Integrated Ecosystem Assessment on the West Coast of Vancouver Island for planning and management

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Vancouver Island
Vancouver Island
Case studies

Clayoquot Sound

Barkley Sound
Barkley Sound
Overall goals

1. Coastal and Ocean Plan for the West Coast of Vancouver Island
   - Ecosystem-based
   - Integrated
   - Sustainable
   - Participatory
   - Collaborative

2. Monitoring social-ecological system health

3. Strategies to cope with changes
Talk outline

• West Coast Aquatic
• Integrated Ecosystem Assessment
  – Elements and Stressors
  – Goals, Objectives, and Indicators
  – Management Strategies and Evaluation
Approach

Don’t get lost in the details.

Simplify!
West Coast Aquatic

A forum for the coastal communities, individuals and bodies affected by aquatic resource management to participate more fully with governments in all aspects of the management of aquatic resources in the West Coast Vancouver Island area.
Participation & Representation

8 Government Appointees
- 2 from Nuu-chah-nulth
- 2 from Federal Government
- 2 from Provincial Government
- 2 from Local Government

8 Non-Government Appointees
- Tourism
- Environment
- Aquaculture
- Labour
- Processing
- Commercial Harvesting
- Recreational Harvesting
- Aboriginal Harvesting

16 Member Board
- Decisions made by consensus
- Guided by principles including Hishukish Ts’awalk and Iisaak

Staff
- Executive Directors, Administration, Director of Marine Planning, Science Director, Communication Director, First Nations Outreach

Constituencies
- Communities, government departments, tourism associations, environmental groups, commercial fishers, food fishery, etc...
Hishukish Ts'awalk – All things are one

Isaak – Respect
OVERALL PLANNING GOALS

• Healthier Ecosystem
• More Jobs and Training
• Increased Access to Opportunities
• Stronger Partnerships and Pride
• Vibrant Recreation and Culture
• New knowledge and tools
• Good Management
Integrated Ecosystem Assessment

Levin et al. 2009
- Understand the social-ecological system
- Identify system elements and stressors
- Identify issues, goals, objectives

- Identify state and pressure indicators
- Select working indicators
- Identify benchmarks and targets

- Staged evaluation of the sensitivity and status of individual indicators

- Assess the status of the whole ecosystem
- Assess perceptions of ecosystem health
The Social-Ecological System

“The Hockey Puck Model”
Ecosystem Realms & Elements

- Environmental quality
  - Physical
  - Chemical

Habitat
- Trophic Structure
- Species & Populations
- Communities & assemblages

Productivity (function)
- Primary & Secondary Productivity
- Population Productivity

Biodiversity (structure)
Multiple Human Stressors

- Fisheries
- Climate change
- Forestry
- Coastal Development
STRESSORS UNPACKED

Agriculture
land-based effects
pollution from fertilizer, animal waste

Aquaculture
Nutrient enrichment
Toxic pollutants
habitat effects
parasites
genetic mixing

Boats and ships
antifouling paint
catastrophic oil spills
fuel and oil leakage
sewage

Watershed modification
other watershed modification
Coastal development & bulkheading
Commercial Buildings
Residential buildings
Roads, High voltage transmission lines, natural gas, pipelines, seismic lines
Urban Sprawl
Water body alteration: damming, diking, channelizing, or culvert lakes, rivers, streams, etc.

Diseases: Marine organisms

Fishing
Bycatch
Commercial
Habitat damage
Recreational
Sport fishing
Subsistence
Illegal and unreported

Forestry
log booms
nutrient changes
sediment runoff
water temp changes

Global change
Changes in upwelling & productivity
Lowered oxygen in ocean
Ocean acidification
Salinity changes
Sea level rise
Snowpack and precipitation changes
Storm activity changes
Water temperature changes

Pollution
Bio-concentrating trace pollutants
Dioxin contamination
excessive nutrients
From energy use, drilling, hydroelectric,

Mercury contamination
nutrient enrichment
Plastics
Point-source chemical
Pulp-mill effluent
Sewage effluent
Styrofoams
toxic biochemicals
Urban runoff
Noise

Recovery of sea otters
Recovery of seals / sea lions

Non-extractive recreation and tourism
Interference with animal behaviour

Scientific research and educational

Governance: Dysfunctional

Harmful algal blooms

Invasive species

Military and strategic

Poaching

Management of natural resources: Poor
Degree of stress exerted

- Energy (renewables; wave/wind/river)
- Recreation / tourism (non-extractive; e.g. kayaking)
- Agriculture
- Fisheries (subsistence)
- Shipping / Boating
- Fisheries (recreational)
- Coastline development (including float-homes)
- Watershed modification
- Aquaculture
- Fisheries (commercial)
- Mining
- Energy (oil/gas/methane exploration)
- Invasive species / disease
- Global change (e.g. climate)
- Other water pollution
- Forestry

\[ n = 48 \]
Relative stress by energy-related activities

- Hydropower
- Offshore oil, gas, methane exploration
- Tanker traffic
- Wave energy development
- Wind energy development
- Other renewables

n = 48
Relative stress by forestry activities

- Log booms
- Water temp changes
- Nutrient changes
- Road construction
- Changes in water runoff
- Debris in rivers
- Forest biodiversity loss
- Erosion and sediment runoff

n = 48
Rated health of marine areas

- Kyuquot Sound
- Ditidaht Sound
- Nootka Sound
- Barkley Sound
- Entire WCVI Area
- Pacheedaht Sound
- Clayoquot Sound
- Offshore of surf line
- Alberni Inlet

$n = 48$
Rated change in health

<table>
<thead>
<tr>
<th>Location</th>
<th>Change Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyuquot Sound</td>
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<tr>
<td>Barkley Sound</td>
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<td>Nootka Sound</td>
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<td>Ditidaht Sound</td>
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<td>Entire WCVI Area</td>
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<td>Alberni Inlet</td>
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<tr>
<td>Offshore of surf line</td>
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</tbody>
</table>

$n = 48$
Rated speed of change in health

- Offshore of surf line
- Alberni Inlet
- Entire WCVI Area
- Clayoquot Sound
- Barkley Sound
- Pacheedaht Sound
- Ditidaht Sound
- Nootka Sound
- Kyuquot Sound

1.00 Very Slowly
2.00 Somewhat Slowly
3.00 Moderate Rate
4.00 Somewhat Fast
5.00 Very Fast

n = 48
Goals and objectives

• Goal: Healthy Ecosystem
• Objectives:
  – Restore, maintain, and conserve biodiversity, structure, and function of biological communities
  – Restore, maintain, and conserve the physical and chemical environments, including the integrity of habitats
• Get specific
Select indicators

Knowledge gathering → Long list → Apply criteria → Review → Indicators → Benchmarks & strategies
DPSIR Framework
## State indicator categories

<table>
<thead>
<tr>
<th>Realm</th>
<th>Element</th>
<th>Indicator Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biodiversity</strong></td>
<td>Communities / Assemblages</td>
<td>Kelp forest communities</td>
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<tr>
<td></td>
<td></td>
<td>Seagrass communities</td>
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<td>Intertidal communities</td>
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<td></td>
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<td>Rocky bottom communities</td>
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<td></td>
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<td>Soft bottom communities</td>
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<td></td>
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<td>Sponge reef communities</td>
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<td></td>
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<td>Plankton communities</td>
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<td></td>
<td></td>
<td>Nekton communities</td>
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<tr>
<td></td>
<td>Species/Populations</td>
<td>Seabirds and shorebirds</td>
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<td></td>
<td></td>
<td>Invasive &amp; unusual species &amp; marine diseases</td>
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<tr>
<td></td>
<td></td>
<td>Charismatic large megafauna</td>
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<tr>
<td></td>
<td></td>
<td>Groundfish and demersal fishes</td>
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<td></td>
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<td>Forage fishes</td>
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<td></td>
<td></td>
<td>Pacific salmon species</td>
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<td></td>
<td>Commercial shellfish</td>
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<td>Other invertebrates</td>
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<tr>
<td>Realm</td>
<td>Element</td>
<td>Indicator Categories</td>
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<tr>
<td>---------------</td>
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<td>--------------------------------------------------------------------------</td>
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<tr>
<td>Productivity</td>
<td>Primary and Secondary</td>
<td>All plankton and ichthyoplankton biomass, assemblage, richness, and evenness</td>
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<tr>
<td></td>
<td>Productivity</td>
<td>Chlorophyll a</td>
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<td></td>
<td></td>
<td>Macroalgae and microphytobenthos</td>
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<td></td>
<td></td>
<td>Benthic secondary producers</td>
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<tr>
<td></td>
<td>Trophic Structure</td>
<td>Whole system indices</td>
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<td></td>
<td></td>
<td>Fishing and catch indices</td>
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<tr>
<td></td>
<td>Population Productivity</td>
<td>Productivity, biomass, and abundance of various species</td>
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</tbody>
</table>
State indicator categories

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<tr>
<th>Realm</th>
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<th>Indicator Categories</th>
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</thead>
<tbody>
<tr>
<td>Marine Environmental Quality</td>
<td>Physical</td>
<td>Climate/oceanographic indices</td>
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<tr>
<td></td>
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<td>Climate and weather parameters</td>
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<td>Physical oceanographic parameters</td>
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<td>Estuarine water quality</td>
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<td>Chemical</td>
<td>Toxins and lesions in wildlife</td>
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<td>Other benthic biota indices</td>
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<td>Chemical parameters of water quality</td>
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<td>Contaminants in water and sediment</td>
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<td></td>
<td>Habitat</td>
<td>Shoreline integrity</td>
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<td>Habitat modification</td>
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<td></td>
<td>Human stressors per habitat</td>
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</tbody>
</table>
Candidate indicators of chemical marine environmental quality

- Dissolved Oxygen
- Biochemical Oxygen Demand (BOD)
- N concentration (nitrate, nitrite, ammonia)
- P concentration (TP—total phosphorous, SRP—soluble reactive phosphate)
- Red tides (phytoplankton bloom) occurrence and cover
- PSP and shellfish toxin outbreak incidence and severity
- Toxic chemical concentrations in offshore waters
- Fish tissue contaminants index
- Chemical oxygen demand (COD)
- Fecal coliform contamination in recreation areas
- Number of contaminated sites by category
- Inorganic Carbon
- Trophic State Index (TSI)
- Acidity (pH), alkalinity
- Copper
- Gold
- Mercury
- other metals
- Cadmium
- Area closed to fishing by dioxin and furan contamination
- Area of sediments that have contaminant levels above sediment quality guidelines
- Level of contaminants in representative non-migratory organisms
- Area of shellfish bed closure by state/province by year
- Background sediment quality in Inlets
- Dioxins in sediment
- Tributyltin concentration levels
- PCBs in sediment
- PBDEs in sediment
- DDT in sediment
- Oil on seabirds
- The AZTI Marine Biotic Index (AMBI)
- Bentix
- Macrofauna Monitoring Index
- Benthic Response Index (BRI)
- Area of sediment with contaminant levels above SQ guidelines
- Organochlorine contaminant (OC) bioaccumulation in seabirds
- Organochlorine contaminant (OC) bioaccumulation in marine mammals
- Seagrass Nutrient Pollution Index
- Heavy metal (HM) bioaccumulation in seabirds
- Plastic particles in stomachs of seabirds
- Contaminants in marine organisms
- Contamination in sediment, benthos and fish by pesticides and heavy metals
- PSP toxins in shellfish
- Amount of dissolved or particulate waste produced by fish farms
- Areas of shellfish bed closure
- Dissolved organic carbon in water
- Hydrocarbons
- Organochlorines
- Contaminated biota
Candidate indicators of species and population biodiversity
Criteria for indicator selection

- Ease of understanding
- Ease of measurement
- Cost efficiency
- Availability of historical data
- Sensitivity to stressors
- Responds predictably and in a known way to stressors
- Specificity of response to stressors
- Anticipatory of broader ecosystem changes
- Integrative
Applying selection criteria

1. Please rate the following indicators based on the following criteria:

   - Easy to understand
   - Easy to measure
   - Cost efficient
   - Historical data available
   - Sensitivity to stressors
   - Responds predictably and in a known way to stressors
   - Specificity of response to particular stressors
   - Anticipatory of broader ecosystem changes

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Easy to understand</th>
<th>Easy to measure</th>
<th>Low cost</th>
<th>Existing data</th>
<th>Sensitivity</th>
<th>Responsiveness</th>
<th>Specificity</th>
<th>Anticipatory</th>
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<tr>
<td>Mean trophic level of the ecosystem</td>
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<tr>
<td>Mean trophic level of the landings</td>
<td>Excellent</td>
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<td>Kelp forest cover</td>
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<td>Eelgrass cover</td>
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<td>Cold water coral cover</td>
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<td>Sponge habitat cover</td>
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<td>Intertidal diversity</td>
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<td>Benthic invertebrate diversity</td>
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<td>Benthic fish community diversity</td>
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</tbody>
</table>
The elements of the socio-economic system

Community (Place) Vision & Values
- Public interests
- Private Interests
- Community Interests

Community Assets
- Financial Capital
- Human Capital
- Cultural Capital
- Social Capital
- Physical Capital
- Natural Capital

Community objectives
- Livelihood objectives
- Sector objectives
- Policy objectives

Institutional Economic Drivers
- Marine-Use Sectors & Activities
- Policies
- Regulations
- Mode of Production
- Mode of coordination
- Treaties

Market –value uses
Non-market value uses
Benchmarks and Targets

• Expert workshops with partners
  – Fisheries and Oceans Canada
  – Parks Canada
  – Coastal First Nations
  – Other partners in the region
• Other literature and expert input
Develop Management Options
e.g. MarZone – protected site selection
InVEST – Scenarios of Ecosystem Services

PNAS – The Natural Capital Project
Major decision support tools for WCVI Coastal and Ocean Planning

- **Ecological & socioeconomic data**
- **GIS data collection, storage, use**

**MARZONE:**
Zoning selection: Selects least cost marine spatial policy options with multiple zoning definitions, multiple costs, and connectivity

**Ecopath:**
Characterizes food web & fisheries

**Ecosim:**
Estimates direct & indirect changes

**Ecospace:**
Estimates temporal & spatial effects of policies

**“Ecopol”:**
Optimizes value (ecological, social, economic)

**InVEST**
- **Scenarios**
  - Estimation of spatial changes in ecosystem services & values
  - Other models:
    - Single stock, Aquaculture, Erosion, Inundation, Recreation, Cultural Services

**Spatially explicit information**
Next steps

- Management strategy development and implementation
- Monitoring program
  - Benchmarks and targets
  - Monitoring for Status and Trends
  - Evaluating Management Strategies
Acknowledgements

- Gordon and Betty Moore Foundation
- DFO
- Parks Canada
- Pew Fellows Program in Marine Conservation
- University of Victoria
- Western Economic Diversification, Industry Canada
- And many others...