Regional analysis on the decadal variation of water quality in three contrasting coastal systems of Ishikawa coast, Japan

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Presentation to EMECS 9 Conference, Baltimore, USA
Wednesday, 31st August 2011
Socio-Ecological Systems Variation and Environmental Change Impact on a Subarctic Coastal Zone on the Sea of Japan: Trends and Drivers

An ongoing research study @ the UNU IAS Operating Unit Ishikawa/ Kanazawa, Japan
Preamble..

Concept: Socio-Ecological Systems (MARINE)

Interaction between humans and the bio-physical subsystems

[Socio - Ecological]

Humans
- Cultural
- Management
- Economic
- Socio-political

Marine
- Physical
- Chemical
- Biological

The IPCC 4th AR identifies the need to make social-ecological systems more resilient by building "adaptive capacity".

Satoumi has been defined as coastal areas with high productivity and biodiversity enhanced through human management.

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Understanding the effects of these changes on phytoplankton biomass and productivity, and the linkages of the controlling factors is paramount to understanding long-term changes in marine ecosystems and the impacts of human activities.
Ishikawa’s Ocean Coastline

Has a general NE-SW orientation

Coordinates: 36°34'N 136°39'E

~581 km alongshore stretch

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Tsushima warm water current

8- Rieman (Liman) Cold Water current from the north

4- Tsushima Warm Water current from the south

Source: Wikimedia Common

Rich marine fish species from cold north and warm south

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Problems

Natural and Anthropogenic Factors

① Land-based sources of pollution
② Oil spills and coastal alterations
③ Land reclamation
④ Excessive groundwater extractions
⑤ Serious and rapid erosion

It is expected that with differences in land use and human impact along the coast, coastal water quality change at this highly contrasting coastal systems will differ on spatial and temporal scale.
**GOAL and Objectives**

Understanding coastal water quality trends and the coupled human-environmental drivers: Towards sustainable coasts.

① Document specific changes for appropriate management actions.

② Identify areas vulnerable to natural and anthropogenic forcing.

③ Improved knowledge on coastal ecosystem dynamics.

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Research Question and Methodology

Preamble

Place-based research addressing socio-ecological systems associated with specific seascape or coastal region

Ecological baselines: How has Ishikawa’s Ocean coastline changed over the years?

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Data Sources and Analysis

A. Environment Unit, Ishikawa Prefectural Office, Japan

Water Quality Monitoring Data: 1984 - 2009
(Hydrogen ion concentration-pH; Dissolved Oxygen-DO; Chemical Oxygen Demand-COD; Total Nitrogen – T-N; Total Phosphorus-T-P)

- Japan Meteorological Agency
- Ishikawa Prefecture Statistical Data

Climatic Data: 1930 - 2010
(Rainfall and Temperature)

Socio-Economic Data: 1930 - 2010
(Population, Fish Catches, Management Units)

B. Questionnaires, Interviews and Historical Reviews
Coastal Compartments: Characterization

- Contrasting physiographic, topographic and geomorphologic features….
- Differences in land use and human impacts along the coast
- Enable better analyses of spatial and temporal trends and drivers
- Twenty three (23) designated stations sampled:
  - @ 0-1 m depth
  - < 5 Km from Shore

Kanazawa Area-KNA  Noto Area-NTA  Nanao Area-NNA

High ocean waves and tides
Sandy beach shore
Rocky/Cliff shore
Sandy/Rocky enclosed shore

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**Results - Climatic Variables**

Highly significant ($P < 0.0001$) temporal and spatial variation

Temperature increased by $\sim 2.2 - 3.5 \, ^{\circ}C$ between 1930 and 2010

Highly significant ($P < 0.0001$) temporal and spatial variation

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Water Quality
Spatial and Temporal Trends

- Decreased ~20% (KNA); ~12% (NNA)
- Increased ~25% (NTA)

Human perturbation from tourism, agricultural and fishing activities (NTA).
Urban migration to KNA

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Hydrogen ion concentration (pH) Temporally: ~ 0.23 units drop in pH values in last 3 decades
Spatially: 0.13 – 0.20 units along the coast

Profound implications for physiological processes in marine organisms

Oceanic calcifying organisms

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Water Quality
Spatial and Temporal Trends

Across three decades
\((r = 0.548; P = 0.001; n = 191)\)
Significant Increase

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Water Quality

Nutrients Relationship @KNA and NNA


Redfield Ratio line (N:P = 16:1)

KNA

\[ y = 0.0468x + 0.0335 \]
\[ R^2 = 0.249 \]

NNA

\[ y = 0.1078x + 0.0023 \]
\[ R^2 = 0.0829 \]

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Vulnerable coastal areas

From the **Water Quality Point of View**

**KNA:** where there was high COD and nutrients (T-N and T-P) concentrations is the **main vulnerable area** of the Ishikawa coast.

**NTA:** refuse abandonment on the coast by tourist has been identified as one of the drivers of change in the coastal water quality.

**NNA:** coastal compartment may be particularly vulnerable to **eutrophication** due to often restricted water exchange with the adjacent ocean.

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Discussion

Correlation Matrix: Water Quality Spatial and Temporal Pattern

<table>
<thead>
<tr>
<th></th>
<th>DO</th>
<th>pH</th>
<th>COD</th>
<th>Year</th>
<th>Area</th>
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<tbody>
<tr>
<td>DO</td>
<td>1</td>
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<td>pH</td>
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<tr>
<td>COD</td>
<td>0.066</td>
<td>0.359**</td>
<td>1</td>
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<tr>
<td>Year</td>
<td>0.548**</td>
<td>-0.502**</td>
<td>-0.026</td>
<td>1</td>
<td></td>
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<tr>
<td>Area</td>
<td>0.107</td>
<td>0.012</td>
<td>-0.249**</td>
<td>-0.016</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Temp.</th>
<th>T-N</th>
<th>T-P</th>
<th>Year</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temp.</td>
<td>1</td>
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<tr>
<td>T-N</td>
<td>-0.172</td>
<td>1</td>
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<td></td>
<td></td>
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<tr>
<td>T-P</td>
<td>0.055</td>
<td>0.467**</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>-0.057</td>
<td>-0.096</td>
<td>-0.024</td>
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</tr>
<tr>
<td>Area</td>
<td>0.105</td>
<td>-0.832**</td>
<td>-0.386**</td>
<td>0.017</td>
<td>1</td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level (2-tailed)**

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Trends and Drivers of Change

Anthropogenic Drivers

① Physical/Structural- reclaimed land, ports and harbor, tripods and walls.

② Cultural- merging of towns and villages resulting in loss or proliferation of local cultures, alienation of humans from sea, changing lifestyles

③ Ecological- biodiversity loss and water quality along the coastline

④ Socio-economic- Ports and Harbour for trade, fishing industries, tourism, agriculture

⑤ Demographic- depopulation problem, decline in fishermen, fisheries management bodies.

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Drivers of Change

Natural Drivers

1. Coastal Erosion/flooding
2. Sea Level Rise
3. Climate Change - Temperature Change
4. Surge Storm
5. Ageing Population
6. Salt Water Intrusion - Rice Farmlands

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Coastline Change: Impacts and Threats

Salt Intrusion
Rice Farmland

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Policy Response

Water Quality/Pollution Trends - MOE

Achievement of Environmental Quality Standards

Rate is still low in inland seas - 74.5%

Source: Japan Coast Guard

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Policy Response

Spatial Variation

Temporal Variation

Low

Moderate

High

Adaptation & Mitigation Strategies

Build Resilience

- Adaptation strategies

Mitigation Strategies

- Nutrient reduction
- Coastal zoning

pH

DO

Bio.

Temp

Pop.

T-P

T-N

COD

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### Deploying the SWOT Analysis

To Assist in Identifying Strategic Direction for Coastal Management Practices

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Environmental Monitoring Data</td>
<td>• Increasing Human Impacts</td>
</tr>
<tr>
<td>• Rich Biodiversity Potentials</td>
<td>• Dominant/Strong “Bottom-Up” Approach</td>
</tr>
<tr>
<td>• Available Environmental Rules</td>
<td>• Declining Fisheries Production</td>
</tr>
<tr>
<td>• Presence of Skillful Environmental Experts</td>
<td>• Declining Management</td>
</tr>
<tr>
<td></td>
<td>• Waning Coastal Cultural Practices</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Tourism Attraction Potentials</td>
<td>• Cheap Foreign Seafood</td>
</tr>
<tr>
<td>• Possibility of Enhancing and reviewing</td>
<td>• Persistent Coastal Erosion</td>
</tr>
<tr>
<td>environmental regulations and supervision</td>
<td>• Incremental Pollution due to Flood River</td>
</tr>
<tr>
<td>• University, Research, Training Centres and</td>
<td>• Climate Change</td>
</tr>
<tr>
<td>International Cooperations</td>
<td>• Alienation of Humans from the Sea</td>
</tr>
<tr>
<td>• Space Technology for Efficient Monitoring</td>
<td></td>
</tr>
</tbody>
</table>

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Community Involvement

**Spirit of Volunteerism**

In the wave of enormous quantity of refuse on the coast especially along Shioya to Sogogi coast at NTA, community involvement in coastal clean-up was launched and has since been sustained.

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Reuters News Service, March 28, 2001

Scientists, fishermen fear Sea of Japan slowly dying

"It is possible that the Sea of Japan is one of the first expanses of water affected by global warming, if that is the case, then we very much fear that eventually the world's major oceans will also be affected,"

-Professor Yoon Jong-Hwa
Research and Institute for Applied Mechanics (RIAM) CREAMS project, Fukuoka.

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Recommendations

① Understanding the important issues and collaborating with other disciplines will be essential in marine social-ecological systems.

② Setting stricter water quality standards in collaboration with industry, stakeholders groups and coastal community resource users.

③ Continuous monitoring of coastal developments and activities - targeted and effective adaptation strategy.

④ Ishikawa coastal planning/zoning to accommodate livelihood and economic changes to changing biodiversity and fishing regimes, sea-level rise and erosion.
Acknowledgement

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② Director, Interns and Staff @UNU-IAS Operating Unit Ishikawa Kanazawa (UNU-IAS OUIK)

③ Ishikawa Prefectural Government

④ Environment Unit, Ishikawa Prefectural Office, Japan
Thank you!

Your Feedbacks

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