

# Taking the pulse of the marine environment

A proposed framework for assessing and reporting on the  
status and trends in oceans and coastal health in Canada

Colleen S.L. Mercer Clarke, M.Sc., M.L.A., Ph.D., FCSLA

*Canadian Healthy Oceans Network*



# Canada's marine environments



- **3 oceans:**
  - Arctic
  - Pacific
  - Atlantic
  - Great Lakes ?
- **longest coastline in the world**
- **(relatively) few scientists**
- **tight and tighter budgets**

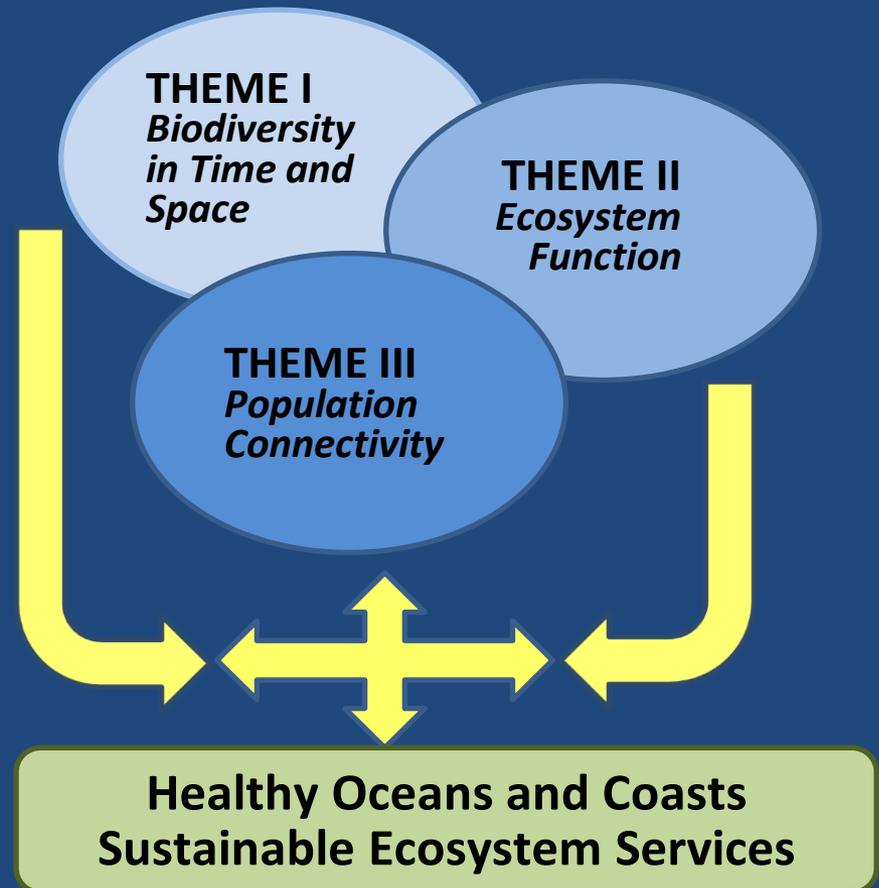


**CHONE**  
CANADIAN HEALTHY OCEANS NETWORK

## *Biodiversity Science for Sustainability of Canada's Three Oceans*

*“The key, unifying output of the Network is the capacity to influence policy on marine conservation and sustainable ocean use.” (Snelgrove et al. 2007)*

- 147 researchers
- 13 universities
- partnership with Fisheries and Oceans Canada
- 35 research projects



## How do we know if our oceans and coasts are healthy?

- ecosystem health or sustained services?
- how do we set boundaries for oceans?  
..for coasts?
- what constitutes health ...or *ill-health*?
- who measures health?
- who reports on health?

...there is no national or regional framework that sets goals, assesses and reports on the changes in the health of our oceans and coasts ...

## **Building the foundation for a multi-scale framework**

- **Science led**
  - **Build on the work of others**
  - **Build on existing knowledge**
  - **Widely applicable**
  - **Widely heard**
- 
- **DEFINE key concepts**
    - **coast, ocean, ecosystem, health**
  - **DESCRIBE and ASSESS conditions**
    - **status, pressures, changes**
  - **REPORT on the trends**
    - **what, where, why, why**

**DEFINE:**  
a struggle towards  
shared understanding

*An ecosystem is*

*“a system with a specific geographic location that includes all living organisms (humans, plants, animals, micro-organisms), the physical, chemical, and climatic environment, and the processes that control the dynamics of the system.”*

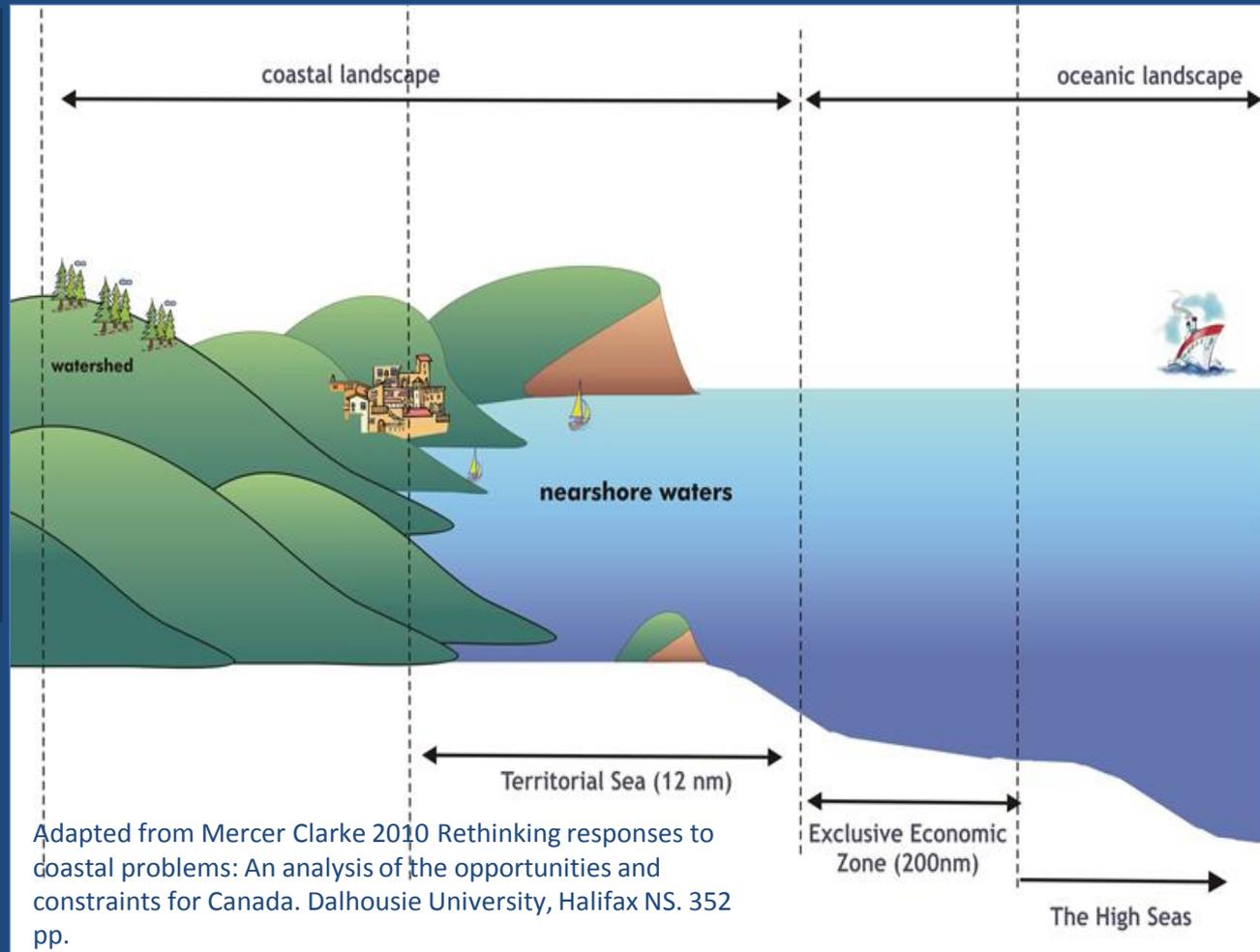
(GOC/DFO 2007)

- What is an ecosystem?
- Are humans part of ecosystems?
- What are ecosystem services?
- What is ecosystem health?
- What is (or is not) an ocean?
- What is a coast?

# What is an ocean?

# What is a coast?

- **Linked/nested ecosystems within landscapes**
- **no universal boundaries**
- **knowledge base is fragmented, inconsistent, non-existent**



**The oceans of Canada are composed of the marine ecosystems that are linked and nested within the oceanic landscapes of the Arctic, Atlantic and Pacific, and the aquatic ecosystems of the sweet water landscapes of the Great Lakes.**

# What is Ecosystem Health?

*“ An ecological system is healthy and free from ‘distress syndrome’ if it is stable and sustainable – that is, if it is active and maintains its organization and autonomy over time and is resilient to stress.”*

*(Costanza and Mageau, 1999)*

*“Distress syndrome refers to irreversible processes that cause an ecosystem to stop functioning and eventually breakdown before its normal life span.”*

*(Rapport et al., 1985, 1992, Costanza and Mageau, 1999)*

**HEALTH is a concept that is..**

- ✓ commonly understood
- ✓ readily communicated
- ✓ effective

**ECOSYSTEM HEALTH - a synthesis of:**

- **ORGANIZATION** (species, populations, diversity)
- **VIGOUR** (functioning, productivity)
- **RESILIENCE** (resistance / adaptation to change)

## What do Canadians Expect of their Oceans and Coasts?



## What are Healthy Oceans and Coasts?

Oceans and coastal environments are healthy when they support diverse, productive and resilient ecosystems, and

when human use is at a level that is ecologically sustainable, safeguarding the present and providing for continued, or unanticipated uses by current and future generations.\*

\* Extracted with little change from the EC MSFD (2008) definition for GES

# How do we describe Ocean and Coastal Health?



1. **Biological Diversity**
2. **Plankton Biodiversity & Abundance**
3. **Food Webs**
4. **Non-indigenous Species**
5. **Landscape & Bottomscape Features**
6. **Water And Sediment Quality**
7. **Eutrophication**
8. **Marine Litter**
9. **Energy and Noise**
10. **Climate Change**
11. **Human Health and Well Being**
12. **Sustainable Communities**
13. **Sustainable Fisheries**
14. **Marine Transportation**
15. **Non-renewable Resource Extraction**

**Contributions:** European Commission (Water Directive, Marine Strategy Framework Directive, DEDUCE); ICES, HELCOM, OSPAR; Australia (OzCoast); Oceans Health Index, USA (Oceans Policy). PICES, ESIP, ESSIM, Arctic, Great Lakes

# Measuring Status and Trends

- Descriptors
- Attributes
- Criteria
- Indicators

## DESCRIPTOR 1: Biological Diversity:

Biological diversity is maintained. The quantity and occurrence of habitats and the distribution and abundance of species are in keeping with prevailing physiographic, geographic and climate conditions, and are consistent with historic records of undisturbed conditions.

### Attribute 1A: Species State

**Criteria 1A:**

- Maintain species abundance/distribution
- Maintain population size
- Maintain population condition
- Maintain reproductive capacity
- Maintain species condition
- Maintain mortalities below threshold limits
- Maintain resilient species

### Indicators

- 1A1 Species abundance
- 1A2 Species distributional range
- 1A3 Species distributional pattern

# What indicators inform on health?

- Indicators of the *Status* and *Trends* in health
  - Ecosystem integrity (biological, chemical, physical)
  - Ecosystem goods and services (food, function)
  - Ecosystem vulnerabilities (threats, impacts)
- no short list that does it all
- 400 + indicators
- each indicator appears only once in the list
- a single indicator could have multiple applications (e.g. temperature, phytoplankton, declines in numbers of large fish)
- alpha-numeric coding to facilitate data-sharing and syntheses

So.... what does an indicator tell us about health?

What might an indicator tell us about change?

## Setting reference points for indicators

- *Thresholds* identify reasonable limits to change
- *Target levels* are to be achieved
- *Tipping points* must be anticipated and strenuously avoided

...what indicators give early warnings of threats to health  
...a heads up for when we should look wider, deeper, faster ...



## **Taking the Pulse: Early warnings of detrimental change**

**Threat indicators are:**

- **meta-indicators of change**
- **easy to measure**
- **proactively report on threats**
- **report on worrisome change**
- **point to the need for more information**
- **should provoke action.**

### **SAMPLE OCEANIC THREAT INDICATORS**

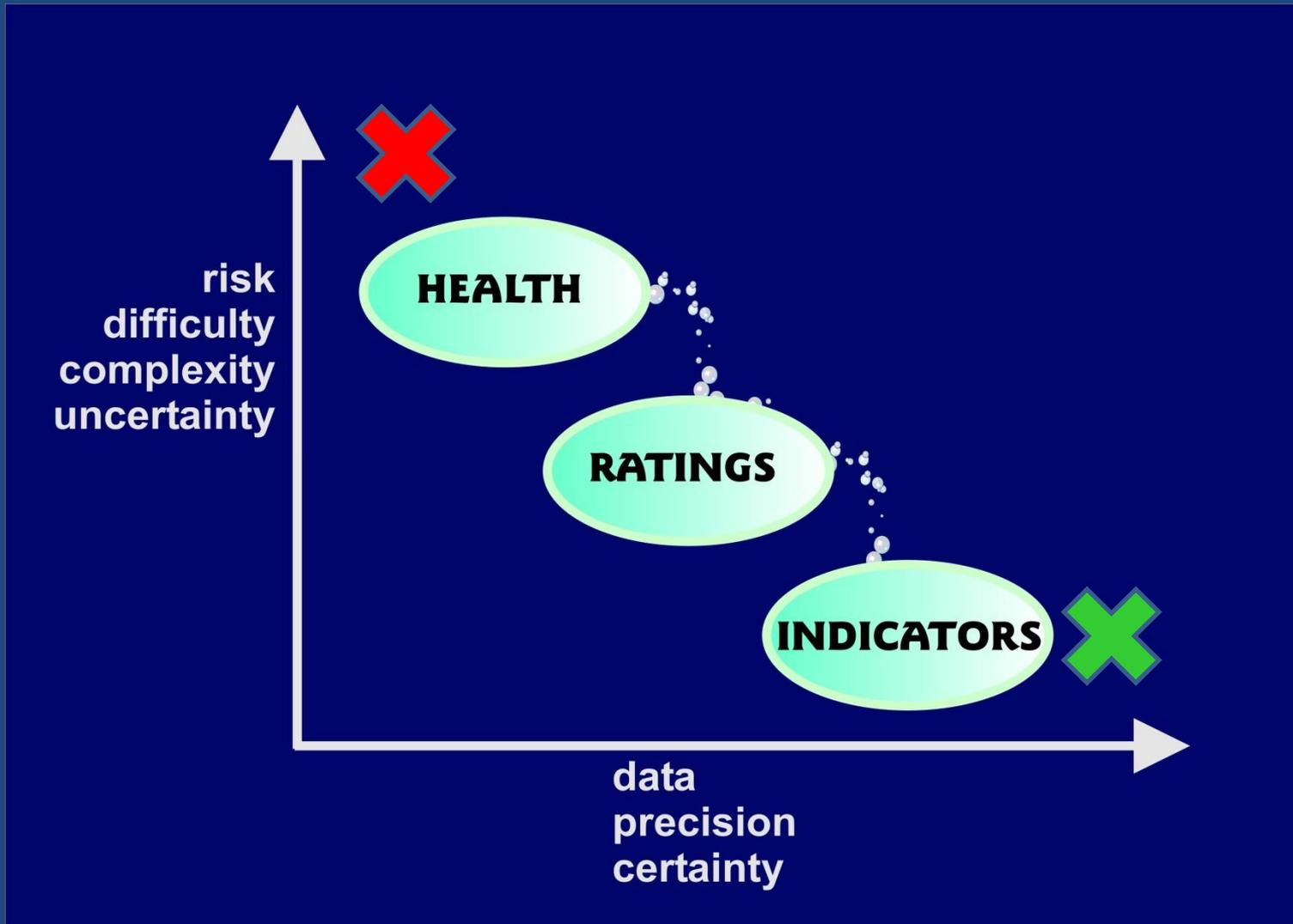
- **Sea temperature & acidity**
- **Plankton biodiversity & abundance**
- **Catch per unit effort**
- **Decline in large predators**
- **Decline in large fish**
- **Contaminants in fish and mammals**
- **Seabird populations**

### **SAMPLE COASTAL THREAT INDICATORS**

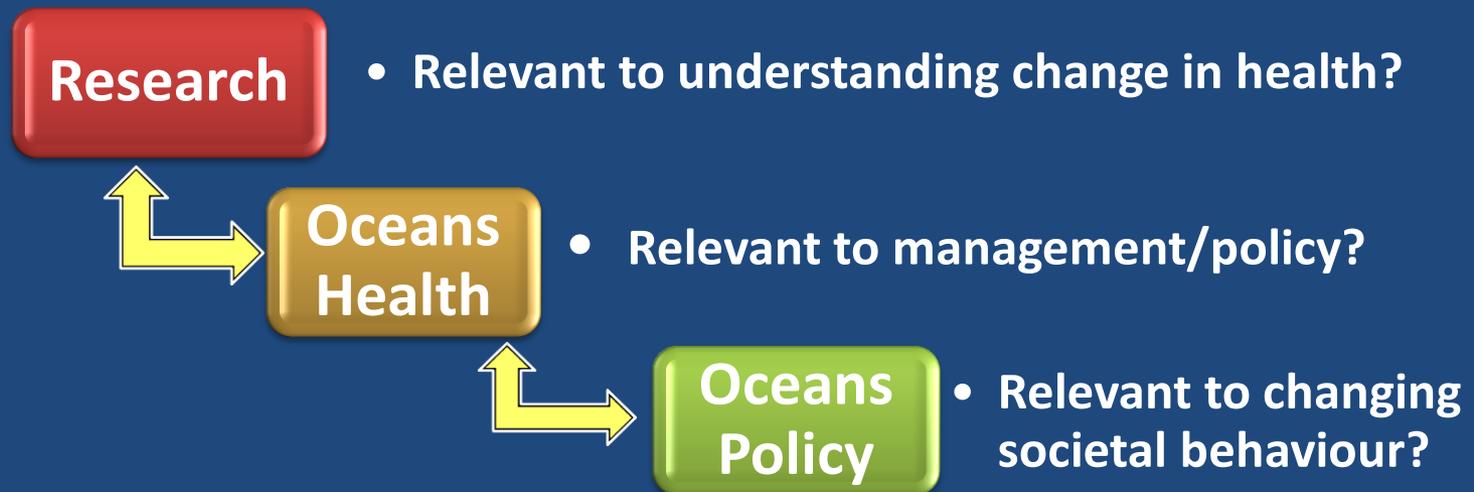
- **Dissolved oxygen**
- **Harmful algal blooms**
- **Nutrients in nearshore waters**
- **Beach closures**
- **Shellfish harvest closures**
- **Contaminant levels**
- **Loss of saltmarshes**

**When do we know enough?**

# The Challenges posed by Scale, Uncertainty, and Risk



# Challenging Science to be Relevant



**“Marine scientists need to develop an understanding of what good health means..., and then policymakers and those who use ocean resources, need to practice preventative medicine.”** *(Pew Oceans Commission 2003)*

# Rating and Reporting on Changes in Health:

## Finding answers

Largely adapted from *A Guide to Ecological Scorecards for Marine Protected Areas in North America* by the Commission for Environmental Cooperation (CEC 2011). Montreal, Canada and from NOAA efforts towards reporting on marine sanctuaries (GOV/USA/NOAA 2011)

- 15 DESCRIPTORS of health
- 28 Questions that ask us to rate how things are, how they are changing

### DESCRIPTOR 1: BIOLOGICAL DIVERSITY

1.5 To what extent do human activities influence habitat extent and quality and how are they changing?

### DESCRIPTOR 5: LANDSCAPE & BOTTOMSCAPE FEATURES

5.10 To what extent has land cover and land use change in the watershed affected riverine and coastal habitat extent and quality and how are conditions changing?

### DESCRIPTOR 6: WATER & SEDIMENT QUALITY

6.13 To what extent are human activities affecting water quality and how are these activities changing?

### DESCRIPTOR 7: EUTROPHICATION

7.15 To what extent have altered nutrient loads affected ecosystem health and how are they changing?

### DESCRIPTOR 11: HUMAN HEALTH & WELL-BEING

11.20: To what extent do water quality conditions pose risks to human health and well-being and how are they changing?

## Putting the pieces together



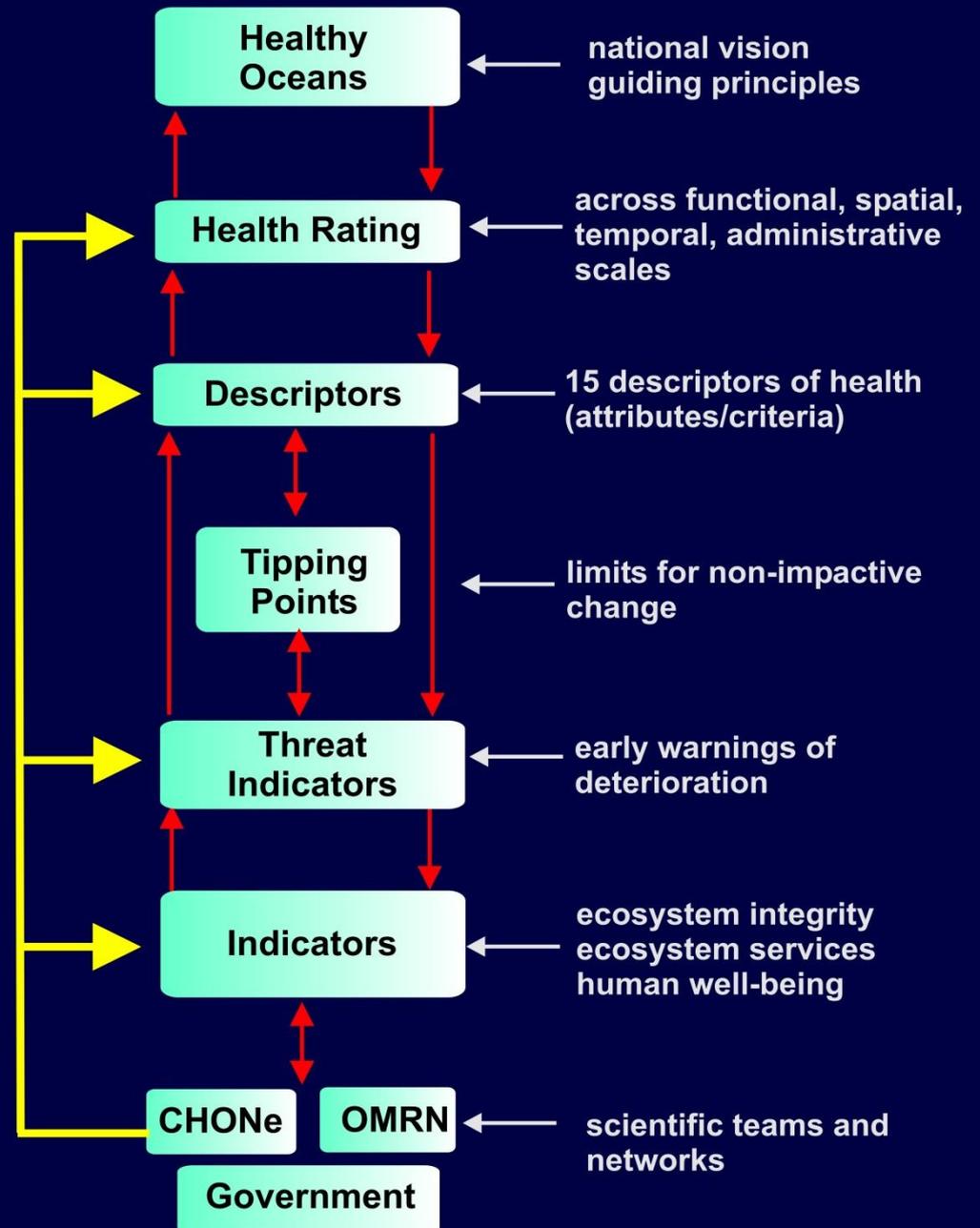
### Rating the STATUS of Health using a 5 point scale

 SUPERIOR	 POOR
 GOOD	 CRITICAL
 FAIR	 UNDETERMINED

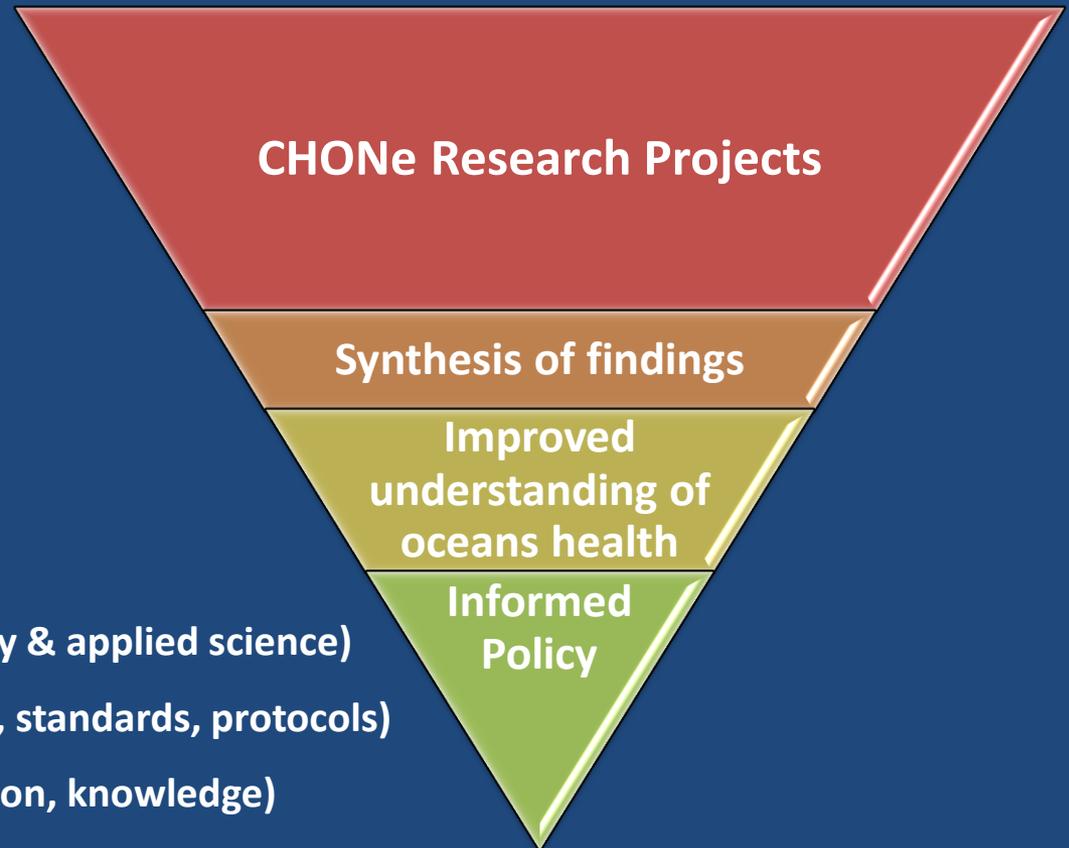
### Assessing TRENDS in Health

<input type="checkbox"/>	Conditions appear to be changing at a rate that will lead to an improved state in five years
▲	Conditions are improving
—	Within natural variability, no consistent changes are expected from either anthropogenic or natural stresses
▼	Conditions are deteriorating
<input type="checkbox"/>	Conditions appear to be changing at a rate that will lead to a degraded state within five years
?	There is insufficient information to establish a basis for a trend, or the data are highly variable and no trends can be identified
n/a	The question does not apply

# Applying the Healthy Oceans and Coasts Framework



# The current and future roles for science



- **Discover** (advance both discovery & applied science)
- **Define** (indicators, tipping points, standards, protocols)
- **Distribute** (share data, information, knowledge)
- **Deliberate** (synthesize, rate & report on status & trends)
- **Disseminate** (publish, speak, challenge)
- **Discover**

When do we know enough?

# Making the bigger picture



## Next Steps

- **Agreement on Framework elements**
- A rationale for each Descriptor/Attribute/Criteria.
- Standardized protocols for each indicator, including defined reference points (target, threshold, tipping point)
- A rationale for each of the rating Questions
- Expert teams to produce and update all of the above

### CHONe is approaching the end of its 5 year mission

#### SCIENCE NEEDS

Ecosystem Function

Biodiversity Observation

#### GEOGRAPHIC NEEDS

Arctic

Coastal Pressures

Changing Oceans

#### UNIQUE TOOLS

Ocean observatories

ROVs

Indicators

**And this is a period of change in federal science funding....**



**LIFE IN A CHANGING OCEAN**  
PROVIDING TOOLS FOR SUSTAINABLE OCEAN USE



**SCIENCE PLANNING COMMITTEE**

**Paul Snelgrove**

*Memorial University of Newfoundland, Canada, chair*

**Patricia Miloslavich**

*Universidad Simón Bolívar, Venezuela, vice-chair*

**Linda Amaral-Zettler**

*Marine Biological Laboratory at Woods Hole, United States*

**Philippe Archambault**

*Université du Québec-Rimouski, Canada*

**S.T. Balasubramanian**

*Annamalai University, India*

**Richard Brinkman**

*Australian Institute of Marine Science, Australia*

**Roberto Danovaro**

*Polytechnic University of Marche, Italy*

**Masahiro Nakaoka**

*Hokkaido University, Japan*

**Henn Ojaveer**

*University of Tartu, Estonia*

**Eva Ramirez-Llodra**

*Institut de Ciències del Mar, CSIC, Spain*

**Lynne Shannon**

*University of Cape Town, South Africa*

**George Shillinger**

*Center for Ocean Solutions, United States*

**Xinzheng Li**

*Institute of Oceanology, China*



**CHONE**  
CANADIAN HEALTHY OCEANS NETWORK



**NSERC  
CRSNG**



Newfoundland & Labrador, Canada



Fisheries and Oceans  
Canada

Pêches et Océans  
Canada



École de gestion

**TELFER**

School of Management



Canadian Fisheries, Oceans and Aquaculture Management