and the value can be

	Option value	derived from actual market also.
Oxygen production	Indirect use Option value	The indirect use is determined by the contribution of oxygen production from marine algae and plant to support the current production and consumption.
Provision of genetic resources	Indirect use value Option value	Wild populations are used to enhance existing cultured species. This function support economic activities indirectly .
Climate regulation	Indirect use value Option value	Algae may regulate climate through absorbing and emitting of greenhouse gases (CO_2, CH_4).this services provided by marine ecosystem is important for human health, crop productivity ,recreation and culture activity.
Waste treatment	Indirect use value Option value	Marine can treat relatively large amounts of organic wastes from human activities acting as ‘free’ water purification plants. This service help society to avoid costs that would have been incurred n the absence of this service.
Biological control	Indirect use value Option value	The cultured shellfish feed red tide algae and to reduce the occurrence of red tide events in eutrophicated coastal waters, therefore reduce the damage to people’s health.
Disturbance regulation	Indirect use value Option value	The service relate to providing safety of human life and human constructions.
Recreation and	Direct use	Marine ecosystem have the important value

tourism	value Option value	as a place where people can come for fishing, swimming or enjoy the scenery, meet human need directly. The recreation and tourism service is not consumptive, and the service may or may not be traded in the market, but it can be valued by revealed preference approach.
Cultural value	Direct use value Option value	Use of nature for production of movie and TV program, production of music, aesthetic and literacy, it meets the human need directly.
Scientific value	Direct use value Option value	Use of nature for scientific research activity. it meets the human need directly also.
Organic carbon production	Indirect use value Option value	Marine ecosystems fix CO_2 and output organic carbon through algal and bacterial production, which provide material and energy sources for marine ecosystem. this service benefit the production indirectly.
Nutrients cycling	Indirect use value Option value	Nitrogen and phosphorus into seawater through air and rivers are transformed by marine algae into organic matter, then transfer through food china , finally go back to the land through the seafood and used by people. The benefit derived from the function is supporting and regulating the economic activities.
Species diversity maintenance	Existence value and option value	People believe all species in the marine ecosystem have the right to exist and would rather to pay for the preserving biodiversity even if the species have neither the use

value nor option value.

4. Regional process for valuing the ecosystem services in the Yellow Sea: focus on mariculture

4.1 An introduction of mariculture activity in Yellow Sea

4.1.1 Mariculture activities in the Yellow Sea

There are massive mariculture activities in the Yellow Sea. The mariculture in the Yellow Sea provides a lot of sea food for human's life whilst leads to ecological degradation in the mariculture waters. Mariculture is one general way to utilize the marine ecosystem service-food production. In the Yellow Sea, the major cultured species cover: shellfish, fish, shrimp, crab and macro algae (e.g. kelp). The major mariculture methods include:

(1) Pond culture for shrimp and crab etc.,

(2) Cage culture for fish etc.,

(3) Suspended net for abalone etc.,

(4) Suspended shelf for oyster, scallop and kelp etc.,

(5) benthic culture for clam, sea cucumber and sea urchin etc.

China mariculture statistics in the Yellow Sea in 2004 is shown in Table 2. The total mariculture area in the Yellow Sea reaches 963,204 ha in 2004, in which fish culture area accounts for 18,823 ha, crustacean culture area is 132,791 ha, shellfish culture area is 643,574 ha, macro algal culture area is 47,905 ha, and the other is 120,111 ha. China total mariculture yield adds up to 5,873,797 ton, in which fish yield is 134,453 ton, crustacean yield is125,755 ton, shellfish yield is 4,561,582 ton , macro algal yield is 931,123 ton, and the other is 120,884 ton. The gross economic value of mariculture in the Yellow Sea reaches 3,523,532×10^4CNY in 2004. The seedlings production is also very important and in which, shellfish seedling are most important. The investment of permanent assets for mariculture reached 642,079*10^4CNY. The mariculture practitioners reach 1,101,146 persons in which 50% are from in Shandong province.

In 2004, China mariculture product losses due to hazard in Yellow Sea are shown in table 3. The total loss of aquatic products amounts to 209,835 ton and 161,877×10^4CNY. The diseases and marine pollution (including red tide) are two major hazard and account for more than 80%. At the same time, many fisheries facilities were damaged by natural hazard, and the total economic loss reached 33,989×10^4CNY(Table 4). The suspended facilities, e.g. cage, lantern, net account for 60% of total loss.

Table 2.China mariculture area and yield in Yellow Sea in 2004

Region	Liaoning	Shandong	Jiangsu	subtotal
Maricultured area				
Fish（ha）	5696	9112	4015	18823
Crustacean（ha）	26206	80121	26464	132791
Shellfish（ha）	313788	206882	122904	643574
Macro algae（ha）	13445	22312	12148	47905
The other（ha）	48221	71141	749	120111
Total area（ha）	407356	389568	166280	963204
Mariculture yield				
Fish (ton)	31027	93573	9853	134453
Crustacean (ton)	23781	67631	34343	125755
Shellfish (ton)	1490500	2648177	422905	4561582

Macro algae (ton)	383705	534701	12717	931123
The other (ton)	41366	74758	4760	120884
Total yield (ton)	1970379	3418840	484578	5873797
Seedling				
Fish（×104 ind.）	6458	20516	522	27496
Shrimp（×104 ind）	557	372	84	1013
Shellfish（×104 ind.）	7449703	13673112	1612385	22735200
Kelp seedlings（×108 ind.）	1	77		78
Laver seedlings（×108 ind.）		60	28.35	88.35
Sea cucumber（×108 ind.）	65	58.73		123.73
Gross benefit of mariculture（×10^4 CNY）	1123957	1902220	497355	3523532
Labor force（persons）	215050	525613	360483	1101146
Investment on permanent	149461	245792	246826	642079

assets（×10^4 CNY）				

Table 3　Loss of China mariculture products in Yellow Sea in 2004

Hazard types	Loss of aquatic products	Liaoning	Shandong	Jiangsu	Subtotal
Disease	in Volume tons	14260	29791	42590	86641
	In value (×10^4CNY)	15522	32978	37517	86017
Pollution & Red tide	in Volume tons	32354	32572	33746	98672
	In value (×10^4CNY)	21252	11802	25624	58678
Typhoon	in Volume tons	9050		1016	10066
	In value (×10^4CNY)	2012		1463	3475
The other	in Volume tons	7032	770	6654	14456
	In value (×10^4CNY)	3521	1014	9172	13707
Total	in Volume tons	62696	63133	84006	209835
	In value (×10^4CNY)	42307	45794	73776	161877

Table 4　Damage of fisheries facilities due to hazard in Yellow Sea in 2004

Damage of fisheries facilities	Liaoning	Shandong	Jiangsu	Subtotal
Area of mariculture hazard (ha)	14682	36084	45323	96089
in value($\times 10^4$CNY)	6969	2932	11128	21029
Dyke（meter）	740	1560	26326	28626
in value($\times 10^4$CNY)	510	753	372	1635
Pumping station（#）		44	37	81
in value($\times 10^4$CNY)		18	107	125
Culvert door（#）	10	1	152	163
in value($\times 10^4$CNY)	16	260	99	375
Pier（meter）	40	100		140
in value($\times 10^4$CNY)	100	80		180
Retaining wall（meter）	2470		10470	12940
in value($\times 10^4$CNY)	2720		36	2756

Breakwater（meter）	2130			2130
in value(×10^4CNY)	410			410
The other in value(×10^4CNY)	5	7000	474	7479
Subtotal loss in value(×10^4CNY)	10730	11043	12216	33989

4.2 Identification ecosystem services affected by (or related with) mariculture

Identify the mariculture affecting the ecosystem and their implication including mariculture's production function and damage to the water quality and the impact on creation function etc.

4.3 Screening and Ranking the affected services by proposed criteria

4.3.1 Importance identification.

Identify how important each ecosystem service is in the studied region according to 3 criteria:

(1) The market income of each ecosystem service,

(2) The non-market utilization of each ecosystem service,

(3) The ecological importance of each ecosystem service.

We defined 3 Importance levels to prioritize each ecosystem service:

(1) VERY IMPORTANT LEVEL (***): If market income of one ecosystem service is very high compared with nearby same-scale region, this service is given as the VERY IMPORTANT LEVEL.

(2) IMPORTANT LEVEL (**): if the non-market utilization of one ecosystem service is very massive compared with nearby same-scale region this service is given as IMPORTANT LEVEL. Or if ecological importance of one ecosystem service is very high compared with nearby same-scale region this service is given as IMPORTANT LEVEL.

(3) NOT IMPORTANT LEVEL (*): if one ecosystem service does not satisfy any of above criteria, it belongs to this level.

4.3.2 Identification of ecosystem service affected by Mariculture

Identify the positive and negative effect from mariculture activities on each ecosystem service and prioritize each ecosystem service based on direction and severity of effect. We defined 3 effect levels to prioritize the each ecosystem service:

(1) POSITIVE EFFECT LEVEL (+): If effect of specific mariculture activity on targeted ecosystem service is positive and obvious in the studied region, this service is classified into POSITIVE EFFECT LEVEL.

(2) NEGATIVE EFFECT LEVEL (-): If effect of specific mariculture activity on targeted ecosystem service is negative and obvious in the studied region, this service is classified into NEGATIVE EFFECT LEVEL.

(3) NON-EFFECT LEVEL (0): If the specific mariculture activity has not any effect on targeted ecosystem service or the effect is very light and neglectable in the studied region, this service is classified into NON-EFFECT LEVEL.

(4) UNKNOWN EFFECT LEVEL (U): If effect of specific mariculture activity on targeted ecosystem service is not sure in the studied region, this service is classified into UNKNOWN EFFECT LEVEL.

4.3.3 Assessment of calculability for ecosystem service value

The ecosystem service affected by mariculture activities will be screened based on its value's calculability.

(1) EASY LEVEL (##): if value of any ecosystem service may be calculated based on its market price, it belongs to this level.

(2) DIFFICULT LEVEL (#): if any ecosystem service has not market price but its value may be indirectly estimated based on non-market method, this service falls at this level.

4.3.4 Screening of ecosystem service for evaluation

The ecosystem services which not only fall in VERY IMPORTANT (***) or IMPORTANT (**) Levels but also in POSITIVE or NEGATIVE EFFECT Levels should be quantitatively evaluated. The other services should be qualitatively analyzed. Quantitative valuation is marked as "√", and qualitative analysis as "×". The screening criteria are shown in table 5.

Table 5. Screening of ecosystem service affected by mariculture for valuation

Screening criterion			Valuation type
Importance Level	Effect Level	Calculability Level	
Very Important Level(***) Important Level**	Positive Effect Level(+) Negative Effect Level(－)	Easy Level (##) Difficult Level(#)	Quantitative valuation (√)
Very Important Level(***) Important Level(**) Not Important Level(*)	Non-Effect Level(0) Unknown Effect Level(U)	Easy Level (##) Difficult Level(#)	qualitative analysis (×)

4.3. 5 Screening cases

Following the procedures developed in section 3, three important maricultural activities, i.e. shellfish, fish and macro algae, in the Yellow Sea are analyzed to screen ecosystem service affected by mariculture for valuation.

Table 6 shows the shellfish culture case. According to the above screening criterion, i.e. importance, effect, calculability, these ecosystem services are selected for quantitative evaluation, i.e. food production, material production, oxygen production, climate regulation, waste treatment, organic carbon production, nutrient cycling and species diversity maintenance. The other services, including provision of genetic resources, biological control, disturbance regulation, recreation value, cultural value and scientific value, are selected for qualitative assess. Of course, these suggestion may change depend on specific waters.

Table 7 shows the fish culture case. These ecosystem services are selected for quantitative evaluation, i.e. food production, material production, oxygen production, climate regulation, waste treatment, recreation value, organic carbon production. The other services are selected for qualitative assess. Of course, these suggestion may change depend on specific waters.

Table 8 shows the macro algae culture case. These ecosystem services are selected for quantitative valuation, i.e. food production, material production, oxygen production, climate regulation, waste treatment, organic carbon production.The other services are selected for qualitative assessment. Of course, these suggestion may change depend on specific waters.

Table 6. Screening the ecosystem services affected by shellfish mariculture for valuation

Marine ecosystem service		Screening criterion			Valuation type
		Importance Level	Effect Level	Calculability Level	
Provision services	(1)Food production	***	+	##	√
	(2)Material production	***	+	##	√
	(3)Oxygen production	**	-	#	√
	(4)Provision of genetic resources	*	-	#	×
Regulation services	(5)Climate regulation	**	+	#	√
	(6)Waste treatment	**	+	#	√
	(7)Biological control	*	+	#	×
	(8)Disturbance regulation	*	+	#	×
Cultural services	(9)Recreation and tourism	*	U, case by case	#	×
	(10)Cultural service	*	0	#	×
	(11)Scientific service	*	U case by case	#	×
Supporting	(12)Organic carbon production	**	+	#	√

services	(13)Nutrient cycling	**	+	#	√
	(14)Species diversity maintenance	**	-	#	√

Table 7.Screening the ecosystem services affected by fish mariculture for valuation

Marine ecosystem service		Screening criterion			Valuation type
		Importance Level	Effect Level	Calculability Level	
Provision services	(1)Food production	***	+	##	√
	(2)Material production	***	+	##	√
	(3)Oxygen production	**	-	##	√
	(4)Provision of genetic resources	*	-	#	×
Regulation services	(5)Climate regulation	**	-	#	√
	(6)Waste treatment	**	-	#	√
	(7)Biological control	*	-	#	×
	(8)Disturbance regulation	*	+	#	×
Cultural service	(9)Recreation and tourism	**	+ or – case by	#	√

			case		
	(10)Cultural service	*	0	#	×
	(11)Scientific service	*	0	#	×
Supporting services	(12)Organic carbon production	**	0	#	×
	(13)Nutrient cycling	**	U	#	*
	(14)Species diversity maintenance	*	-	#	*

Table 8 Screening the ecosystem services affected by macro algae mariculture for valuation

Marine ecosystem service		Screening criterion			Valuation type
		Importance Level	Effect Level	Calculability Level	
Provision services	(1)Food production	***	+	##	√
	(2)Material production	***	+	##	√
	(3)Oxygen production	**	+	#	√
	(4)Provision of genetic resources	*	-	#	×
Regulation	(5)Climate regulation	**	+	#	√

services	(6)Waste treatment	**	+	#	√
	(7)Biological control	*	+	#	×
	(8)Disturbance regulation	*	+	#	×
Cultural services	(9)Recreation and tourism	*	0	#	×
	(10)Cultural service	*	0	#	×
	(11)Scientific service	*	0	#	×
Supporting services	(12)Organic carbon production	**	+	#	√
	(13)Nutrient cycling	**	+	#	√
	(14)Species diversity maintenance	*	-	#	×

5. Methods and valuation techniques for assessment the economic and environmental impact affected by mariculture.

Various methods are available to measure economic values. According to ADB （1996）， there are two main types of methods: primary and secondary methods. The former requires to collect and analyse field data(i.e, primary information source), while the latter uses the finds of the studies that employed primary methods(i.e , secondary information source). Discussing the primary methods followed by the secondary ones, this second overviews the major techniques to value the benefits of ecosystem services. At the end of this section, the application of the methods which are commonly used for measuring specific economic values is also described.(provisional guideline UNDP/GEF, YSLME 2006)

5.1 Primary valuation methods(see the provisional guideline UNDP/GEF YSLME 2006)

5.2 Secondary valuation methods------- Benefit transfer

5.2.1 An overview of benefit transfer

Benefit transfer refers to the process by which a demand function or value, estimated for one environmental attribute or group of attributes at a site, is applied to assess the benefit attributable to a similar attribute or site (Guy Garrod 1999).

Compared to other more basic economic evaluation methods on project appraisal, benefit transfer is a less costly and more feasible approach, particularly due to the constraint of research data, budget and time.

As a matter of fact, it is an indirect method for economic evaluation. It adopts the research results from one or more basic evaluation methods and “trans-plant” them to the targeted project after making necessary adjustments.

Although the effects of the “source” or “study” site (the site, or sites, at which the original valuation study was conducted) do not have to be exactly the same as that of the “target” or “policy” site (for which benefits estimates are required), it is expected that they are comparable in the following aspects:

(1) Service functions, including the characteristics, the ranges, degree as well as the duration of environmental effects.

(2) Market condition. This actually shows people’s preferences and expectations towards the economic valuation on environmental effects, including the sizes and socio-economic characteristics of the relevant populations.

(3) The lapse of time between the two sites should not be too long. It is only in a suitable time lapse can data be adjusted.

5.2.2 Summary of pros and cons of BT

Benefit transfer has been a widely used methodology in policy analysis and natural resources decision making for decades, but many issues remain unresolved. The accuracy of the method depend on the availability of data, generally speaking, the more difference between the original study sites and target sites, the less accuracy of estimation. The summary of pros and cons of BT is as following:

(1) Pros of the benefit transfer

1) Benefit transfer is typically less cost than conducting an original valuation study.

2) Economic benefits can be estimated more quickly than when undertaking an original valuation study.

3) The method can be used as a screening technique to determine if a more detailed, original valuation study should be conducted.

4) The method can easily and quickly be applied for making gross estimates of recreational values. The more similar the sites and the recreational experiences, the fewer biases will result.

(2) Cons of Benefit transfer

1) Benefit transfer may not be accurate, except for making gross estimates of recreational values, unless the sites share all of the site, location, and user specific characteristics.

2) It may be difficult to track down appropriate studies, since many are not published.

3) Reporting of existing studies may be inadequate to make the needed adjustments.

4) Adequacy of existing studies may be difficult to assess.

5） Unit value estimates can quickly become dated.

(Source from http : www.ecosystemvaluation. org/ benefit _transfer. htm)

5.2.3 The circumstances and ecosystem services for appropriate benefit transfer

1) The target site (the region to which estimated economic benefits are transferred) context should be thoroughly defined. The extent, magnitude, and quantification of the expected impacts from the proposed policy action on the target (policy site) should be identified. The availability of current primary and/or secondary data at the policy site and further data needs for benefit transfer application should be identified also, including the type of measurement (unit, average, or marginal value), the kind of value measured (use, non-use, or total value).

2) The original study site should meet certain conditions for successful benefit transfer. It is necessary that original study sites transferred should be based on adequate data, sound economic method, and correct empirical technique (Freeman 1984).

3) The study site(s) and the target site (policy site) should exhibit an adequate level of similarity in terms of the environmental resource evaluated, the nature of an environmental change, and the characteristics of the affected populations and sites.

4) As a less costly and time saving method, the primary goal of benefit transfer practice is to estimate economic benefits of non-market activities with an acceptable degree of accuracy for one context (a policy site) by transferring benefit estimates from some other context (a study site). It was used in natural recourse damage assessment(James J. Opaluch and Marisa J. Mazzotta) health risk from surface water contamination (susan Kask) , recreational fishing benefits(Mary Jo Kealy). Among the marine ecosystem services, recreation value and biodiversity are typical non-market value. Although environmental economists have developed particular methods for valuing the non- market benefits of ecosystem services in CVM or TCM, both of them are too costly and take too much time to conduct, Speedy and inexpensive yet acceptably accurate alternative method of estimating non- market value would be necessary in increasingly many occasions. As a result of the increasing demand for non-market valuations under time and financial constraints, benefit transfer is appropriate to value the target site (policy site)recreation or biodiversity value. From the view of historical background of benefit transfer, the practice of benefit transfer became popular in the economic analysis of the consequences of environmental regulations in the United States during the mid1980s. Both the U.S. Water Resources Council's and the U.S. Forest Service's RPA used the benefit derived from past empirical studies to value various outdoor recreation activities. So among marine ecosystem services, the valuation of recreation service or biodiversity service is appropriate for benefit transfer method. As noted above, the circumstance referring to the adequate level of similarity in terms of the environmental resource evaluated, the nature of an environmental change, and the characteristics of the affected populations between the study site and target site are critical.

5.2.4 List and examine existing online databases for the Benefits Transfer approach,

The list below summarizes existing information sources relevant to this study:

(1) Environmental Valuation Reference Inventory (EVRI)

The Environmental Valuation Reference Inventory (EVRI) is a North American database of valuation studies accessible through the Internet. EVRI was designed by Environment Canada, and both Environment Canada and US EPA currently use EVRI to guide their policy work. At present, the database contains detailed information of about 700 environmental valuation studies, primarily from North America but with about 10 % of its studies from Europe. One of the potential uses of the database is in facilitating benefits transfer — the transfer of a monetary valuation for an environmental asset from an existing study to a similar environmental asset.

1) Pros of EVRI

- ✓ Searchable storehouse of over 800 empirical studies on the economic value of environmental benefits
- ✓ Developed as a tool to help policy analysts use the benefits transfer approach

2) Cons of EVRI

- ✓ Information in the EVRI is available to subscribers only
- ✓ Few original study sites are from developing country.

(2) ENVALUE: A Searchable Environmental Valuation Database EPA Economy and Environment

The ENVALUE environmental valuation database, developed by the NSW EPA and first released in 1995, is a systematic collection of environmental valuation studies presented in an on-line database. It is expected that the ENVALUE database will assist decision makers in government and industry as well as academics, consultants and environmental groups, to incorporate environmental values into cost-benefit analyses, environmental impact statements, project appraisals and overall valuation of changes in environmental quality.

1) The pros of ENVALUE:

- ✓ Systematic collection of environmental valuation studies presented in an on-line database
- ✓ Database provides guidance on transferring estimates to other sites
- ✓ Values estimated by the original studies have been converted into A$ 1997 values and can be shown in other currencies as an option
- ✓ Summaries and results reported in the database were subject to a process of peer review
- ✓ More than 125 studies of “Natural Areas” are summarized

2) Cons of ENVALUE

- ✓ Few study on marine ecosystem services

- ✓ Most study cases are from U.S.A , U. K and Australia.

5.2.5 Basic steps in benefit transfer

Generally speaking, there are 4 steps involved in benefit transfer:

(1) Literature search. Combing through available literatures such as journal articles, working papers, books, unpublished government reports, conference papers and select useful data that are applicable to the policy site, while at the same time keep the following basic rules:

1) There are similarities between the study site and policy site in their degrees and specifications of the expected environmental changes.
2) If possible, choose the analysis or researches that similar to the policy site in terms of the population and location. This is because economic values shows preferences based on social economic characteristics, etc.
3) Careful considerations should be adopted in terms of the differences in society, economy and culture of the researches. Sometimes the values that the study sites are based on do not necessarily exist in the target sites.
4) The technical standards of the research done in the study sites should be evaluated and appraised, including whether or not they are sufficient information support, whether they are based on sufficient resources, whether the economic valuation method is reasonable.

(2) Make value adjustments.

It is most likely that the characteristics of sites and affected populations and the nature of environmental changes at the study and policy sites are not identical, adjustment processes for the selected study site benefit estimates or benefit function to better reflect the differences in these attributes. More systematic adjustments of study site benefit estimates could provide more reliable and valid benefit transfer estimates for the policy site. Different approaches have been used to make value adjustments, including Value transfer , function transfer and Meta-analysis. Detailed discussion regarding to their transferability will be provided in the following section.

(3) Calculate value per time unit

The total value per time unit effect is obtained by multiplying the value by relevant population. For instance, suppose the estimated potential payment for a specific illness in the proposed project area is ￥10 per illness per day, the average duration for this illness is 7 days and it is estimated that 1% of the 2 million populations in the project area will be affected during the 1^{st} year of this project.

Therefore, the total value for each person is ￥10×7＝￥70, the total value for the project's 1^{st} year is $140. In addition, if the affect changes over time, estimations for the total value of each period is to be calculated individually.

（4） Discount the total value

There are mainly 2 tasks in this step:

1） Specify the time periods in which the effects are expected to appear. It should be noted that normally the cost and return of a project appears at different periods. Typically, cost incurs at the very beginning of the project, whereas returns and damages appear long after a project finishes.

2) Apply the suggested discount rate (and any other appropriate discount rate for the purpose of sensitivity analysis) and calculate the discounted annual return or loss. The same treatment of inflation rate (that is, both use actual inflation rates or both use nominal inflation rates) should be apply in calculating discount rate and effect value.

5.2.6 .Benefit Transfer Approaches

This section briefly explores how different approaches have been used to implement Benefit Transfer of environmental values, and assesses the validity and accuracy of these attempts.

(1) Value transfer method

This is simplest technique of benefit transfer. it estimate aggregate economic value of recreation activities or environmental resources (e.g., recreational fishing or water quality improvement) at the policy site by simply taking a single mean unit value (consumer surplus per trip or per day) or the average of several mean unit values from study site estimate(s), and multiplying this by the number of the affected population and possibly by their estimated recreation trips at the policy site.

The main underlying assumption with these value transfer methods is that the change in welfare for an average individual at the study site would be equivalent to the change in welfare for an average individual at the policy site. If the physical characteristics of the policy and study sites, the socio-economic profiles of relevant populations, or the nature of environmental resources or changes being evaluated is different, direct transfer of benefit estimates could be misleading.

(2) Function transfer method

Adapted policy site benefit transfer estimates can be predicted by inserting the mean values of the study site function's variables available at the policy site into the benefit function estimated at the study site. Function transfer assumes that underlying behavioral relationship between a recreation trip and the variables representing site and population characteristics is identical, and adjusts to the differences in these variables between the policy and study sites. Compared to value transfer benefit estimates, function transfer benefit estimates tend to be less biased from primary study value estimates available at the policy site (assumed true value for the purpose of convergent validity test) possibly due to more systematic adjustment by inserting available policy site mean values into the estimated study site benefit or demand function.

(3) Meta-analysis method

Meta-analysis improves upon some intuitive judgment by using data-based aids to explain variations in estimated benefits across different studies. It attempts to assess environmental values by investigating the relationship between benefit estimates, the features of the goods, and the assumptions of the models, with the explicit aim of applying past results to future resource policy decisions. Meta-analysis thus entails the systematic application of statistical methods to assess common features and variations across a wide range of prior studies.

Meta-analysis can be undertaken using a variety of techniques, encompassing both qualitative and quantitative econometric methods. It is a relatively underdeveloped field of enquiry in the assessment of the transferability of benefit estimates. Meta-analysis should not be seen merely as modifying existing estimates to produce a value for a new policy situation; but also as a means of investigating the factors and issues involved in the derivation and construction of values.

5.3 The methods to value the ecosystem services affected by mariculture

Mariculture has different impacts on the marine ecosystem services and the valuation methods of these impacts are different accordingly. As noted above, the most important impacts should be emphasized and the selection of valuation methods should be based on their feasibility and manoeuvrability. Under the principles above, the selection results and valuation methods of mariculture's impacts on marine ecosystem are displayed in the table below (classification of mariculture's positive and negative effects on marine ecosystem will be discussed in benefit-cost analyses)

Table 9 The valuation methods of ecosystem services affected by mariculture

Marine ecosystem service value	Tapes of mariculture in the Yellow Sea					
	Shellfish culture		Fish culture		macro algae	
	Screen result	method	Screen result	method	Screen result	method
Food production	√(+)	Market price	√(+)	Market price	√(+)	Market price
Material production	√(+)	Market price	√(+)	Market price	√(+)	Market price
Oxygen production	√(−)	Related good method	√(−)		√(+)	Related good method
Provision of genetic resources	×					
Climate regulation	×		×		×	

Waste treatment	√(+)	Avoided cost	√(−)	Effect on production	√(+)	Avoided cost
Biological control	×					
Disturbance regulation	×					
Recreation value	?	CVM or TCM	√(−) or (+)	CVM or TCM		CVM or TCM
Cultural value	×					
Scientific value	×					
Organic carbon production					√(+)	Related goods method
Nutrient cycling	×		×		×	
Species diversity maintenance	√ (-)	CVM	√(−)	CVM	√(−)	CVM

√ Quantitative valuation ; ×qualitative analysis ; (+) positive effect ;(-) negative effect

6.Valuation of mariculture's impact on ecosystem services

6.1 Valuation of mariculture's impact on ecosystem direct use value

（1）Direct use value of mariculture

Mariculture is one general way to utilize the marine ecosystem service-food production. Mariculture systems operate in coastal waters at depths less than 15m in intertidal mudflats, shallow seas and bays, but recently, mariculture areas have expanded to depths up to 50m.(Yang YuFeng, Li ChunHou, 2004). It is defined as the cultivation, management and harvesting of marine organisms in their natural habitat or in specially constructed rearing units, e.g. ponds, cages, pens,enclosures or tanks.(sustainable aquaculture- working document, PMO, 2006). So mariculture impact on ecosystem direct use value is the economic benefit of mariculture development. In another words, mariculture impact on ecosystem direct use value is the direct use value of Mariculture. Because the products provided by Mariculture are exchanged in markets, so the direct use value can be estimated by market price method.

1) Market price method

The economic value of mariculture products are basic value for their qualities as goods, meet human preference in the form of food protein, fishmeal which are trade in markets. According to King and Mazzotta ‘s definition, the economic value of a good or service is measured by the willingness to pay for it. The willingness to pay for the services or goods can be derived from its demand.(the Provisional Guideline, PMO,2006)

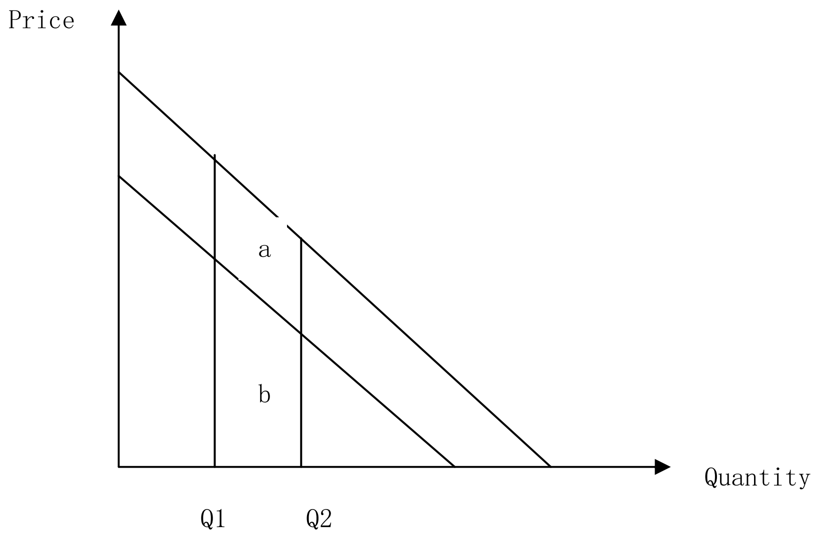

Figure 2: shown the mariculture benefit use the demand curve compare to the capture benefits only in the Yellow Sea.

For the case of economic value of mariculture, figure 2 shows two demand curves, and on the horizontal axis two quantity levels are indicated. Suppose Q1 is the quantity of capture in the Yellow Sea, Q2 is the quantity of mariculture, so for the lower demand curve the benefit of mariculture are equal to an amount shown by area *b*, where’s the benefit in the case of the higher demand curve are equal to the total area *a+b* Suppose the increased area *(a+b) +a* is the increased willingness to pay, that is the economic value of mariculture.

The economic value of mariculture should be measured in this way including maximum willingness to pay and the actual. Due to limitations in available data or resources , however, the existing prices of concerned ecosystem services ,,,,,may be used as the proxy for the maximum willingness to pay for the services(Provisional Guideline, PMO, 2006) so the economic value of mariculture could be measured from actual market data while the goods are bought and sold.

2) Applying the Market Price Method

The market price method uses prevailing prices for goods and services traded in markets, such as shellfish or fish sold commercially. Market price represents the value of an additional unit of that good or service, assuming the good is sold through a perfectly competitive market (that is, a market where there is full information, identical products being sold and no taxes or subsidies).

The basic formula is:

$$Vj=\sum_{i=1}^{n} Sij \times Wij \times Pij$$

Where, j=(1,2,3,,,n) is different tapes of mariculture

i=(1,2,3,,,n) is species of every tape of mariculture

Vj: Economic Value of mariculture product

S: mariculture area (ha)

W: mariculture output per unit area (kg/ha)

P: Average price of mariculture product

3) Data and information requirement:

- ✓ Mariculture product market price
- ✓ If the market is non-competitive, a subjective judgement (shadow price) is needed. e.g. when taxes or subsidies are present in mariculture , shadow price is needed.

(2) Valuation of mariculture's impact on recreation and tourism value

During this century, sport fishing of wild and stocked game fishes in lakes, rivers, and along coasts has become one of the most popular recreational activities internationally(FAO 1996). With the economic growth in China , the demand for recreation and tourism such as sport fishing, swimming or just walking in the seaside is increasing also. Mariculture, one side, might be developed into entertaining region, can supply recreational values by providing fishing in farming ponds . for example, Red Island clam festival has become a popular event in Qingdao. However, the exploitation of beach and ponds has damaged the integrity of coastal sight, e.g. construction of aquatic product ponds deforms the topography and physiognomy of the coastal belt; the interweaving intake pipes and filtering routes, as well as the sand ponds and water channels, have great impacts on the maintenance of beach view. (Xie Donghai, Han Qi, 2005) In particular, mariculture will deprive the benefits in the development of recreational tourism in regions where certain limited resources are already reserved for tourism in the coastal belt function scheme. Such losses are the opportunity costs of mariculture. No matter Mariculture supply recreation value by providing fishing in farming area or damage recreation value by constructing the pond , the impact on recreation and tourism can be valued by Travel Cost Method.

1) Nature of Travel –Cost Method

The travel cost method (TCM) uses the cost of travelling to a non- priced recreation site as a means of inferring the recreational benefits which that site provides.

The technique rests on actual quantity and cost data and so should provide true values. A demand curve is derived from the quantity and cost data, using standard procedures and a few plausible assumptions. Benefit is then valued as willingness to pay, and measured as the area under the curve. Recently, several ways have be developed to approach travel cost method, which including the zonal travel – cost method(Clawson and Knetsch 1966) , the individual travel – cost method, random utility models, hedonic travel cost method (Brown and Mendelsohn, 1984) . Compare the different ways, every way has the advantage and limitation and ask for different data collection. Considering the objective of the project, recreation impact is only one of the multi impacts of mariculture, the guideline will focus on the ZTCM which is the simplest and least expensive approach

ZTCM is based on data relating to the zones of origin of site visitors. The zonal travel – cost model approach defines the trip generating function as:

$$V_{hj}/N_h = f\left(P_{hj}, SOC_h, SUB_h\right)$$

Where, the dependent variable V_{hj}/N_h is the participation rate for zone h (visits per capita to site j), with independent variable comprising P_{hj} the cost of travel from zone h to site *j*, SOC_h a vector of the socio- economic characteristic of zone *h*, and SUB_h a vector of substitute recreational site characteristics for individual in zone *h.*

2) Application of the Zonal Travel Cost Approach

- ✓ Identify site and data collect data from visitors relating to their points of origin and the number of visits to the site in the specified time period(e.g. a year)

- ✓ Define zones of origin and allocate visitors to the appropriate zone. These may be defined by concentric circles around the site, or by geographic divisions. In China origin zone can be define by administrative divisions.
- ✓ Calculate zonal visits per household or per 1000 zone population to the site and average travel cost from each zone to the site. This is simply the total visits per year from the zone, divided by the zone's population in thousands.
- ✓ Calculate the average travel cost per trip
- ✓ Estimate the demand function for the average visitor. Using regression analysis the equation that relates visits per capita to travel costs and other important variables. From this, the researcher can estimate the demand function .In this simple model, the analysis might include demographic variables, such as age, income, gender, and education levels, using the average values for each zone.
- ✓ The sixth step is to construct the demand function for visits to the site, using the results of the regression analysis.
- ✓ Estimate the total economic benefit of the site to visitors by calculating the consumer surplus, or the area under the demand curve

3) Data and information requirement

- ✓ number of visits from each origin zone (usually defined by zipcode)
- ✓ demographic information about people from each zone
- ✓ round-trip mileage from each zone
- ✓ travel costs per mile
- ✓ the value of time spent traveling, or the opportunity cost of travel time

(Source from the web site: www. ecosystemvaluation.org)

6.2 Valuation of mariculture's impact on ecosystem indirect use value

(1) Valuation of negative influences of added sewage

With immense economic gains from mariculture, also comes a severe threat to the eco environment. Especially in the Yellow Sea coastal area where abounds in large-scale mariculture bases, the heavy direct discharge of undisposed sewage into the sea has brought about serious adverse impacts on the inshore ecosystem. For example,the accumulation of waste feeds and fish faces in the sediment give rise to anoxic conditions resulting in an anoxic layer of sediment and bottom waters depleted in oxygen. Under anoxic conditions , ammonia, hydrogen sulphide and methane are released from the sediment, posing a threat to fish, shellfish, as well as other marine organisms. (Yang Yufeng, Li Hunhou 2004, Cui yi, Chen Bijuan 2005). If the linkage that sewage from mariculture (self pollution) influence the profitability of producers by reducing their outputs is identified by scientists, here Effect on Production (EOP) approach is adopted to estimate the losses of ecosystem's sewage disposure function, which is brought about by intensive mariculture.

1) Nature of EOP

Environmental project or regulation may influence the profitability of producers by constraining the production process, and hence either increasing their production cost or reducing their output. Where such regulation or project has an effect on the price and supply of goods, it also impinges on the welfare of consumers. If this is the case then the impact of an environmental project or regulation can be measured by the value of the change in output it causes: this is effect on production approach (EOP) This approach can estimate the magnitude of both negative and positive impacts, e.g. the impact on fishery of water pollution (negative) , water quality improvement (positive) . In this case, sewage from mariculture (self pollution) influence the profitability of producers by reducing their outputs. where such result has an effect on the price and supply of goods. so the valuation of negative influences of added sewage from Mariculture can be measured by EOP.

2) Application of EOP

- ✓ Estimate environmental changes' physical effect and scale on receivers. e.g. suppose one sequence of mariculture pollution is illness and death of fish and shells, influenced area is ***ha) .This may be done in a number of ways , e.g. by estimating a damage function in a dose-response model, Or by using controlled experiments to observe the outcome when a given effect on control group is deliberately induced.
- ✓ Estimate the above influences' impact on costs or output. Illness and death cause ***% loss of aquatic products output, and assuming without such impacts, the output would be *** kg/ha, so the output loss would be *** kg/ha
- ✓ Estimate the market value of change in output. Assume the output of shells will decrease ***kg/ha as pollution increases, the influenced scale being *** ha. If the price of certain shell is *** yuan/kg, then the loss of this shell caused by mariculture pollution would be ***kg/ha×***ha×*** yuan/kg.

Assume that the economic effect (E) of environmental changes is represented by the output, price, and cost of influenced product, that is, the change of net production, and here we could apply the formula below:

$$E = \left(\sum_{i=1}^{k} PiQi - \sum_{j=1}^{k} CjQj \right)_x - \left(\sum_{i=1}^{k} PiQi - \sum_{j=1}^{k} CjQj \right)_y$$

Where E = effect on production

P=price of product

C=cost of product

Q= output of product

i= （1，2，3，，，，k) kind of product

j= (1，2，3，，，，，k) kind of input

X= Before environmental change

Y= After environmental change

3) Data and information requirement `

- ✓ The linkage between the mariculture pollution and the yield loss.
- ✓ The market price of related goods.
- ✓ If the goods or service is non- market , the substituted goods information is necessary.

4) Limitation of this method

Although EOP is one of the most widely used with the advantage of being easily aggregated and observable. There are clearly a number of limitations to the EOP approach.

- ✓ Some of the physical relationships between activities affecting the environment and the resulting effect on output changes are not well understood.
- ✓ It is difficult to separate the physical effects of pollution from one source from those generated by other sources.

(2) Valuation of mariculture 's impact on Oxygen production value

Shellfish and macro algae can increase or decrease O2, improve or degrade ecosystem function. Because the product oxygen which mariculture provide is public product with non-market price, the benefit is difficult to priced. Although environmental economists have explored different ways to value non- market goods or services, such as contingent valuation, surrogate market price which will be describe as following, it commonly require complex sometimes questionable sets of assumption. So , the approach and the result should be treated with caution. In this guideline the method to value the O2 generated by mariculture will be elicited as following, and the result can be clearly explained to decision maker instead of aggregate the data to the benefit of mariculture directly. The economic valuation of

Mariculture' s impact on oxygen production value can be defined by related good method

1) Nature of related good method

Related good method use of an actual market price of a related good or service to value this function that is non-marketed. This method just provide a rough indicator of economic value, subject to data constraints and the degree of similarity or substitutability between related goods.

In the case of Oxygen production value, oxygen production generated from Mariculture is benefit or cost which are not exchange in market, but oxygen production do benefit to society or support the human being economic activity. According to ADB (1994), there is a related good method for the non market oxygen function value. That is industrial use Oxygen value can be substitute good.

2) The application of the related good market prices

$$V_0 = \sum_{i=1}^{n} \Delta Qi \times P$$

Where i=(1,2,,,n) is the is species of every tape of mariculture

$\triangle Q_i$ increased or decreased oxygen every unit Mariculture output（? O_2/ kg）

P: Price of oxygen for industrial use

4) Data and information requirement

- ✓ the data of substituted price
- ✓ the output of oxygen unit aquaculture
- ✓ similarity between non-market good and a marketed product.

(3) Valuation of mariculture's impact on waste treatment value

Another impact on the indirect value of marine ecosystem generated from mariculture is to absorb the sewage from the river or land. In this case, an avoided cost (replacement cost) method could be adopted to assess the benefit of the Mariculture. In order to elicit the benefit, the study will use unit cost of waste treatment factory to be as proxy for the value generated from mariculture. So the benefit of waste treatment may be defined to potential benefit by mariculture with the avoided cost method. Here we need to assume that waste treatment investment respond to the pollution from inland and other sources.

1) Nature of Avoided (Damage) Cost Method

The avoided (damage) cost method uses either the value of property protected, or the cost of actions taken to avoid damages, as a measure of the benefits provided by an ecosystem. In the case of mariculture , shellfish and algae culture can treat relatively large amounts of organic wastes from inland and acting as 'free' water purification plants. so, the value of natural waste treatment by shellfish and algae culture which can be (partly) replaced with costly artificial treatment systems.

2) Application of the Avoided Damage Cost

- ✓ Assessing the environmental service(s) provided. This involves specifying the the waste absorbing level unit shellfish or algae kg or unit ha.
- ✓ Estimate the potential physical damage to property or potential management
- ✓ Calculate the value of potential damage to property or the amount management spent to avoid such damagement.

The basic formulae is:

$Vw = Cw \times Qw$

Vw =Value of mariculture's sewage disposure

Cw = Cost of unit sewage disposure (yuan/kg) in waste treatment plant

Qw = Quantity of disposed sewage from mariculture's purification ability (kg/ha or kg/kg)

3) Data and information requirement

- ✓ Purification quantity from Mariculture
- ✓ Cost of artificial treatment in plant
- ✓ Suppose that no related benefit from artificial treatment in plant

6.3 Valuaiton of mariculture's impact on ecosystem existence value

As an industry which is defined as the cultivation, management and harvesting of marine organisms in their natural habitat or in specially constructed rearing units, e.g. ponds, cages, Mariculture has impact on marine ecosystem biodiversity.

Mariculture can modify, degrade or destroy habitat, disrupt trophic systems, deplete natural seedstock, transmit diseases and reduce genetic variability. For example, coastal mangroves have been converted into shrimp ponds, enclosed or semi-enclosed waters have been affected by nutrient loading (or stripping), and benthic habitats affected by bivalve bottom culture practices as well as by sedimentation. However, Mariculture could also provide local biodiversity enhancement under certain circumstances, for example birds could be attracted to mariculture sites and artificial reefs, acting as species aggregating devices, may result in enhanced biodiversity. In situ coral replanting programmes have also proved to have a positive effect on reef biodiversity. (Sustainable Aquaculture-working document, UNDP/GEF YSLME 2006). As noted in section 3, Biodiversity is typical existence value which reflects people's willingness to pay for improving or preserving ecosystems that they will never use. Contingent valuation method is the only effective means of quantifying existence value by monetization. This method is realized by investing consumers' WTP or WPT. WTP can measure the whole value, including commercial value and consumer surplus, of any existence, such as forest, natural protection zone, endangered species, environmental commodities, and etc. This research aims to quantify and evaluate the biodiversity value of Yellow Sea ecosystem service function by CV study based on WTP investigation.

(1) Nature of Contingent Valuation Method

The contingent valuation method involves directly asking people, in a survey, how much they would be willing to pay for specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services. It is called "contingent" valuation, because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service (Dennis M. King, Marisa Mazzotta 2006). Contingent valuation is one of the only ways to assign dollar values to non-use values of the environment—values that do not involve market. In the case of Mariculture In the Yellow Sea, as noted above, mariculture has native or positive impact on biodiversity, so the impact valuation can be estimated by CVM.

(2) Application of a contingent valuations study

1) Setting up the contingent valuation or hypothetical market

The mariculture around in Yellow sea is a developing industry which contributes to the local economy as well as the supplement for animal protein to majority of people in coastal area. But the intensive Mariculture has the impact on ecosystem biodiversity. In order to give some attention to improve management on biodiversity, Individuals might be asked how much they would to pay to conserve the biodiversity via proposed protection.

2) Eliciting WTP or WTA Bids

Bids are obtained through some form of questionnaire survey and elicitation format, in which individuals are asked to state their maximum WTP for the environmental good (biodiversity); or their minimum WTA compensation for the environmental good. The principle elicitation methods are:

- ✓ An open- ended question in which no value is specified and individuals are asked a simple question on their maximum WTP for the good; e.g.

‘ Suppose the Yellow Sea authority charge a fee to protect the service of biodiversity. What is the most you would be willing to pay to conserve it per person per year?’

Considering the respondents especially in China have no prior experience of purchasing the environmental good – biodiversity then respondents may experience considerable difficulty with this format. For this reason some organization (NOAA ,1993) advocated that open –ended formats should not be used to elicit non-use or passive use values for environmental goods which there is no market in the good or a similar good.

- ✓ A closed – ended question in which a range of values are specified and the respondents choose one of the values; e.g.

‘ Suppoes the Yellow Sea authotity charged a fee to enter to protect the service of biodiversity. What is the most you would be willing to pay to conserve it person per year?’ (please circle one value)

￥ 1 ￥2 ￥3 ￥4 ￥ 5 ￥6 ￥ 7 ￥8 ￥9 ￥10’

Such a format anchors the respondent’s answer to the range of values presented, although they can be offered an ‘ other’ category in which they specify a value.

- ✓ An iterative bidding format or series of dichotomous choice questions. The iterative bidding approach begins as a dichotomous choice question: is the response willing to pay ￥ *** for the environmental good. Depending upon the response, the respondents is the asked if she would be willing to pay ￥ *** =/- 1 and if the answer is affirmative, then ￥ *** +/- 2, and so on. This type of iterative bidding game has been employed by Whittington et al. (1989, 1990) to estimate WTP for water services in Nigerial and Haiti; and to estimate WTP for coastal protection in Britain.(Bateman et al, 1995). To avoid tedious repetition the iteration might double or halve the previous dollar bid presented to the respondent. However, this can lead to a wide monetary range within which the exact WTP amount of the respondent is unknown. the bidding process must then iterate between the sum the respondent is willing to pay and that which she is not, to determine a more precise WTP amount.

3) Questionnaire survey

After the hypothetical scenario has been set up and the elicitation method decided, WTP or WTA bids are obtained through a questionnaire survey. CV questionnaires typically obtain three sets of information from respondents:

- ✓ Importance of marine biodiversity in Yellow Sea, perhaps in relation to uses of other services and any perceived non-use benefits of the biodiversity; the reason of the loss of biodiversity in Yellow Sea.
- ✓ WTP and / or WTA bids for the good using one or more of the elicitation methods outlined above, with questions to respondents exploring their reasons for their bids.
- ✓ Socio-economic information on the respondent and his or her household.

The survey can be administered in number of ways: by face to face interviews; telephone interviews; and mail shots.

4) Sample size

The choice of sample size in a CV survey determines the precision of the sample statistics used as estimates of population parameters such as mean WTP or WTA. In general , the larger the sample the smaller the variation in mean WTP as measured by the standard error, and described in confidence intervals.

5) Estimating Mean and Median WTP and WTA Amounts

Mean WTP or WTA amounts are easily derived from a survey by averaging the observed bid responses.

6) Aggregating WTP or WTA Amounts

Mean WTP or WTA estimates from the CV sample survey must be aggregated across the total population to derive a total value figure. There is a difficulty problem of the relevant population which will lead to the varies of total value. e.g. local population; the state population; or international population. This is particularly problematic in the case of the non-use value of goods. Economists suggest (guy, garrod,2001) if the public goods are small, relatively unknown, and local in extent, and non-use values many not extend over a great distance. In this guideline, the public good is biodiversity value in the Yellow Sea, the value exist in the Yellow Sea, so the relevant population is the local resident populations.

(3) Data and information requirement

1) Information about importance of marine biodiversity in Yellow Sea , threat to biodiversity in Yellow Sea, the relation between Mariculture and change of biodiversity. If necessary, use photographs, videos, or other multi-media techniques to convey this information.

2) Socio-economic information of respondents including age, born place, income, educated level, profession, knowledge to biodiversity

(4) Issues and Limitations of the Contingent Valuation Method

Although the contingent valuation method has been widely used for the past two decades, there is considerable controversy over whether it adequately measures people's willingness to pay for environmental quality.

1) Technical bias may arise in using the CVM such as information bias, instrument bias, starting point bias and strategic bias etc.

2) The assumption that respondents are well educated and have enough environmental ideas is not realistic in developing country especially in China.

3) When conducted to the exacting standards of the profession, contingent valuation methods can be very expensive and time-consuming, because of the extensive pre-testing and survey work.

4) The lack of survey tradition in China will influence the accuracy of the estimate.

5) Many people, including jurists policy-makers, economists, and others, do not believe the results of CV.

7. Benefit-cost analyses of maricultrue

7.1 Introduction of BCA

Economics provides simple yet effective criteria for decision-making: Comparing the gains (benefits) with the losses (costs) of an action, if the former exceeds the latter, support the action; otherwise, oppose it (Tietenberg, 2003). This normative criteria is a foundation of benefit-cost analyses, helping decision-makers answer difficult questions such as: Should we preserve wetland or convert it to agricultural land? Should we regulate fishing effort to preserve fish stock? Should we control emissions from industries to prevent water pollution? By assessing the net benefits (the difference between benefits and costs) with or without each action (i.e., preserving wetland, regulating fishing efforts, controlling emissions), decision-makers can determine whether they should take the action. If the net benefits are positive, the decision-makers would proceed with the action. These criteria are preferable for the society as a whole because employing them prevents resources from being wasted by not taking actions that have fewer net benefits.

The benefits contain all the gains of a specific action, including direct and indirect gains that derived from it. And the costs are the expenditures of getting the benefits, also including two components. One of them is the actual cost, which is actually expended to get the benefits of the specific action. The other is called opportunity cost—the forgone net benefit—which otherwise would be realized in other beneficial uses.

7.2 Methodology of BCA

In normal circumstances, the benefits and costs accrue over time in various timings. If it happens, the decision-maker cannot consider the difference between the benefits and costs only. Otherwise they must incorporate the time factor into the analyses, because the economic valuation of benefits or costs with same quantity at different time is not equal. The earlier's economic valuation is larger than the later one.

7.2.1 Techniques of BCA

There are two methods following considering time factor, which can analyze the profitability of specific actions.

- ✓ Net Present Value (NPV)

The indicator assesses the sum of a stream of net benefits {B0, …, Bn} that arise Over time, which is computed as

$$NPV[Bn] = \sum_{i=0}^{n} \frac{Bi}{(1+r)^{i}}$$

Where r is the appropriate interest rate and Bi is the net benefits accruing in various timings. The idea of this calculation is to discount future net benefits by the interest rate so that they represent today's values; therefore, this interest rate is also called a discount rate. After discounting, the same normative criteria can be applied. If the NPV of a stream of net benefits is positive, support the action, otherwise, oppose it. If the projects with equal costs have different positive NPV, the decision-maker should choose the larger one. But NPV is an absolute value, which cannot assess projects with different costs. The following criteria NPVR can resolve this problem.

- ✓ Net Present Value Rate (NPVR)

NPVR is the ratio of the sum of a stream of benefits' present value over time to that of costs, which is calculated as

$$NPRV = \sum_{i=0}^{n} {}^{Bi}\!/_{(1+r)^{i}} \Big/ \sum_{i=o}^{n} {}^{Ci}\!/_{(1+r)^{i}}$$

Where *Bi* and *Ci* represent the benefits and costs of specific actions respectively, *r* is also the appropriate discount rate. Using NPVR decision-makers can contrast projects with different costs, because it is a relative criteria. If NPVR of an action is larger than 1, support it, otherwise oppose it. If decision-makers have more than 2 available choices, choose the one with largest NPVR.

7.2.2 The discount rate

The discount rate is the rate by which the present value of future cash flows is calculated. It is also understood as the expected rate of return in practice. Generally speaking, discount rate includes risk-free return rate and risk premium. Risk-free return rate is the average return that can be earned with certainty, under no risk and inflation (generally the return on short-term US Treasury Bonds). Risk premium is the excess return required from an investment in a risky asset over that required from a risk-free investment. Risk premium differs among different industries and assets of different functions.

Principles of Calculating Discount Rate:

(1) Discount rate should exceed risk-free rate. Under normal conditions, treasury securities and bank deposits are considered as low-risk or even risk-free investment, so their interest rates are called risk-free rates, which are the minimum return rates of any investment. Thus the return rate of all investment should be no less than the risk-free rate.

(2) Discount rate should be matched with returns. If the influences of inflation and other factors are considered in the expected returns, then such influences should be considered in the discount rate as well. This is a matching principle.

(3) The level of discount rate should be based on industry average return rate. The return levels have distinct industry features. The industrial structure strongly affects the establishment of competition rules and all the enterprises within the industry, and then it further decides the industrial return rate and the margin of profitableness.

Discount rate = Risk-free return rate + risk premium + inflation rate

The risk-free return rate refers to the interest rate of treasury bonds or bank deposits. In China, the interest rate of three-year Treasury bond in 2006 is 2.34%, one-year fixed bank deposit 2.25%, and two-year fixed bank deposit 2.70%, three-year 3.24%, and five-year 3.60%.

Methods of calculating the risk premium:

- ✓ Accumulation Method:

Risk premium + industry risk premium + business risk premium + financial risk premium Industry risk premium refers to the compensation of specific industrial risks, which are related with industry characters, national industry policies and such factors. β coefficient method is adopted in calculating industry risk premium on the bases of β coefficient and social average rate of return. Industry risk premium is chosen from a certain range according to overseas and internal evaluation experiences and China's reality.

Business risk premium: business risk is the uncertainty of return due to the unique business operation of a particular company. It could be estimated by the distribution of operating income in the operating period. Business risk grows as operating income increases, and vice versa. Business risk can be classified into two categories, internal and external risk. Internal business risk is related with the internal controllable operating conditions, and it could be reflected by the operating efficiency. External risk is related with the operating conditions forced upon the enterprise by the external environment, such as political environment and economic environment.

Financial risk premium: Financial risk comes from the debt in the capital structure of the enterprise. Generally it is measured by the ratio of debt and equity. Financial risk increases as the percentage of debt in the capital structure increases, so the financial risk premium is correlated with capital turnover, capital distribution, capital financing and etc.

Accumulation method is the most frequently used method at present in calculating discount rate in practice. However, business and financial risk is mostly judged and quantified by experiences, so the disadvantage of this method is obvious. A good knowledge and understanding of macroeconomic status, industry perspectives, market situation and competition, is required in making reasonable judgment of the discount rate. (Reference: < Methods of Calculating Discount Rate in Corporation's Whole Asset Appraisal>2004.5.19)

✓ Bcoefficient method:

Social average rate of return – risk-free rate of return = Social risk premium.

Risk Premium= (Social average rate of return － risk-free rate of return) * β

The key problem of this method is to determine Bcoefficient. In the United States, Bis mainly decided by data analysis of the stock market, the methods and models of the analysis depending upon historical data, market data, basic data and their comprehensive data. In China the conditions under which this method is adopted are still immature, and the reason is that China's stock market is still underdeveloped. The government's capricious management policy and investors' strong speculation motive lead to frequent fluctuation of stock price. The financial information of listed companies is false and misleading. Such problems as above lead to low correlation between stock price and the actual return.

- ✓ Weighted Average Cost of Capital (WACC) Method

Sources of capital available are diverse, such as equity, bonds, bank debt, financial leasing, retained profit and etc. Investors, when making an investment in a particular project, always expect that the return could cover at least the opportunity cost. A calculation of a firm's cost of capital in which each category of capital is proportionately weighted. All capital sources - common stock, preferred stock, bonds and any other long-term debt - are included in a WACC calculation. WACC method takes WACC as the discount rate in calculation.

In the Benefit-Cost Analysis of Mariculture, since there're no evident creditors or shareholders and thus it's hard to define the sources of capital, the use of WACC method to get discount rate is restrained

- ✓ Capital-Profit Ratio Method

Capital-profit ratio is closely related with industries. The capital-profit ratio method uses industry average capital-profit ratio as the basic rate of calculating discount rate and then adjust this rate according to the practical situation.

With balanced production and sales and basically consistent industrial rate of return and social rate of return, social rate of return could be adopted as discount rate. As for the situations of unmatched demand and supply, or of underdeveloped market or heavily policy-restrained market, when there's an evident difference between industrial rate of return and social rate of return, industrial rate of return is chosen as the discount rate. If the enterprise is of distinct particularity, such as small production scale with low management level or with high technology input, then such particularities should be taken into consideration and industrial rate of return should be adjusted accordingly. In China, the present basic rates of return in maciculture and aquaculture are 7% and 7.5% respectively.

By comparing the above methods, discount rate of mariculture should be evaluated by combining industrial rate of return in capital-profit ratio method with a view to the whole industrial rate of return of mariculture industry.

7.3 BCA for Mariculture

7.3.1 Identification of the problem of Mariculture in Yellow Sea

Mariculture is an important industry in China, which covers the all the 11 costal provinces and municipality cities. It has a direct employment of1.436 million people , and indirect employment of 376.4 thousand in processing, transportation, logistics and such related industries(employment in non-state enterprises excluded, which is estimated as 3-4 times as that in state-owned enterprises). At present, China is the biggest mariculture country in the world and has the largest aquatic products export. In the long run, mariculture in China is an industry with strong international competivity, and represents an important economic area with great potential. Mariculture has gradually ascended from a traditional sideline industry to a strategic industry in the economy of rural area.

With immense economic gains from mariculture, also comes a severe threat to the eco environment. Especially in the Yellow Sea coastal area where abounds in large-scale mariculture bases, the heavy direct discharge of undisposed sewage into the sea has brought about serious adverse impacts on the inshore ecosystem. In recent years, the impact of mariculture's self-pollution on the environment has become a focus in the present mariculture eco-environmental science and research area.

Based on aware of the self-pollution, damage to water quality from intencive mariculture, scientists put forward many management such as controlling the species and density of commercially cultivated animals, remove pollution by integrated culture, develop submerged cages, which will undertake fish- culture operation in deeper and well flushed waters etc(Yang Yufeng, Li Chunhou 2004).

From policy makers' perspective, the environmental impacts of mariculture requires careful economic analysis.The benefit of mariculture may seem obvious, but allowing negative impact continues causes damage and cost money . BCA is an important economic analysis tool for decision making on competing priorities. In the field of mariculture management, it will be applied to help set environment action priorities by identifying and measuring the cost and benefit (include environmental benefit and cost) of Mariculture. After the BCA, present scale is supported when benefits exceeds costs and scale control or adjustment of mariculture pattern is needed when costs exceeds benefits.

7.3.2 Identification of benefits and costs for mariculture

Observingly, mariculture provides numerous benefits to human being, which can be classified into primary and secondary. The primary benefits reflect the benefits from consuming the provisioning products of mariculture, including the output from project and the social-culture value. Based on the primary benefits, we can further classify them into priced and unpriced benefits. The priced benefits derived from the actual market price and the unpriced benefit address the externality such as recreation and tourism value, education and scientific value, because the benefits are not exchanged in markets. The secondary benefits are indirect benefits include two aspects, priced and unpriced. Priced benefits are additional benefits that accrue to the secondary industries that service the project, such as increased surplus to aquaculture processors and input suppliers or the increased employment. These kind of benefits could be extract from actual markets, so they are price benefits also. For unpriced secondary benefits are from using the regulation services or supporting services of Mariculture, such as oxygen production, climate regulation, the outcomes lack market prices , so we call them unpriced secondary benefits. Note that, although there remains a debate over whether secondary benefits and cost really exist, and whether to include them if they do. Considering the fact that there are unemployed resources such as idle labour or surplus factory capacity in China, the secondary industries may increase production without imposing opportunity costs elsewhere in the economy. Further more, secondary industries may generate an increase in the supply of productive resources, as such new workers who are drawn into the labour force.

Meanwhile, to get the above benefits of mariculture, human being have to pay some costs. Same with benefits, the costs basically consist of two components which are primary and secondary costs. The former is the actual costs incurred directly within the project for material, labor and construction etc, and the latter is the negative impact of the mariculture project on ecosystem or the opportunity cost of it, including damage cost from extra pollution from extra fertilizer, loss of recreation, loss of biodiversity, etc. This classification can be categorized the third tier with priced and unpriced costs.

A classification of benefits and costs from Mariculture (table 10 and table 11)

Table 10 A classification of benefits from Mariculture

Primary				Secondary			
Priced	method	unpriced	method	Priced	method	unpriced	method
Increased surplus to producer of mariculture	Market price	Recreation fishing or other relaxing activity in Mariculture zone	TCM or CVM	Increased surplus to aquaculture processors and input	Market price	Oxygen production	Related goods method

				suppliers			
						Waste treatment	Avoided damage cost
				Increased surplus to input suppliers	Market price	Climate regulation	Related goods mehtod

Table 11 A classification of costs from Mariculture

Primary				Secondary			
Priced	method	unpriced	method	Priced	method	unpriced	method
Costs of material, labours, construction and maintenance	Market price	Damage cost from pollution from fertilizer	EOP			Loss of biodivesity	CVM
		Loss of opportunity for recreation use	TCM or CVM				

7.3.3 Value the benefits and costs of each tape of Mariculture

After identifying the benefits and costs of mariculture, the next step is to value the benefits and costs respectively. As noted in section 6, different Mariculture impact on ecosystem services or different kinds of benefits and costs should be valuated with different approaches. Here we will sum up the methods from the view of priced and unpriced.

First, for the benefits (costs) with actual markets (such as food production, material production, labor; Construction, etc.), we can use the market price method derive the data from actual market to estimate them.

Second, for the benefits (costs), which can not be traded in the actual markets, but have some relevant services being traded in actual markets, we can use the indirect observable method to get their economic values, including travel cost, avoided damage cost or replacement method etc. In this case, waste treatment and loss of recreation to local community should be valued in this way.

·Third, for the benefits and costs without observable markets or relevant service, we could use the direct hypothetical method, known as contingent valuation to value them, that is to estimate the economic valuation of a project from the survey results on individuals' willingness to pay for the specific services. For example, we can estimate of the loss of biodiversity with the data collected from a random sample of households. The benefit of climate regulation could also be estimated in this way.

7.3.4 Process of BCA for Mariculture

As can be seen from analysis above, the majority of benefits and costs of Mariculture in China can be estimated by market prices and market investigation. So the following problem would be choosing an appropriate BCA.

In the short term, as long as benefits exceed costs, the present situation is favorable. However, in the long run, both benefits and costs will change as other factors change. A research report by United States Environmental Protection Agency in 2000 indicates that the benefits from eco-environment will diminish gradually and the environment will deteriorate if no proper measures are taken. This is an inevitable result of over-exploitation of nature by humankind. At present, more and more scholars appeal to sustainable development, the aim of which being to weaken the deteriorating status, and slow down the diminishing of benefits. However, measures guaranteeing stable benefits will also inflict certain costs. Such costs should be taken into consideration in the long-term Benefit-Cost Analysis.

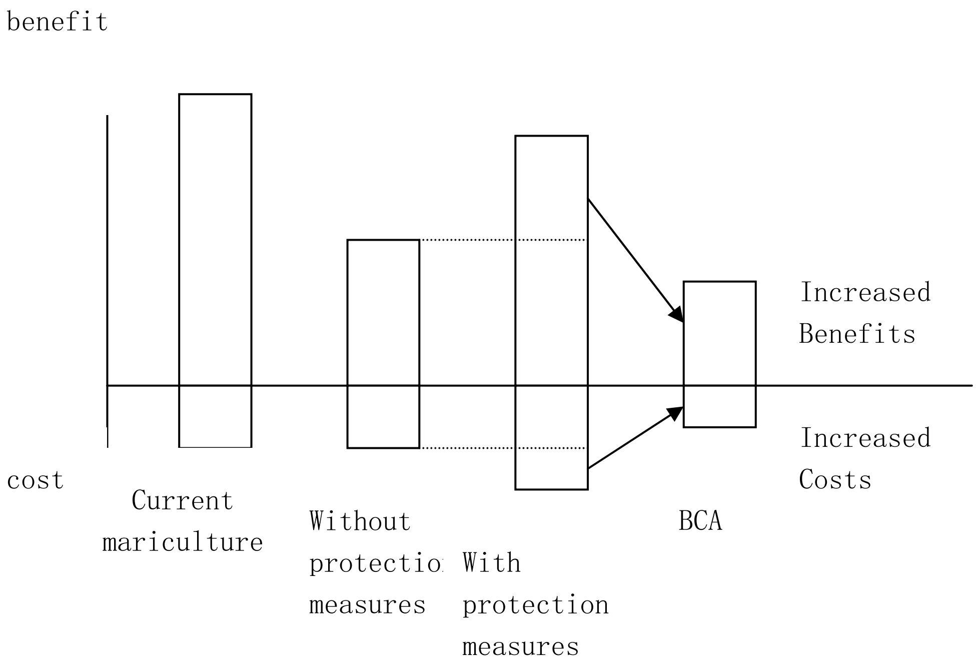

Figure 3: Benefit – cost analysis Mariculture management

The figure3 above indicates the Benefit-Cost relationship, from which we could observe that with certain protection measures taken, both benefit and cost increase. So the comparison of the increased benefit and cost is essential in deciding the propriety of the protection measures.

To analyze the benefits and costs of mariculture involves three main tasks: (1) estimating the benefits and costs of mariculture using the measuring methods discussed in the section 6; (2) calculating the present value of all benefits and costs;(3) computing key criteria of BCA, such as NPV and NPVR. Specifically, the whole BCA process can be divided into following seven steps:

STEP 1:Collect the data on the actual production and expenditure of each kind of benefit and cost with actual markets over the past years.

STEP 2: Collect the data on the market prices for the same period of each benefit and cost in Step 1.

STEP 3: Separately calculate the sum economic value of all the benefits and costs for each year.

STEP 4: Conduct necessary surveys, collect corresponding data about the rest benefit and costs without actual market and estimate the annual economic value of them under consideration.

STEP 5: Using the results of Step 3 and Step 4, estimate the total annual benefit and cost of the whole period under consideration separately.

STEP 6: Calculate the sum of all the present value of each annual benefit and cost with the specific discount rate separately.

STEP 7: Calculate NPV and NPVR.

STEP 8: Sensitivity tests if necessary

STEP 9: Make the final recommendation

So far, we have implicitly assumed that each benefit and cost can be estimated with certainty and so we have a single value for the net benefit of current Mariculture project. But the benefits and costs may turn out to be different from these estimates. The analyst and policy maker will therefore ask---what the change in net benefit if there is a change in the value of a particular variable? For example, what is the change in benefit if change(reduce or enlarge) the production scale by 10% or 20% from the current scale? What is the change in net benefit with different discount rate? What is the change in net benefit with different costs or a different project life? There is a way to treat the difficulties created by uncertainty. A sensitivity test is a recalculation of net benefit with different data, together with the re-interpretation of relative desirability of the alternatives.

In the case of Mariculture, if the net present value is + ￥××× or (－￥×××)，a sensitivity test will be conducted to assess the effects of uncertainty.

- ✓ Current scale are sustainable? If we change (reduce or enlarge) the production scale by 10% or 20% , what is the change of benefit? Which scale is optimal scale from the point of sustainable?
- ✓ What is the change in net benefit with different discount rate?
- ✓ Do the remaining unvalued , unpriced benefits (costs) exceed the remaining unvalued , unpriced cost (benefits)?

The sensitivity test will help the analyst and policy maker to clear the factors which most strongly or little influence economic desirability.

7.3.5 Worksheets for data collection, analysis and result presentation

This section provides sample templates for the BCA of mariculture. These twelve tables correspond to the analytical process that is described in the previous section. In this template, we assume the period under consideration is N years. Table12 through Table 13 represents the volumes of benefits and costs without actual market of mariculture. Correspondly. Table 14 and Table 15 represent the market price of them. Table 16 and Table 17 compute the valuation of the benefits and costs by multiplying the volume by the corresponding price. In Table 19, there are the estimation of benefits and costs without actual markets collected from specific surveys. Table 20 summaries all the benefits and costs of mariculture and conduct a BCA without time factor. Table 21 is the compound present value factor of specific discount rate r% over the period under consideration, which can be used to calculate the present value of the benefits and costs. Table 22 is the results of discounting the total benefits, costs and net benefits. Table 23 represents NPV and NPVR of mariculture.

Table 12 Production volumes of benefits with actual market (in the n-year term)

	Year						
	1	2	3	4	5	. . . .	N
Species							
Food production	××	××	××	××	××	. . . .	××
Material production	××	××	××	××	××	. . . .	××

Table 13 Expenditure volumes of costs with actual market

	Year						
	1	2	3	4	5	. . . . . .	N
Species							
Land or Pond Acquisition	××	××	××	××	××	. . . .	××
Labor	××	××	××	××	××	. . . .	××
Material	××	××	××	××	××	. . . .	××
Construction	××	××	××	××	××	. . . .	××
Maintenance	××	××	××	××	××	. . . .	××

Table 14 Market price of each benefit with actual market

Species	Year 1	2	3	4	5	. . . .	N
Food production	××	××	××	××	××	. . . .	××
Material production	××	××	××	××	××	. . . .	××

Table 15 Market price of each cost with actual market

Species	Year 1	2	3	4	5	. . . . . .	N
Land or Pond Acquisition	××	××	××	××	××	. . . .	××
Labor	××	××	××	××	××	. . . .	××
Material	××	××	××	××	××	. . . .	××
Construction	××	××	××	××	××	. . . .	××
Maintenance	××	××	××	××	××	. . . .	××
Loss of coastal fisheries	××	××	××	××	××	. . . .	××

Table 16 Valuation of each benefit with actual market(Table 12×Table 14)

Species	Year 1	2	3	4	5	. . . .	N
Food production	××	××	××	××	××	. . . .	××
Material production	××	××	××	××	××	. . . .	××
Total (1)	××	××	××	××	××	. . . .	××

Table 17 Valuation of each cost with actual market(Table 13×Table 15)

	Year						
	1	2	3	4	5	......	N
Species							
Land or Pond Acquisition	××	××	××	××	××	......	××
Labor	××	××	××	××	××	......	××
Material	××	××	××	××	××	......	××
Construction	××	××	××	××	××	......	××
Maintenance	××	××	××	××	××	......	××
Loss of coastal fisheries	××	××	××	××	××	......	××
Total (2)	××	××	××	××	××	......	××

Table 18 Valuation of benefits without actual market

	Year						
	1	2	3	4	5	....	N
Species							
Waste treatment	××	××	××	××	××	....	××
Climate regulation	××	××	××	××	××	....	××
Total (3)	××	××	××	××	××	....	××

Table 19 Valuation of costs without actual market

	Year						
	1	2	3	4	5	....	N
Species							
Loss of recreation to the local community	××	××	××	××	××	....	××
Loss of biodiversity	××	××	××	××	××	....	××
Total (4)	××	××	××	××	××	....	××

Table 20 Benefit and cost analysis for mariculture without time factor

	Year 1	2	3	4	5	. . . . . .	N
Total benefits (5)=(1)+(3)	××	××	××	××	××	. . . . . .	××
Total costs (6)=(2)+(4)	××	××	××	××	××	. . . . . .	××
Net benefits (7)=(5)-(6)	××	××	××	××	××	. . . . . .	××

Table 21 Compound present value factor of specific discount rate r%

	Year 1	2	3	4	5	. . . . . .	N
specific valuation	××	××	××	××	××	. . . . . .	××

Table 22 Present values of total benefit, cost and net benefit each year (Table10×Tbale11)

	Year 1	2	3	4	5	. . . . . .	N
Present value of total benefits	××	××	××	××	××	. . . . . .	××
Present value of total costs	××	××	××	××	××	. . . . . .	××
Present value of net benefits	××	××	××	××	××	. . . . . .	××

Table 23 Benefit and cost analysis for mariculture incorporating time factor

Year	Present value of total benefits	Present value of total costs	Present value of net benefits
1	××	××	××
2	××	××	××
3	××	××	××
4	××	××	××
5	××	××	××
.	. .	. .	. .
.	. .	. .	. .

.	. .	. .	. .
.	. .	. .	. .
N	××	××	××
Total	**××(8)**	**××(9)**	**××(10)**
	NPVR=(8)/(9)		**NPV=(10)**

If NPVR>1, NPV>0,support it, other while oppose it.

8.Case study

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