Diversity of perceptions and utility of marine ecosystem services

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Ecosystem services

The benefits people obtain from ecosystems (MA, 2005)

Valuation of ecosystem services: one of the tools that support decision-making in environmental management

Notable research has accumulated. (Bingham et al., 1995; Costanza et al., 1997; De Groot et al., 2002; Loomis et al., 2000)
Four groups of ecosystem services at Millennium Ecosystem Assessment in 2005 and other previous publications

- **Provisioning** (food, fresh water)
- **Regulating** (Climate regulation)
- **Cultural** (Aesthetic, recreational)
- **Supporting** (Nutrient cycling, primary production)
There is variation in how the value or importance of ecosystem is viewed and expressed, depending on different disciplines, cultural norms, philosophical views, and schools of thought. (Goulder and Kennedy, 1999)

The general public’s perception of ecosystem is quite different from what is conceptualized by conventional economists. (Kumar and Kumar, 2008)
Our question: How do people perceive marine ecosystem services?

1st Objective

Marine ecosystem services

- Provisioning services
- Regulating services
- Cultural services
- Supporting services
Utility: satisfaction experienced by the consumer of a good or service

Why “utility” is important in marine and coastal management?

- It forms the basis of decision-making which usually involves choices among alternatives.
Key concept and hypothesis

2nd Objective

- Explore the utility that residents derive from marine ecosystem services, and how this influences their behavioural intentions for marine conservation.

Key concept: “indispensability”

A presumption:
the higher the perceived indispensability, the greater the utility.

A hypothesis:
the higher the indispensability, the greater its influence on enhancing behavioural intentions for marine conservation.
An online survey was conducted on human utility of marine ecosystem services and behavioral intentions for marine conservation

**Survey method**
Online survey (contract with Macromill and Univ. of Tokyo)

**Survey period**
February 15-17, 2013

**Respondents**
1,100 residents *
(Tokyo, Osaka, Ishikawa, Nagano, Shizuoka)

**Analysis methods**
- Factor analysis
- Structural equation model

* Ultimately 814 responses were used after being stratified according to the gender and age per each prefecture.
Steps of research

Online Survey
Perception of Marine Ecosystem Services by respondents

Factor Analysis
Classification of Marine Ecosystem Services by respondents

Structural Equation Model
Causal relationships between perceived value of Marine Ecosystem Services by respondents and their intentions of behaviour for marine conservation
### Questionnaire items

- 18 questionnaire items on marine ecosystem services developed based on a review of existing literature

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q1</strong></td>
<td>Without <strong>foodstuffs like fish and seaweed</strong> provided by the sea, our diet would be extremely affected.</td>
</tr>
</tbody>
</table>
| **P**    | **P**food 1 strongly agreed  
2 agreed  
3 neither  
4 disagreed  
5 strongly disagreed |
| **Q7**   | (sandy beaches to reduce waves)                                              |
| **Q12**  | (marine recreational opportunities)                                          |
| **Q18**  | (place for marine organisms to live)                                        |
## Results of factor analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explained variance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.44</td>
<td>46.25</td>
<td>5.46</td>
<td></td>
</tr>
<tr>
<td>Rotated loadings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P_{\text{food}}$</td>
<td><strong>0.52</strong></td>
<td>0.33</td>
<td>-0.12</td>
</tr>
<tr>
<td>$P_{\text{med}}$</td>
<td>-0.14</td>
<td><strong>0.80</strong></td>
<td>0.13</td>
</tr>
<tr>
<td>$P_{\text{mineral}}$</td>
<td>0.00</td>
<td><strong>0.82</strong></td>
<td>-0.06</td>
</tr>
<tr>
<td>$P_{\text{energy}}$</td>
<td>0.10</td>
<td><strong>0.75</strong></td>
<td>-0.10</td>
</tr>
<tr>
<td>$P_{\text{water}}$</td>
<td>-0.09</td>
<td><strong>0.72</strong></td>
<td>0.10</td>
</tr>
<tr>
<td>$R_{\text{beach}}$</td>
<td>0.13</td>
<td><strong>0.64</strong></td>
<td>0.05</td>
</tr>
<tr>
<td>$R_{\text{reef}}$</td>
<td>0.18</td>
<td><strong>0.59</strong></td>
<td>0.08</td>
</tr>
<tr>
<td>$R_{\text{tidal}}$</td>
<td>0.37</td>
<td><strong>0.47</strong></td>
<td>-0.01</td>
</tr>
<tr>
<td>$R_{\text{cd}}$</td>
<td>0.21</td>
<td><strong>0.52</strong></td>
<td>0.07</td>
</tr>
<tr>
<td>$C_{\text{religion}}$</td>
<td>-0.12</td>
<td>0.26</td>
<td><strong>0.60</strong></td>
</tr>
<tr>
<td>$C_{\text{rec}}$</td>
<td>-0.08</td>
<td>0.01</td>
<td><strong>0.68</strong></td>
</tr>
<tr>
<td>$C_{\text{health}}$</td>
<td>-0.16</td>
<td>0.02</td>
<td><strong>0.80</strong></td>
</tr>
<tr>
<td>$C_{\text{culture}}$</td>
<td>0.32</td>
<td>-0.11</td>
<td><strong>0.66</strong></td>
</tr>
<tr>
<td>$C_{\text{scenery}}$</td>
<td><strong>0.46</strong></td>
<td>-0.07</td>
<td><strong>0.48</strong></td>
</tr>
<tr>
<td>$S_{\text{life}}$</td>
<td><strong>0.90</strong></td>
<td>-0.07</td>
<td>0.00</td>
</tr>
<tr>
<td>$S_{\text{ncycle}}$</td>
<td><strong>0.81</strong></td>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>$S_{\text{place}}$</td>
<td><strong>0.90</strong></td>
<td>0.04</td>
<td>-0.16</td>
</tr>
</tbody>
</table>

* Rotated factor loadings above 0.4 retained.
Hidden Factor & Naming Latent Constructs

\[ P_{\text{food}}, S_{\text{life}}, S_{\text{ncycle}}, S_{\text{place}}, C_{\text{scenery}} \]

Essential Benefits
Hidden Factor & Naming Latent Constructs

\[ P_{\text{med}} \]
\[ P_{\text{mineral}} \]
\[ P_{\text{energy}} \]
\[ P_{\text{water}} \]
\[ R_{\text{beach}} \]
\[ R_{\text{reef}} \]
\[ R_{\text{tidal}} \]
\[ R_{cd} \]

Indirect Benefits
Hidden Factor & Naming Latent Constructs

C_{scenery} \rightarrow Cultural Benefits

C_{religion} \rightarrow Cultural Benefits

C_{rec} \rightarrow Cultural Benefits

C_{health} \rightarrow Cultural Benefits

C_{culture} \rightarrow Cultural Benefits
- 5 questionnaire items on behavioral intentions for marine conservation developed ← based on a review of existing literature

<table>
<thead>
<tr>
<th>Q19</th>
<th>I would accept a <strong>tax</strong> increase for marine conservation.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 strongly agreed</td>
</tr>
<tr>
<td></td>
<td>2 agreed</td>
</tr>
<tr>
<td></td>
<td>3 neither</td>
</tr>
<tr>
<td></td>
<td>4 disagreed</td>
</tr>
<tr>
<td></td>
<td>5 strongly disagreed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q20</th>
<th>(<strong>donate money</strong> )</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Q21</th>
<th>(<strong>volunteer</strong> )</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Q22</th>
<th>(<strong>support company that contribute to marine conservation</strong> )</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Q23</th>
<th>(<strong>purchase pro-environmental goods</strong> )</th>
</tr>
</thead>
</table>
Latent variables and behavioral intentions in our hypothetical model (structural equation model)

**Indirect Benefits**
- Pmed
- Pmineral
- Penenergy
- Pwater
- Rbeach
- Rreef
- Rtidal
- Rcd

**Essential Benefits**
- Pfood
- Slife
- Sncycle
- Splace

**Cultural Benefits**
- Cscenery
- Creligion
- Crec
- Chealth
- Cculture

**Behavioural Intentions for Marine Conservation**
- MCtax
- MCdonation
- MVCvolunteer
- MCsupcon
- MCenvgoods
Standardized estimated hypothetical model

Behaviours intentions are most positively driven by “Cultural Benefits”.

* “a” indicates significance at the 0.001 level. Dashed line indicates path that is not significant at 0.05 or better.

Indirect Benefits

Essential Benefits

Cultural Benefits

Behavioural intentions for marine conservation

GFI=0.846
AGFI=0.807
RMSEA=0.089
## Indispensability of marine ecosystem

<table>
<thead>
<tr>
<th>Latent constructs</th>
<th>Essential Benefits</th>
<th>Indirect Benefits</th>
<th>Cultural Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>39.6% 40.2%</td>
<td>24.4% 42.7%</td>
<td>11.9% 34.7%</td>
</tr>
<tr>
<td></td>
<td>17.6% 2.4% 0.3%</td>
<td>26.8% 5.1% 1.0%</td>
<td>36.8% 13.5% 3.1%</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

* 1: strongly agreed, 2: agreed, 3: neither, 4: disagreed, 5: strongly disagreed
Residents in Japan perceive the sea in three categories:

- **Essential Benefits**
- **Indirect Benefits**
- **Cultural Benefits**

**Behavioral intentions for marine conservation**

1. Essential Benefits
2. Indirect Benefits: Statistically insignificant
3. Cultural Benefits

**Discrepancies** between the value of marine ecosystem services that respondents identified as the most indispensable, and how this affects their behavioural intentions for marine conservation:

The hypothesis was rejected.
Applying “scarcity principle”, the discrepancies above might be caused because of their perceiving “Cultural Benefits” as scarce, while perceiving “Essential Benefits” as abundant and secured.

Residents in Japan perceive sea in three categories

- **Essential Benefits**: abundant
- **Indirect Benefits**: statistically insignificant
- **Cultural Benefits**: scarce

Policy implication

- Utility of marine ecosystem services would fluctuate in accordance with scarcity of the services in their places of residence.

Behavioral intentions for marine conservation

- **No. 1**: Heart
- **No. 2**: Heart
Delving into results of residents of Nagano, Landlocked Prefecture
## Results of factor analysis: Nagano residents

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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40.64</td>
<td>8.95</td>
<td>6.74</td>
</tr>
<tr>
<td>Rotated loadings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P ornament</td>
<td>-0.06</td>
<td><strong>0.40</strong></td>
<td>0.27</td>
</tr>
<tr>
<td>P med</td>
<td>-0.16</td>
<td><strong>0.48</strong></td>
<td>0.06</td>
</tr>
<tr>
<td>P mineral</td>
<td>0.09</td>
<td>-0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>P energy</td>
<td>0.11</td>
<td>-0.03</td>
<td>-0.04</td>
</tr>
<tr>
<td>P water</td>
<td>-0.15</td>
<td><strong>0.56</strong></td>
<td>0.12</td>
</tr>
<tr>
<td>R beach</td>
<td>0.14</td>
<td><strong>0.73</strong></td>
<td>0.02</td>
</tr>
<tr>
<td>R reef</td>
<td>0.17</td>
<td><strong>0.75</strong></td>
<td>0.04</td>
</tr>
<tr>
<td>R tidal</td>
<td>0.39</td>
<td><strong>0.50</strong></td>
<td>-0.09</td>
</tr>
<tr>
<td>R cd</td>
<td>0.09</td>
<td><strong>0.83</strong></td>
<td>-0.12</td>
</tr>
<tr>
<td>C religion</td>
<td>-0.13</td>
<td>0.26</td>
<td><strong>0.49</strong></td>
</tr>
<tr>
<td>C rec</td>
<td>-0.07</td>
<td>-0.13</td>
<td><strong>0.69</strong></td>
</tr>
<tr>
<td>C health</td>
<td>-0.16</td>
<td>0.28</td>
<td><strong>0.60</strong></td>
</tr>
<tr>
<td>C culture</td>
<td>0.32</td>
<td>-0.14</td>
<td><strong>0.68</strong></td>
</tr>
<tr>
<td>C scenery</td>
<td><strong>0.41</strong></td>
<td>-0.03</td>
<td><strong>0.55</strong></td>
</tr>
<tr>
<td>S life</td>
<td><strong>0.80</strong></td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>S ncycle</td>
<td><strong>0.75</strong></td>
<td>0.16</td>
<td>0.04</td>
</tr>
<tr>
<td>S place</td>
<td><strong>0.90</strong></td>
<td>-0.03</td>
<td>-0.09</td>
</tr>
</tbody>
</table>

* Rotated factor loadings above 0.4 retained.
Latent Constructs and observed variables on perceptions of Nagano residents (1)

- $S_{\text{life}}$
- $S_{\text{ncycle}}$
- $S_{\text{place}}$
- $C_{\text{scenery}}$

Essential Benefits

- $P_{\text{food}}$
- $S_{\text{life}}$
- $S_{\text{ncycle}}$
- $S_{\text{place}}$
- $C_{\text{scenery}}$

Observed variables on perceptions of all respondents
Latent Constructs and observed variables on perceptions of Nagano residents (2)

Indirect Benefits

- $P_{ornament}$
- $P_{med}$
- $P_{water}$
- $R_{beach}$
- $R_{reef}$
- $R_{tidal}$
- $R_{cd}$

Observed variables on perceptions of all respondents
Latent Constructs and observed variables on perceptions of Nagano residents (3)

Cultural Benefits

$C_{\text{scenery}}$, $C_{\text{religion}}$, $C_{\text{rec}}$, $C_{\text{health}}$, $C_{\text{culture}}$

Observed variables on perceptions of all respondents
Latent variables and behavioral intentions: Nagano residents

- Essential Benefits
  - $S_{life}$
  - $S_{ncycle}$
  - $S_{place}$

- Cultural Benefits
  - $C_{scenery}$
  - $C_{religion}$
  - $C_{rec}$
  - $C_{health}$
  - $C_{culture}$

- Indirect Benefits
  - $P_{ornament}$
  - $P_{med}$
  - $P_{water}$
  - $R_{beach}$
  - $R_{reef}$
  - $R_{tidal}$
  - $R_{cd}$

- Behavioral intentions for marine conservation

- MC$_{tax}$
- MC$_{donation}$
- MC$_{volunteer}$
- MC$_{supcon}$
- MC$_{envgoods}$
Latent variables and behavioral intentions: Nagano residents

GFI=0.809  
AGFI=0.754  
RMSEA=0.095

* “a” indicates significance at the 0.001 level. Dashed line indicates path that is not significant at 0.05 or better.

Influenced by scarcity principle?
Annual consumption of fish and shellfish

※Average of annual consumption of fish and shellfish from 2011 - 2013
Q. “How often do you see the sea?”
More attention is needed for cultural aspects of marine ecosystem services if we want to obtain better support from citizens.

Perception of marine ecosystem could vary reflecting scarcity of the services in their place of residents, i.e., proximity/relationships with the sea and cultural background.

Marine policy needs to be tailored in line with cultural context of respective places.
This work was supported by the JSPS KAKENHI (Grant number 4403) “New Ocean Paradigm on its Biogeochemistry, Ecosystem and Sustainable Use (NEOPS)”. This is a five year project from 2012 aiming at advancing our understanding of ocean biogeochemistry and ecosystem dynamics in the Pacific Ocean for the sustainable use of ecosystem services, with particular attention to the high seas.

http://ocean.fs.a.u-tokyo.ac.jp/research-e.html
Thank you.