Y S L M E

Environmental Valuation and Cost-benefit Analysis of Management Actions

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Topics of this Presentation

- **Environmental Valuation**
  - Economic value of goods & services
  - Negative externalities
  - Valuation techniques
- **Cost-benefit analysis (CBA) of management actions**
  - Benefits and costs of actions
  - With-or-without action scenarios
  - CBA procedure
- **A case study of mariculture as an example**

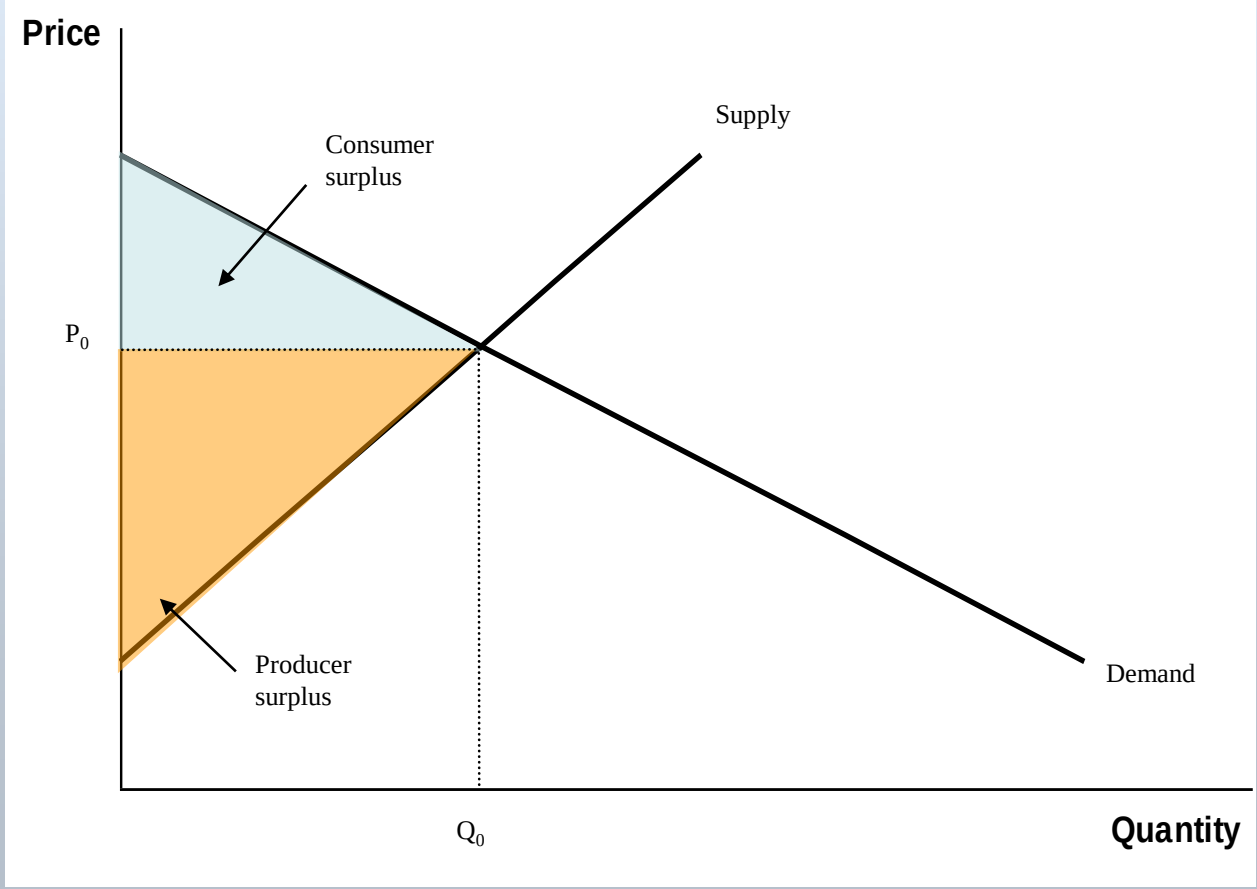
Y S L M E

Basic Environmental Valuation

Economic Value of Goods & Services

Economic Value =

Consumer Surplus + Producer Surplus



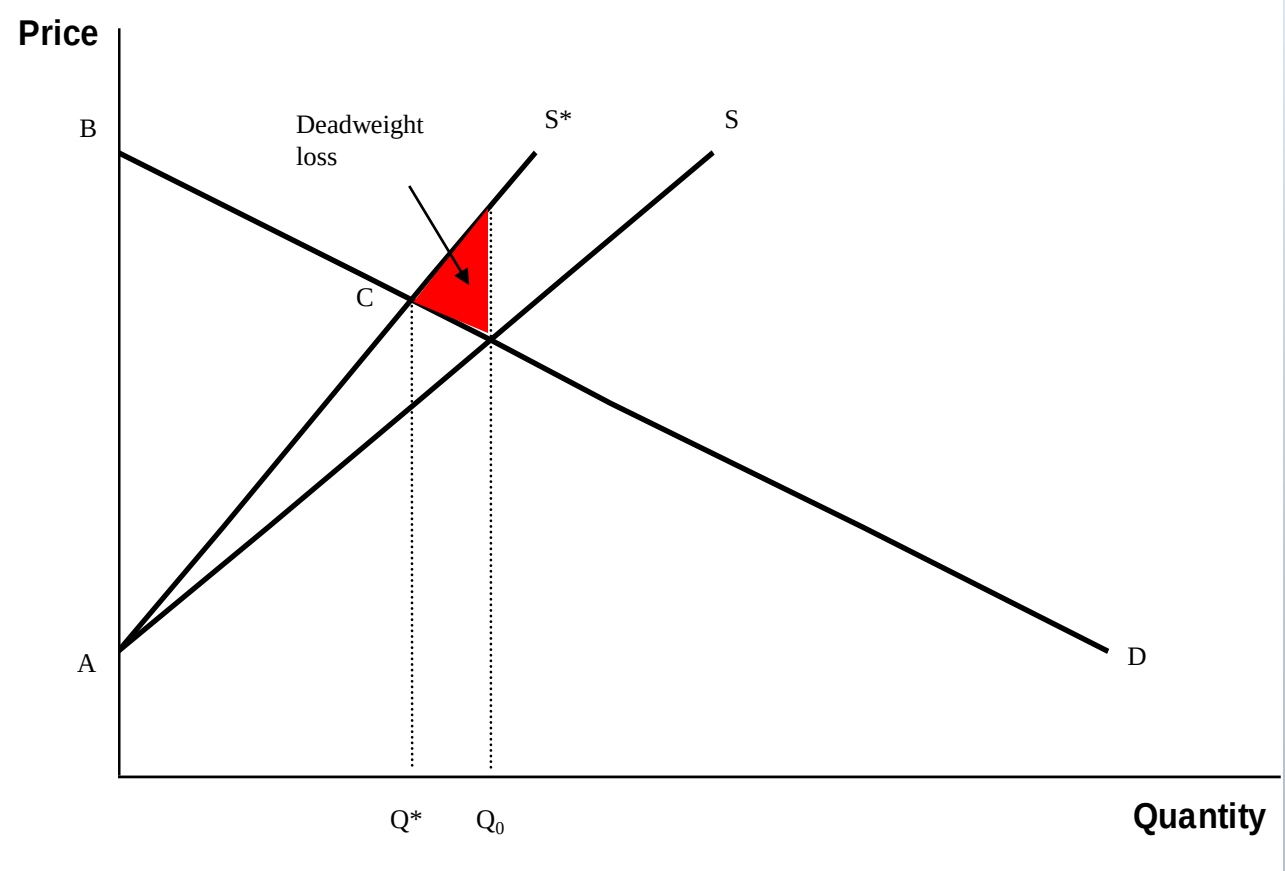
Economic Value (cont.)

- Demand curve is derived from **consumer behavior**, while supply curve is derived from **producer behavior**.
- **Economic value is maximised** if goods are provided at the price and quantity when the demand curve and the supply curve for the goods intersect.
- Society is well-off when the economic value is maximized.

Welfare Loss due to Negative Externalities

Negative externalities cost society:

"Deadweight loss"



Externalities (cont.)

- **More goods are produced than the socially-optimal level ($Q^* < Q_0$).**
- Society would not suffer from this loss if "external cost" were internalised.
- Economic analyses should incorporate negative externalities, if any.

Valuation Techniques

Methods	Observed behavior	Hypothetical
Direct	Market price/empirical technique Simulated markets	Contingent valuation
Indirect	Travel cost Hedonic property values Hedonic wage values Avoidance expenditures Cost-of-illness Cost-of-restoration/replacement	Contingent ranking

Source: Tietenberg, 2003

Techniques (cont.)

Target goods	Valuation technique*	Procedure	Necessary data	Reference
Market goods (e.g., commercial fish)	Empirical technique	1.Collect empirical data on market information 2.Analyse data statistically 3.Calculate consumer surplus and producer surplus	• Market price and trading volume of target good	• Estimate consumer and producer surplus • Statistical technique: Regression analysis
Non-market goods (e.g., scenic views)	Zonal travel cost method	1.Collect data on tourists 2.Analyse data statistically 3.Calculate and aggregate consumer surplus	• Cost information associated with trip to target site • Wage information of visitors • Number of visits per person • Local government districts • Population statistics	• Estimate consumer surplus • Statistical technique: Regression analysis
	Contingent valuation method (dichotomous choice method)	1.Collect data on willingness to pay 2.Analyse data statistically 3.Calculate and aggregate consumer surplus	• Individual's willingness to pay • Population statistics	• Estimate consumer surplus • Statistical technique: Logistic regression analysis • Survey via interviews

Notes: *Other methods are not discussed due to the limitation of data availability in the Yellow Sea region.

Empirical Technique for Market Goods

1. Collect and statistically analyse empirical data on the market prices and trading volumes of concerned goods to **estimate a demand curve**.

2. Collect and statistically analyse empirical data on the marginal variable costs of producing the goods to **estimate a supply curve**.

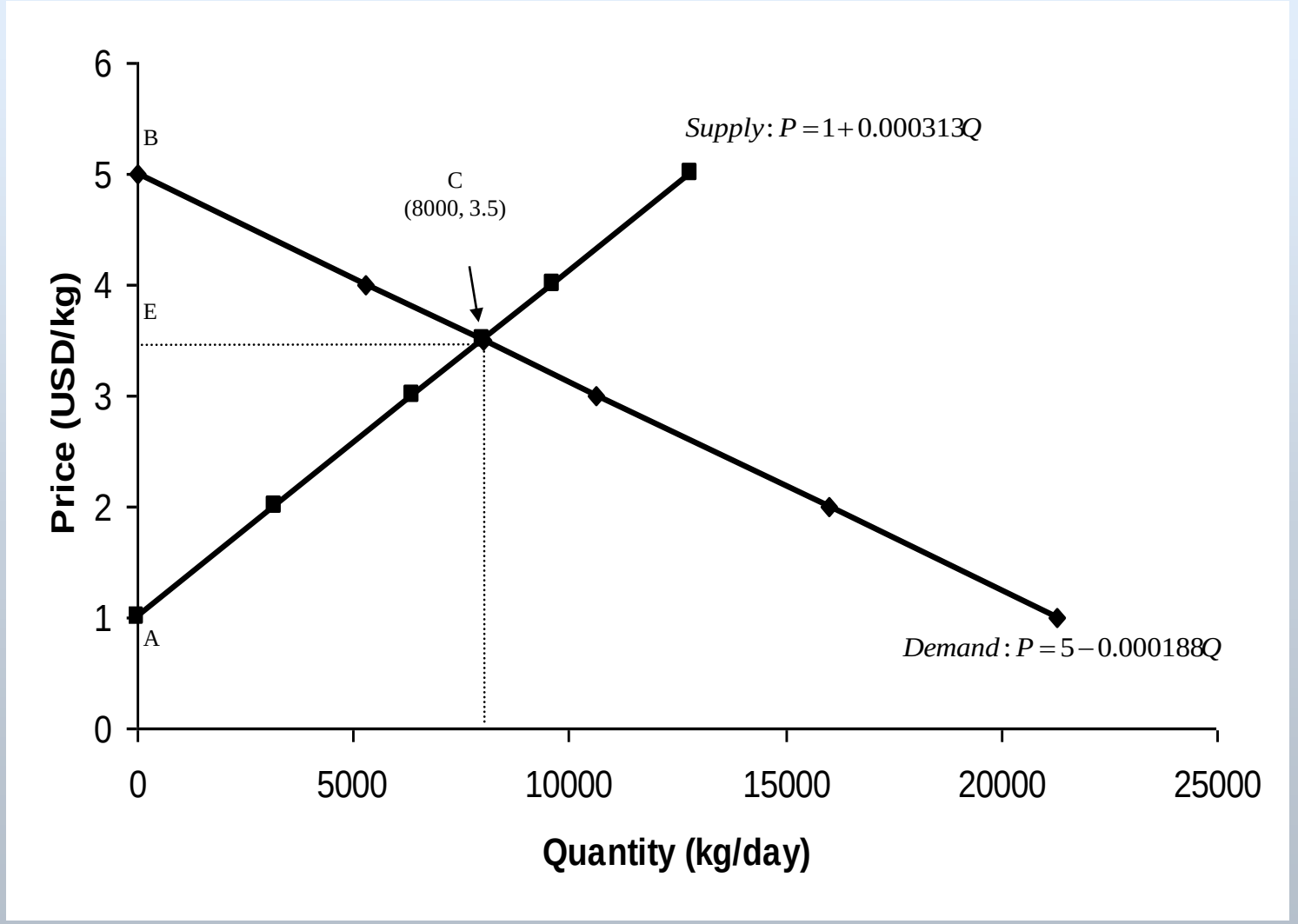
3. Calculate economic value based on the estimated demand and supply curves.

Example: Commercial Fisheries

Price (USD per kg)	Demand (kg per day)	Supply (kg per day)
1	21,300	0
2	16,000	3,200
3	10,600	6,400
4	5,300	9,600
5	0	12,800

Source: Adapted from Lipton et al., 1995

Estimated Demand & Supply



Estimated Value of Fish

Economic value of commercial fisheries

= Area ABC

= Consumer surplus (Area EBC) +
Producer surplus (Area AEC)

= (5 – 3.5) x 8,000 x ½ + (3.5-1) x 8,000 x ½

= USD 16,000 per day

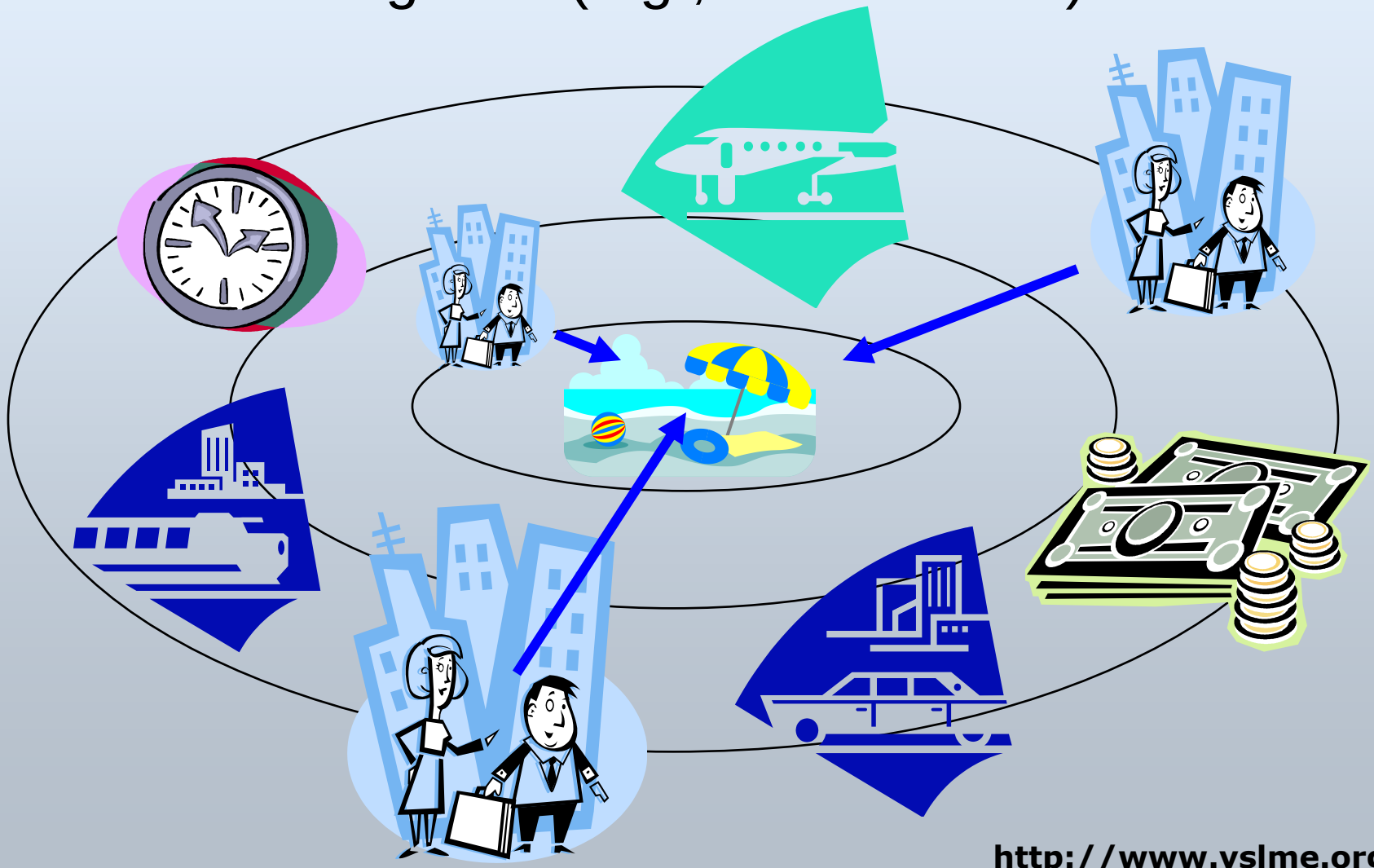
= **USD 1.6 million per year**

(USD 16,000 x 100 days)*

*The total number of fishing days is assumed to be 100 days a year.

Zonal Travel Cost Method

Non-market goods (e.g., scenic views)



TCM: Procedure

1. Collect data on the travel cost information of visitors to a site.

2. Analyse the collected data statistically to estimate the **individual visitor's demand curve**.

3. Calculate and aggregate the consumer surplus for visitors from different zones.

Necessary Data

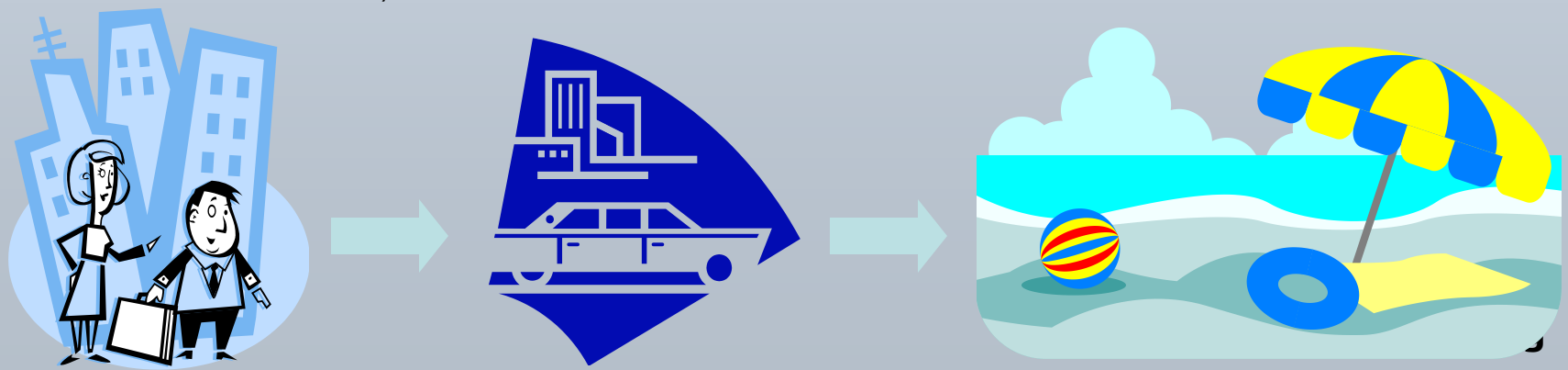
- Travel distance
- Travel time
- Operating cost of vehicles (e.g., gasoline cost)
- Opportunity cost of the travel time (e.g., foregone time wage)
- Admission fee of the recreational site, if any

- Average number of visits per person per year

Example: Information of Visitors to a Beach

Item	Cost (USD)	Reference
Opportunity cost	9.4	USD 9.4 x 0.5 hour x 2 trips
Operating cost	0.6	USD 0.15 x 2 km x 2 trips
Admission fee	10	One-time fee per trip
Total travel cost	**20**	Visits 15 times per year

Source: Boardman et al., 2006

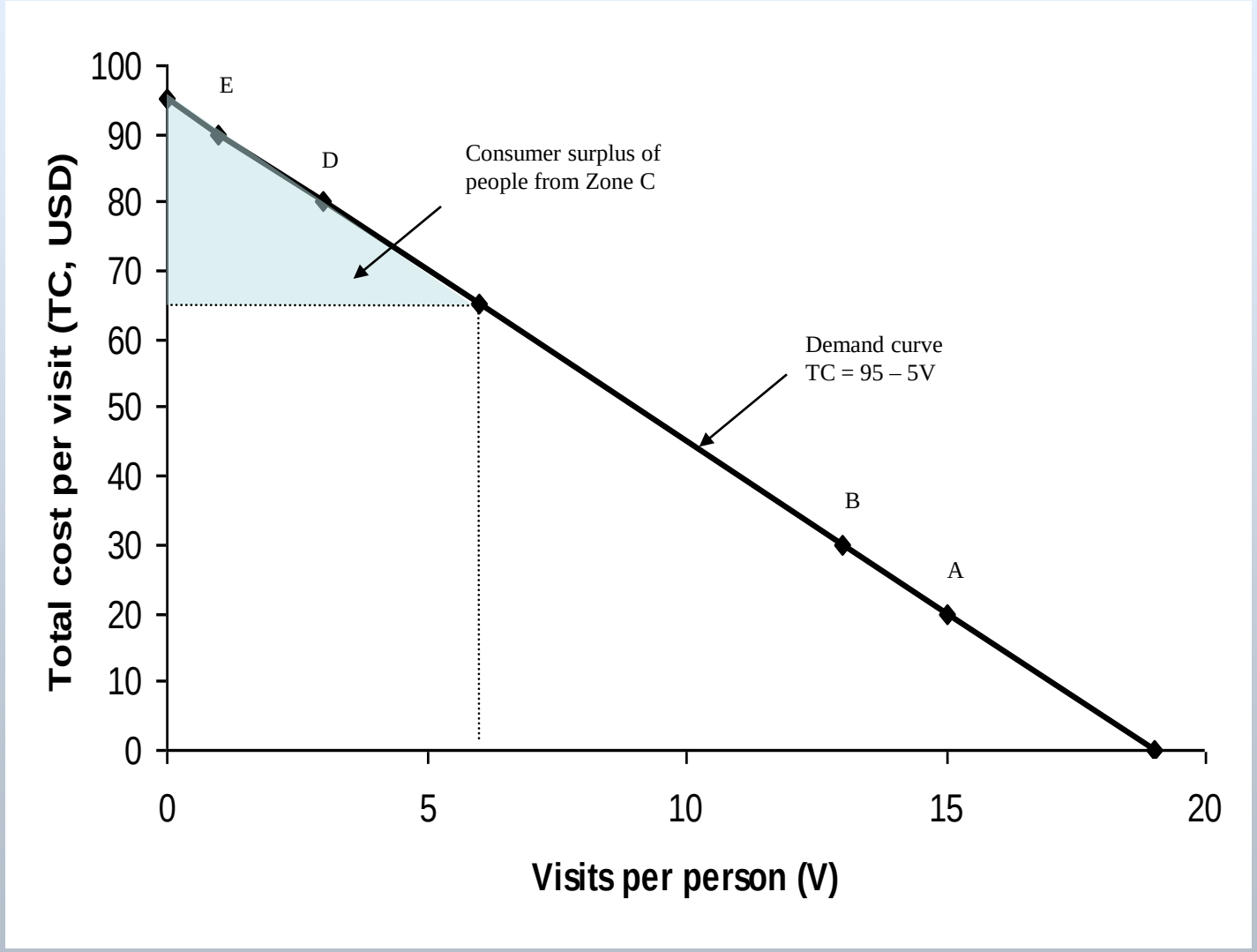


Example: Beach Tourism (cont.)

Zone	Travel time (hours)	Travel distance (km)	Average total cost per person per visit (USD)	Average number of visits per person per year
A	0.5	2	20	15
B	1.0	30	30	13
C	2.0	90	65	6
D	3.0	140	80	3
E	3.5	150	90	1

Source: Boardman et al., 2006

Estimated Demand for a Beach



Calculation of Consumer Surplus

- Using the estimated demand function, one can calculate consumer surplus for people from different zones.

- For example, the consumer surplus for those who are from Zone C is USD 90 per person ([USD 95 - USD 65] x 6 visits / 2).

- Given population statistics, one can estimate consumer surplus in each zone by multiplying the consumer surplus per person in each zone by corresponding population.

Calculation (cont.)

Total consumer surplus:

Approximately USD 11.9 million per year

Zone	Average number of visits per person per year	Consumer surplus per person per year (1)	Population (2)	Consumer surplus per Zone per year (USD thousand) (1) x (2)
A	15	562.5	10,000	5,625
B	13	422.5	10,000	4,225
C	6	90.0	20,000	1,800
D	3	22.5	10,000	225
E	1	2.5	10,000	25
Total				**11,900**

Source: Adapted from Boardman et al., 2006

Contingent Valuation Method

- Applicable to a wide range of goods & services
- Questionnaire survey
- Providing plausible hypothetical scenarios
- **Asks how much respondents would pay**
- **“Dichotomous choice method”**

CVM: Procedure

1. Collect data on **individual's willingness to pay (WTP)** for environmental goods (e.g., coastal site with biodiversity).

2. Analyse the collected data statistically to estimate the individual's WTP.

3. Calculate and aggregate the WTP to reveal the consumer surplus of having the goods for the society as a whole.

Example

- Suppose that a coastal site faces serious environmental problems. A local government decided to **rehabilitate the site**.
- Data were collected on 12 individuals' (e.g., city residents and visitors who use a site) WTP for rehabilitating the site.
- Given one randomly drawn price, referred to as a **"bid price,"** a respondent was asked to state whether s/he would be willing to pay the price.

Sampled Individual's WTP

Bid price (USD per visit)	Response (1 = "yes," 0 = "no")
5	1
6	1
7	1
9	1
10	1
11	0
25	1
30	0
35	0
50	0
55	0
60	0

Source: Loomis, 1988

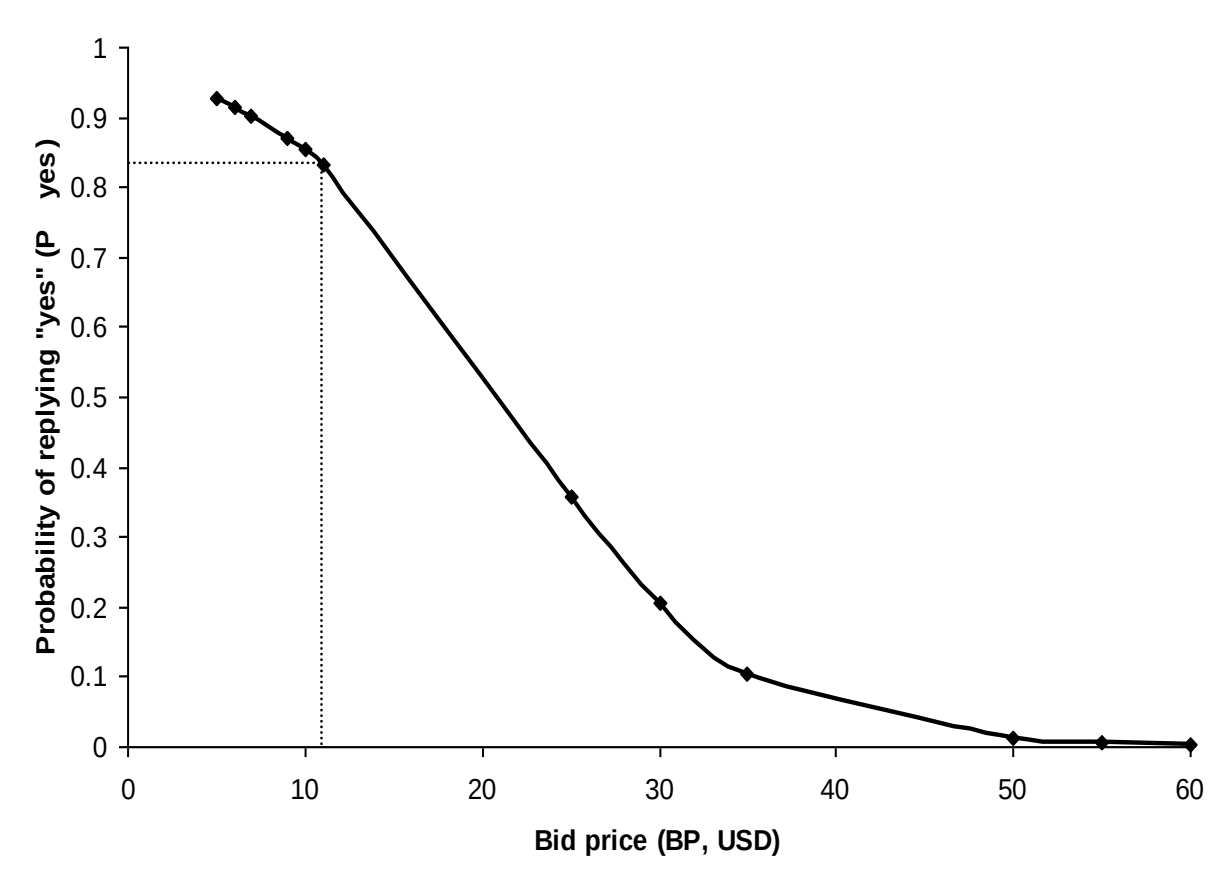
Logit Model for WTP Estimation

$$RY = \ln\left(\frac{P_{yes}}{\left(1-P_{yes}\right)}\right) = 3.321 - 0.156BP$$

$$\Rightarrow \quad P_{yes} = \frac{\exp\left(3.321 - 0.156\,BP\right)}{1+\exp\left(3.321 - 0.156\,BP\right)}$$

where RY is the ratio of the probability that respondents would reply “yes” at given bid price, *BP*, to the probability that respondents would reply “no.”

Estimated Relationship betw'n Bid Prices & Probability



Source: Adapted from Loomis, 1988

For example, when the bid price is 11, the probability of an individual agrees to pay that amount is approximately 0.83 (*Pyes* = exp(3.321 – 0.156 x 11) / (1 + exp[3.321 – 0.156 x 11]) = 0.832).

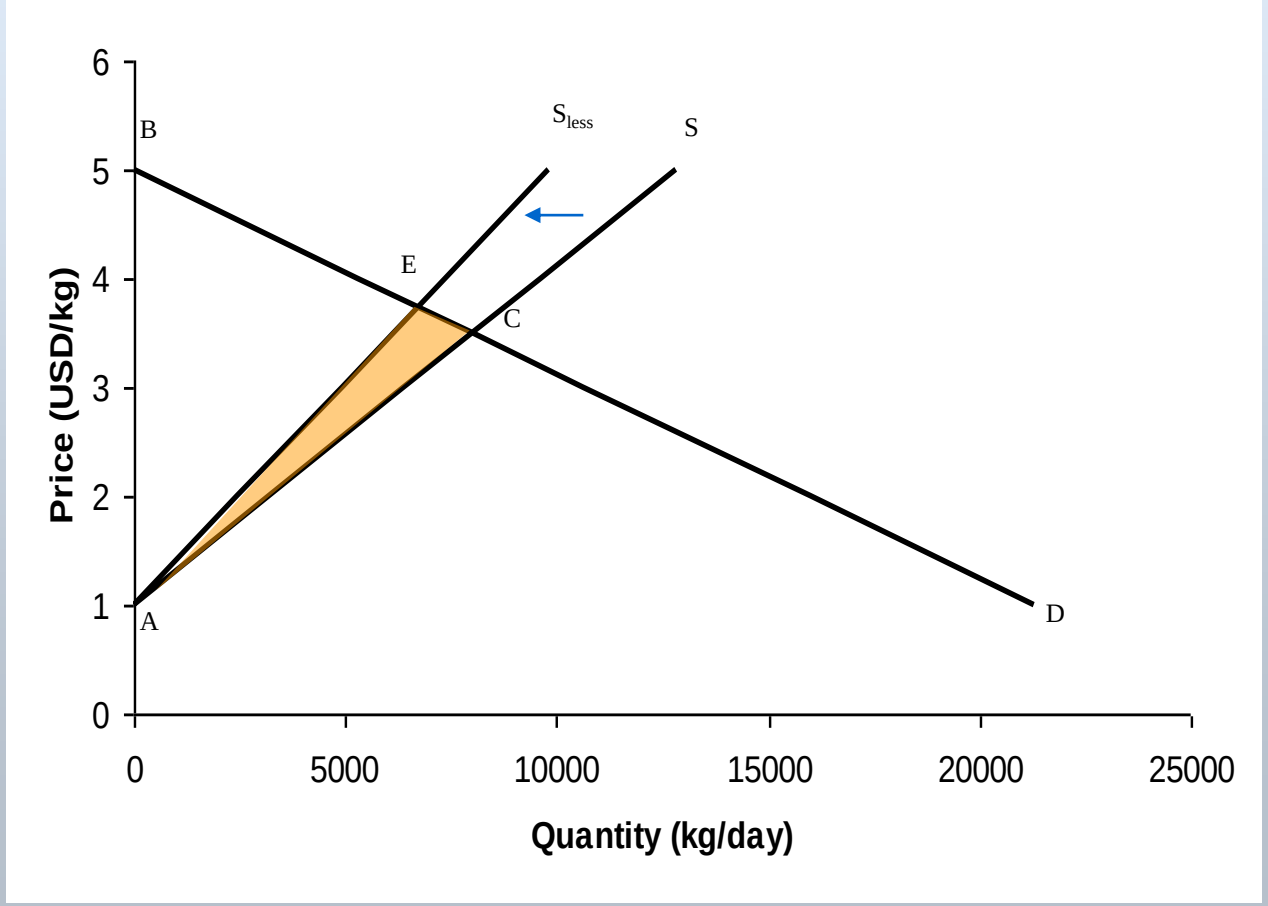
Estimated Consumer Surplus

- The **area under the function** approximates the individual's mean maximum WTP or the individual's consumer surplus for the site.
- The estimated individual's consumer surplus for the site is approximately USD 21.
- The economic value of the site is **approximately USD 6.3 million per year** (USD 21 x 300,000 people), assuming that there are 300,000 people concerned.

Cost-benefit Analysis of Environmental Management Actions

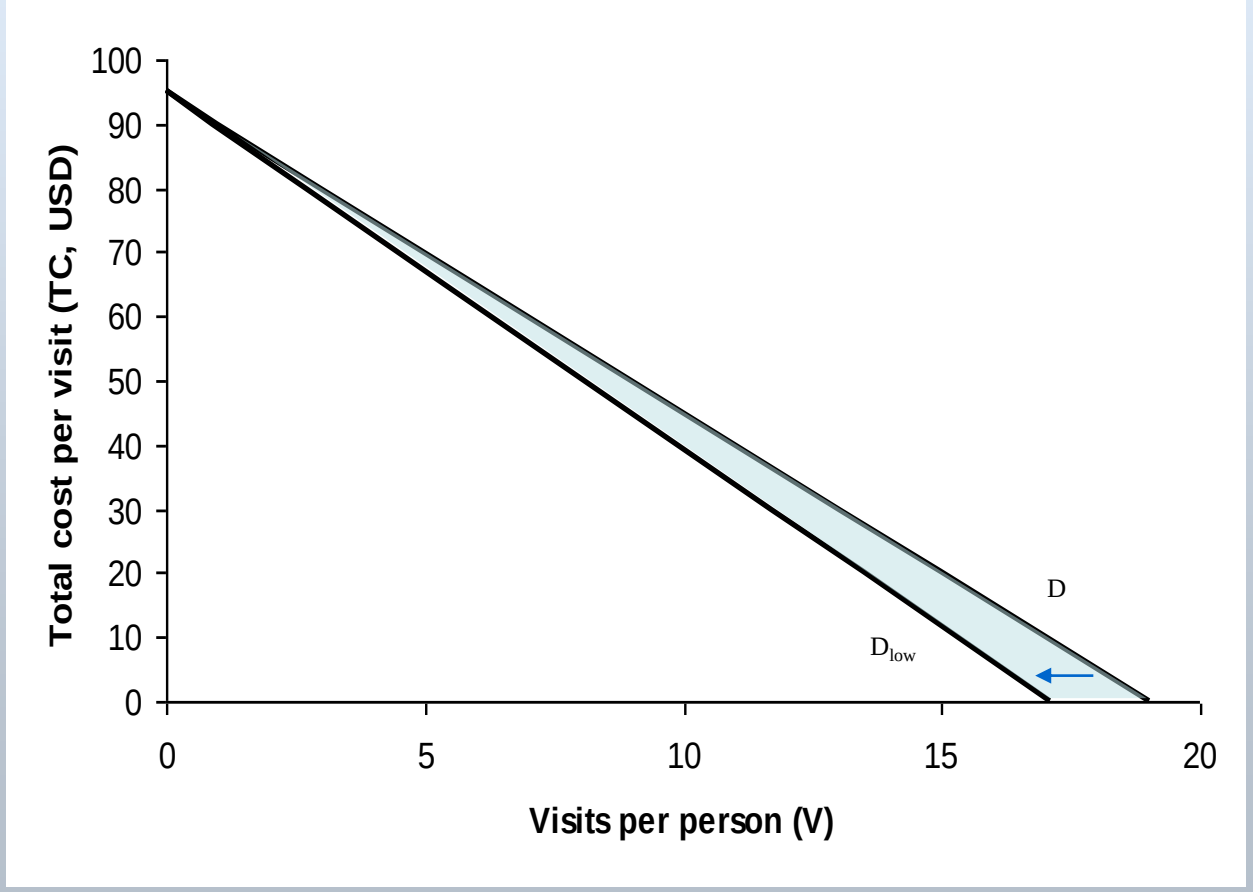
Change in Economic Value due to Environmental Degradation

Shift in supply for commercial fish due to the decline in fish stock



Change in Economic Value (cont.)

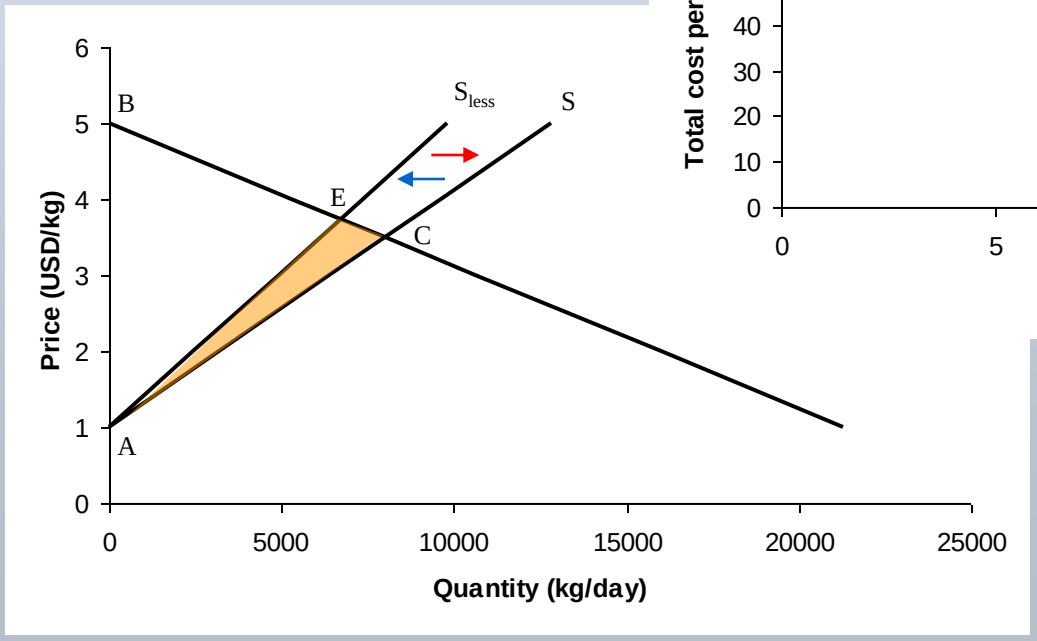
Shift in demand for a hypothetical recreational site due to water degradation

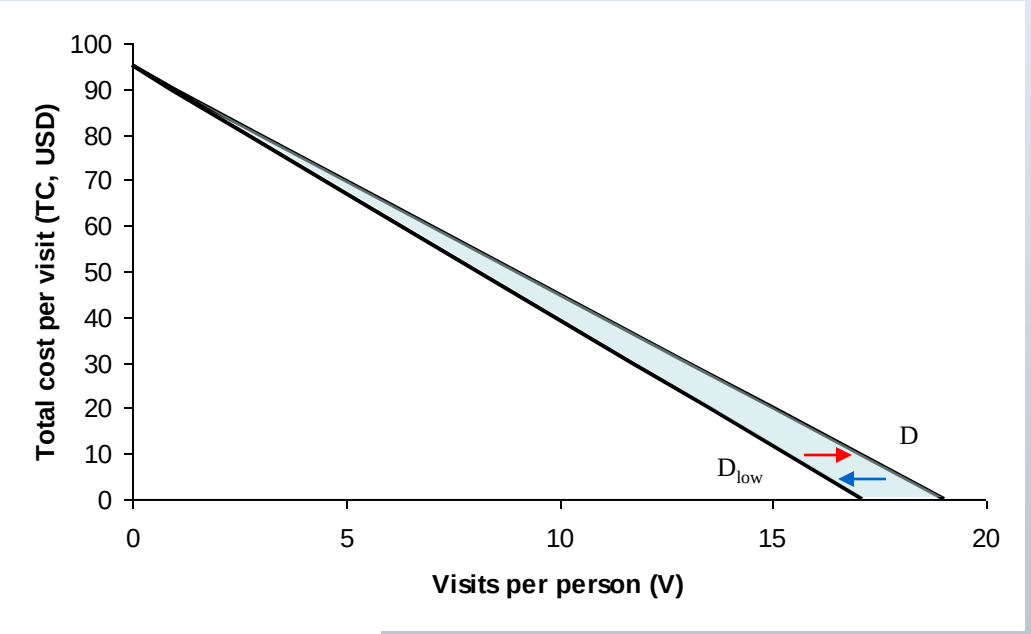


Benefit of Management Actions

Benefit of Action =

Prevented loss in Economic Value





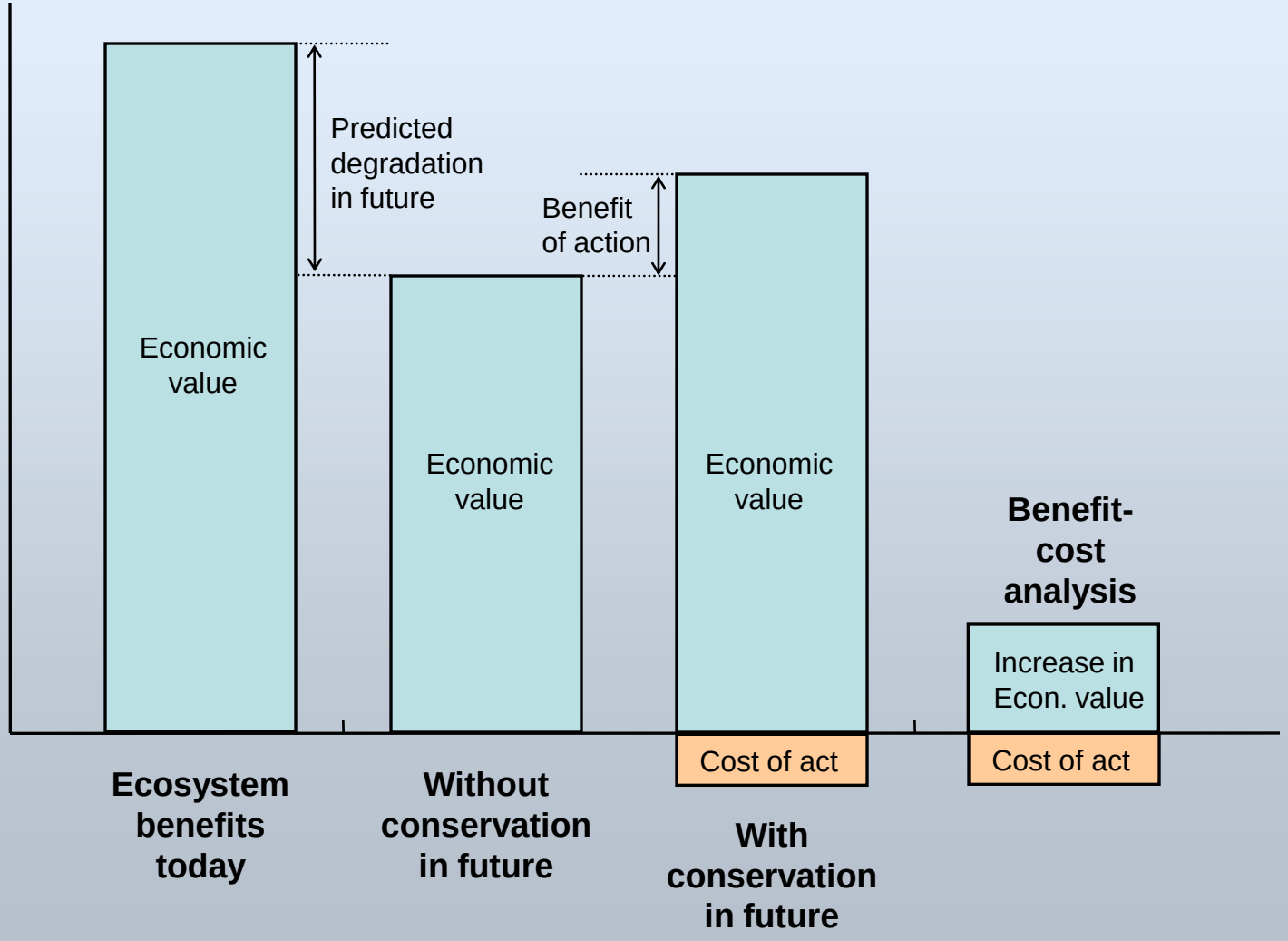
Cost of Management Actions

- Cost of Action =

  Cost incurred to implement proposed actions

- Cost consists of:
  - Costs of implementing conservation measures
  - **Opportunity costs** of foregone uses.

Cost-benefit Analyses for Decision-making



Source: Adapted from Pagiola et al., 2004

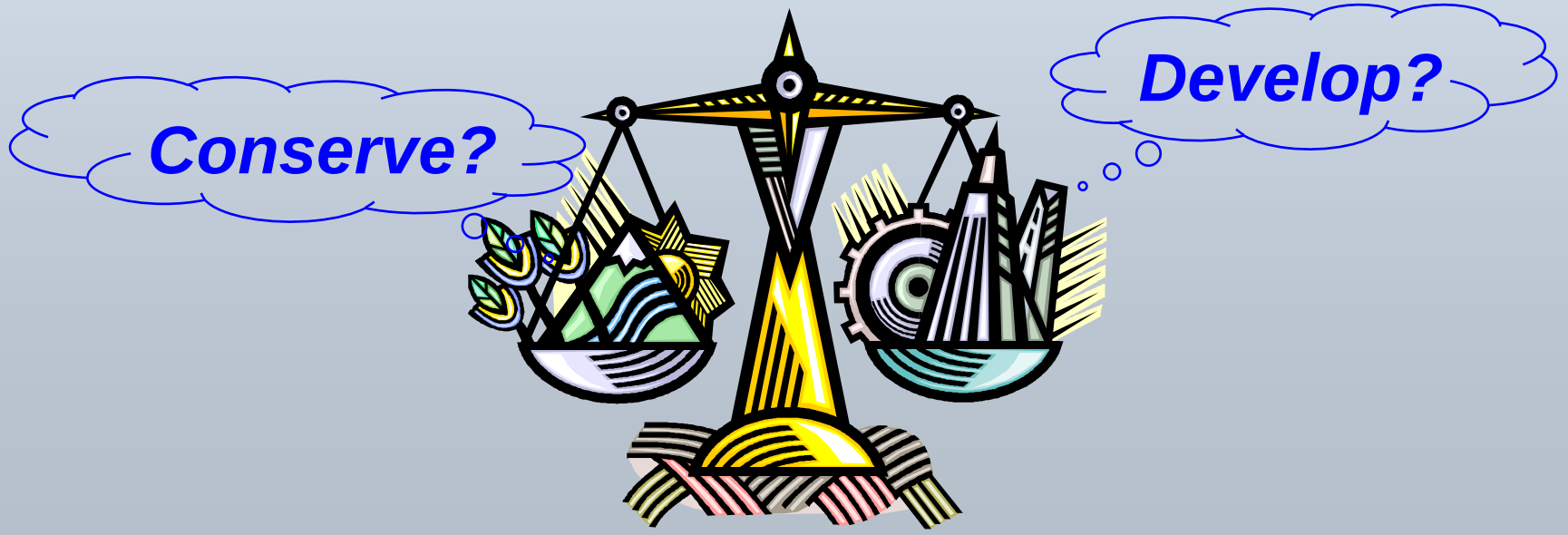
CBA: Procedure

1. Specify management actions to analyse.
2. Predict future environmental degradation.
3. List expected benefits and costs of the actions.
4. Predict the benefits and costs quantitatively.
5. **Monetise the benefits and costs.**
6. Calculate the net present value of the benefits and costs.
7. Conduct a sensitivity analysis.
8. Make recommendations.

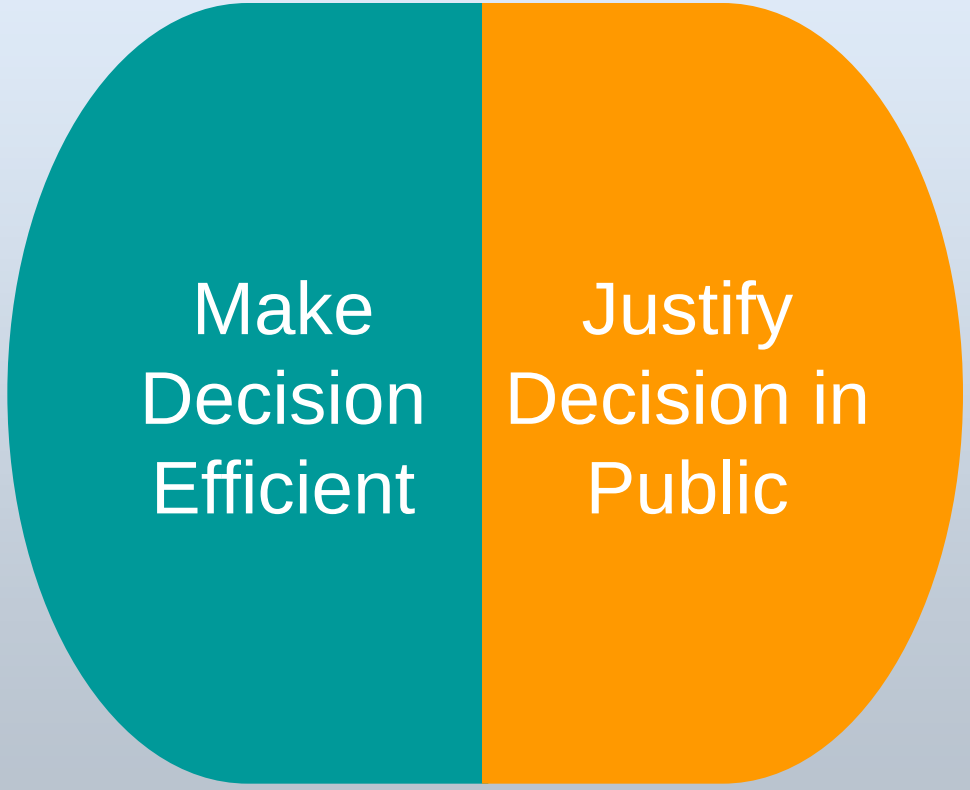
Decision Criteria

Compare Benefits and Costs of an Action.

- If **Benefits > Costs**, take the action.
- If Costs > Benefits, think other alternatives.



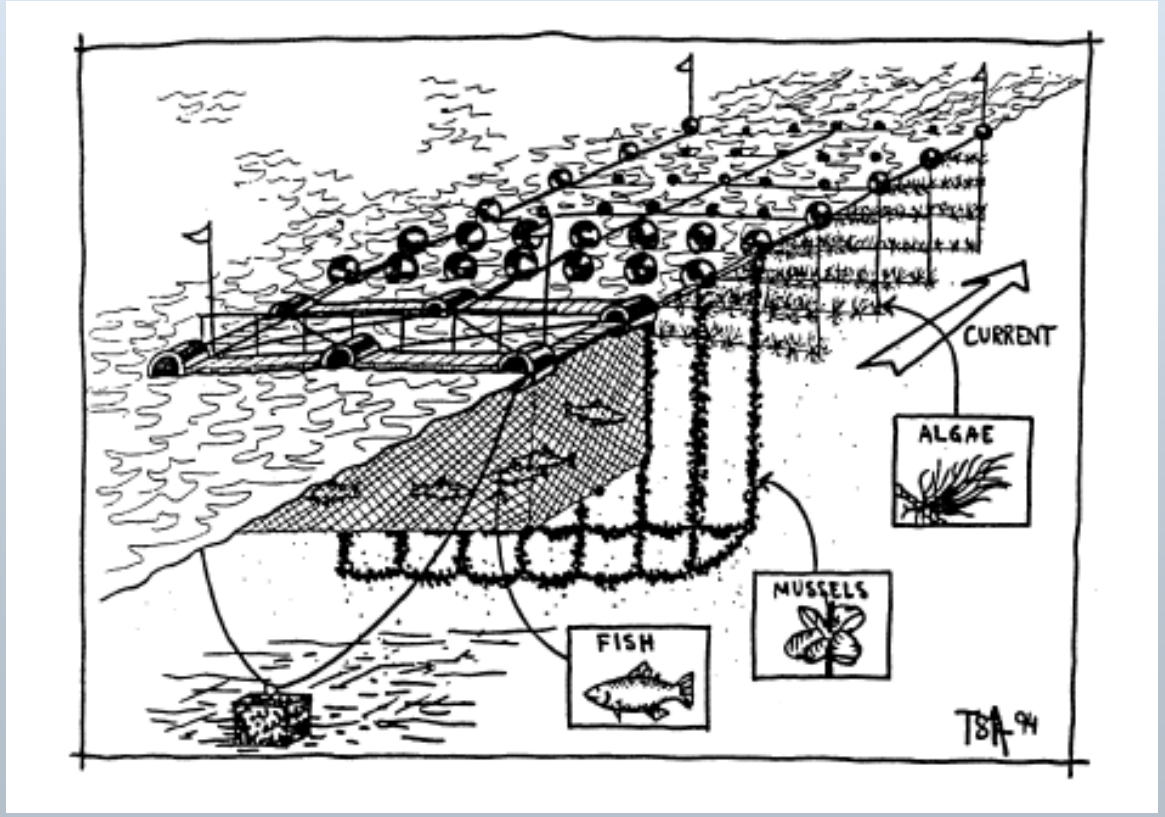
How to Use CBA Info?



Case Study: Mariculture

Polyculture

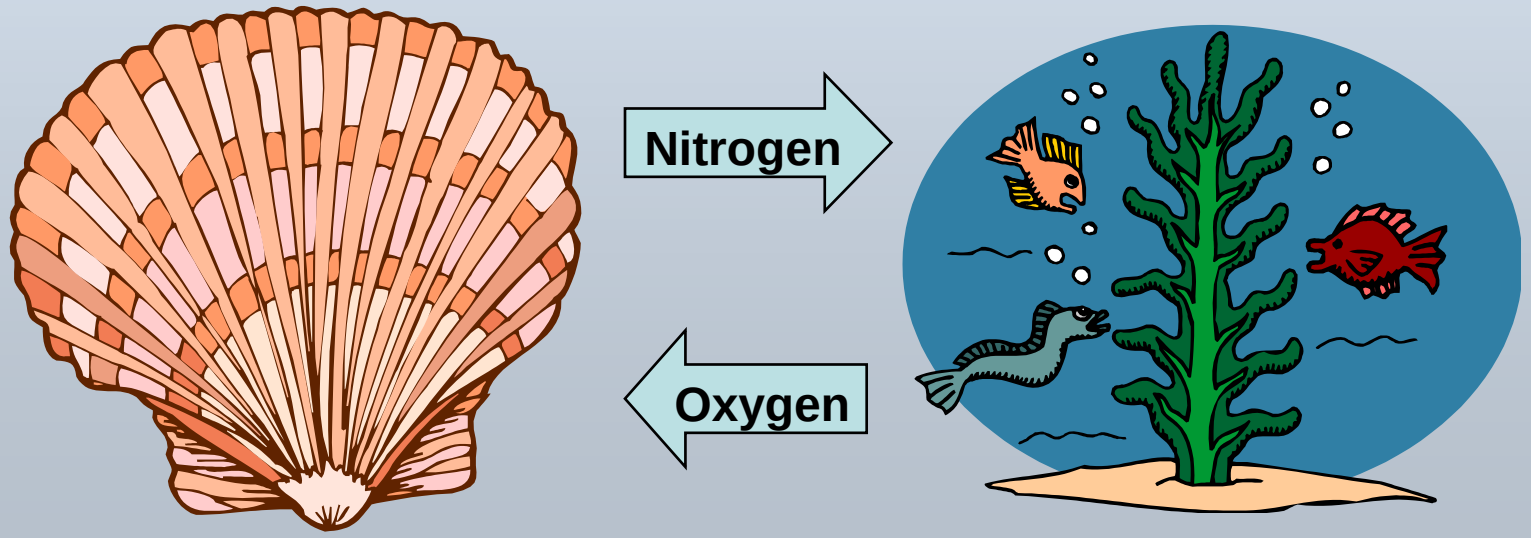
"Polyculture" is a type of aquaculture to grow different complementary species (i.e., finfish, shellfish, and marine plants) together.



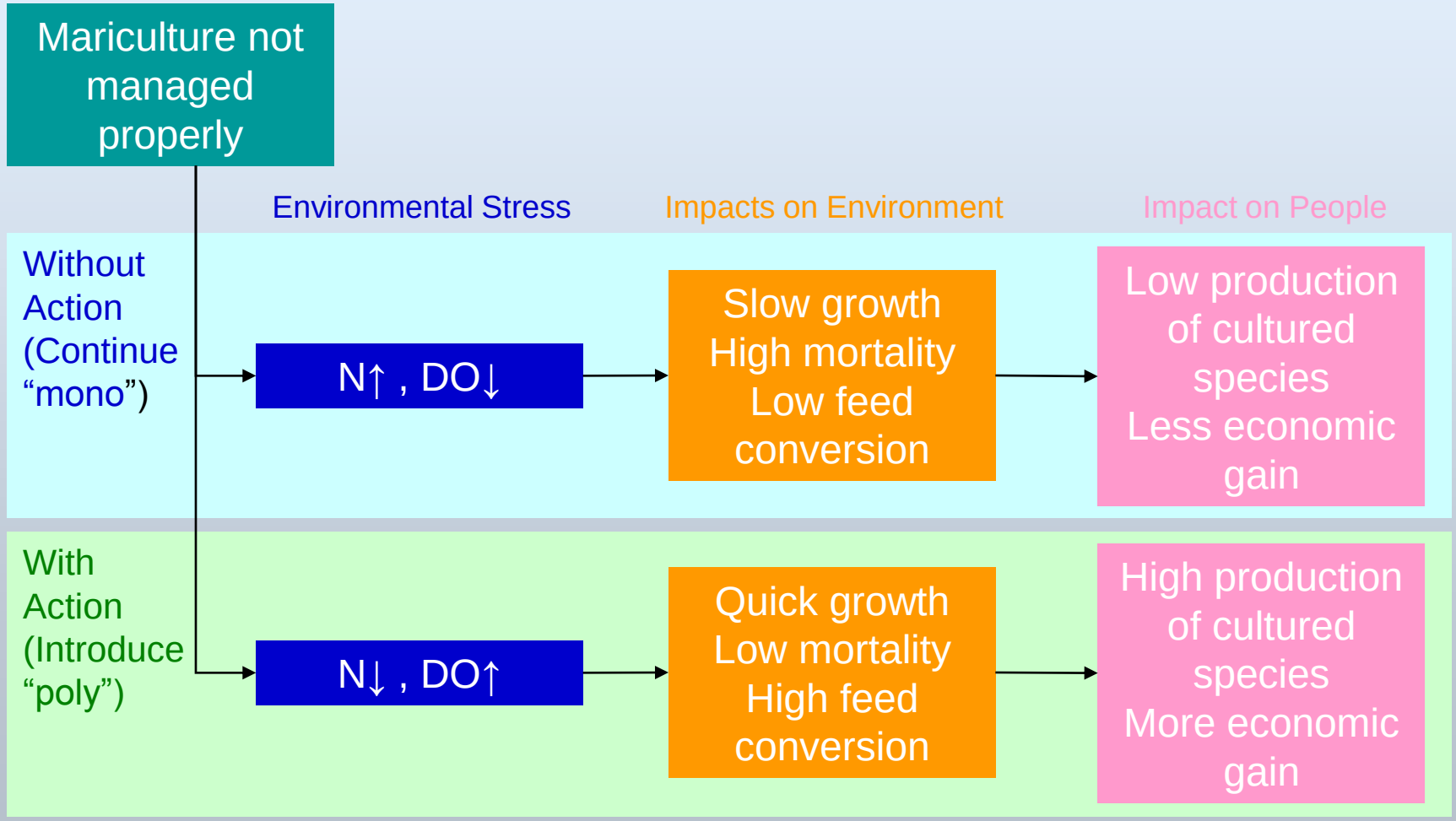
Source: Troell & Norberg, 1998, cited in Chung, 2007

Polyculture (cont.)

It is expected that polyculture not only **increases revenues** in aquaculture production, but also **reduces environmental impacts** by removing excess nutrients.



With-or-Without-Scenarios



Cost & Benefit of Polyculture

Cost	Benefit
• Initial cost (e.g., cages, ropes, seeds) • O&M cost (e.g., labor)	• Increase in economic gain (more producer surplus) • Less environmental impact

Preliminary Result of Polyculture CBA

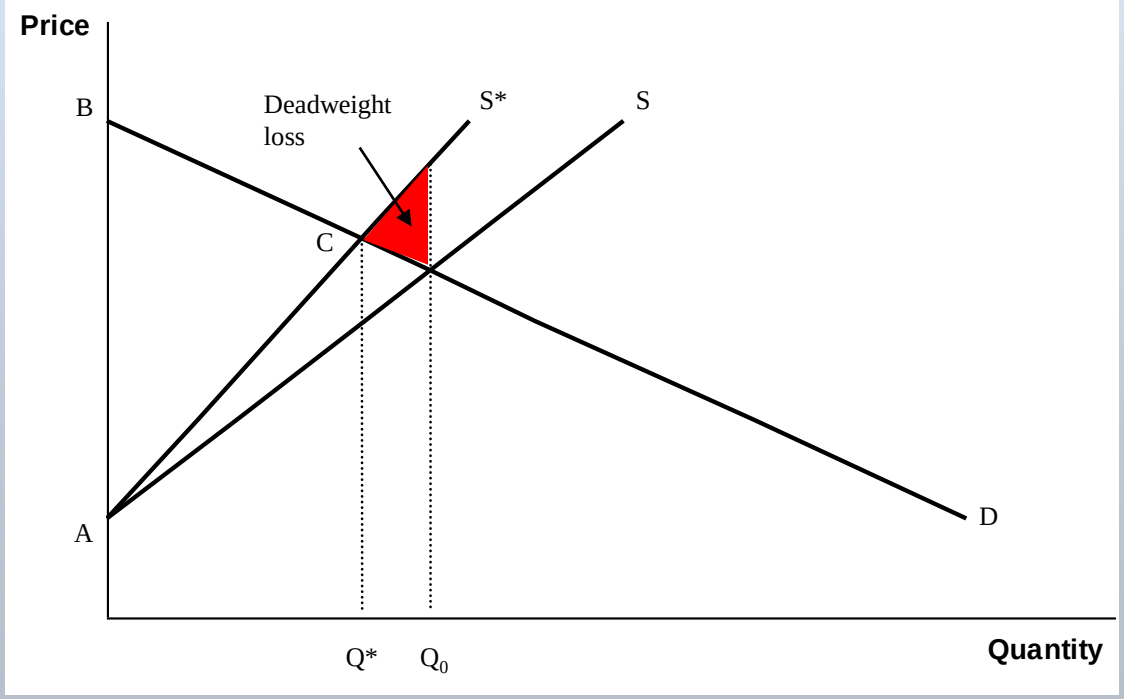
Type of maricultu re*	Cultured species	Gross revenue (Yuan/ha)	Net revenue (Yuan/ha) ** (1)	Additiona l cost to introduce kelp (2)	Additiona l benefit *** (3) = (1) – (Baseline net rev.)	Net benefit (4) = (3) – (2)
Monocultu re (baseline)	Scallop	4,000 -- 5,000	2,000 -- 2,500	NA	NA	NA
Polycultu re	Scallop + Kelp	7,000 -- 9,000	3,500 -- 4,500	500	1,000 -- 2,500	**500 -- 2,000 (> 0)**

Source: Interview with Dr. Jianguang Fang and Dr. Jihong Zhang, Yellow Sea Fisheries Research Institute, on 13 July 2007.

Note: ***It is assumed that the environmental impact of polyculture is less than that of monoculture (e.g., less excess nutrients), and that negative externalities of culturing scallops on ecosystems are negligible.** **Cost of operating mariculture is assumed to be 50 percent of revenues. ***Increase in revenue by introducing polyculture, compared to monoculture (baseline).

What If There's an Externality?

Mariculture, **even polyculture, might cause negative externality** by still producing excess nutrients. Recall the "deadweight loss."



What If Externality? (cont.)

- Excess nutrients from mariculture might cause **eutrophication** and **algal blooms**, impacting negatively on other enviornmental goods and services (e.g., tourism, biodiversity).
- Management action: **Regulate mariculture production** up to the socially-optimal level (Q*).
- Does this action make sense economically?

CBA of Regulating Mariculture

Cost	Benefit
Compliance monitoring & enforcement Opportunity cost as a result of regulating mariculture operations	Prevented loss of: e.g., biodiversity and/or recreational opportunities in coastal area (can be measured by TCM and/or CVM)

Recap of the Main Points

- Economic Value =

  Consumer Surplus + Producer Surplus
- To measure value, estimate demand & supply for concerned goods.
- Consider negative externality, if any.
- Various valuation techniques are available, including empirical technique, TCM, and CVM.
- 8-step procedure for CBA of management actions
- Compare with-or-without action scenarios.
- Management actions make sense if their benefits > costs.

End of Presentation

Thank you!

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